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A CORPUS- AND PSYCHOLINGUISTIC TESTING OF THE STRONG VERSION OF THE EMBODIMENT HYPOTHESIS IN COGNITIVE LINGUISTICS

A Doctoral thesis submitted in partial fulfilment of the requirements for the PhD degree in Psychology in the Department of Cognitive Science, Budapest University of Technology and Economics, Hungary.

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DECLARATION

I declare that *A Corpus- and Psycholinguistic Testing of the Strong Version of the Embodiment Hypothesis in Cognitive Linguistics* is my own work, that it has not been submitted before for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged as complete references.

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GLOSSARY OF ABBREVIATIONS

ANOVA	Analysis of variance
LSD	Least significant difference (test)
ERP	Event-related potential
EEG	Electroencephalography
MEG	Magnetoencephalography
fMRI	Functional magnetic resonance imaging
PET	Positron emission tomography
LASS	Language and Situated Simulation Theory
FUSS	Featural and Unitary Semantic Space Model
LSA	Latent semantic analysis
RT	Reaction/reading time
SOA	Stimulus-onset asynchrony (onset-to-onset interval)
CMT	Cognitive Metaphor Theory
ESL	English as a second language
NLP	Neuro-Linguistic Programming

KEYWORDS

Cognitive Metaphor Theory, metaphor, Lakoff, idioms, psycholinguistics, corpus linguistics, concrete and abstract language, mental simulation, sentence understanding, embodiment, environmental sounds, thematic roles, amodal symbols

KULCSSZAVAK

Kognitív metaforaelmélet, metafora, Lakoff, idiómák, pszicholingvisztika, korpusznyelvészet, konkrét és elvont/absztrakt nyelv, mentális szimuláció, mondatmegértés, testesültség, környezeti hangok, tematikus szerepek, amodális szimbólumok

ABSTRACT

Do people think in terms of concrete representations when they use abstract language? According to the strong version of the Embodiment Hypothesis, our abstract knowledge and higher cognitive processes are *directly* grounded in sensory-motor representations rather than in amodal symbols. Crucially, according to this view, sensory-motor states, which are claimed to be *conceptual features*, are *partially* and *automatically* re-activated during both concrete and abstract language use. However, this conception is highly debated on theoretical and empirical grounds and other approaches have emerged.

In a test of this radical hypothesis, we carried out corpus- and psycholinguistic experiments. The thesis first reviews theoretical claims with empirical evidence for and against the strong version of the Embodiment Hypothesis, then five studies are presented, four of which provide novel empirical data and one reviews theoretical positions. It is argued that effects revealed by psycholinguistic measures do not clearly support the strong version of the Embodiment Hypothesis but rather an amodal view of language processing, according to which linguistic-propositional representations underlie language understanding.

The results of a series of experiments with environmental sounds and language provided support for the conclusion that sound representations are not conceptual features because they are not necessarily and automatically activated during normal language use. All in all, the findings support the weak version of the Embodiment Hypothesis, according to which abstract concepts are represented separately from concrete concepts.

KIVONAT

Konkrét reprezentációkra épül-e gondolkodásunk, amikor elvont nyelvezetet használunk? Az ún. testesültség hipotézis erős verziója szerint az elvont tudásunk és a magasabb kognitív folyamatok *közvetlenül* szenzomotoros reprezentációkban lehorgonyzottak, mintsem amodális szimbólumokban. Lényeges az elméletben, hogy a szenzomotoros állapotok, amelyekről azt gondolják, hogy *fogalmi jellegek*, *részlegesen* és *automatikusan* újraaktiválódnak mind a konkrét, mind az elvont nyelvhasználat során. Ezt az elméletet sokan vitatják elméleti és empirikus alapon, s újabb megközelítések hódítottak teret.

Az említett radikális hipotézis tesztelése végett korpusznyelvészeti és pszicholingvisztikai kísérleteket végeztünk. Az értekezés először az elméleti álláspontokat tekinti át a testesültség hipotézis erős verzióját támogató és cáfoló empirikus kutatásokkal együtt, majd öt tanulmány bemutatására kerül sor, amelyekből négy új empirikus eredményeket prezentál, egy pedig az elméleti pozíciókat taglalja. Amellett érvelek, hogy a pszicholingvisztikai vizsgálatokban feltárt hatások nem egyértelműen támogatják a testesültség hipotézis erős verzióját, hanem inkább a nyelvfeldolgozás amodális nézetét, mely szerint nyelvi-propozícionális reprezentációk képezik a nyelvi megértés alapját.

Egy a környezeti hangok és nyelvfeldolgozással foglalkozó kísérletsorozat eredményei azt a következtetést igazolták, hogy a hangreprezentációk nem fogalmi jellegek, mivel nem szükségszerűen és automatikusan aktiválódnak normál nyelvhasználat során. Összességében, az eredmények a testesültség hipotézis gyenge verzióját támogatják, mely szerint elvont fogalmaink a konkrét fogalmaktól külön tároltak.

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1. INTRODUCTION[1]

How are we able to understand and reason about abstract domains like ‘love’, ‘truth’, ‘banter’, or ‘whistleblowing’? These concepts are considered abstract because they are more complex than concrete material concepts, such as ‘table’. First, they are complex in the sense that they are instantiated and manifested in a variety of contexts, actions or attitudes in a complex way (e.g., jealousy). And second, they are complex because they cannot be experienced directly. For example, we cannot see or grasp ‘jealousy’ but we can see and grasp ‘table’.

It is crucial to highlight that, for example, the *concept* of ‘love’ or ‘jealousy’ may be abstract based on its complexity but their personal manifestation and subjective expression is concrete, that is directly experienced. However, there are problems with the complexity criterion because some concrete concepts may be complex, such as ‘animal’ because it comprises multiple types and tokens, and some of our abstract concepts approximate concrete concepts, e.g., ‘wall’ in the sense of ‘obstacle’; ‘wall’ is less abstract than ‘jealousy’.

The definition of abstractness is crucial because abstract concepts are claimed to be structured by concrete concepts and not the other way round (Lakoff and Johnson, 1999). What this amounts to is that concrete and abstract concepts should be easily distinguished. For a comprehensive investigation into the graded nature of concrete and abstract concepts and the quantification of abstractness, see Chapter 1.2.1., or Fekete and Babarczy (2007). Another investigation of ours also revealed very low levels of inter-annotator agreement of 17% and 48% as to what is considered a metaphor (abstract) and what is not despite the fact that we followed a pre-defined procedure in annotation (Babarczy et al., 2010, see also Chapter 3.1.).

[1] The Introduction of the dissertation is inspired and based on the author’s unpublished Master’s thesis with major revision and modifications (Fekete, I. (2006). A Comparative Psycholinguistic Analysis of the Hungarian Temporal Suffix –ig and the English Temporal Preposition until, unpublished Masters thesis, MA in English studies, ELTE, Budapest, Hungary).

The definition, representation and grounding of abstract concepts is one of the most difficult enterprises in cognitive linguistics. Traditional approaches to abstractness have defined abstractness *negatively*, characterizing the representation of abstract concepts as the absence of image-evoking ability. Others, for example, Brown (1958), claimed that the abstractness level of a word is given by the number of its subordinate concepts. More recent approaches have strived to characterize our abstract knowledge positively, as the presence of some functional variables. For example, the dual-coding model (Paivio, 1986, 2007) proposes that concrete concepts are associated with imagery, while both concrete and abstract concepts can be represented in a language-like code. Other research has suggested that besides imagery, context availability (Schwanenflugel and Shoben, 1983), word associations, metaphors (Lakoff and Johnson, 1999), introspection (Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005), motor information (Glenberg and Kaschak, 2002), or emotional affective states (e.g., Winkielman, Niedenthal & Oberman, 2008) are all important aspects of how abstract concepts are represented. Relevance Theory (Sperber and Wilson, 1986/1995) should also be added to this list because it proposes a distinct and *domain-general* mechanism which governs the comprehension of concrete and abstract language. However, the relevance-theoretic representational mechanism in abstract language comprehension is far from clear.

Jenő Putnoky (1975, 1976, 1978, 1979), a less known Hungarian theorist on the international scale was also on the quest of defining and grounding abstract knowledge. He demonstrated using a rating procedure that abstract concepts possess more intense motor-evoking capacity, which he called “motority”, than concrete concepts (Putnoky, 1975). In order to assess motority, he asked his participants to judge concrete and abstract nouns against a 7-point bipolar Likert-scale regarding the motor-arousal capacity of concepts. He defined motor-arousal vaguely as the potential and capacity of concepts to arouse motion, i.e., “to elicit some motion tendency or to mobilize some inner energy to carry out an action or activity” (Putnoky, 1979, p. 545). Mean motority values showed a significant negative correlation with mean imagery values and a significant positive correlation with abstractness.

Motority in Putnoky's research has not been scrutinized in the literature, and no specific or non-specific function has been assigned to it so far. Putnoky himself also asked the question whether motority has a peripheral or central source. In the light of the present research 40 years after his activity, it is still unclear whether motority in his meta-judgement task reflects specific higher motor processes in the sense of Glenberg and Kaschak (2002) in the representation of abstract concepts, or whether Putnoky's motority springs from a different domain, such as sub-vocal articulation. It also remains to be answered whether motority is a specific or non-specific phenomenon. Glenberg and Kaschak (2002), for example, propose in line with Lakoff and Johnson (1999) that abstract concepts preserve their specific concrete motor content. For example, 'grasp the idea' involves the representation of reaching for a proximal object (i.e., abstract entity) and keeping that object. Motor information in the representation of abstract concepts in the sense of Glenberg and Kaschak (2002) is therefore specific and derives from the concrete motor activity. Putnoky's abstract concepts, on the other hand, are not specifically built on such motor inferences. He speculates that motority plays a regulative role at higher levels of organization of word meaning in the central nervous system (Putnoky, 1978).

Out of the variables and representational processes of abstract concepts enumerated above, I am going to deal with the metaphorisation process in greater detail in my dissertation. My dissertation aims to investigate only the representation of abstract concepts compared to that of concrete concepts. But before proceeding to the question of representation, let us turn back to the question of definition of abstract concepts. I have already shown that the complexity criterion is an unsatisfactory definition of abstract concepts, and second, because it is a post-hoc categorization. Fekete and Babarczy (2007) in their survey of abstract concepts on Hungarian offer two variables along which abstract concepts can be better grasped: *definability* and *imageability*. Their results demonstrated that abstract concepts are highly definable and poorly imageable compared to concrete concepts which are less definable but highly imageable. Chapter 1.2.1. elaborates on this study in greater detail.

It should now be evident that theories have a hard time coping with the definition and grounding of abstract concepts. Jesse Prinz (2002), for example, enlists seven desiderata about an acceptable theory of concepts. I would like to deal with two of them here: *scope* and *publicity*. Scope refers to the desideratum that a theory of concepts must "accommodate the large variety of concepts that we are capable of processing" (p. 3). So, for example, both concrete and abstract concepts must be included. One of the most serious problems in cognitive linguistics is coping with the scope desideratum when it comes to abstract concepts.

Prinz's seventh desideratum, *publicity* requires that "concepts must be capable of being shared by different individuals and by one individual at different times" (p. 14). Given the complex nature of grounding abstract concepts, the publicity desideratum is best satisfied by theories which propagate the existence of objective meaning. Just to give one example, Fodor's informational atomism (Fodor, 1998), according to which all lexical concepts are unstructured symbols, accommodates the desideratum of publicity by eliminating the inner structure of concepts (for a review in Hungarian, see Fekete, 2010). However, the opposite view, radical constructivist semantics also posits a view on how communication might work perfectly without any representations or objective meaning (for an extensive review of radical constructivist semantics, see Chapter 3.1. or Fekete, 2010). Suffice it to say now that for this thesis it is only important to underscore that abstract concepts are highly complex, poorly definable and the least imageable concepts.

If we want to adopt the desideratum of shared knowledge (publicity) to abstract concepts, then we have to assume that abstract concepts share something in common, so that they can be easily shared by individuals. I am going to elaborate on this question throughout the dissertation and propose that amodal symbols, frames, schemas, image schemas, or standing knowledge (Prinz, 2002) all satisfy this desideratum.

Let us return now to the first question at the beginning of the dissertation. My first question is difficult to answer because one can argue that we understand these concepts with the help of other neighbouring concepts in an abstract semantic network, where concepts are represented as nodes, or it is also possible that concrete non-linguistic representations are activated, such as visual or auditory representations that ground and guide semantic processing.

Specifically, for example, how do we understand an abstract sentence, such as *The story rings true*? One of the questions, which arises here, is whether the perceptual symbol, that is a sound representation of some type is activated or not. It is logical to ask the same question about concrete sentences, such as *The telephone is ringing or The alarm bell is ringing*. Crucially, the three sentences with the verb 'ring' refer to three different types of ringing sounds. How do we comprehend these sentences? If a sound representation is activated, then is it the same sound representation in the three sentences, or three proxytypes in the sense of Prinz (2002), i.e., three different samples of ringing sound?

Not much easier is the question how we understand concepts and situations that we do encounter in the material world (the concrete experiential world). For example, the utterance *The boy stayed together with the girl* is the result of a spatial-perceptual scenario that we saw in the material world and deemed relevant to convey as a piece of information. This scenario is based on spatial and perceptual representations of the mental referents ('boy', 'girl', their spatial setting, their dynamic actions, etc.). The question is as to what role these representations play (if they play a role at all) in the understanding process of such a sentence.

Does the sentence *The boy stayed together with the girl* have a linguistic-propositional meaning or the words in the sentence (function as labels and) activate only spatial-perceptual representations? If spatial-perceptual representations are activated, are these the same representations as the ones activated during perception? Is language understanding different from perceptual simulation? How are subtle aspects, such as the involvement of actors represented mentally? So, for example, does the sentence *The boy broke up with the girl* differ from the sentence above in terms of their representation of thematic roles? How are thematic roles encoded mentally? Are they encoded in an abstract propositional/linguistic format or in thematic frames (templates)? In one sentence, the question is directed to the quality of representational mechanisms in concrete and abstract sentence comprehension.

An extreme suggestion is that abstract domains (such as, time, love, truth, etc.) are understood in terms of more concrete, experience-based domains (Lakoff & Johnson, 1980, 1999). On this view, for example, the abstract domain of time is understood in terms of more concrete, spatial schemas. This theory, thus, predicts that whenever we process a temporal expression such as *until seven o'clock* we have access to a spatial representation that simulates an analogical motion in space. This view is usually referred to as the strong version of the Embodiment Hypothesis (Lakoff & Johnson, 1980, 1999). On this embodiment account, "an embodied concept is a neural structure that is actually part of, or makes use of, the sensorimotor system of our brains" (Lakoff & Johnson, 1999, p. 20).

On the strong embodiment account, low-level sensory and motor information is activated in the primary cortices as part of automatic semantic processing. In other words, semantic processing is operating in the primary cortices according to this view and it is fully contingent on sensory and motor systems.

Three aspects of the strong version of the hypothesis are the *automatic* nature of activation of sensory-motor representations, the *necessary* nature of activation irrespective of task demand, and the *direct* activation of these representations. I am not going to test the latter aspect of the hypothesis in absence of suitable methods, therefore the former two aspects will be examined throughout the dissertation.

In contrast, the weak version of this hypothesis contends that abstract concepts are *represented separately* from concrete concepts and from sensory-motor representations. Importantly, the weak version of the hypothesis claims that sensory-motor representations are *in close contact* with concrete or abstract conceptual representations, that is, they are closely associated to these representations, but they are *not necessary* for conceptual representation, so effects may *not necessarily be consistent* across experimental tasks. By close contact, it is meant that these representations are rapidly activated and that they may reside in close proximity to amodal representations.

Crucially, on the weak account, sensory-motor representations may be activated *automatically* but they are *not necessary* (inherent) parts of conceptual representations, whereas the strong version claims that semantic processing is impossible without sensory-motor representations. I am going to elaborate on the weak version of the hypothesis later in the dissertation.

As for the direct nature of activation, according to the weak version of the hypothesis, sensory-motor representations and conceptual representations may be *indirectly* linked to each other. Since the *direct* testing of the weak version of the hypothesis falls beyond the scope of the dissertation, no inference will be made about its validity. Second, it would be illegitimate to jump to the conclusion that the weak version is supported in case the strong version should be falsified. Therefore, I am going to examine the first two crucial aspects of the strong version, *automaticity* and *necessity* of activation of modality-specific representations.

The aim of this thesis is to give some insights into the broader scope of this theory, into empirical evidence for and against this theory, present alternative theories, and provide novel empirical evidence related to this field. The dissertation strives to integrate a variety of approaches and research techniques, starting with theoretical reviewing and proceeding to corpus-analysis and psycholinguistic experimentation.

One might ask the question why the strong version of the Embodiment Hypothesis in cognitive linguistics should be tested at all. First of all, the general strong embodiment approach is pertinent and vital to a number of other disciplines, such as system biology[2], speech recognition systems, or artificial intelligence (robots). The idea of strong embodiment is also present in bio-psycho-social approaches, which view humans holistically as being embedded in their biological, psychological, and social environment and being in a constant cohesive interaction with their body and environment as well. It is therefore crucial to test the psychological reality of the strong embodiment view in cognitive linguistics too because such an investigation adds to the strong embodiment research program in higher cognition.

[2] More on system biology, e.g., Maturana and Varela's theory, see Chapter 3.1. or Fekete (2010).

Second of all, if the strong embodiment claim is correct, then we might expect a break-through in understanding emotions, empathy, our conceptual knowledge, or certain congenital or acquired brain conditions better. For example, the strong embodiment approach can be a useful paradigm in neuroscience or in neuropsychology. I have opted for testing specifically the strong version because it is a highly debated position, for it claims that semantic processing is implemented in modality-specific areas of the brain without access to amodal representations, and that no semantic processing is possible without sensory-motor representations.

Third of all, the Cognitive Metaphor Theory by Lakoff and Johnson (1999), which is the representative theory of the strong embodiment approach in cognitive linguistics, is highly relevant to a number of applicable disciplines, such as psychotherapy. For example, in Metaphor Therapy (Kopp, 1995) patients describe their situations with metaphors, and the therapist connects to this creative process by unfolding the metaphors or suggesting new metaphors that help the clients overcome their problems. Clients' (patients) problem is usually that their creative activity is blocked. The psychotherapist's task in Metaphor Therapy is to re-activate the client's creative resources with the help of metaphors. In one sentence, metaphor may help the client when they are reluctant to accept other types of techniques or accept what the psychotherapist tries to convey to them (Barker, 1985, p. 39). Finally, it is also worth investigating metaphor comprehension because metaphor is extremely pervasive in our thinking. Gibbs (1992), for example, showed that in English people use roughly 6 metaphors in every minute on average.

The structure of this dissertation is as follows. First, I describe the broader context surrounding the representation of knowledge, that is the modal and amodal approaches in cognitive sciences and the main conceptions about the representation of conceptual knowledge (Chapter 1.1.). I next describe theories on metaphor (Chapter 1.2.) along with cognitive psychological and neuropsychological evidence (Chapter 1.3.). I devote dedicated attention to the domain of time and space, a particularly famous area of research in the embodiment research program (Chapter 1.3.2.). The Embodiment Hypothesis is presented distinctly from the Cognitive Metaphor Theory because it is a broader field (Chapter 1.4.). After this, again, I cite cognitive psychological and neuroscientific evidence in the area of the Embodiment Hypothesis (Chapters 1.4.1. and 1.4.2., respectively).

I next present the criticism of the strong version of the Embodiment Hypothesis (Chapter 1.5.). Finally, I canvass the Synopsis and Rationale of the Theses in the dissertation (Chapter 2.) and the empirical research in the form of papers (Chapter 3.). In Chapter 2., the background, hypotheses and results of each study is summarized and their relation to the strong version of the Embodiment Hypothesis is spelled out. I then turn to the General Discussion of the papers presented in this thesis (Chapter 4.), and conclude by outlining the potential rewards of the empirical research in the Conclusions and Further Directions (Chapter 5).

1.1. The Representation of Conceptual Knowledge

Since the issue of conceptual representation is central to the present research, it is crucial to overview the two main conceptions on representation[3] in cognitive sciences and to provide a wider context for the strong version of the Embodiment Hypothesis. For a review in Hungarian, see Fekete (2010). Mental representations will henceforth be called simply *representations* and used synonymously. If a distinction between mental and neural representations is necessary, then a clarification will be made.

Representational cognitive sciences, as its name suggests, presuppose the existence of neural *representations*. Representational cognitive sciences can be divided into two sub-schools: (a) amodal and (b) modal approaches to cognition. The basic debate between amodal and modal approaches is over the existence of amodal symbols/representations. Amodal theorists (e.g., Fodor and Pylyshyn, 1988; Newell and

[3] Cognitive sciences can be divided into two main schools: (i) non-representational and (ii) representational cognitive sciences. Proponents of the first school (e.g., Maturana, Varela and Thompson) disagree with standard representational approaches that presuppose a causal-explanatory relationship between internal neural representations and contents in the outer world as well as of consciousness. Instead, they propose a 'radical embodiment' approach, and assume that there is no outer world which is represented. Thus, one cannot speak of representations in this paradigm (Thompson & Varela, 2001). This paper will not deal with the non-representational view.

Simon, 1972) assume that conceptual representations are amodal, and that conceptual processing involves the sequential processing of amodal symbols. They acknowledge the existence of modal/perceptual representations, but they insist on a so-called ‘transduction’ process which transforms modality-specific representations into amodal representations (overviewed by Barsalou, 1999, p. 578; and Barsalou, Simmons, Barbey, & Wilson, 2003, p. 85). These amodal representations serve as input to higher cognitive processes such as thinking, language and memory systems[4]. Importantly, the assumption of amodal theories is that there is a separate system for perception and cognition and that symbols are amodal and arbitrary in the sense that they bear no correspondence to the underlying perceptual states.

To illustrate amodal theories, Collins and Quillian (1969) conceptualize concepts as being stored in a hierarchical semantic network in which nodes represent concepts. Conceptual information arises from the pattern of connections among nodes in this semantic network. Meaning arises in networks of other meanings. To illustrate further, Kintsch and van Dijk (1978) conceive of text representation as a structured set of propositions. In their model, a proposition is a basic unit of a text which has meaning and contains a predicate and one or more arguments.

On the other hand, modal theorists (b; e.g., Barsalou, Glenberg, Lakoff, Johnson) hold amodal symbols for redundant and non-existent. They argue that conceptual knowledge is grounded in modality-specific areas of the brain, and is fully represented there. Modal representations serve as direct input to thought processes, language and memory systems.

Advocates of modal theories believe that the repertoire of empirical evidence (see Barsalou et al., 2003, pp. 86–87) support exclusively the existence of modal representations. However, there is still hesitation as to whether amodal symbols can be found in neural systems (p. 87). A prominent modal theorist is Lawrence Barsalou, who developed his ‘Perceptual Symbol Systems’ theory (Barsalou, 1999). He argues that cognitive representations are not only grounded in modality-specific areas of the brain

[4] For a comparison of amodal and modal approaches, see Barsalou (1999), Barsalou et al. (2003), and Markman & Dietrich (2000).

but they are also implemented by the same mechanisms underlying perception and action. Such a conception is still being debated, yet the investigation of applicability of any of the two theories falls out of the scope of the present dissertation.

So far, the problem of conceptual knowledge has been dealt with in the light of two main representational theories (modal and amodal approaches to cognition). Many scholars claim that abstract knowledge[5], which is assumed to be embodied on their view, is produced by metaphor[6].

It should be noted that metaphor is one of the solutions to the problem of grounding abstract concepts. There are other solutions too. For example, Barsalou propagates *grounding by simulation* (Barsalou, 1999). Simulation in grounded cognition research, which is regarded as a basic simulation computational mechanism in the brain, is the partial reactivation of neural states from the modalities (perception, motor action, and introspection; touch, taste, smell, audition, vision, etc.). For example, when we think of a dog, we re-experience *some* of the previous sensory inputs, such as its smell, bark, fur, running, etc. That is, simulations typically only re-enact instances partially and unconsciously. Simulation has been demonstrated in a variety of tasks besides conscious imagery-generation, e.g., in language processing (Barsalou, 1999).

Crucially, simulation is *situated*; concepts are processes not in isolation but situated in background settings and events. “In general, the function of these sensory-motor resources is to run a simulation of some aspect of the physical world, as a means of representing information or drawing inferences” (Wilson, 2002, p.633). More on Barsalou’s theory and on simulation, see Chapter 3.1. or Fekete (2010).

Importantly, after having defined simulation, the concept of *simulator* should be elaborated on here because it constitutes a central part of Barsalou’s theory. A simulator

[5] Lakoff & Johnson (1999, p. 77) call this school second-generation embodied cognitive science, which contradicted many tenets of Anglo-American philosophy. For example, under this view reason is imaginative and embodied, and the conceptualization of abstract concepts is based on sensorimotor processes.

[6] Langacker (as other cognitive linguists) identifies meaning with conceptualization. He claims that conceptualization derives from *embodied human experience* and incorporates *imaginative phenomena*, such as metaphor. (Langacker, 2004, p. 2)

is basically equivalent to a *concept* or *type* in the traditional sense. That is, simulators implement the concepts. Simulators integrate information multi-modally across the instances of a category, and simulations are the specific conceptualizations of a category. Some of the problems with Barsalou's theory are compositionality and abstraction, and cases where the two are combined. An adequate theory of concepts should explain compositionality (Prinz, 2002), e.g., it should be able to ground the Hungarian compound *pálfordulás* (literally 'turn of Paulus', meaning 'turnaround', or 'radical change of mind or behaviour'). It is clear that the meaning of this compound is more than the sum of its components. Likewise, to say that abstractions are just the arrangements of simulations is like saying that they are the sum of them, which is clearly implausible.

Crucially, frames can provide the fundamental representation of knowledge in cognition (Barsalou, 1992). Frames contain different attribute-value sets and can encode a variety of relations. For example, Barsalou's example of a vacation frame contains an 'agent', 'transportation', 'location', 'activity', etc. Further, it also contains sub-frames, e.g., 'car', 'jet', etc. under 'transportation'. Frames are like schemata, which are structured representations that capture typical information about an event or situation (Barsalou, 1992; Barsalou and Hale, 1993). For example, the schema for a birthday party includes guests, gifts, and a cake. The birthday schema is structured in the sense that it encodes that guests bring gifts, and that the cake is eaten by the guests. Experimental evidence for the existence of schemata comes from a variety of domains of psychology, such as social psychology, memory research, reasoning, etc. To name one of the earliest studies on schemata, Bartlett (1932) demonstrated that schemata produce strong expectations about past events, which can distort our memories.

Turning back to frames, just like Barsalou (1992), Hampton (2003) also uses frames in his model. He strives to revive prototype theory by re-introducing the concept of frame, which is a schema-like organization of knowledge. The existence of frames may help the operation of dynamic mental representations, e.g., the situated simulation of concepts in different situations. Hampton proposes that instantiation is the process of "filling out abstract representations with specific features to help the concept to fit into the current context" (p. 1256). His theory is based on similarity theories, yet he criticizes exemplar models and refines prototype theory. Crucially, he adds that these models involve abstraction, which should not be discarded.

In Hampton's theory, the prototype remains the representative concept of a category. However, Hampton assumes a schema-like organization associated to it. An advantage of this more powerful hybrid model is that it can better capture the content of novel combinations in new situations. He calls this intentional content.

Amodal symbols complement modality-specific representations in that they categorize, for example, the regions of a picture or encode spatial relations. Amodal symbols help inferential processes. Further, they also serve the purpose of integrating modal representations. For example, Damasio's convergence zones (1989) comprise conjunctive neurons that merge, for example, feature information with size or colour information within and across modalities. There are lower and higher convergence zones. Higher convergence zone integrate category information across modalities, while lower convergence zones integrate within a modality. What follows from the convergence zone account is that simulations that represent a category should be distributed across modalities in the brain (Martin, 2001; Martin and Chao, 2001).

It is evident that meaning cannot be perfectly captured by attribute lists. Wittgenstein also questioned the cognitive reality of attributes in conceptual representations (cf. Chapter 3.1. or Fekete, 2010). His famous question 'what makes a game a game?' illustrates the implausibility of attribute lists. Prototype theory solved this problem by positing that categories are represented by prototypes that represent the average of exemplars of a category. One of the criticisms of prototype theory is that no all concepts have prototype characteristics. Hampton (1981), for example, suggests that 'belief' and 'rule' do not have prototype structure.

A refined version of prototype theory, schema-based prototypes use frames. For example, a frame representation for APPLE involves the variables 'shape', 'colour', 'taste', etc. The set of slots for a domain reflects the level of abstraction. Importantly, these schema representations are prototypes because a schema stores the central tendency in the category, however, no exemplar is stored. An advantage of this model is that the schema does not delineate precisely the boundaries of a category, as I have already mentioned it before. Barsalou and Hale (1993) also propose frame-based representations and argue that such a solution yields more powerful representations. Such frame-based representations are considered abstract knowledge. In sum, schematic prototypes involve frames with slots and values.

Similarly to Barsalou, Prinz (2002) defends and rehabilitates concept empiricism by claiming that perception is the fundamental source of mental representation, and that concepts are basically re-activated copies and combinations of perceptual representations (p. 108). Prinz’s model also incorporates frames and simulations; the latter being equivalent to a concept. Similarly, Barsalou equates the notion of concept with simulator.

Abstract language is usually interpreted in terms of the Cognitive Metaphor Theory. However, there are other alternative theories, such as the grounding by interaction conception by Mahon and Caramazza (2008), which combines the hypothesis that concepts are abstract with the assumption that sensory and motor representations may ignite online conceptual processing. The view of Mahon and Caramazza shall be discussed later in Chapter 1.5.

1.2. Theories on Metaphor

1.2.1. The Continuous Nature of Abstractness and the Strong versus Weak Version of Metaphoric Representation

The theoretical perspective of this study is the Cognitive/Conceptual Metaphor Theory (CMT, see Lakoff & Johnson, 1980, 1999). A fundamental tenet of the CMT is that a metaphor is not merely a poetic device in language but it is a cognitive operation on two conceptual domains *in our thoughts*. In the CMT, a metaphor is basically the understanding of an abstract domain in terms of a more concrete domain by establishing relational mappings between the two domains.

The more concrete domain is called the *source* domain (sometimes called ‘vehicle’), the abstract domain is called the *target* domain (sometimes called ‘topic’). Abstract domains are, for example: life, love, happiness, fear, anger, debate, insanity, emotions, hope, understanding, theories, difficulties, change, causes, intimacy, affection, personality, ideas, mind, organization, argument, desire, purposes, and time. Concrete domains are, for example: journey, war, building, container, seeing, hunger, thirst, warmth, closeness, destinations, motion, and space.

This binary classification concrete/abstract is arbitrary because abstractness is a graded notion, since abstractness is contingent on multiple variables, such as imageability, affective load, etc. An expression is considered metaphorical if the two domains can be shown to be distinct. What it amounts to is that distance between the two domains can be measured, and that metaphoricity becomes a graded notion. In a metaphor the source domain characterizes the target domain in terms of another thing, feature, etc. The source domain therefore juxtaposes the target concept from a *separate domain of experience*. As a rule of thumb, the more concrete concept is the source concept, and the more abstract concept is the target concept.

As a confirmation of the hypothesis that abstractness is a graded notion, Fekete and Babarczy (2007)[7] measured three correlates of abstractness in a rating study on Hungarian concepts: ***abstractness***, ***imageability***, and ***definability***. Three surveys were conducted to examine the relationship between abstractness (N=106 participants), imageability (N=151 participants), and definability (N=109 participants) values of nouns. We deliberately chose abstractness as one of the variables to test because we wanted to have a baseline and compare the abstractness ratings against the other two variables. Second, it is obvious that words differ in their degree of abstractness, but we also wanted to tease apart abstractness from the other two variables.

296 Hungarian nouns were rated on seven-point numbered scales on the basis of their abstractness, imageability, and definability values. Three different groups of participants performed the ratings of the nouns on the internet. A sampling procedure was employed to determine the relationship between the role of imageability and definability in different domains of the concrete-abstract continuum. Therefore, three

[7] This research was conducted as part of the ABSTRACT Project (*What makes us humans?*, FP6-2004-NEST-PATH-HUM, NEST Scholarship 028714, "The Origins, Representation and Use of Abstract Concepts." Principal Researcher and Coordinator: Dr Anna Babarczy). A description of the project can be found here: ftp://ftp.cordis.europa.eu/pub/nest/docs/4-nest-what-it-290507.pdf. Further information can be found here: http://www.x-andrews.org/index.php?page=people.php. The research referred to was presented at the ABSTRACT Project meeting at UCL, London, June, 2007.

sub-samples were selected separately from the entire word sample: the 70 most concrete nouns (concrete domain), the 70 most abstract nouns (abstract domain), and 70 nouns that were selected from the middle of the entire word sample in terms of abstractness (intermediate domain). Both imageability and definability predicted concreteness ratings for the entire sample. Mean imageability values show a very high negative correlation with mean definability values. We found that definability is a better predictor of abstractness in the intermediate and the abstract domains than imageability, whereas imageability is a good predictor of abstractness in the concrete but not in the abstract domain.

Results are summarized for the entire word sample as follows: we found a high negative correlation between *abstractness* and *imageability* (r = - 0.869, $p < 0.001$), which supports Putnoky (1975): the more abstract a concept is, the lower its imageability value. Further, a similarly high correlation between *abstractness* and *definability* was yielded (r = - 0.888, $p < 0.001$): the more abstract a concept is, the easier it is to define it. The measures of *imageability* and *definability* also showed a very high correlation (r = 0.939, $p < 0.001$): the easier it is to imagine a concept, the more difficult it is to define it (e.g., knife, pen, etc.). The following figure illustrates the continuous nature of the two correlates of abstractness (imageability and definability):

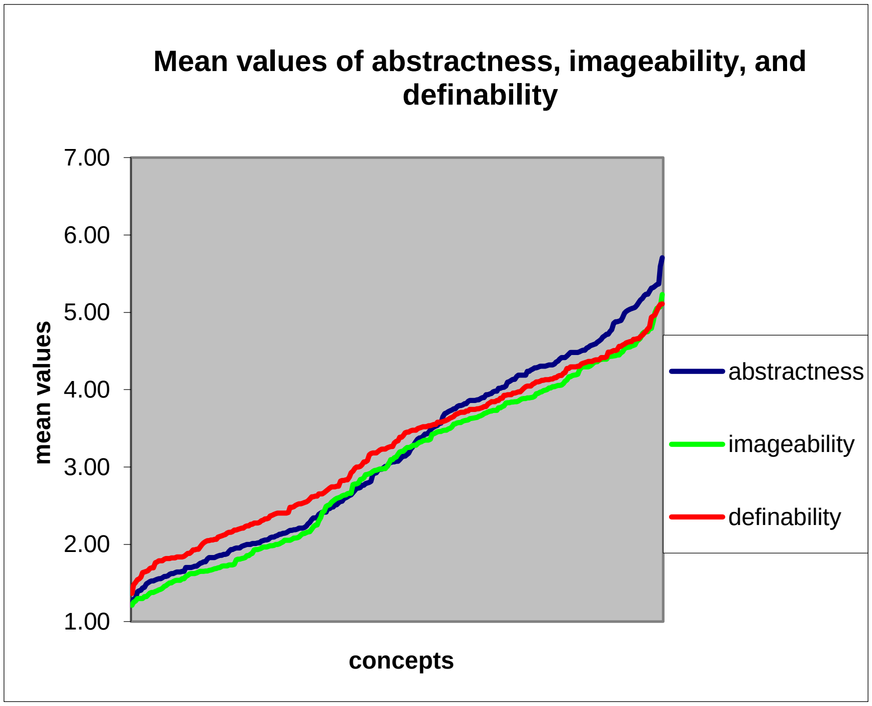

Figure 1. ***Mean values of the three linguistic determinants of abstractness in the study of Fekete and Babarczy (2007)***

The continuous nature of abstractness illustrated in the above diagram is also consistent with our discussion at the beginning of the dissertation about the difficulty of defining abstract concepts. The following three figures illustrate the results of spectral cluster analyses by Fiedler-vector on our data of abstractness ratings (the analyses were conducted by Dr Ivan Slapnicar, University of Zagreb). This type of cluster analysis organizes the data according to some hidden clusters (see APPENDIX A/3. at the end of this dissertation for the complete cluster analyses of the three variables). Results of these analyses clearly show that instead of the presence of a concrete-abstract dichotomy with two clear-cut clusters, the concrete-abstract continuum can be divided into multiple clusters too (3 and 4 clusters). This finding is consistent with our previous result yielded from the ratings that abstractness is a graded notion (see Figure 1. above). Figure 2. below illustrates the data points organized into 2, 3, and 4 clusters:

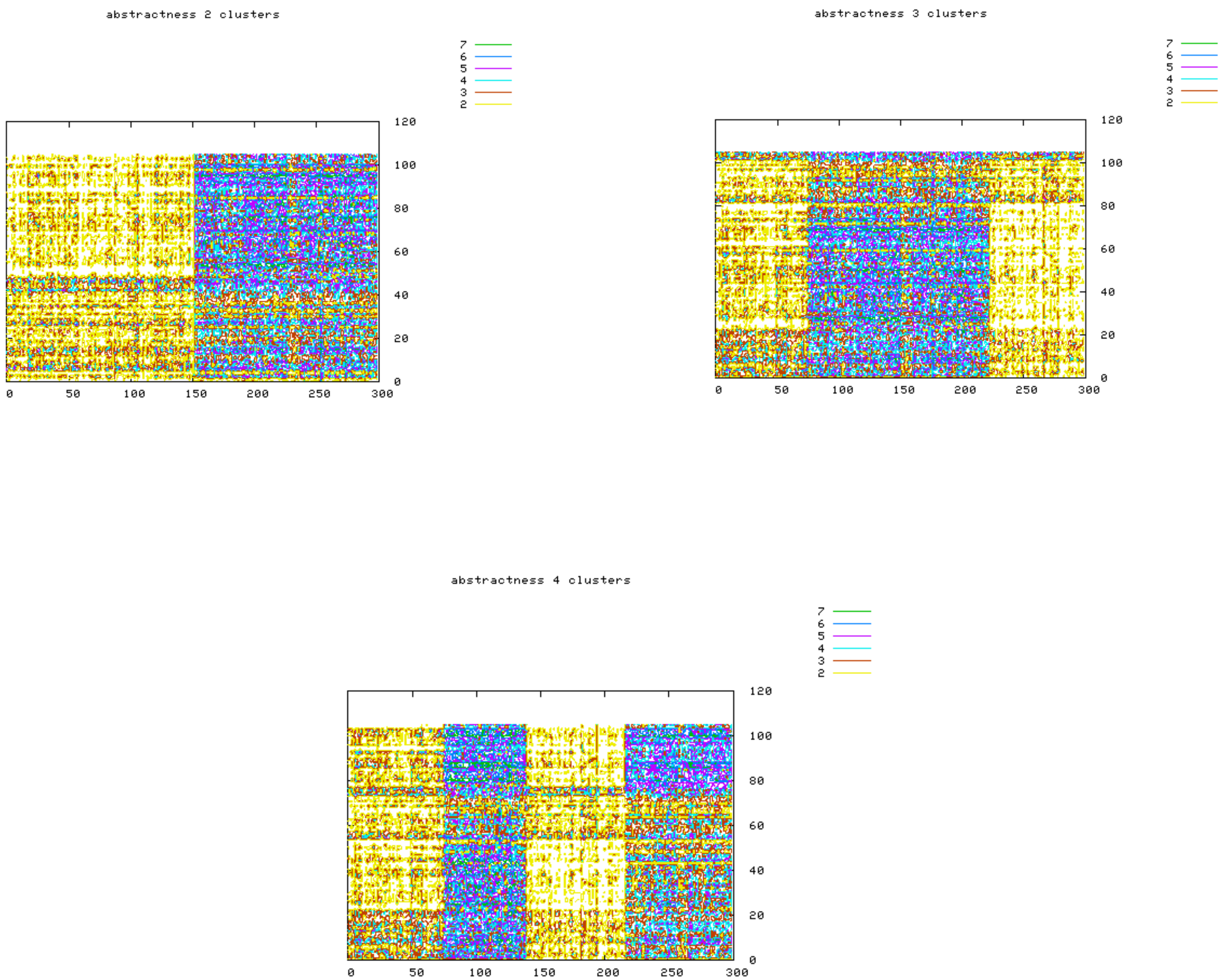

Figure 2. ***A spectral cluster analysis by Fiedler-vector of the abstractness ratings in the study of Fekete and Babarczy (2007)***

Given that this cluster-analysis is a mathematical method, we cannot infer to what the clusters represent. It is plausible that the variables of imageability and definability delineate the boundaries of the possible abstractness clusters because data points group together along similar clusters there too. We can but speculate that multimodality may also play a significant role in the representation of concepts.

Taken together, our data suggest that definability overtakes the role of imageability in the intermediate and abstract conceptual domains. This finding shows that the verbal code is highly dominant in the abstract domain, and extends our understanding of abstraction in the light of imageability and definability. On the basis of the results, definability (verbal code) may play a more important role in the representation of abstract concepts than imageability (visual attributes): abstract concepts, which are less perceivable, can be differentiated more easily based on the language system. This finding about abstract concepts and their definability is consistent with the results of our corpus study (Babarczy et al., 2010) to be presented in Chapter 3.2., which shows that abstract language, specifically metaphor use, is determined by statistical co-occurrences in language rather than by psycholinguistic properties.

Based on the evidence above, it may therefore well be that abstract language can be better tapped in terms of statistical co-occurrences and other linguistic symbols than it could be grasped through concrete representations. However, the Cognitive Metaphor Theory claims that every metaphor in language is a manifestation of a more general Conceptual Metaphor, which is in our thinking and not in language per se. Let us consider the following metaphors taken from Kövecses (2003, pp. 2–3):

(1) in Chinese:

Ta hen gao-xing.

he very high-spirit

He is very high-spirited/happy.

(2) in Hungarian:

Ez a film feldobott.

this the film up-threw-me

This film gave me a high.

(This film made me happy.)

These examples suggest that Chinese, English and Hungarian conceptualize happiness in very similar ways. According to the CMT, these metaphors are linguistic manifestations of the Conceptual Metaphor HAPPINESS IS UP[8], and when we process these metaphors in language, we make use of this Conceptual Metaphor in the following way: conceptual mappings are established in our mind between the base domain (which is the Conceptual Metaphor HAPPINESS IS UP) and the target domain (which is a linguistic manifestation of the Conceptual Metaphor). According to the CMT, we cannot understand the happiness metaphors in language without having access to the HAPPINESS IS UP Conceptual Metaphor.

Within the CMT, our metaphorical concepts are structured by more concrete domains, which entails that an abstract concept does not have its own pre-structured representation but receives its representation and meaning from a more concrete domain. This is called the *strong version of metaphoric representation* (Murphy, 1996, p. 177; 180). On the other hand, the *weak version of metaphoric representation* (p. 178; 182) claims that the representation of our concepts are not metaphoric, instead they have their own representations. Murphy (p. 179) emphasizes that the difference between the strong and weak versions of metaphoric representations lies in the independence of representations. The weak version does accept that a more concrete domain or a metaphor has an influence or a causal effect on an abstract domain, but it rejects the view that the representation of an abstract concept is structured by a more concrete domain.

[8] Notationally, the author of the present dissertation follows the convention in cognitive-linguistic literature that Conceptual Metaphors are typed in the uppercase.

Similarly to the weak version of the metaphoric structuring view (Murphy, 1996), the weak version of the Cognitive Metaphor Theory, and also the weak version of the Embodiment Hypothesis in general (e.g., Meteyard and Vigliocco, 2008), claims that (1) activation of sensory-motor systems is not necessary when achieving semantic content (*non-essential condition*, cf. Meteyard and Vigliocco, 2008). Second (2), sensory and motor representations are activated during semantic access in a task-dependent manner (*indirect condition*). Crucially, these sensory-motor representations are mediated by cognitive processes, such as attention.

Finally, the weak version is completely different from amodal theories of cognition in that it assumes a non-arbitrary relationship between sensory-motor states and semantic representations, while amodal theories presuppose an arbitrary connection between the two. So, for example, amodal theories of cognition assume an arbitrary connection between the amodal symbol of car and the modality-specific simulations of the concept ‘car’, that is, the car simulator in terms of Barsalou (1999). Crucially, on the amodal account, conceptual representations are autonomous non-perceptual symbols.

Importantly, the weak version of *metaphoric structuring* (Murphy, 1996) and the weak version of embodiment (e.g., Meteyard and Vigliocco, 2008) are different theories with different predictions. The former deals with the emergence of abstract domains, while the latter is concerned with the real-time representation of concrete and abstract knowledge.

One can interpret the strong version of metaphoric structuring in terms of a skeleton analogy (Murphy’s personal communication with George Lakoff, see Murphy, 1996, p. 187). Each domain has a structure or “skeleton” that is directly represented, but many details of the concept are difficult to conceptualize directly. The metaphors provide the “flesh” of the skeleton. The flesh is represented indirectly: “The metaphor is filling the gaps in the framework by transferring information from the metaphoric domain to the topic domain” (p. 187). In other words, on the strong account source and target domains are share relational structure. The following illustration exemplifies the LOVE IS A JOURNEY metaphor according to the CMT:

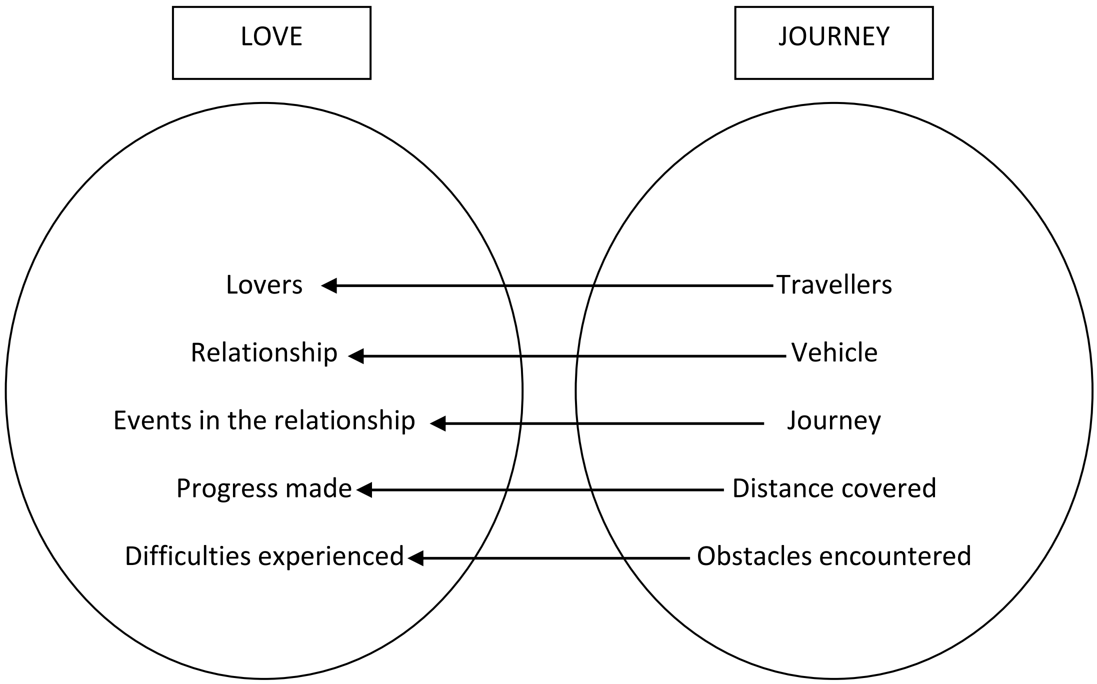

Figure 3. ***The Conceptual Metaphor View by Lakoff & Johnson***

How do we make sense of a conceptual metaphor such as LOVE IS A JOURNEY? In Figure 1, we can see that there is a set of systematic correspondences or mappings between the source domain of journey and the target domain of love. The elements in the source domain are mapped onto the target domain. That is, the speaker of *Our relationship isn't going anywhere* will mean that no progress is made in their relationship, and not that the relationship literally is motionless. (Destinations of a journey are common goals in a relationship.)

However, the question arises if there can be pre-existing structural similarity between the source domain and the target domain. In other words, what if people just compute structural mappings between two pre-structured domains? The strong version of metaphoric structuring claims that the target domain did not have a pre-structured representation before it was structured by its source domain. In a way, it is the source domain that structures the target domain, which is a concept. That is, an abstract concept (the target) did not have its own structure (only its "skeleton" structure) and meaning before it was structured by a source domain. We cannot think[9] of the choice, goal and problems of a relationship without thinking of a journey[10]. This is the cognitive-linguistic hypothesis for the strong version of metaphoric structuring[11].

In sum, the weak version of the Embodiment Hypothesis claims that our abstract knowledge is stored separately from modality-specific representations, though they may originate in sensory-motor representations. In contrast, the strong version of the hypothesis insists that modality-specific representations guide abstract language processing. However, there exist alternative accounts that can explain the psychological reality of metaphors.

1.2.2. The Structural Similarity View

An alternative view to the CMT is the Analogy-view proposed by Gentner et al. (2001). An analogical mapping establishes a structural alignment between two represented situations or domains. This structure-mapping theory assumes the existence of pre-structured representations. That is, on this view, debaters in the DEBATE IS WAR metaphor are *de facto* debaters.

[9] The thought that we "cannot think of" these abstract concepts without concrete concepts does not necessarily implicate that abstract concepts should be represented metaphorically. As an alternative, there may be associative links or pointers to concrete concepts during the activation of abstract concepts. Of course, neither of the arguments can be supported or refuted on empirical grounds in the CMT. In the case of space and time, Lakoff and Johnson (1999, p. 166) suggest that we cannot think about time without motion and space.

[10] This statement implies that we cannot make sense of an abstract concept (e.g. love) without accessing to the source concept (e.g. journey). Therefore, the CMT is not only a theory of metaphor but it is also a theory of (cognitive) semantics. On this view, image schemas and motor schemas underlie our processing of abstract concepts (Lakoff & Johnson, 1999, p. 77).

[11] This argument is an extreme position in cognitive linguistics. Alternatively, Langacker (2004, p. 6) distinguishes between Fully Analysable Expressions (such as *flinger*, because this a novel expression) and Partially Analysable Expressions (such as *computer*). He suggests that in the latter case we do not need to mentally access to the components [compute]+[er] in order to understand the expression *computer*. He claims that in the case of *understand* there is phonological access but no mental access to the components [under]+[stand], which entails that there are no metaphorical effects. He proposes that fixed expressions can vary in their degree of analyzability: *flinger* > *complainer* > *computer* > *propeller* > *drawer*.

But whichever theory (CMT or Analogy) we prefer, the question arises if conceptual metaphors such as ANGER IS A HEAT or DEBATE IS A RACE are understood in terms of conceptual mappings. That is, if we understand *Anna was boiling mad*, do we access the ANGER IS HEAT Conceptual Metaphor?

Gentner et al. (2001) present experiments in which participants had to read stories that contained *novel* linguistic manifestations of the Conceptual Metaphor DEBATE IS A RACE or the DEBATE IS A WAR. The last sentence was once consistent with the Conceptual Metaphor used in the text and once inconsistent with it. They found that it took more reaction time for participants to understand the last sentence if a shift occurred from one Conceptual Metaphor (DEBATE IS A WAR) to another Conceptual Metaphor (DEBATE IS A RACE), that is, in the inconsistent case. This supports the domain-mapping hypothesis for novel metaphors, such as *far behind him*, *finish line*, *use every weapon*. The experiment was repeated with conventional metaphors, where no such effect was found.

The experimental evidence presented in Gentner et al. (2001) support the structure-mapping hypothesis only for *novel* metaphors but not for *conventional* metaphors. This finding is the basis of the Career of Metaphor theory (Bowdle & Gentner, 2005). This theory claims that novel metaphors are understood as analogies, but as a result of many structure-mapping alignments these metaphors get conventionalized and no structure-mapping process between source and target is needed.

The structure-mapping hypothesis proposed by Gentner et al. (2001) is a model of conceptual metaphors in the spirit of Murphy's Structural Similarity View (Murphy, 1996). Murphy (1996, p.179; 195) comes up with an analogy-like theory of conceptual metaphors (*structural similarity view*) that is non-metaphoric in nature. On this view, there is also a conceptual similarity between the pre-existing representations of the two domains. Murphy (p. 180) adds that only conceptual metaphors can be explained by the structural similarity view proposed by him.

It is unclear what specific differences there are between the representational mechanisms of the CMT and Gentner's structure-mapping process. Murphy's theory of Structural Similarity bears a resemblance to Gentner's Structure Mapping Theory, which can be the basis of Lakoff's CMT. Gentner's structure mapping approach assumes an alignment process, which operates in a local-to-global fashion. This process creates a maximal match between the two domains. It remains a matter of future research to further investigate the exact representational mechanisms and differences behind the CMT and Gentner's analogical processing. As much as I have gathered from the literature, on Gentner's account metaphors are processed as analogies, however, no specific or distinct representational mechanisms have been proposed from the CMT side which may be inconsistent with Gentner's account.

According to Gentner and colleagues' structure mapping theory (2001), the initial semantic comparison between source and target domains is the same in novel metaphor and analogy comprehension. Note that in their theory, novel and conventional metaphors are processed differently. Novel metaphors are comprehended by structural alignment followed by comparison of source and target domain properties. Later in processing, property attributions are inferred and aligned. In the case of conventional metaphors, the source domain word can acquire a connotation, which speeds up the metaphor comprehension process.

1.2.3. The Grounding of Metaphorical Concepts

Given that abstract concepts are originated in concrete concepts, the question arises as to what motivates our metaphorical concepts. Studies in cognitive linguistics have suggested that conceptual structure is grounded in sensorimotor experience, and image schemas and motor schemas implement our conceptual processing (e.g., Lakoff & Johnson, 1999, p. 77). Image schemas, which emerge throughout sensorimotor and kinaesthetic activity, are pre-conceptual representations that provide the basic structure of many metaphorical concepts (Gibbs, 1996, 2004).

Importantly, image schemas, such as PATH, LINK, PART-WHOLE, PROCESS, COUNTERFORCE are not only spatial (*analogical*) representations, but they can also be conceived of as abstract representations. In a way, image schemas are like frames (e.g., Hampton, 2003). Abstract concepts do not inherently have image schematic representations, therefore they have to be structured by frames and image schemas. What it all means is that CMT can be made compatible with amodal theories of cognition, which propagate frames and abstract representations, such as image schemas, to structure and organize mental representations of abstract domains.

Because image schemas are considered abstract representations, at least abstracted away from concrete modality-specific experience, further explanation is needed for the link between them and the concrete embodied experiences. Image schemas are abstract schematic gestalts because they arise from sensorimotor experiences, and second, they are abstract because they integrate information from different modalities. In the context of abstract representations and the CMT, the question arises whether analogical mappings or correspondences can be conceived of as abstract (amodal) representations.

As for grounding of metaphors, the general and nontrivial question arises as to how the appropriate schemas are selected from a broad array of potential solutions and possibilities? The discussion of image schemas, frames, analogical mappings raises the question of the need of amodal mappings and abstract representations within the CMT framework. Crucially, however, this does not make the CMT ungrounded or does not falsify it. Also, it is unclear how and why correspondences are different from analogies or similarities.

It is trivial that saying that correspondences or similarities are innate or given would not solve the question of the absence of representational mechanisms behind structure mapping. Lakoff and Johnson claim that image schemas derive from sensorimotor experiences pre-conceptually, which raises the possibility of their presence before concepts. A question related to real-time processing is whether image schemas are psychologically real entities in language processing. Richardson, Spivey, Barsalou, & McRae (2003), for example, tested if image schemas are real or they are just meta-cognitively accessible constructs as in their previous investigation (Richardson et al., 2001). For a review on Richardson and colleagues' experiments, see Chapter 1.3.1.

To illustrate the grounding of an image schema, let us take the ANGER IS HEATED FLUID IN A CONTAINER metaphor[12]. On the basis of this conceptual metaphor, one can conjecture that anger has to do with hot fluid and the image schema CONTAINER. First, it is suggested that people have embodied experiences of containment (bathtubs, cars, and buildings) and that we perceive our bodies as being filled with substances. Second, we feel heat in our bodies when we are angry. Moreover, when we get even more angry, we perceive our bodies (which are conceptualized as CONTAINERS) as pressurized and about to explode. These two bodily experiences motivate the emergence of the conceptual metaphor ANGER IS HEATED FLUID IN A CONTAINER. This type of motivation for metaphors is called *embodiment*.

It is suggested by cognitive linguists that "primary" or "primitive" metaphors, which emerge out of our embodied functioning in the world, such as HAPPINESS IS UP "are motivated by universal correlations in bodily experience" (Kövecses, 2003, p. 3): "when we are joyful, we tend to be up, moving around, be active, jump up and down, rather than down, inactive and static" (pp. 3–4). By embodied functioning, the universal physiological mechanisms and perceptual experiences are meant that build the basis of primary metaphors. Empirical evidence have also been provided for such an embodiment claim. For example, American and Brazilian students do not only talk of their desires in terms hunger (HUNGER IS DESIRE) but they also share common folk knowledge about hunger, which is correlated with their understandings of desire (Gibbs, 2004, pp. 1198–1207).

Murphy (1997, p. 99), being sceptical about embodiment, points out that some metaphors such as LOVE IS A FINANCIAL TRANSACTION cannot be explained on the basis of bodily processes and experiences. He remarks that in this conceptual metaphor

[12] Some linguistic manifestations of this conceptual metaphor include *His pent-up anger welled up inside of him*, *Bill is getting hot under the collar*, *Jim's just blowing off steam*, *He was bursting with anger*, *She blew up at me* (Gibbs, 1996). For an exhaustive writing on the conceptualization of anger, see Lakoff & Kövecses (1987).

the target domain (love) is much more embodied than the source domain (financial transaction) is. He adds that the present evidence for embodiment is inconclusive. Gibbs (2004, p. 1208) also admits that embodiment is not the only motivation for metaphors. It should be noted that there are other theories of metaphor other than the CMT or the Structural Similarity View, and that there are a lot of cognitive psychological experiments which have tested the assumptions of the CMT.

1.2.4. Theories of Metaphor Processing

"The figurative meaning of a metaphor is the literal meaning of the corresponding simile"

- Davidson (1978: 38)

The above quote introduces us to one aspect of the topic of this chapter: the meaning of metaphors and similes. However, other questions in metaphor comprehension are whether metaphors are understood as similes and whether they are understood via the activation of the literal meaning first. One theory, the Comparison Theory claims that metaphors carry the meaning of a simile (X is like Y) except for the omission of a comparative word (like) (Gentner et al., 2001). In other words, the Comparison Theory assumes that metaphors are implicit similes and understood as comparisons.

For example, to understand the expression *Az élet nem egy habostorta* ('Life isn't a piece of cake'), a reader would infer the shared relation between *life* and *cake* (i.e., both are sweet, enjoyable). After this insight, the arguments of the relation would be spelled out (i.e., *life* with *cake*, *live* with *eat*, or *experiences in life* with *tastes*) to create analogies, such as *life can be lived in an enjoyable way like a cake can be eaten in the same way*. Or, *experiences in life can be so sweet as tastes can be sweet when eating a cake*.

Thus, the Comparison Theory claims that metaphors are implicit similes and understood as comparisons. However, this claim should entail that a metaphor consisting of the same words as its simile version should have the same meaning, given that (i) the two utterances share the same words and (ii) the Comparison Theory is true. Let us take the affirmative of the above example and its simile version: *Life is a piece of cake* (metaphor) and *Life is like a piece of cake* (simile). Intuitively, the metaphor means that life can and should be enjoyed as a piece of cake. Or, that life is easy in the slang interpretation of ‘piece of cake’. However, the simile version evokes a perceptual/literal reading, too: e.g., the diverse flavours, or the fact that the top of the cake is the tastiest part and the rest has a different flavour. In my view, this casts doubt on the conception that metaphors and similes share the same meanings. Also, if the two constructions shared the same meanings, then one of them would be redundant.

This line of thought is consistent with recent findings; Roncero et al. (2012), for example, recorded eye movements as people read metaphors and comparable similes containing the same words. Measures indicated that metaphors were initially more difficult to process than similes: forward saccade lengths were significantly shorter in the metaphor than the simile condition. Second-pass eye-gaze data showed that more time were spent re-reading metaphor vehicles than simile vehicles, and also more regressions were measured. Roncero and colleagues also found that skilled readers had more initial difficulty processing metaphors than similes.

Because the Comparison Theory has already been introduced in this thesis in Chapter 1.2.2. (under the name of Structural Analogy theory, structure-mapping hypothesis), therefore new aspects and alternative theories are to be presented next.

In my view, metaphor is distinct from simile also in that it engages the process of search for *identity*, whereas simile comprehension engages the process of search for *similarities*. Such an intuitive difference between metaphor and simile is consistent with the findings of Roncero et al. (2012) who demonstrated that metaphors are more difficult to process in the first-pass phase of processing. However, such a difference does not yet mean that the two constructions have different meanings. Identity is hypothesized to be computed as mentally merging two entities, which may require more attention and might evoke distinct cognitive(/stylistic/emotional) effect, such as a new insight about an entity, attributing a new property to an entity, qualifying the topic, or the feeling of surprise.

Similarity, on the other hand, is computed via alignments between two entities (juxtaposition), with similarity hypothetically conveying less cognitive effect (e.g., expressing just a parallelism, rather than conveying a new insight about the topic). Also, similarity is a graded notion as opposed to identity. The metaphoric meaning will be a more powerful and more vivid picture than the one achieved by simile. Further, the point in metaphor is the force, the emphatic value, the profound effect beyond and rather than the parallelism of similes. What it all amounts to is that metaphors and similes may be processed differently from the early phase of processing on because the two linguistic devices evoke different cognitive effects. A metaphoric image is more vivid or powerful, whereas simile just illustrates parallelisms.

In contrast to the Comparison Theory, the Pragmatic Model (e.g., Searle, 1979) assumes that the comprehension of metaphors involves three major stages: (i) first the activation of the literal interpretation; then (ii) the realization that the literal interpretation is defective, and (iii) the search for an alternative meaning (speaker's meaning). There is, however, no consensus among researchers on how the meaning of a metaphor is achieved. A processing prediction from the pragmatic model is that metaphors should take longer to process than literal sentences because metaphors would require the search for non-literal meanings. However, most studies have failed to find a processing difference between metaphors and literal sentences, in particular when the metaphors in question were familiar (Bowdle and Gentner, 2005; Gentner et al., 2001).

A third theory, Categorization Theory, as its name suggests, assumes that readers comprehend metaphors through categorization processes, which are distinct from comparison processes used to process similes (Glucksberg, 2003). For example, when comprehending *Life is a piece of cake*, certain properties of cakes are interpreted as being true of life.

A prediction of Categorization Theory is that comparison processes during the interpretation of novel similes are slower than categorization processes during the interpretation of novel metaphors because comparing two items is harder than accessing only a sub-set of vehicle attributes. These vehicle attributes consist of abstract attributes.

This conception is consistent with Gernsbacher and Robertson (1999) and Keysar (1994), who claim that metaphor comprehension involves the suppression of irrelevant concrete attributes and the enhancement of attributes that support the metaphorical meaning. For example, understanding the metaphor *My lawyer is a shark* involves the activation of the metaphorical shark-properties, such as ‘vicious’ or ‘tenacious’, while the literal shark-properties, such as ‘fast swimmer’, ‘has fins’, or ‘has sharp teeth’ are suppressed. To sum up, Categorization Theory hypothesizes that novel similes are comprehended slower than novel metaphors, and novel metaphors are comprehended via categorization processes, while novel similes via comparison processes.

The Career of Metaphor theory (Bowdle and Gentner, 2005), which has already been addressed, assumes that novel metaphors engage comparison processes, whereas familiar metaphors activate categorization processes. The next sub-chapter details cognitive psychological experiments that investigate (i) the activation of concrete representations during metaphor comprehension, as predicted by the CMT, and second (ii) which are aimed at testing alternative metaphor theories.

This Chapter intended to present theories of metaphor processing. It has also been suggested that metaphors and similes are not comparable in terms of meaning and processing resources. However, further research is needed to clarify this proposal.

1.3. Experimental Evidence

1.3.1. Behavioural Studies

Since the CMT is based exclusively on cognitive linguistic analysis and thought experiments, cognitive psychological experiments have been conducted towards the testing of the psychological reality of the CMT. These experiments have partly supported, partly refuted the tenets of the Metaphor Theory. The main question to ask is whether concrete representations are activated during normal language processing, or not. A more sophisticated question is the determination of the circumstances (discourse context, environmental context, task demand nature, etc.) under which these representations are activated.

It is also crucial to bear in mind that the activation of concrete representations may not clearly speak for the strong version of the CMT which claims that concrete representations are conceptual features. By conceptual feature, we mean that a feature or representation is an inherent part of the representation of a concept.

Recent experimental studies have investigated the question whether understanding spatial sentences recruits concrete spatial representations. In an online experiment conducted by Kaschak and his colleagues (Kaschak et al., 2005), subjects listened to spatial sentences (e.g. “The car approached you.”) that they had to judge as sensible or non-sensible, while they simultaneously viewed black-and-white stimuli that produced the perception in the same (congruent) or in the opposite direction (incongruent) as the action specified in the sentence. Response times (RTs) were faster in the second case (2), while RTs were slower in the first case.

Kaschak et al. (2005) argue that the slower RTs in the first case (congruent direction) may be due to a neural mechanism: the perceptual stimuli presented on the screen engage the same processing mechanisms needed to simulate sentences, and this causes interference in processing. That is, if the same direction of motion is simulated on the screen as specified in the sentence, then the two representations interfere, which results in slower RTs. Kaschak and colleagues conclude that this result pattern shows that the processing of sentences encoding motion automatically results in mental simulation of motion.

An alternative explanation, namely that a third type of transient representation between image and language is activated, is not stated in Kaschak et al. (2005). This representation would mediate between spatial (perceptual) representations and language. It may also be that image perception (spatial representations) subconsciously and unwillingly activates the spatial representations in/behind the sentences describing motion in space, but this phenomenon might not appear in other situations. It is also conceivable that the presence of the visual stimuli in the experiment causes the effect. It is also crucial to emphasize that such embodiment experiments may not inform us about conceptual or lexical representation but rather they can be interpreted in a framework of co-occurring modality-specific and lexical representations.

Zwaan, Madden, Yaxley, & Aveyard (2004) have also come to the same conclusion as Kaschak et al. (2005) that language comprehension involves dynamic perceptual simulations. In an online experiment, participants heard sentences describing the motion of a ball either toward or away from the observer (e.g. “The pitcher hurled the softball to you”). After the offset of the sentences, two pictures of balls were sequentially presented. The difference in size of the balls evoked a sense of motion either toward or away from the observer (the two pictures were presented sequentially with an interval of 175 ms).

RTs were faster when the simulated motion on the screen matched the motion specified in the sentence (congruent). Crucially, Zwaan and colleagues revealed a *match advantage effect*, while Kaschak and colleagues a *mismatch advantage effect*. This may seem to be a conflict at first sight; however, this contradiction can be resolved: in the experiment conducted by Zwaan and colleagues, sentence stimuli and picture stimuli were presented consecutively, while in Kaschak et al. they were presented simultaneously. In other words, congruence has facilitation dominance in consecutive settings, while it can also exert an inhibitory effect in simultaneous settings. However, this is not a principle because effects can depend on many factors beyond the synchrony of presentation (course of presentation), such as the modality of presentation (intra- or intermodal). For a deeper discussion of this question, see Bergen (2007).

All in all, the experiment of Zwaan and colleagues also supports the hypothesis that perceptual representations are simulated during online language comprehension. Here, again, we have to consider another alternative explanation, namely that it was only image perception that motivated perceptual simulation in language.

Richardson, Spivey, Edelman, & Naples (2001) have found offline experimental evidence for image schemas[13] of concrete and abstract verbs. They surveyed one hundred and seventy-three participants to see if their spatial representations of concrete (e.g. *push* and *lift*) and abstract (e.g. *argue* and *respect*) verbs (altogether 30 verbs were used in the experiment) were similar. In a forced-choice paradigm, participants had to select one image schema (out of four simple image schemas) that best described the meaning of the given verb. On average, about two third of the participants chose the same image schema for the particular verb. Richardson and his colleagues repeated the experiment with free-form drawing tasks to see if the results gained from this experimental design converge with that of the forced-choice paradigm. They found considerable similarities in the image schemas that participants selected and drew.

However, it is crucial to underline that participants in Richardson and colleagues' (2001) study came from the same cultural and SES (socioeconomic status) background (Cornell University undergraduates), which raises the question whether the similarities in schematic depictions may be attributable to these factors, rather than to universal embodied representations. In my view, it may well be the case that participants from other cultures have different schematic representations, but the study just wants to show that there is a stable agreement in schematic representations among participants. However, it is true that there is variance at the cultural level. For example, different cultures conceptualize time differently than the Judeo-Christian pattern: in the Aymara language the future is behind ego, the past is in front of ego (Núñez and Sweetser, 2006), or the past is up and the future is down in Mandarin Chinese (Boroditsky, 2001).

I firmly agree that such variance could in principle speak against the universality of embodied representations. Yet, it may also be the case that cultural and environmental factors determine and structure embodied representations. Therefore, more refined versions of embodiment are needed, such as 'cultural embodiment', which

[13] The term image schema comes from Mark Johnson. Image schemas are pre-conceptually structured representations that emerge mainly from our bodily interactions. Many modal theorists claim that image schemas establish patterns of understanding and reasoning, and that they are activated during online language use. For example, a *bathtub* is conceived of as a CONTAINER. The linguistic manifestation of this representation is the expression *in the bathtub*. We can find further examples for the CONTAINER-schema in abstract language: *in June*, *in love with somebody*, *in debt*, etc. For a review of image schemas and metaphorical meaning, see Gibbs (2004, 1192–1196).

synthesize universal cognitive bases with sociocultural factors. The fact that words, like 'depression' or 'concept' are seemingly not embodied in English (because they are abstract and opaque in English), does not necessarily mean that English speakers do not conceptualize them in terms of embodied representations. The Hungarian equivalents, *levertség* and *fogalom* do show signs of embodied meaning (they encode the roots 'down' and 'grasp', respectively). The very fact that English phrases associated to 'depression' (*feel down*, *downcast*, etc.) and 'concept' (*grasp the idea*) are embodied shows that these concepts themselves are also embodied and that English speakers also think in similar terms as Hungarian speakers.

Regarding Richardson et al. (2001) from the critical perspective of embodiment, I found the choice of paradigm confusing. The forced-choice paradigm presupposes the existence of underlying schematic representations while leaving out the possibility that the underlying representation may not be schematic but rather amodal or non-spatial. It would be interesting to see how many participants would not associate any spatial representation to concrete or abstract concepts, such as those in their study.

However convincing the results of Richardson et al. (2001) might be, it is still unclear whether image schemas are components of linguistic representations of verbs and not just meta-linguistic abstractions. Therefore, Richardson, Spivey, Barsalou, & McRae (2003) tested the claim that image schemas are not just meta-cognitively accessible constructs. They predicted that comprehending a sentence with a vertical/horizontal verb interferes with participants' visual stimulus discrimination. For example, after comprehending a sentence with a vertical verb (e.g. "The strongman lifts the barbell"), participants' discrimination of a circle or square in the top or bottom locations of the screen (along the vertical axis) is inhibited, and vice versa. This interference effect was confirmed in this experiment, which provides further evidence for the claim that spatial representations are activated by verbs.

Overall, these experiments all seem to support the perceptual simulation hypothesis, however, the question whether abstract expressions (those not describing spatial language) also (and always) recruit perceptual simulations is still left open. It is still unclear whether concrete representations, such as spatial representations, are part of the conceptual representation, or not. It is also possible that modality-specific simulations are excluded from conceptual representations, and that the effects revealed in cognitive psychological experiments are co-occurring in an epiphenomenal manner. I will return to this critique later in this dissertation in Chapter 1.5. The next sub-chapter focuses on one particular field of investigation, the abstract concept of time in the light of experimental results. The abstract domain of time is a fruitful field to test the strong version of the Embodiment Hypothesis.

1.3.2. The Case of Space and Time

The case of space and time is a famous field of investigation. The CMT proposes that we understand time in terms of space. This statement is based on cognitive linguistic data analyses and thought experiments. Several cognitive psychological studies have found spatial influence on the processing of time (e.g., Alloway et al., 2001; Boroditsky, 2000, 2001; Boroditsky & Ramscar, 2002; Gentner, Imai & Boroditsky, 2002), yet the question as to whether space is always necessary for temporal thinking is still unsettled. Kemmerer (2005) claims that “there is no evidence that spatial schemas are absolutely necessary for temporal reasoning”. Boroditsky (2000, p. 16) also concludes that her findings support the weak view of Metaphoric Structuring.

The CMT claims that we always need to access the concrete domain of space in order to think about time: “Try to think about time without any metaphors we have discussed […] We have found that we cannot think (much less talk) about time without those metaphors.” (Lakoff and Johnson, 1999, p. 166)

First, let us look at the language system. It may be tempting to think that temporal prepositions are inherently spatial preposition. However, there are a few exceptions where the linguistic manifestation of the Conceptual Metaphor TIME IS SPACE does not reflect metaphorisation[14]: *ago*, *during*, Hungarian *–kor* (temporal ‘at’), German *binnen* (temporal ‘within’), *für* (‘for’), *seit* (‘since’), *während* (‘during’) – which are not spatial

[14] Does the existence of these exceptions imply that we can think about time without visualizing any spatial schemas?

prepositions. What kind of spatial representation is activated when we process, for example *ago*?

There are two problems with the extreme view (the strong version of the Embodiment Hypothesis) that we cannot think about time without space. First, it is based solely on linguistic data, which have indeed proved the cognitive linguistic validity of this claim, and thought experiments. Second, it does not make a distinction between conceptualization patterns and thinking processes. That is, it presupposes that since we conceptualize, for example, seasons as CONTAINERS, we necessarily have to think about them that way too.

In order to test the claim whether temporal prepositions are represented separately, Kemmerer (2005) tested four brain-damaged subjects on their knowledge of English spatial and temporal prepositions. He found that two of them performed well on the test of temporal prepositions but failed on the same spatial prepositions. The other two patients exhibited the opposite dissociation: they understood the spatial prepositions but couldn't make sense of the temporal prepositions. The same prepositions were used in both spatial and temporal meanings, e.g.: *The cap is in* / *<u>on</u>* / *beside the chair*. *It happened through* / *on* / *<u>in</u> 1859.* This double dissociation suggests that understanding temporal prepositions does not require establishing structural alignments between the domain of space and the domain of time, as predicted by the CMT.

However, Kemmerer's ingenious method presupposes that being able to select a sensible preposition amounts to knowing and understanding that preposition. That is, selecting *in* instead of *through* or *on* (in the sentence: *It happened through* / *on* / *in 1859.*) entails that the person *understands* and can *produce* temporal expressions with *in*. Can it be the case that the frequency of having seen *in* with dates is so high (as opposed to *on*) that patients selected the matching prepositions as a result of a visual stereotype? This alternative explanation of Kemmerer's results has its shortcomings, for it may well be that sensibility judgements (*in 1859* is sensible as opposed to *on 1859*) are tantamount to understanding processes. However, a counterargument to this counterargument would be that given this scenario, there would not be a double dissociation if the effect were purely frequency-driven. Therefore, Kemmerer's finding is considered one of the few results refuting the strong version of the Embodiment Hypothesis.

On the weak version of metaphoric representation, temporal prepositions and, of course, suffixes in some languages, as in Hungarian, have their own lexicalised meanings. On this view, we can understand temporal prepositions without having access to the corresponding spatial schemas (cf. *Career of Metaphor* for the same finding, Gentner et al., 2001; Bowdle & Gentner, 2005). These spatial schemas can, however, influence the understanding process but they are not necessary for the understanding. On this weak version, the domain of time is not structured by the domain of space. Boroditsky's weak version of the Metaphorical Structuring View (2000, pp. 3–4), however, differs from the weak version of metaphoric representation (Murphy, 1996) in that it does not allow pre-existing representational structures. It acknowledges that temporal expressions become conventionalized with time and frequent use, and that the mappings between the two domains become redundant (p. 4), but at the same time it also endorses the view of the CMT that an abstract domain is structured by a more concrete domain.

Boroditsky (2000, 8–11) found in on offline experiment (Experiment 1) that spatial schemas (the ego-moving and the object-moving schemas) influenced the interpretation of an ambiguous temporal statement ("Next Wednesday's meeting has been moved forward two days. Which day is the meeting now that it's been moved?"). The ego-moving spatial schema refers to a spatial representation in which the ego is dynamic and moving in space, e.g., *I'm approaching the station*, while the object-moving schema describes a spatial representation in which the ego is static and on object is moving, e.g., *The bus is approaching me*. Crucially, these two spatial schemas have their abstract time-related correspondences (time-moving schemas). For example, by analogy, we can say that *The deadline is approaching*, which is consistent with the object-moving schema in which we, that is our ego, were static and the deadline was "coming" towards us.

Participants answered prime-consistently. That is, those who were primed according to the ego-moving scheme tended to interpret the question in the ego-moving perspective. On the other hand, those who were primed in the object-moving scheme tended to interpret the question in the time-moving perspective, as if time was moving towards them. Those who were not prime at all interpreted the question variously (45.7% said Monday, and 54.3% answered Friday). These findings allow us to conclude that the ego/object-moving distinction does have a psychological reality during the processing of time (ego/time-moving).

Szamarasz and Babarczy (2008) also tested a similar ambiguous temporal sentence in Hungarian as Boroditsky's sentence (2000), such as *Tekerd két perccel előbbre, ott lesz.* ('Wind it forward two minutes, you'll find it there' – referring to the search of a track on an old-school magnetic tape in a cassette). The baseline condition in the Hungarian experiment, however, showed that the perspective preference is not strictly 50-50%. Surprisingly, Szamarasz and Babarczy got the opposite result pattern in Hungarian than Boroditsky when testing those participants who have just got off the train at a railway station.

Their results show that participants in the train condition, which is consistent with the ego-moving perspective, responded according to the 'rewind' interpretation of the sentence, which is consistent with the object-moving perspective. This reverse finding is counter-intuitive because we would expect participants after an ego-moving train ride to respond according to the 'wind forward' interpretation (ego-moving perspective). Thus, the Hungarian experiment does not confirm Boroditsky's results.

Boroditsky's second offline experiment (Boroditsky, 2000, 11–17) investigated if spatial schemas are necessarily accessed in thinking about time. In order to answer this question, we would need to determine if the priming effect described in Experiment 1 is also found in the reverse direction (time-to-space). If this were the case, then we could conclude that the abstract domain of time is necessarily understood in terms of space.

A two-page questionnaire was constructed. The first page always contained TRUE/FALSE schema priming questions, while the second page contained ambiguous target questions. In order to investigate whether the priming effect is symmetric between the domain of space and the domain of time, four levels of transfer type were established: (i) space-to-space, (ii) space-to-time, (iii) time-to-time, (iv) time-to-space. The TRUE/FALSE schema priming questions were the ego-moving and the object/time-moving schemas.

A symmetric priming effect would mean that spatial schemas prime temporal thinking ((ii) space-to-time), and temporal thinking also primes spatial thinking ((iv) time-to-space). The results of this experiment show that participants were indeed influenced by spatial schemas (as in Experiment 1) when thinking about time (63.9% consistent) but were not influenced by temporal primes when thinking about space (47.2% consistent) (Boroditsky, 2000, p. 14). This asymmetric priming effect, thus, supports the weak version of Metaphoric Structuring that claims that spatial schemas may help in the processing of time but they are not obligatory (activated).

In a series of other experiments on time, Boroditsky (2001) proved that English and Mandarin speakers talk and think about time differently. In English, there are predominantly horizontal metaphors (e.g., before/after June, from June, etc.), whereas in Mandarin Chinese there are vertical metaphors (e.g., the last month is the 'up-month', the next month is the 'down-month'). In one study, Mandarin speakers tended to think about time vertically even when they were thinking for English. Subjects were presented vertical and horizontal primes. A target sentence was, for example: *March comes earlier than April.* Mandarin speakers answered this statement faster after vertical primes, and the reverse was true for English speakers.

Again, as in connection with Richardson and colleagues' (2001) study, the question arises if deviance from the English conceptualization pattern speaks against embodied cognition. That is, given that all humans have the same body plan and sensorium, spatial representations for time should be universal. However, the refutation of embodied cognition would mean the absence of embodied representations, rather than culture-specific diversity in spatial representations. It is true that the body serves as the basis for embodied representations but there may be other factors, such as culture or the environment, which may alter embodied representations in different settings.

Variance at the cultural level may indicate that humans are not predisposed for the exact structure of embodied representations, they may only be born with the capacity to establish embodied representations without the exact outcome or form of these representations at the outset. In other words, the TIME IS SPACE conceptual metaphor is universal but deviations from this metaphor may occur at the cultural level.

Embodied cognition just claims that the way how representations are established is embodied; diversity is reflected in the culture-specific embodied solutions. The notion of 'embodiment' can mean either of the two things: it can refer to the capacity which uses the body (parts of the body) and the brain, or other embodiment theorists say that embodied mental capacities are those that depend on mental representations or processes that relate to the body (e.g., Glenberg and Kaschak, 2003). Saying that the abstract concept of time is not embodied is tantamount to saying that there are no mental representations or processes associated to time that are related to the body.

What can be the representational mechanisms behind spatial metaphors, such as 'connections between ideas' or 'upward spiral'? Taking image schemas, which are abstract schematic gestalts, we already know that spatial metaphors all share image schemas in common. Therefore, first, we can therefore conjecture that image schemas are abstracted from concrete concepts (e.g., a concrete upward-moving spiral) and they are projected onto an abstract concept (e.g., 'happiness'). What we get is the metaphor 'I got into an upward spiral'. Further, 'upward' evokes the HAPPINESS IS UP metaphor.

Second, however, in my opinion image schemas themselves are not sufficient to the representation of spatial metaphors. For example, just projecting the upward image schema to the target domain of 'happiness', as in the case of the metaphor 'I got into an upward spiral' is not enough. Emotional affective states (Winkielman et al., 2008) and introspection (Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005) are also needed. Were they not needed, it would be hard to predict what metaphors emerge and what metaphors do not surface at all. For example, when we are in an upward spiral we experience uplifting and progress. This feeling is controlled by an external force, which lifts us higher. Therefore, the existence of image schemas themselves do not explain why the expression 'an upward spiral' is possible to describe happiness but 'an upward arrow/look' is not. Further, the fact that this spatial metaphor is non-existent in

Hungarian, at least not with the word spiral in it, further renders the exclusive role of image schemas in metaphorisation implausible.

Third, clearly, based on the above line of thought an integrative view should be adopted which uses both symbolic (amodal) and embodied (spatial, affective, etc.) representations. Hampton's (2003) frames offer a solution by rendering concepts more flexible representations by retaining the psychological reality of prototypes. Such frames may provide a more powerful cognitive basis for metaphors and would also help to explain variation in metaphor use. Lastly, some theories even posit amodal symbols of spatial relations, such as ABOVE, or LEFT-OF.

To conclude, the experiments on time and space (Boroditsky, 2000; Kemmerer, 2005, Szamarasz and Babarczy, 2008) point to the conclusion that the strong version of the Embodiment Hypothesis within the CMT framework does not have a cognitive psychological reality. However, it is possible that the theory is tenable in child developmental, language historical and meta-thinking perspective. Finally, the following chart summarizes the main the views on the representation of conceptual knowledge:

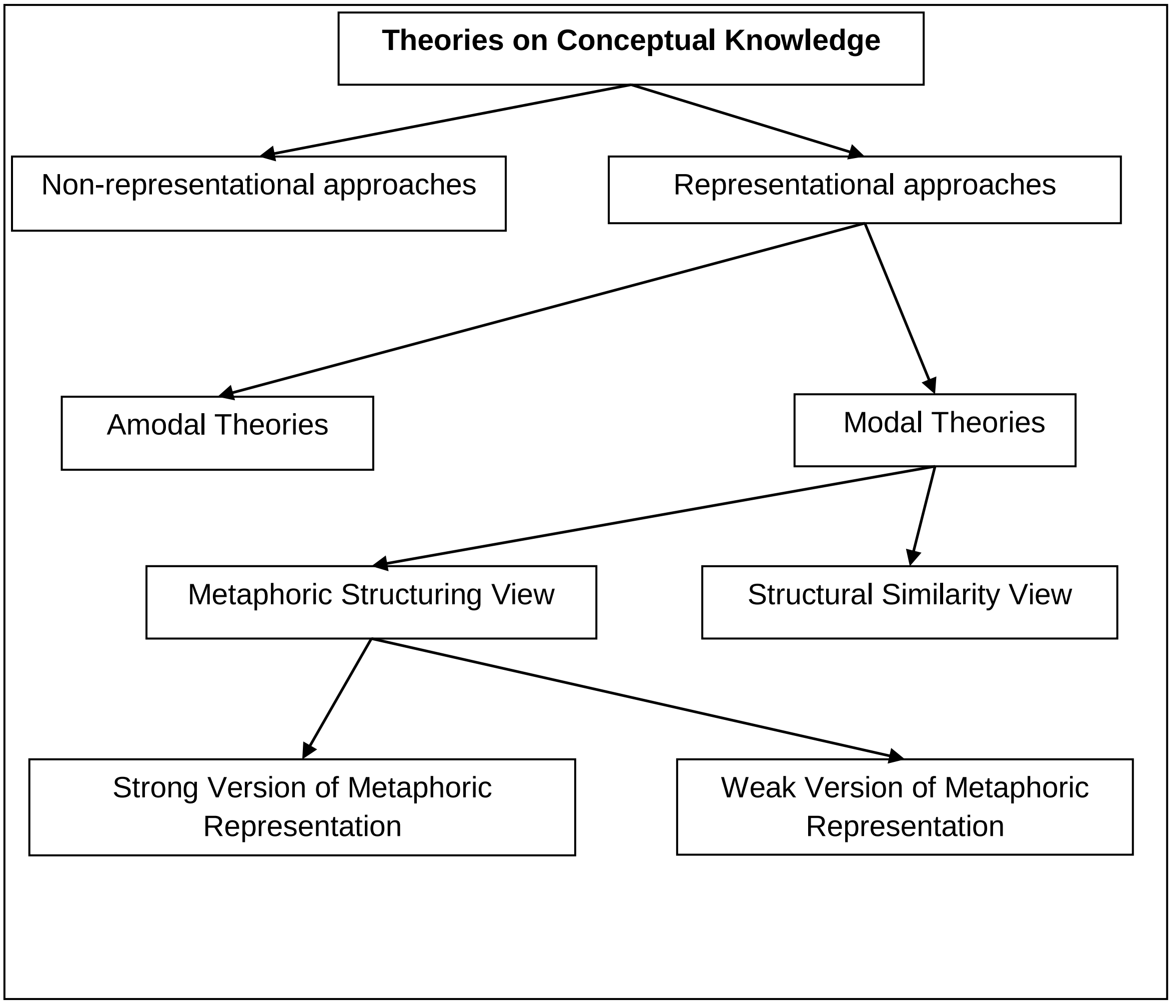

Figure 4. ***An Overview of Theories on Conceptual Knowledge***

1.4. The Embodiment Hypothesis

It is crucial to emphasize that CMT falls under Embodiment theories because CMT proposes that embodied representations are recruited through the process of metaphorisation. However, there are other embodiment theories outside CMT that should be addressed here.

In terms of cognitive neuroscience, the Embodiment Hypothesis has been supported by observations that sensory and motor neural representations ground cognitive processes. The Embodiment Hypothesis has been seemingly supported by the mirror neuron hypothesis to some extent (Cattaneo and Rizzolatti, 2009; Rizzolatti and Craighero, 2004, for a review in Hungarian, see Kemény, 2007). Some even claim that the mirror neuron hypothesis can be conceived of as the neural version of embodied cognition.

According to the mirror neuron hypothesis perception and thinking is embodied in the sense that they are implemented in the same motor systems that are recruited when implementing motor actions. The main idea of the mirror neuron hypothesis is that understanding actions of others, either by observation of their actions or through words encoding actions, activates mirror neuron ensembles.

However, the mirror neuron hypothesis cannot be seen as strong evidence for embodied cognition because it can be argued that mirror neurons reflect the conclusion of action interpretation rather than simulation. Csibra (2007) claims that activation of the mirror system is the result of action interpretation outside the mirror system, and that this activation serves the purpose of anticipation of on-going actions and has predictive value, further, it can have action coordination function.

Similarly to Csibra, the simulation interpretation of neural resonance has been criticized on similar grounds. Jacob and Jeannerod (2005), for example, claim on theoretical grounds that there are reasons to doubt mirroring could suffice for understanding emotions, actions, or intentions. Their argumentation goes that action understanding seems to require a more abstract representation than motor representation, that is, some form of conceptual processing because one type of action can be implemented with different movements and different types of actions can be implemented with one and the same movement in different contexts.

Most approaches in embodied cognition focus on simulation, which is the process by which concepts re-evoke perceptual and motor states. These neural and mental states are also activated during real perception and action.

It should also be noted that embodied cognition refers not only to domains, such as memory, language (the representation of concepts), emotions, time perception, and decision making, but also extends to developmental psychology, social cognition, theory of mind, philosophy, education, psychiatry, artificial intelligence, or therapy.

1.4.1. Behavioural Evidence for Embodied Cognition

Behavioural evidence in support of embodied cognition emphasizes communications between sensory or motor systems and conceptual processing (Glenberg and Robertson 2000; Barsalou 1999; Fischer and Zwaan 2008). A number of behavioural experiments have shown that sensory-motor representations modulate higher cognitive functions and processing, such as language processing. This Chapter presents the results of some of these experiments.

Stanfield and Zwaan (2001) asked participants to decide whether pictures depicted the actions described in sentences previously presented. The actions described either a vertical or horizontal orientation, such as driving a nail into the wall or into the ceiling. Results showed that subjects responded more quickly to the pictures that described the same orientation as the action described. Stanfield and Zwaan (2001) conclude that participants activated perceptual imagery of the action described in the sentence and this causes the effect. Their conclusion, however, does not necessarily confirm the strong version of the Embodiment Hypothesis because it may be the case that image generation is post-conceptual and operates after critical semantic access.

Richardson et al. (2003), for example, have shown a direct connection between perceptual and conceptual representations. They demonstrated that comprehension of verbs that encode horizontal or vertical schemas, such as push, evokes spatial representations. The processing of such verbs interacted with shape discrimination along the horizontal or vertical axis. Other investigations also demonstrate that motion words affect the detection and perception of visual motion (Zwaan and Taylor 2006, Kaschak et al. 2005).

Pecher et al. (2003) revealed a modality-switching cost in a linguistic task in which subjects verified verbal sentences involving one modality, such as the statement that ‘leaves rustle’, more rapidly after verifying a statement involving the same modality, such as ‘blenders make noise’, than after verifying a statement involving a different modality, such as ‘cranberries are tart’. Results are interpreted as showing that words activate their modalities.

Glenberg and Kaschak (2002) demonstrated that judgments on sentences like *Courtney handed you the notebook* or *You handed Courtney the notebook*, were affected by participants' motion (whether they moved towards or away from their own body in making their responses). What it amounts to is that comprehending these sentences involves simulating the motor action being described.

Scorolli and Borghi (2007) asked subjects to judge whether sentences containing a verb and a noun made sense. Participants had to respond either by pressing a pedal or speaking into a microphone. The verbs described actions that were performed with the mouth, hands, or the feet. Results showed that response times with the microphone were fastest with sentences encoding "mouth-verbs" and response times with the pedal were fastest with sentences encoding "foot-verbs".

The general interpretation of this experimental evidence is that words evoke analog perceptual and motor representations that are associated with the real world referents of the words that they refer to. It is usually concluded that the evocation of sensory and motor information is a simulation that constitutes word meaning (Kaschak et al., 2005). The experiments are usually interpreted in the Embodiment framework; however, critical points can be made about the validity of these claims. Chapter 1.5., A Critical Look at Embodied Cognition Effects in General, is going to detail some of these critical points. In the next Chapter, neuroscience evidence is discussed that seem to support the Embodied Cognition paradigm.

1.4.2. Neuroscience Evidence for Embodied Cognition

Neuro-scientific evidence in favour of the embodied cognition framework are usually supported by neuroimaging, electrophysiological (ERP and MEG), transcranial magnetic stimulation (TMS), and lesion studies. Damasio's convergence zones (Damasio, 1989) theory unifies embodied cognition with amodal representations on neurobiological basis.

Damasio's conception is based on two neural components. The first one is that representations of sensory and motor attributes reside in lower unimodal sensory and motor association cortices, and second that amodal convergence zones synchronise time-locked activations of these representations. The two aforementioned brain regions contribute to the meanings of events and entities, that is, meaning is not represented in one location of the brain, but rather represented distributionally.

In the field of neuropsychology, Grossman and colleagues (2008) demonstrated that patients with amyotrophic lateral sclerosis (ALS), which is a neurodegenerative disease of motor neurons in the nerve cells in the brain and spinal cord that control voluntary muscle movement, have difficulties with action words, and that this condition correlates with atrophy of motor cortex. Patients performed word-description matching and associativity judgements with actions and objects. They had greater difficulty with verbs (knowledge of actions) than nouns (knowledge of objects), and performance on verbs correlated with cortical atrophy in the motor cortex. Atrophy in the premotor cortex correlated only with impaired knowledge of action words. Grossman and colleagues conclude that action features are represented in the motor cortex.

Kemmerer et al. (2008), for example, investigated neural activation patterns using fMRI while participants made semantic similarity judgments on five different categories of verbs, which included verbs of running, speaking, hitting, cutting, and changes of state. Kemmerer and colleagues found different brain-topographic activations for these different verb categories in modality-specific areas of the brain. The relevant areas correspond to those areas of the brain that are also active when performing non-linguistic tasks. The results are suggestive of an embodied cognition account, however, the semantic similarity task raises the question whether the results are artefacts and such brain areas would not be recruited during normal language processing.

Recent neuroimaging (fMRI) and EEG research by Kiefer et al. (2008), for example, confirms that acoustic features constitute the conceptual representation of sound-related concepts, such as ‘telephone’. Kiefer and his colleagues measured ERPs while subjects performed lexical decisions on visually presented words. Their results show that words that denote objects for which acoustic features are highly relevant (e.g., ‘telephone’) rapidly activate cell assemblies in the posterior superior and middle temporal gyrus (pSTG/MTG) that are also activated when listening to real sounds.

Importantly, activity in the left pSTG/MTG had an early onset of 150 ms, which suggests that the effect has a conceptual origin rather than reflecting late post-conceptual imagery because pre-lexical processes, such as visual word recognition, operate in this time-window. In other words, the results of Kiefer et al. (2008) support the strong version of the Embodiment theory (e.g., Lakoff and Johnson, 1980, 1999) in that they show that the understanding of language referring to auditory phenomena is grounded in auditory representations. The results of Kemmerer et al. (2008) and Kiefer et al. (2008) may point to the conclusion that sound-related language automatically evokes auditory representations, which is the research question in Thesis 4 (Chapters 3.4 and 3.5.).

Pulvermüller and colleagues (2005) used transcranial magnetic stimulation (TMS) over left hemisphere motor regions while participants made lexical decisions about action words related to the hand (e.g., pick) or to the leg (e.g., kick). They showed a significant interaction between locus of stimulation and reaction times to the types of action words on which lexical decisions were made. The results are compatible with an embodied cognition account. Although, again, the question arises whether these effects can be epiphenomenal in the sense of Mahon and Caramazza (2008). This critique shall be discussed in more detail in Chapter 1.5 later.

The afore-mentioned evidence for embodied cognition (Kemmerer et al., Kiefer et al., Pulvermüller et al.) all point to the conclusion that knowledge is represented modality-specifically in the brain. Importantly, fMRI investigations have confirmed that this modality-*specific* representation is not only *specific* as it has been shown in the studies before but also distributed globally in the brain as a function of modalities involved. So, for example, Martin (2001) and Martin and Chao (2001) showed using neuroimaging that an object concept is represented as a distributed circuit of property feature representations across modality-specific regions in the brain. As the conceptual representation of an object is accessed, modality-specific areas are activated that respond to the properties of that object.

Importantly, Martin and Chao (2001) suggest that “category-specific” activations in the brain reflect neural activity that is also part of the specific representation of other objects (Martin and Chao, 2001). On this account, the representation of an object category is not restricted to a specific anatomical area, but rather the representation is widespread, that is, distributed across several distinct cortical networks. To emphasize again, Martin and Chao propose that category-related activations represent the retrieval of feature representations shared by exemplars of that category, rather than the retrieval of categories themselves. This conclusion is in line with several other accounts, such as Damasio (1989), or Rogers et al. (2005).

Finally, it is also interesting to see that today modal and amodal theories are not mutually exclusive but rather, amodal symbols are incorporated in some neuroscientific theories of semantics. For example, Bozeat et al. (2000) propagate a model of semantics which incorporates both amodal and modality-specific representations. Such models propose an amodal semantic hub, sometimes referred to as the “semantic hub” hypothesis, in which different inputs from modality-specific areas converge. Bozeat and colleagues showed that this hub, which incorporates the anterior temporal lobe (ATL) regions, forms amodal semantic representations, which follows from the observation that there is a significant item-specific consistent deficit between different input and output modalities in semantic dementia (SD) patients with bilateral ATL atrophy. Patients with SD have an amodal semantic impairment which affects their comprehension of verbal stimuli, picture stimuli, faces, objects, and sounds.

The role of the ATL regions is to form amodal representations and make generalizations based on semantic similarities. Importantly, the detection of such semantic similarities is domain-general rather than active only in one specific domain.

Further evidence for the existence of a semantic hub in the ATL regions comes from neuropsychological investigations (e.g, Lambon Ralph et al., 2007). Patients with herpes simplex virus encephalitis (HSVE), which produces bilateral frontotemporal damage, display similar semantic deficit patterns as patients with semantic dementia (SD) based on an investigation by Lambon Ralph et al. (2007). They report a comparison of semantic deficit in SD and HSVE.

According to the semantic hub hypothesis, the core of semantic processing is some amodal representation, which may be connected to modality-specific representations. These may be ignited in certain tasks when particular concepts are instantiated.

This semantic hub hypothesis is similar to Damasio's convergence zone hypothesis (1989). The semantic hub in ATL may be similar to Prinz's (2002) conception of *standing knowledge*, which is information stored in long-term memory. Importantly, the semantic hub does not code explicit semantic content, it just abstracts away from modality-specific representations. Arguments and empirical evidence for the existence of such amodal hubs is presented, for example, in Chapter 3.1. or in Fekete (2010).

1.5. A Critical Look at Embodied Cognition Effects in General

> "... sensory and motor information plays, at best, a supportive but not necessary role in representing concepts"
> - Mahon and Caramazza (2008, 67)

Embodied cognition has also received some critiques (Dove 2009; Mahon and Caramazza 2008). The interpretation of experimental effects supporting embodied cognition is still unclear. It might be the case that these effects emerge after semantic analysis and that activity in sensory-motor regions of the brain revealed in many experiments could be the result of spreading activation from amodal conceptual representations to sensory and motor systems (Mahon and Caramazza, 2008). Mahon and Caramazza emphasize that the empirical decision between embodied and amodal theories is very difficult because amodal symbols may well reside near modality-specific areas. It can also be the case that the effects would not emerge under normal conditions but only under experimental conditions. What it means is that embodiment effects are also consistent with disembodied theories.

Further, it may also be the case that the activation of modality-specific representations is not necessary for conceptual representations, but rather they emerge in an epiphenomenal manner, i.e., "on top of" the phenomenon. In other words, concepts may be represented separately from modality-specific representations as incidental by-products of conceptual representations. Mahon and Caramazza (2008) argue in this light that interference could be happening at a decision making level after semantic analysis. The crucial question to ask is whether sensory and motor representations are necessary components of conceptual representations or whether they are epiphenomenal.

If these representations are epiphenomenal, then they serve the purpose of elaboration, sophistication, elicitation, affordances, etc. It might also be that the degree of activation of modality-specific representations is contingent on context and individual differences. Thus, what still remains unclear is what exactly embodiment results really show. It might be, for example, that the motor system only contributes to the sophistication and differentiation of actions, rather than representing semantic attributes of actions. Consistent with this critique, Mahon and Caramazza (2008) also emphasize that degree of sensory-motor activation in language comprehension depends on the specific context, which casts doubt on the strong version of the Embodiment Hypothesis.

The shallow versus deep levels of processing have also cast doubt on the strong version of the Embodiment Hypothesis (e.g., Barsalou, 1999) in that it draws a distinction between deep conceptual processing, which requires mental simulation of modality-specific (embodied) representations, and shallow language processing, which does not tap into embodied representations.

There are few studies which directly speak against the strong version of the Embodiment Hypothesis. For example, Rüschemeyer et al. (2007) demonstrated that that the comprehension of verbs with specific motor contents (i.e., German *greifen* 'to grasp') differs from the processing of verbs with abstract meanings (i.e., German *denken* 'to think'). Crucially, Rüschemeyer and colleagues also investigated the neural correlates of the processing of morphologically complex verbs with abstract meanings that originally have concrete motor meanings, for example, German *be<u>greifen</u>* 'to comprehend' and abstract verbs that do not have a concrete motor meaning, for example, *bedenken* ‘to consider’. Contrary to the predictions of the strong version of the Embodiment Hypothesis, interestingly, no evidence for motor cortex activation was explored in the former case.

The results of Rüschemeyer and colleagues can be best interpreted in a framework in which abstract verbs are represented predominantly in the language system, whereas the processing of concrete verbs involves the partial activation of the motor cortex. Their results are similar to other papers reporting an absence of motor cortex resonance when processing idioms with action verbs, such as *kick the bucket* (e.g., Raposo et al., 2009). Their finding clearly contradicts the strong version of the Embodiment Hypothesis.

In my view, results, such as those of Rüschemeyer et al. (2007) and Raposo et al. (2009) may only indicate that abstract verbs that are originally built on concrete action verbs do not produce motor activation in the brain because their abstract meaning is distinctly represented. However, it may still be the case that these abstract verbs also produce some other type of modality-specific activation in other areas of the brain, which may confirm the Embodiment Hypothesis but not the strong version of the Embodiment Hypothesis which claims that the exact same modality-specific representations are activated in normal language comprehension which are also activated in perception and action. According to this counter-argument, comprehension would always involve the activation of some modality-specific content.

A general problem with embodied theories is that embodiment results are usually interpreted as conflicting with the predictions of amodal theories (e.g., Glenberg and Robertson, 2000). However, it is not necessarily the case because embodiment theories can have extended versions too, that is a theory which incorporates both modal and amodal representations (e.g., Mahon and Caramazza, 2008; Dove, 2009). The present dissertation follows this trend.

Lastly, another general critique and refinement of the embodiment approach and of modality-specific approaches is that knowledge is not stored category-specifically in the brain but rather the apparent category-specificity reflects processing demands and processes that are determined by representational structure (more on it, see Fekete, 2010). In other words, seemingly there is “category-specific” activation/effect because exemplars within the category share similar overall representational features, such as shapes or functional and behavioural attributes.

The results of Rogers et al. (2005), for example, supported this hypothesis. They used positron emission tomography (PET) in a category-verification paradigm, in which subjects categorized colour photographs of real objects (animals and vehicles) at three different levels of specificity (general: e.g., animal or vehicle; intermediate-level: e.g., bird or boat; or specific level: e.g., robin or ferry). Participants’ task was to decide whether the object matched the category label or not. Results showed that when category exemplars with similar representations are discriminated at the specific level (e.g., Labrador or BMW), the lateral posterior fusiform gyri respond equally strongly to animals and vehicles, suggesting that these regions do not encode domain-specific representations of animals and vehicles.

Specifically, their findings indicate that category-specific activation in the lateral fusiform does not signal that this region stores domain-specific representations or visual attributes of animals. Instead, such activation patterns seem to reflect the processing demands of the task being performed by participants. The fact that activation patterns are similar is attributable to the similar structure of the representations encoded in this brain region.

In summary, the question whether sensory-motor representations are essential for understanding concrete language and getting metaphors is still subject to on-going debate. Transcranial magnetic stimulation (TMS) can disable modality-specific areas in the brain, which could help answer the question above because such an intervention can interfere with the processing of concrete and abstract language. However, even this method cannot stand the critique of Mahon and Caramazza (2008) who claim that embodiment effects are epiphenomenal and reflect post-semantic access. Further research should therefore focus on the *function* and mechanisms rather than the *format* of representation (i.e., amodal or modal).

1.6. Outline and Choice of Studies in the Dissertation

The purpose of this dissertation is to explore the theoretical and, more importantly, the empirical validity of the strong version of the Embodiment Hypothesis. This sub-chapter describes and explains the diverse methodology deployed in the dissertation and my choice of methods. In striving for a comprehensive understanding of language, one has to combine methods and evidence types, which was a major rationale of the dissertation. The three main objectives of this dissertation are theoretical, methodological and empirical. The theoretical objective is to overview arguments for and against the strong embodiment position. This is accomplished in Thesis 1. The methodological objective explores quantitative procedures for identifying metaphors by applying corpus-linguistic tools (Thesis 2). The empirical objective is to explore the extent to which the strong embodiment position holds (Theses 3 and 4). This dissertation aims to address and resolve theoretical positions around the strong embodiment approach.

The theoretical paper tied to Thesis 1, although a weak contribution to the existing body of research on embodiment, is intended to show that the strong embodiment approach can be criticized on theoretical grounds and that there are strong arguments against it. The methodological objective addresses the question of how metaphors can be identified in corpora and whether the presence of source-domain words predicts metaphors, the latter being a theoretical import of corpus-linguistic metaphor identification (Thesis 2). However, the corpus-linguistic study, which adheres to this objective, is also considered a weak contribution to the strong version of the Embodiment Hypothesis because it cannot *directly* test 'strong embodiment'-related questions. Finally, the empirical objective (Theses 3 and 4) addresses two to some extent neglected domains of investigation, language describing social relations (comitative constructions) and fictive (and concrete) sounds in language. *Fictive* is used on purpose instead of *metaphoric* to refer to abstract language which is not motivated by a conceptual metaphor. Previous investigations into embodied cognition are largely restricted to visual and motor cognition, while language describing auditory phenomena and social events have been under-researched. The eclectic choice of methodology applied in the studies in this dissertation fulfils the objective to provide novel empirical data and to refine previously-made assertions in the area of the strong embodiment approach.

The theoretical review paper tied to Thesis 1 was primarily motivated to present the on-going debate and the theoretical perspective and cognitive science context of the strong embodiment view. However, the specific reason for focusing only on theoretical arguments against the strong embodiment approach in Thesis 1 is due to the sometimes one-sided interpretation of empirical results in the field. Glenberg and Robertson (2000), for example, explicitly state that embodiment effects are not predicted by amodal theories of cognition, which is an unfounded and radical statement that ignores theoretical concerns and is usually criticized by the amodal camp. Thus, it is crucial to highlight that the assumptions of the strong version of the Embodiment Hypothesis are consistent also with the predictions of amodal theories of cognition (Dove, 2009; Mahon and Caramazza, 2008).

One major assumption of the strong Embodiment Hypothesis is that semantic processing *automatically*, *necessarily* and *directly* recruits low-level sensory and motor systems. A weaker version of the same line of thought claims that semantic processing does require close contact to sensory and motor systems, however, the activation of those modality-specific processes is *not necessary*. This latter weak hypothesis prompted the psycholinguistic studies tied to Theses 3 and 4. The logic that I followed throughout the studies is that if any of the above three stipulations about the strong version (*automatically*, *necessarily*, *directly*) proves false, then the strong version of the Embodiment Hypothesis is disconfirmed.

The corpus-study tied to Thesis 2 *indirectly* assessed the hypothesis of whether source-domain concepts are *necessary* based on corpora, thereby tested the aspect of *necessity* of the strong version of the Embodiment Hypothesis. The study was also motivated by a need to understand how metaphors work not only during online language comprehension but also as reflected in corpora. Corpora, which can be viewed as sources of natural language production data, offer a window to test the *source-domain* *hypothesis* which cannot be tested in comprehension experiments because comprehension experiments employ prefabricated linguistic stimuli rather than natural language samples. Corpora are consistent with a psychological approach which demands ecological validity and that natural language data by language users are used as the base for any inferences about language.

The second rationale for the corpus-study was to use real-life data. Sometimes the scarcity of instances of conceptual metaphors is brought up as a criticism of the Cognitive Metaphor Theory. One issue of concern in Cognitive Metaphor Theory is therefore that linguistic manifestations of conceptual metaphors may not always be verified in corpora, or that their frequency is low. Alan Cienki (2004, 2005), for instance, searched for examples of two metaphors (MORALITY IS STRENGTH and MORALITY IS NURTURANCE) postulated by Lakoff (1996/2002) in coded transcripts of television debates between the presidential candidates, George Bush Jr. (a Republican) and Al Gore (a Democrat), and found only a few expressions (48) of the two conceptual metaphors in a 41,000-word corpus. In other words, the cognitive models behind these conceptual metaphors cannot be confirmed based on corpora. One argument to choose the corpus-study approach was therefore to study real-life language phenomena of high frequency in corpora.

The third rationale for the corpus-study was to provide Hungarian data for conceptual metaphors and compare them with their English manifestations in order to examine the extent of *inter-cultural variance* because cross-linguistic comparisons are needed to generalize to *universal cognitive models*. Also, since the strong version of the embodiment view is consistent with a universalist approach, therefore a cross-linguistic perspective is adequate and adds to the diverse methodology of the dissertation. However, it is crucial to underscore that cultural diversity in terms of conceptualization patterns does not necessarily falsify the strong version of the Embodiment Hypothesis because differences may just emerge at the level of language use rather than at the conceptual level. In my view, linguistic diversity in terms of conceptualization does not add to the strong versus weak version discussion of the Embodiment Hypothesis. Instead, evidence for the absence of metaphoric effects in conceptualization could falsify the strong version, for example, evidence showing that in some language speakers think abstractly and form abstract concepts without any links to concrete terms.

The primary motivation of the study in Thesis 3 is based on the principles outlined above: to preserve ecological validity and to provide real-time measures to approximate psychological reality because off-line corpus-data arguably mirror psychological reality only indirectly. The second rationale for the studies in Thesis 4 was to test the strong version of the Embodiment Hypothesis at the interface of language and perception (perception of sound stimuli) in order to gain a better understanding of how language understanding works in this domain.

The nature and format of representations in Thesis 3 cannot be explored because of the indirect nature of the task. Therefore, lessons learned from this study were used as a frame of reference in Thesis 4. The problem of the *format* of representations is alleviated in Thesis 4 by using real perceptual stimuli (environmental sounds). As for the strong version of the Embodiment Hypothesis, the two studies tied to Thesis 4 were motivated to test the questions of *automaticity* and *necessity* in a series of experiments. The fact that Theses 3 and 4 examined different linguistic phenomena is irrelevant to the research questions of the dissertation. However, the focal point in both Theses 3 and 4 was to systematically compare concrete and abstract language.

The reason for including two similar studies in Thesis 4 is because the second study extended the first one by using the same material but eliminating a potential confound. This potential confound could be that mental simulation of sounds may operate in a later time frame, i.e., after the sentence-final position. I stepped around this problem by putting critical verb stimuli in the middle of the sentences.

This dissertation begins, in Chapter 1, with an overview of the existing body of research into embodied cognition. This chapter provides a background into theoretical and empirical aspects of the topic. Importantly, theories on metaphor are discussed in this chapter. Chapter 2 then outlines the synopsis and the rationale of theses.

Chapter 3 comprises the studies which build the basis of the theses. In every empirical investigation presented in the studies of this thesis (Chapter 3.), concrete and abstract language were tested in parallel and systematically compared to each other. The rationale behind this setting was the assumption that concrete and abstract language – though sharing the same structure and origin – may "behave" differently, as it has been shown previously (though not unanimously), for example, by Richardson et al. (2003). Also, it is sometimes the case in experiments that concrete language is tested without a comparison to abstract language, for example, in the case of Kaschak et al. (2005).Chapter 3.1. suggests that there are strong arguments on the amodal side too. It is also argued that empirical investigations seemingly supporting the strong embodiment view can be criticized on theoretical grounds. Chapter 3.2. exploits corpus-linguistic methodology to investigate the automatic identification of metaphors and to assess the validity of the hypothesis that a metaphoric sentence should include both source-domain and target-domain expressions. Chapter 3.3. takes a different approach to the investigation into the strong embodiment view by applying psycho-linguistic techniques. Chapters 3.4 and 3.5. also follow the same methodology as the previous chapter. The study reported in 3.5. is to some extent an extension and confirmation of the similar study in 3.4.

The concluding Chapter 4. draws these results together, and outlines the theoretical and methodological contributions made by this dissertation. On the theoretical level, the dissertation argues that based on the empirical results presented in Chapters 3.3., 3.4. and 3.5., language processing does not necessarily and automatically results in the re-enactment of modality-specific representations. These findings speak against the strong version of the Embodiment Hypothesis. In terms of methodology, the dissertation addresses issues of identifying metaphors in corpora. The diversity of the methodology applied in the dissertation (from theoretical reviewing to corpus and psycholinguistic techniques) is eclectic because I believe that embodiment-related questions can only be resolved with the help of a versatile methodology.

The dissertation has a deductive approach. It starts out with a literature review in the Introduction. This is then followed by a theoretical article which further elaborates on the broader context of the research. The choice of starting with this review paper was not to break the flow of the literature review of the Introduction. The corpus-study precedes the psycholinguistic studies to preserve the logic of presenting methods and arguments in a from-weak-to-strong order: the degree of strength of arguments from the review article through the corpus study to the psycholinguistic studies is becoming stronger. Data presented in the dissertation, which are all qualitative data, are primary data, they have not been reanalysed from earlier studies.

2. SYNOPSIS AND RATIONALE OF THESES

The general aim of this thesis is to shed light on the following questions: Does the strong version of the Embodiment Hypothesis hold? Are sensori-motor representations/experiences necessarily and automatically activated for concrete and abstract language processing? These questions were investigated by applying corpus-linguistic (cf. Thesis 2) and psycholinguistic techniques in various domains of investigation (cf. Theses 3 and 4). The psycholinguistic techniques that were employed in the present thesis aimed to investigate visual sentence processing using the self-paced reading paradigm. Throughout the Thesis points, both concrete and abstract conceptual language were investigated and compared to each other because the weak and the strong version of the Embodiment Hypothesis generates different predictions in this respect.

I included four theses that embody the main scope of this work. In Thesis 1, theories are presented within and outside the Embodiment Hypothesis. The article attached to Thesis 1 reviews the problem of conceptual and lexical representation in cognitive science and critiques of the strong version of the Embodiment Hypothesis. Based on the principles above, the studies investigate aspects of the research question in three different domains: a study tied to Thesis 2 aims to examine the question from a corpus-linguistic point of view, and studies in Theses 3 and 4 aim to investigate the research question using psycholinguistic techniques.

The Thesis points, especially the two articles tied to Thesis 4 speak against the strong version of the Embodiment Hypothesis because it is demonstrated that sound representations are not necessarily and automatically activated. The thesis argues both on theoretical (cf. Thesis 1) and empirical grounds (Theses 2, 3 and 4) that amodal representations should not be dismissed.

Thesis 1: The Strong Version of the Embodiment Hypothesis (Radical Embodiment) versus Amodal Theories of Cognition

The amodal account of conceptual processing cannot be dismissed because there are articulated arguments on the amodal side. There are different kinds of amodalism, such as the theory of Newell and Simon (1972), Fodor's LOT theory (1975), Minsky's Frame-conception (1975), or conceptual atomism (Fodor, 1998). There are accounts which also use amodal representations, such as Damasio's convergence zone theory (1989), or the metamodal organization theory (Pascual-Leone and Hamilton, 2001). These newer amodal theories, but not propositional theories, can predict embodiment effects and can be integrated well into embodiment theories. Amodal symbols may reside near modality-specific areas of the brain. Embodiment effects in empirical investigations can also be explained in terms of propositional/amodal theories in cognition (e.g., Machery, 2006; Pylyshyn, 2003). Embodiment effects supporting the strong version of the hypothesis may be epiphenomenal (Mahon and Caramazza, 2008). There are neuro-scientific investigations, which demonstrate that there are specific brain regions (e.g., LOtv, POT) that implement amodal (modality-independent) mechanisms (Amedi et al., 2002; Wilkins and Wakefield, 1995). There are various accounts of Radical Embodiment; one of these is the Cognitive Metaphor Theory (Lakoff and Johnson, 1980, 1999) which claims that sensorimotor representations underlie the processing of concrete and abstract language. Embodiment effects can be interpreted in frameworks other than the Cognitive Metaphor Theory, for example, in the Perceptual Symbol Systems Theory (Barsalou, 1999), or other modality-specific theories (e.g., Bergen, 2007; Damasio, 1989; Pecher and Zwaan, 2005; Glenberg and Robertson, 1999). A radical constructivist account of linguistic semantics is presented.

- **Fekete, I.** (2010). A nyelvi szemantika a kognitív tudomány perspektívájából [Linguistic semantics from a cognitive science perspective], *Magyar Pszichológiai Szemle* [Hungarian Journal of Psychology], Vol. 65. (2), 355–388.

Thesis 2: A Corpus-Linguistic Investigation of the Strong Version of the Embodiment Hypothesis

The strong version of the Embodiment Hypothesis is not confirmed by corpus-linguistic data because the concept of source and target domains of metaphors is best characterized by statistical patterns rather than by psycholinguistic factors.

The research tested the question whether the automatic identification of certain widespread conceptual metaphors could be successful based on the processes proposed by the strong version of the Embodiment Hypothesis. According to our hypothesis, a metaphoric sentence should include both source-domain and target-domain expressions. This hypothesis was tested relying on three different methods of selecting target-domain and source-domain expressions: (1) a psycholinguistic word association method, (2) a dictionary method, and (3) a corpus-based method. Results show that for the automatic identification of metaphorical expressions, the corpus-based method is the most effective strategy.

- Babarczy, A., Bencze, I., **Fekete, I.**, Simon, E. (2010): The Automatic Identification of Conceptual Metaphors in Hungarian Texts: A Corpus-Based Analysis. In *Proceedings of LREC 2010 Workshop on Methods for the Automatic Aquisition of Language Resources*, Malta. 31–36.
- This article is available in Hungarian: Babarczy, A., Bencze, I., **Fekete, I.**, Simon, E. (2010). A metaforikus nyelvhasználat korpuszalapú elemzése [A corpus-based analysis of metaphoric language use]. In VII. Magyar Számítógépes Nyelvészeti Konferencia [Hungarian Computational Linguistics Conference], Szeged. 145–156.

Thesis 3: A Psycholinguistic Investigation of the Strong Version of the Embodiment Hypothesis at the Interface of Argument Structure and Semantics.

This study explores how bidirectional and unidirectional comitative constructions are processed. Bidirectional comitative constructions describe events where the two actors undergo the same effect described by the predicate (e.g., John was kissing with Mary), whereas unidirectional comitative constructions describe events in which one of the *actors is the Agent, and the other one is the Patient (e.g., John was messing with Mary). In particular, we used the self-paced reading paradigm to determine if the two constructions access distinct mental representations. The findings suggest that distinct mental representations are activated automatically by bidirectional and unidirectional verbs during online language comprehension.*

However, the processing of bidirectional and unidirectional comitative constructions can be explained by propositional/linguistic rather than embodied representations (cf. Thesis 1). The results of this study should not necessarily be interpreted in the framework of strong Embodiment theories, Simulation theories (Bergen, 2007; Zwaan and Madden, 2005), Situation models (Zwaan and Radvansky, 1998), or the CMT framework. Second, the finding, according to which the two constructions are read differently, is consistent with both a procedural and a representational account. On the procedural account, thematic roles are organized in a higher-order amodal representation and different thematic roles are processed differently as a function of cognitive load. For example, computing an AGENT - PATIENT representation is more difficult because of its asymmetry than computing an AGENT - CO-AGENT thematic representation. Thus, the strong version of the Embodiment Hypothesis is not confirmed because the result profile obtained in the experiments can well be explained by alternative conceptions (linguistic/propositional or amodal theories).

- **Fekete, I.**, Pléh, Cs. (2011). Bidirectional and Unidirectional Comitative Constructions in Hungarian: a Psycholinguistic Investigation at the Interface of Argument Structure and Semantics, *Acta Linguistica Hungarica*, Vol. 58. (1–2), 3–23.
- **Fekete, I.**, Pléh, Cs. (2011). „Ne viccelődj a rendőrökkel”: egy- és kétirányú társas viszonyok a nyelvben [Don’t Fool around with the Cops”: Unidirectional and Bidirectional Comitative Relations in Language], *Magyar Pszichológiai Szemle* [Hungarian Journal of Psychology], Vol. 66. (4), 559-586.
  (This article, which is the Hungarian translation of the above article, contains additional statistics for the experiments presented in the above article. The

experiments, the dataset and the conclusions are the same. The additional statistics are reported in Chapter 3.3. before the paper.)

Thesis 4: A Psycholinguistic Investigation of the Strong Version of the Embodiment Hypothesis in the Domain of Environmental Sounds and Language.

Both fictive (abstract, metaphoric) and concrete sound events are processed in a shallow manner (Barsalou, 1999; Louwerse and Jeuniaux, 2008) without access to embodied sound representations. Congruency-effects, counter-intuitively, do not emerge at a short SOA, while at the same time category-external items exert an inhibitory effect under the same condition. Congruency-effects cannot be explored in the shallow control question condition. A congruency-effect was yielded only in the sensibility judgement task under a long SOA condition. Congruency-effects cannot be observed on the region following the critical verb either, or at the end of the sentence (no carry-over effects), while the effect of inhibition is still present at the end of sentence. Taken together, four experiments with four different settings unanimously demonstrate that specific sound representations are not accessed routinely during normal reading of sound-related language.

Thus, these results do not confirm the psychological reality of the strong version of the Embodiment Hypothesis at the interface of concrete/abstract sounds and language but rather support the Good-Enough processing approach of language processing, as proposed by Ferreira et al. (2002, 2009) and the shallow processing account (Barsalou, 1999; Louwerse and Jeuniaux, 2008). The findings in this Thesis point are suggestive for an independent storage of abstract concepts from modality-specific representations.

- **Fekete, I.**, Babarczy, A. (accepted, 2012): Mi van akkor, ha a macska ugat? Kognitív templátok és a valóság illesztése a nyelvi megértés során [What if the cat is barking? Cognitive templates and the matching of reality during real-time language understanding], *Általános Nyelvészeti Tanulmányok XXV* [General Linguistic Studies].

- **Fekete, I.**, Babarczy, A. (submitted, 2012): A psycholinguistic analysis of 'fictive' sound events.

3. STUDIES

3.1. Thesis 1: The strong version of the Embodiment Hypothesis (Radical Embodiment) versus amodal theories of cognition

Fekete, I. (2010). A nyelvi szemantika a kognitív tudomány perspektívájából [Linguistic semantics from a cognitive science perspective], *Magyar Pszichológiai Szemle* [Hungarian Journal of Psychology], Vol. 65. (2), 355–388.

The following article is the English translation of the Hungarian paper above.

LINGUISTIC SEMANTICS FROM A COGNITIVE SCIENCE PERSPECTIVE[15]

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Abstract

Cognitive science can be divided into two streams: representational and non-representational cognitive science. Within the representational paradigm two approaches emerge: amodal and modal views. The goal of this summary is to review the main theories and interpret the status of linguistic semantics in these. Special attention is devoted in this summary to the theory of Perceptual Symbol Systems proposed by Barsalou (1999), which claims that conceptual processing is modality-specific. An opposing view is propagated by Fodor (1998), according to whom part of our elementary concepts are represented in unstructurable conceptual atoms; the latter are stored in modality-neutral

[15] I am indebted to Csaba Pléh for his comments. The EU FP6 program supported me in preparing this paper: NEST Scholarship 028714, „The Origins, Representation, and Use of Abstract Concepts". Coordinator: Dr Anna Babarczy.

(amodal) symbols. Last, an influential paradigm in cognitive science (Maturana and Varela's radical constructivism) is presented, which totally dismisses the existence of representations.

Key words: *semantics, representation, radical constructivism, modality-specific, amodal, concepts, symbol processing*

Introduction

This reviews deals with linguistic semantics in the representational and non-representational cognitive theories: first the questions of symbol-grounding and conceptual knowledge will be reviewed in the amodal, modal, and non-representational theories, then the problem of linguistic semantics will be analysed in these three paradigms. Since non-representational theories dismiss the existence and cognitive reality of symbols and conceptual processing, I will investigate instead how this paradigm solves the questions of symbol- and conceptual processing.

The topic of this paper is timely, because the empirist-rationalist debate, which has been around for hundreds of years, has also emerged in the cognitive sciences by today. Modal theorists, „neo-empirists" face the amodal camp (Machery, 2006). My goal is to review how different cognitive theories think about the brain, conceptual processing, and linguistic meaning.

The questions of symbol-processing and conceptual knowledge in the cognitive sciences

Before presenting the different theories, it is worthwhile reviewing the variant uses of the concept *symbol*. Csaba Pléh's (1998b) review about symbols gives an excellent introduction to the development of the symbol-concept and its variants in the cognitive sciences. The concept of symbol possesses multiple meanings in psychology (Pléh, 1998b). Most of the time arbitrariness is the defining feature (Peirce, Morris, Bruner, and Saussure): linguistic symbol is not motivated. Paul Grice combines symbol use with intentionality: we exert an effect on the listener, whereby they recognize our intention. Gombrich claims that iconic mapping is the source that leads to arbitrariness. Mérei emphasizes the connection with group-level meaning and personal meaning, and the extra experience or force, whose source is the context, the associated key situation. Freud highlighted personal meaning, that is the filling of signs with personal meanings. Jung extends this personal filling of signs, and claims that this is culturally determined. Piaget ties his concept of symbol to representations; in his system the basis of representation is the dissociation of stimulus-dependence.

Some preliminary words about the radical constructivist conception of language: radical constructivists dismiss the concept of representation. Language – as we will see – in the system theory of Maturana and Varela is conceived of as – connotative, and not denotative. The function of language is the orientation of our communicational partner within their cognitively construed reality, rather than referring to or describing objects in an objective reality, which exists independently from us. Signs, which are psychologically speaking not real, thus, do not convey information. Meaning is strictly contextually determined. Radical Constructivism also dismisses conventionality on grounds that the basis of efficient communication is the parallel uses of cognitive processes that play a role in language production and comprehension. The ultimate function of language is the sustainment of self-organization in the biological sense. Radical constructivist semantics is therefore in line with usage-based models of language from Peirce and Dewey to Wittgenstein.

Amodal and modal theories

Two rival approaches exist about symbol-processing and the representation of conceptual knowledge[16]: (1)(a–b) (reviewed, for example, by Barsalou et al., 2003):

(1)(a) The classical approach (e.g., Fodor and Pylyshyn, Newell and Simon) conceives of conceptual knowledge as construed of amodal representations, which derive from modality-specific representations: *car* as a physical stimulus induces a sensory representation on the level of the nervous system, which gets transformed into an amodal representation. This process is usually referred to as *transduction*. The meaning of the word implies that an already existing representation is re-written *into another form*. This type of representation is an amodal representation, which is not a perceptual representation anymore; that is, perceptual and cognitive representations are stored in two distinct systems according to the classical cognitivist view.

[16] The two conceptions can be coupled with the analog versus propositional knowledge theories (see Pléh, 1998, 125–132).

The amodal symbol of *car* can be composed of its *feature list, semantic network*, and *frame* according to some amodal theories (e.g., Minsky, 1975). The feature list of *car* is composed of the following items: physical object, machine, engine, wheels, etc. The semantic network of *car* is hierarchical, the frame is the whole semantic variable, which is filled up by the feature list (wheels=*4*, colour=*red* etc.).

Fodor's amodality (1975) refers originally to the *Language of Thought* – LOT. LOT is propositional (amodal) in nature. Fodor' LOT conception was designed in analogy to the early computer architectures. LOT is like the operation system of computers. Fodor's language of thought is a compositional system with its own syntax, which is independent of the spoken language. The existence of this mental language can be bolstered by the fact that both babies and animals can think, although numerous empirical evidence show that thinking involves analog (perceptual and motor) representations (Barsalou, 1999). According to Fodor propositions cannot be represented solely with imagery.

According to amodal theories, every cognitive operation is performed on amodal representations in a sequential manner, and not on the original sensory states. This approach contends that knowledge, which is stored in amodal representations, is dissociated from modality-specific systems. The amodal symbol of *car*, for example, represents every type of car. Table 1. illustrates the five theses of the classical approach about representation based on Markman and Dietrich (2000):

1. Representations are internal mediating states of cognitive systems	There has to be a representing and a represented world[17], further there have to be representing connections between these two and processes that can use information in the representing world.

[17] The representing world can both be within the system or outside the system in the form of external representing information.

2. Cognitive systems need some enduring representations.	For us to be able to use our experiences, we need to store some of our representations (e.g., the colour *blue* has to be stored even if we are not perceiving the colour itself.
3. Cognitive systems contain symbols	Properties (features) are stored in the form of symbols in the representing world. These symbols bear an arbitrary relationship with the contents of the represented world.
4. Some of the representations are tied to perceptual systems, but there are also amodal representations.	Our abstract concepts, such as *truth*, are said to be amodal according to some amodal approaches, because they are distinct from our perceptual experiences.
5. Numerous cognitive functions can also be modelled by ignoring some of the sensori- and effector systems of the cognitive agent.	According to the assumption, when interpreting some representations perceptual and motor representations can be ignored.

Table 1. The classical view about representation based on Markman and Dietrich (2000, 471)

(1)(b) The other approach (e.g., Barsalou, 1999; Lakoff and Johnson, 1980, 1999; Pecher and Zwaan, 2005; Glenberg and Robertson, 1999; Damasio, 1989) claims that knowledge is represented in modality-specific neural states, which provide direct input to memory systems, language, and thinking. Importantly, knowledge is represented directly in a modality-specific manner. This approach contends that the basis of both cognition and perception is the same representational system. Thus, the following are considered as modality-specific operations, which do not use any amodal symbols: *type/token distinctions*: type is a concept/category (e.g., *bicycle*), which contains various exemplars (different bicycles); *categorical inferences*: the ability to infer, for example, that one can put a certain book on a table; the representation of abstract concepts; conceptual productivity: productivity refers to the binding of pre-existing components, which serves the basis of the construction of a new concept or situation; the processing of propositions.

One of the founding figures of this approach is Lawrence W. Barsalou who devised his *Perceptual Symbol Systems Theory* (PSS, Barsalou, 1999). Perceptual symbols are dynamic and compositional multimodal neural representations which reside in the sensorimotor areas of the brain and encode schematic components of perceptual experiences. Multimodal perceptual symbols refer beyond sensory modalities also to the phenomena of proprioception and introspection within the PSS framework. Perceptual symbols do not exist independently from one another, but rather related symbols are organized into a *simulator* which re-enacts a pre-existing, enduring representation. A concept is equivalent to a simulator in the PSS framework.

Related perceptual symbols organize themselves in a *simulator* in Barsalou's theory. *Car* can be viewed from multiple perspectives by focusing our selective attention; the perspectives are organized spatially, and they are organized in the same simulator in our memory (*car-simulator*). The concept of *car* is the same as the *car*-simulator, as it has already been mentioned.

The theories mentioned in (1)(b) are supported by neuro-scientific studies which emphasize that our knowledge is stored in modality-specific systems of the brain. This observation is bolstered by numerous neuro-scientific evidence: for instance, a damage of a sensori-motor area of the brain can result in a category-specific conceptual deficit. However, category-specific deficits are nowadays interpreted as showing that not strictly the categories themselves are defective but rather the perceptual symbols that serve the basis of these categories. Barsalou reasons that amodal representations can be refuted based on these observations (reviewed, for example, by Barsalou, 1999, 579; Barsalou et al., 2003, 87). It is not unthinkable that this evidence do not clearly dismiss the existence of amodal representations. It is in theory possible that amodal and modality-specific representations are not dissociable at a conscious level. Thus, modality-specific representations cannot operate without amodal representations. Category-specific deficits (the selective deficit of conceptual categories, such as birds, animals, objects, tools, etc.) according to this interpretation would show that amodal representations cannot operate without sensori-motor representations. In other words, modality-specific representations would be the obligatory associates of amodal representations, and would serve the basis of *symbol-grounding* in Hernád's (1996) terms.

Behavioural reaction time experiments have also demonstrated that when reading two words consecutively, decision is faster on the second word if the contents of the two words refer to the same modality. For example, decision is faster to the question whether leaves are green, if the previous decision also required the visual modality. In Pecher and colleagues' (2003) property verification task participants decided about pairs of words; the task was to decide if the property is associated to the word, or not, for example, *cranberry-sour, turmix-machine-loud* (incongruent trial: different modalities). They found that verification becomes slower if the two trials belong to different modalities as opposed to the case when the two words share modality. In their second experiment, they controlled for the associative priming between the two words in the cases of shared modality. Furthermore, since the task demand did not require participants to use imagery in the absence of explicit imagery instructions, therefore, it can also be excluded that the unravelled effects were artefacts that were caused by the task demand nature.

The results suggest that concepts are represented in modality-specific areas of the brain because it takes time to switch between modalities, however, Machery (2006) criticizes such results based on the following line of thought: the very same results were yielded, if concepts belonging to different modalities were represented near the relevant (corresponding) perceptual symbols. To illustrate, the amodal concept of GREEN would be represented according to his hypothesis near the visual system, while the conceptual representation of sounds were represented near the auditory system in the brain. That is, Machery defends the amodal theory with his critique.

Zenon Pylyshyn (2003), a founder of the propositional theory, comes up with another kind of critique against the exclusiveness of modal (modality-specific) theories: participants solve the tasks in such experiments by using imagery, that is, they rely on visualization. Participants are asked in these tasks, for example, to memorize a map, and then fixate on a point on the map. After this points are named, and participants have to react "when" they see these points. Results show that internal images, that is perceptual visual representations, are construed by the process of *mental scanning*. In other words, we mentally simulate pictures of reality. What it amounts to is that it takes longer time to process mentally what is farther in reality (linear function). These results support the use of visual imagery in these tasks according to modal theorists.

A general criticism is that task demand determines the outcome of the experiment, that is the type of representation. In other words, the existence of propositions (amodal "statements/descriptions") cannot be that easily dismissed in imagery processes either. Pylyshyn's line of thought is usually brought up as criticism in other behavioural and neuroscientific investigations which reason that language processing automatically involves activation of modality-specific representations and brain regions.

Numerous psycholinguistic experiments support modality-specific theories (Bergen, 2007). I would like to mention one particular investigation from the bodies of experiments. Zwaan and colleagues (2002) asked participants to perform a picture-verification task: participants had to decide if the concept depicted in the picture had been mentioned in the sentence that they had previously read or not. Sentences encoded objects and their orientation, e.g., *The ranger saw the eagle in the sky*, or *The ranger saw the eagle in the nest*.

If implicit information, such as orientation, is represented during language processing, as it is argued in the PSS framework, then participants would decide faster in the congruent condition when the eagle is depicted with outstretched wings, if the sentence is about an eagle in the sky. The picture-verification experiment showed the predicted compatibility-effect. Results support the notion that language processing automatically recruits mental simulation of modality-specific information encoded in sentences. Furthermore, this phenomenon happens also, when no explicit instruction is given to visualize the implicit scene in the sentence. It is concluded that propositional theories would not predict this effect, since the amodal representation of 'eagle' is the same in both sentences.

Amodal theories

Amodal theories propose that cognitive and perceptual representations are tied to neural systems that work on their own distinct principles (e.g., Fodor, 1975; Newell and Simon, 1972). These theories also accept the view that perceptual states emerge in sensori-motor areas of the brain, however they disagree with modal theories in that according to the amodal view modality-specific representations are re-written into modality-independent representations. Importantly, the latter are bound to distinct neural networks. So, for example, a neural assembly that is activated when perceiving a colour is distinct from that neural assembly which fires when that colour is retrieved in the absence of that colour (Barsalou, 1999, 578): the cortical representation of a colour resides in different region in the brain according to the amodal view than the neural representation of that colour in the perception situation.

Since symbols are amodal in nature in such systems, therefore there is an arbitrary relationship between them and the perceptual states which give rise to them. To illustrate, the arbitrary relationship between perceptual states (e.g., the neural representation of perceiving a ‘chair’) amodal symbols (e.g., the amodal representation of a ‘chair’) is the same as the relationship between the object of a chair and the word *chair*.

Marvin Minsky’s classical *Frame*-theory (1975) also assumes the existence of amodal symbols. According to Minsky our knowledge is organized in *frames*, and when we find ourselves in a new situation, then such an entity or frame is retrieved. A *frame* is a complex of nodes and relations. *Frames* are organized around prototypes, and related frames are organized in frame-systems. The examples of the restaurant-frame and the birthday party-frame are usually brought up in the psychological literature. In this conceptualization, conceptual meaning refers to the whole of the network.

The script theory of Schank and Abelson (1977) similarly argue that the bulk of our knowledge is stored in the form of scripts. Sequence of typically associated events, objects, protagonists, scenes, etc. are all parts of such panels. Scripts are hierarchically organized knowledge structures. Some examples for scripts include: angling, cinema, medical examination, rendezvous, preparing breakfast, etc. Empirical investigations have confirmed that details of scripts are predominantly the same in our minds. Bower, Black and Turner (1979), for example, found based on the responses of participants that sequence of the key elements of the restaurant script are the same in everyone (going into the restaurant, sitting down, looking at the menu, ordering, eating, paying the bill, going away). Friedman (1979) showed that participants looked at unexpected objects almost twice as long as expected items which were compatible with the script.

Scripts and language processing are related because scripts help language processing as background structures, and they support inferences to implicit details. Scripts generate expectancies, which serve the basis for efficient communication. The sentence *The soup was cold, therefore we did not tip the waiter* activates the restaurant script, which builds the coherence between the cold soup and tipping.

Scripts elicited by texts and pictures can vary as a function of text type. János László’s (1990) seminal experimental work dealt with literary texts and texts from newspapers, and investigated the processing of these contents with the method of content analysis. He investigated these texts during text interpretation with special respect to the quality of the elicited pictures. László found that pictures elicited by literary texts resemble our own subjective experiences, while pictures construed based on newspaper texts rather depict objective social categories. Based on the reports of the participants who were performing the reading task in the experiments, it can be concluded that literary and real pictures contain more attributes and physical-perceptual features. In other words, these stimuli were richer in detail and sensory aspects than those pictures that were elicited by newspaper texts. László's real-time method (reaction time to picture stimuli) also demonstrated that pictures of life-time events and literary texts have the highest degree of elicited perceptual accessibility.

The neuro-psychological literature connects the damage of script-knowledge to pre-frontal dysfunction, which can either result from trauma or dementia (Sirigu et al., 1995, 1996). Such a condition damages the ability of sequencing script-like events and goal-oriented actions. In Schank and Abelsons' theory, the constructs of scripts are propositions. It is worthwhile pondering about the quality of amodal representations in Schank's script-conceptualization. In Schank's theory, propositions determine the relations of events to one another, that is, events of a script are linked together in a proposition. Hierarchical knowledge-structures are also organized in propositions, e.g., LIVING [ANIMAL/birds, fishes/, PLANT/flowers, trees/].

The following questions arise about script-like knowledge, and in broader sense about pragmatic knowledge: (i) what exactly in incorporated in this knowledge-set? (ii) to what extent is this knowledge domain-specific (the question of modularity)? One should organize and conceive of pragmatic knowledge along effects and processes, as it is done also by Pléh (2000): knowledge-effects (our conceptual knowledge), context effects (e.g., our geographic knowledge, which helps understanding), discourse effects (previously mentioned contents help and guide understanding), and conversational effects (contents previously mentioned construct models in the conversational partner).

Of course, a defect of script-like knowledge in the narrower sense does not support or refute the concept of modularity or domain-general conceptions, because our whole pragmatic knowledge is vast, as it has been shown before. A further opaque question related to domain-specificity is the exact function of isolated brain regions: what exactly is involved in our script-like knowledge, and what function is exactly tied to the pre-frontal cortex? There are two conceptions about the role of the pre-frontal cortex in the processing of scripts: (i) according to the representational conception, every aspect of content (semantic knowledge) as well as the capability of sequencing events reside in the pre-frontal cortex (Wood and Grafman, 2003). (ii) However, others propagate the two-component model, according to which aspects of sequencing events in scripts are tied to distinct brain systems than semantic knowledge (Cosentino et al., 2006). In the latter conceptualization, the event-organizational component, which is implemented by goal-oriented executive functions, and semantic knowledge – though residing in distinct neural networks – construct scripts in interaction.

Schank (1972) details also language understanding. In his view, the primary meaning of numerous action verbs can be captured with the help of about a dozen simple actions, so-called primitives. This is the so-called semantic decomposition theory, which will be detailed later. In this conception, every motion verb can be analysed and decomposed into a general motion-encoding primitive, e.g., MOVE is the primitive of every bodily action. Events can be analysed into event structures similarly as in case grammars, e.g., AGENT, ACTION, OBJECT, DIRECTION, etc. To illustrate, the sentence *John has read a book* involves the MTRANS primitive, which refers to mental transfer (reading).

Returning to amodal representations: the content of an amodal symbol is usually defined linguistically, e.g., CHAIR: *back*, *seat*, *leg*). However, this procedure is problematic in the case of colour concepts. The amodal symbol of, for example, red can only be captured with circumscriptions, such as „similar to/like", or „blood is red", and experience-based associations. The question arises at this point whether and to what extent experience-related definitions can be considered as amodal.

Do we have pure modality-specific concepts beyond the assumed amodal ones? If colour concepts are processed only as modality-specific concepts, then is this incompatible with amodal theories? The question is legitimate; however, a colour-blind person can also conceptualize colours to a certain extent. A good example for such a phenomenon is the case of the almost entirely achromatic psychologist, Knut Nordby, researcher at the Oslo University. Congenital achromatopsia is a very rare non-progressive genetic vision disorder. Based on his own report, Nordby can identify some colours, as numerous achromats are able to do so, yet he does not have any colour-experience whatsoever (Nordby, 1990). The ability of achromats to identify colours is explained with the baseline activation of cones in the blue-lilac spectrum by scientific research.

Machery (2006) comes up with an interesting piece of evidence for the existence of amodal representations. He brings up the concept of *cardinality*. Adults and to a certain degree babies also are able to approximate the number of different entities within a class (objects, events, etc.) and are able to compare classes along this variable; that is, they possess so-called *approximate cardinality*. According to developmental and behavioural observations, approximations are as precise within a modality as across modalities (audition and vision); Machery interprets this observation as evidence for the existence of amodal representations. He further adds that amodal representations are phylogenetically ancient and may be independent from language, as other primates are also able to approximate and compare (p. 406).

Amodal conceptions usually do not detail the process of *transduction* and the question how amodal symbols emerge. So far, no cognitive or neural evidence has emerged for the existence of this process. On the other hand, transduction is a logical analogy to the process of sensory transduction, which operates within one modality (e.g., visual or olfactory transduction): sensory transduction in receptor-physiology refers to the transformation/conversion of a stimulus from one form to another.

Finally, let us take a look at some strength of amodal theories: the implementation of *type/token* distinctions, *categorical inferences*, the representation of abstract concepts, conceptual productivity, and the processing of propositions. As we will see later, modal theories also suggest alternative mechanisms to the implementation of these operations (e.g., PSS). Figure 1. illustrates the schematic representation of the concept ‘table’:

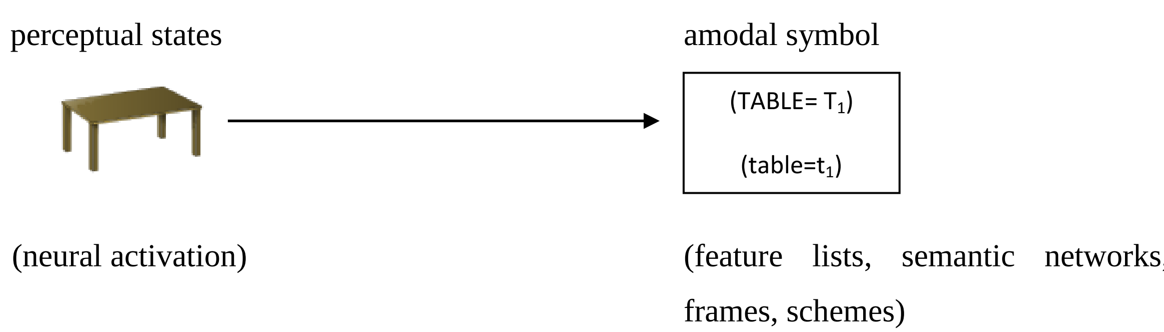

Figure 1. A schematic representation of the amodal symbol of *table*

Figure 5. A schematic representation of the amodal symbol of *table*

Atomism (Fodor, 1998), another form of amodalism, should be mentioned briefly. Fodor's (1998) *informational atomism* (the atomistic theory of concepts) claims that a set of our concepts, lexical concepts (those that we have one word for) are ontologically and semantically primitive. Common features of such concepts are: (i) such concepts are *unstructured*, that is, they do not have an internal complex semantic content-structure (i.e., they do not have the structure that is illustrated in Table 1.), and (ii) the content of an atom is *not* determined by its relations to other concepts. Instead, the relationship between the content of the atom to features of the environment is nomic (or *nomological*). The content of an atom is determined by *mind-world relations*. The concept nomological relates to basic physical laws. Nomic necessities are physical-natural laws, which – in Fodor's conceptualization – determine the contents of atoms.

Based on the two principles above, Fodor dismisses the cognitive reality of definitions, that is, the featural theory of concepts, according to which concepts are represented in our minds along features that define them. Thus, the information semantics of atomism denies that, for example, the concept HORSE means 'horse' because of its relations to other linguistic symbols {ANIMAL, FOUR-LEGGED, NEIGHS, etc.}.

Following the logic of Fodor, one can infer that our primitive lexical concepts cannot be learned. Yet, they do not possess the inherent contents when we are born. Fodor's conception about the atomistic learning process is as follows: primitive atomistic (pre-)symbols are grounded/locked with the help of perceptual modules.

However, it is not clear how fodorian theory generalizes from perceptual atomistic concepts (e.g., *red*) to other categories (e.g., horse), and as to how it follows from conceptual atomism that these conceptual atoms can only be amodal symbols? Another question is how abstraction works in the fodorian atomistic system.

The *nomological locking*/grounding of horses involves the mental representation of the represented. In the case of verbs, the process operates in the same way: the verb *keep* refers to the concept KEEP, that is, we nomologically get locked on the inherent content of *keep*.

Fodor's examples are not considered as atomistic concepts in Hungarian: the English word for the concept BACHELOR (*agglegény* in Hungarian) is unstructured in English, that is, the concept is not composed of the features that define it (UNMARRIED, MALE). Likewise, (VIXEN/ Hungarian ‘nőstényróka’) does not contain the conceptual constituents ANIMAL, FOUR-LEGGED, FEMALE, VIXEN, FOX, or RED according to Fodor’s conceptual atomism. In a thought experiment of brain damage, Fodor’s conceptual atomism would predict that if someone loses the concepts ANIMAL and FOUR-LEGGED, then their concept of FOX would still remain intact.

According to Fodor, conceptually necessary constituents or relations are only metaphysically necessary[18]: the HORSE concept (‘horse’) does not contain the concepts ANIMAL, FOUR-LEGGED, and NEIGH, however, they are metaphysically related to the HORSE concept. Thus, in Fodor’s theory conceptual relations are “illusions”[19].

Fodor’s argument against prototypes is the following: if the concept DOG has a prototype, then the concept NOT-DOG has also have to have one, however, we cannot associate a prototype to such a concept. However, one can question to what extent NOT-DOG can be considered a concept in the psychological sense; that is, to what extent do aspects of conceptual processing apply to such a concept. Formal logic dictates that NOT-DOG can refer to any entity outside the dog concept (e.g., ‘table’, ‘ball’, ‘tiger’, etc.), however, it is more plausible in natural language processing that it refers to another animal. One can argue that context determines if we picture an animal very similar to a dog, or another animal which belongs to another category, such a cat. In the latter case, NOT-DOG activates the prototype of ANIMAL with the category DOG subtracted. In the former case, we arrive at an exemplar which is perceptually very similar to a dog, such as a coyote or wolf. In other words, NOT-DOG would allow for multiple prototypes because NOT-DOG is not a stable concept with well-defined boundaries. Context is the defining marker which guides the selection from the set of possible prototypes. It is also conceivable that the ambiguity of NOT causes the effect: the utterance *I wasn’t running* can mean the negation of the action (‘I wasn’t running, I was swimming’), or it can imply a sophistication, such as ‘I wasn’t running, I was rushing’).

In my view, Fodor’s indefinability argument does not clearly point to conceptual atomism, since linguistic meaning is not fixed along the variables of time, communicative situation, or

[18] The semantic *versus* epistemic terminology is also in use. The distinction refers to the difference between conceptual *versus* meta-conceptual knowledge (knowledge about the concept). The atomistic semantic representation of ‘horse’ does not contain the ‘four-legged’ feature; the latter feature is the feature of “horse*ness/-hood*” in the fodorian system.

[19] This thought emerges also in Radical Constructivism, which claims that such theories are constructed by the observer at a meta-level.

social status. Therefore, language use allows for deviations from the standard meaning, which would provide the basis for language use in a community, for metaphor, and for humour inter alia.

It is also conceivable that we arrive at the intended contextual meaning through the standard meaning when it comes to humour. Yet, these contextual meanings provide the basis for the illusion of indefinability. To illustrate, the expressions *interrogation* or *bloodbath* can also be interpreted in the school context: they both refer to the questioning process of a pupil in class. Thus, slang and humorous language use (metaphorisation) give rise to the indefinability of concepts. This notion, however, does not exclude the possibility that these two concepts are structured and definable.

According to the latter criticism, the concept *girl* would have a core meaning which is not atomistic, and which contains the most important defining features: [+FEMALE], [+YOUNG]. Connotations and sophisticated meanings, which give rise to the indefinability argument, are based on this core meaning: girl can refer to somebody’s daughter, or it can refer to a teenager. In other words, indefinability can emerge from the various grounding of the core concept in various contexts and environments, rather than resulting from the atomistic nature of the concept.

One can ask how and with what empirical methods *atomism* versus *decomposition semantics* can be tested. Lexical causatives (e.g., ‘burn’, ‘bend’, ‘melt’) and perception verbs (e.g., ‘sniff’, ‘see’, ‘hear’) differ in terms of semantic complexity because perception verbs are semantically simpler in structure. Mobayyen and de Almeida (2005) used the technique of proactive interference to investigate whether verbs are represented in terms of decomposition semantic features in semantic memory. Such features include, for example, perceptual and conceptual features, such as ‘round’, ‘red’, ‘one can sit on it, etc.

According to the semantic decomposition theory, sentence recall is contingent on the semantic complexity of verbs. What it amounts to is that the absence of a significant difference in meaning recall would verify lexical atomism. Mobayyen and de Almeida asked participants to read sentences on a computer screen. Sentences were followed by a counting task in every trial. After the counting task, participants wrote down the recalled sentences. Results showed that semantically more complex sentences, that is those with causative verbs, were recalled more easily than the simpler ones with perception verbs. These results could also show that semantic complexity does not belong to the meaning of verbs. The processing of lexical concepts was equally easy irrespective of their semantic complexity.

de Almeida's (1999) fodorian atomistic conception also claims that concepts are atoms, that is semantic constituents are not incorporated in verbal meanings. Category-specific deficits are interpreted as showing the dysfunction of inferences generated by conceptual atoms, as if a conceptual atom activated meaning postulates. A dysfunction of these meaning postulates causes category-specific deficits according to the hypothesis. Meaning postulates are considered as associations, which are conceptual features (i.e., inherent parts of conceptual representations) according to the traditional conception. de Almeida proposes that these features are non-constitutive features (non-conceptual). Such a proposal is consistent with the criticism of modal theories: modality-specific representations and embodiment effects are epiphenomenal, rather than showing inherently conceptual effects.

Damage to the 'dog' concept can be manifested in naming/recognition/definition deficit of the concepts 'cat' and 'cow' because these two concepts fall in the inferential domain of the 'dog' concept. It is interesting to observe how de Almeida's conception explains category-specific deficit patterns with inferences.

Methods in neuro-psychology are also aimed to investigate the representation of the meaning of verb concepts. In the neuro-psychological literature, case studies usually report *category*-specific deficits and damage to features that cut across *category*-boundaries. These damages are usually interpreted as showing that verb concepts are represented in the brain in the form of feature bundles, and damage to a constitutive feature, for example, as a result of a functional lesion, necessarily leads to the damage of that concept (Tyler and Moss, 2001).

Mobayyen and colleagues (2006) investigated patients suffering from Alzheimer-type dementia. Previous investigations interpreted the defective knowledge patterns of dementia patients as category-specific deficits. Category-specific deficits are usually interpreted as a processing difficulty of conceptual features. Following this logic, we can conjecture that semantically more complex concepts are more prone to impairment in semantic dementia. Mobayyen and colleagues concentrated on the representation of verbs in their investigation of 10 patients. They employed two action-naming tasks: (1) in the first task participants had to name events/actions and objects based on colour photos, while in the second task (2) participants watched videos which depicted events that can be described with verbs that fall in three distinct categories: (i) causatives ('burn'), (ii) perception verbs ('see'), and (iii) motion verbs ('climb').

If the representation of verbs is contingent on semantic complexity, then we would expect that in serious semantic dementia the processing of semantically more complex verbs causes more difficulty than the semantically simpler ones. Surprisingly, results show the reverse pattern: the naming of events encoded by perception verbs (e.g., 'John can hear/see the thunder') proved to be more difficult. This finding is seemingly in contradiction with the semantic decomposition theory, and could in principle be consistent with fodorian atomism as well.

An alternative explanation for the reverse complexity effect, that is the impaired processing of perception verbs but intact processing of more complex verbs, could be that perception verbs assign an *Experiencer* thematic role whose processing is more difficult than that of agent thematic constructions, such as 'John kissed Mary' (personal communication, de Almeida). The *Experiencer* thematic-role entails that the subject is not the *Agent*, as for example in the case of the agentive verb 'kiss', but it is an "experiencer" or "participant" (e.g., 'frighten', 'fear' or 'scare') because the verb makes a statement about the state of mind or change of mind of the subject. The subject of psychological verbs is *Experiencer*. Thus, this interpretation explains the performance pattern of patients with the processing impairment of thematic-roles.

Manouilidiou and colleagues (2009) also argue that Alzheimer patients have impairment in thematic-role assignment. Alzheimer patients performed a sentence completion task in which they had problems with psychological verbs (e.g., 'fear', 'scare'), which require experience-subjects; these verbs do not project the canonical *Agent-Patient*/theme thematic structure to the subject-object positions but the *Experiencer* and *Theme* roles to the subject position. Their results also show that the patients made errors within the same semantic field (e.g., instead of choosing 'fear' they chose 'frighten' as response), rather than choosing semantically irrelevant verbs, e.g., those that do not belong to the semantic field of the expected verb. What it shows is that patients were aware of the core-meaning of psychological verbs, they had only problem with the assignment of thematic roles.

Fear-type verbs are subject-experiencer verbs because the subject of the sentence is assigned the *Experiencer* thematic role ('John feared the thunder'). *Frighten*-type verbs, on the other hand, are object-experiencer verbs because the subject is the theme and the object is the *Experiencer* ('The thunder frightened John'). Alzheimer patients had the most difficulty with object-experiencer verbs (after subject-experiencer verbs). Patients did not have impairment in the processing of canonical agent/patient structures.

Taken together, these results show that the difficulty with processing psychological verbs is due to the impaired assignment of non-canonical thematic-roles to grammatical roles; this explanation, thus, accounts for the difference between verb types not along the simplex/complex dimension but along the dimension of canonical/non-canonical thematic structure (i.e., what thematic role the verb assigns). The findings do not provide evidence for or against the existence of conceptual atoms.

Modal theories: Barsalou's (1999) Perceptual Symbol Systems (PSS)

Modal theories have to live up to the expectations of conceptual systems. To name a few: *type/token* distinctions, *categorical inferences*, the representation of abstract concepts, conceptual productivity (the infinite combination of symbols to build a conceptual structure) and the processing of propositions. How does the theory of perceptual symbol systems implement these (Barsalou, 1999, PSS)?

Let us first look at the implementation of *type/token mappings* in the PSS framework. Let us imagine a balloon above a cloud and an airplane left to the cloud. This scene can be described with a complex proposition. First it is crucial to show that type/token distinctions can be implemented within the PSS framework, then to demonstrate that PSS can cope with propositions without the use of any amodal symbols. Since the perceived entities in the scene (cloud, airplane, and balloon) and their concepts (which are simulators in PSS) appear in the same situation, therefore the ultimate representation will be the "merge" or binding of the two.

In Barsalou's system – since perceptual symbols are schematic – perceptual symbols can be merged or bound; thereby imaginary concepts can emerge, such as those that we can see in cartoons. Since the representation of an object is composed of many simulations, therefore conceptual productivity can be interpreted as being contingent on the cooperation of various simulators. So, for example, the simulation of *blue ball* results from the fusion of the simulators of *blue* and *ball*.

Merging the simulator (*type*) with the perceived entity (*token*) results in a successful type/token distinction. A strength of amodal theories is the processing and interpretation of propositions. A proposition describes or interprets a situation, such as the one in (2)[20]:

(2) CONTAIN (vegetables, apples)
ABOVE (ceiling, floor)
CAUSE (HUNGRY (customer)), BUY (customer, vegetables)
NOT CONTAIN (grocer, mountains)

In propositions we tap into aspects of conceptualization. Essentially, propositions encode *type*/*token* distinctions between concepts, which are essentially *simulations*, and the perceived world. If we return to the previous scene, we can understand that the perceived type/token distinctions implicitly contain propositions, such as: *It is true that the perceived thing is a cloud.* The merge or binding between the perceived object and the simulator results in the representation of a complex scene (e.g., the airplane is above the cloud).

Categorical inferences are also implemented by the binding of the simulator and the perceived contents, which is called *binding process* – as it is claimed in the PSS theory. To illustrate, if the airplane flies into a cloud and it is out of our sight, then it is the simulator which can predict where the airplane will appear. Likewise, every feature of the airplane is encoded in the simulator: there is a pilot, there are passengers, luggage, etc. The multimodal simulator of the concept 'airplane' leads to many *top-down* inferences. The *binding process* refreshes the airplane-simulator every time it is accessed.

The modality-specific representation of abstract concepts is one of the most problematic enterprises in the PSS framework. As we have seen before (cf. Table 1.), amodal theories propagate the amodal representation of abstract concepts, such as *truth*, events, mental states and social institutions, on grounds that these concepts are dissociated from our perceptual experiences, and that they are not directly based on them. Cognitive Linguistics (e.g., Lakoff and Johnson, 1980, 1999), on the other hand, argue that abstract concepts are represented metaphorically, which means that abstract knowledge is linked to more concrete, perceptual experiences. Abstract expressions can get conventionalized during language use, by this process

[20] The examples are based on Barsalou (1999, 595).

polysemy (multiple meanings) emerges (Barsalou, 1999, 600). Barsalou (600) enlists three mechanisms that are linked to the representation of abstract concepts (3):

(3)

A. *framing*: abstract concepts are not represented out of context but rather in the context of the conceptualized background event. PSS – as we have seen – can represent this background with the mechanism of simulation.

B. *selective attention*: since an abstract concept is not equivalent to the simulation of the whole background event, therefore selective attention guides the focus on the abstract concept, which is part of the simulation of the whole background event. PSS can implement this as we have seen before in connection with the *top-down* inferences. Since perception and simulation are implemented by the same neural system, *top-down* effects can operate without abstract amodal concepts. The representation of the concept *airplane* emerges as the result of interplay of many conjoined experience-based simulators; if we have to decide about an object if that is an airplane or not, then our inferences are aimed at the comparison of the perceived object and the simulator.

C. *introspective states*: introspective states are inherent parts of the representation of abstract concepts, further the process of symbol forming on the physical world is the same as on introspective states. Barsalou mentions three forms of introspection: (1) *representational states*; these refer to the representation of an entity in the absence of it, (2) *cognitive operations*, which include repetition, elaboration, search, comparison and transformation, and (3) *affective states* (emotions, affect, and mood).

Finally, let us look at the question of conceptual productivity in the PSS framework. A definition of conceptual productivity is: the ability to construct an infinite number of complex representations with a finite set of symbols. Combinatorial and recursive mechanisms are at play in this construction process (Barsalou, 1999, 592). Perceptual symbols are organized into complex simulations, that is, new perceptual symbols emerge productively. For example, the simulations of *cloud*, *balloon* and ABOVE organize themselves into a complex simulation, in which the balloon is simulated above the cloud. PSS schematically extracts certain details of imagery, and integrates them into simulators. Linguistic productivity is understood as conceptual productivity: the conceptual productivity of features, entities, processes and other conceptual elements are reflected in the productive combination of adjectives, nouns, verbs and other linguistic elements.

The linking of different features is called *binding problem* in the neurosciences; the question is how our brain constructs the concept or image of a 'brown cow' from the representations of 'brown' and 'cow'? Damasio's convergence-zone theory claims that there are certain cell assemblies in our brain which collect multimodal sensory information and organize and integrate them (Damasio, 1989). Convergence zones do not store images or representations, but rather they play an active role in reconstructing these. Each convergence zone manages a category of objects, such as animals, plants, body parts, vegetables, or faces.

Convergence zones, which are also organized hierarchically, are hypothesized to amount to thousands. It is crucial to know that convergence zones in Damasio's modal theory are storages for amodal representations (26) because they handle perceptual symbols, rather than being perceptual symbols themselves. These regions in the brain serve organizing function, rather than representing function. This thought is similar to the one mentioned earlier in connection with scripts: the prefrontal cortex handles the organization of scripts rather than containing semantic information about the contents of scripts (Cosentino et al., 2006).

Multimodal symbols are organized into unitary representations at these convergence zones: the linking of features into entities and the integration of entities into events happen here. These nodes provide the basis for the re-activation of experiences later when *bottom-up* sensory processes are not accessible in the absence of perceptual input. Convergence zones are organized hierarchically, as it has been said before. So, for example, a higher convergence zone links semantic and phonological information. A convergence zone contains *amodal* mechanisms in this sense. However, it is important to note that amodality is understood here not as the amodal representation of a concept but of a linking mechanism.

Lower convergence zones send information up the hierarchy to higher convergence zones. These convergence zones can be conceived of as bundles of indexes, rather than representational mechanisms[21]. The indexes organize and activate modality-specific information. In other words, they are not images but mechanisms that manage and construct images.

Neurons in these convergence zones exclusively activate neural effects but not behavioural ones. According to modal theories, modality-specific representations are the basis of higher cognition. On the other hand, according to amodal theories amodal representations contain meaning; thus, amodal representations substitute modal representations according to amodal theories. It is important to note that Damasio's theory does not exclude the possibility that the amodal representation of concepts reside in higher convergence zones, and that these amodal representations would ignite the simulation of categories.

Recent neuro-scientific studies have confirmed modality-specific theories in that they demonstrate that language processing partially activates sensorimotor representations via mirror neurons. Mirror neurons are typical "grab-neurons" which are activated when humans or a monkey is reaching for an object, or in those observer situations when the other person or animal is implementing this specific action (Rizzolatti and Craighero, 2004; reviewed in Hungarian by Kemény, 2007). Mirror neurons reside in the F5 field of the premotor cortex of the simian brain, whose homolog brain region in humans is the Broca-area. This brain region is an important speech centre, which also serves the function of implementation of sophisticated movements. Many theorists speculate that mirror neurons are evidence for the language evolutionary thesis that language was based on gestural communication (Arbib, 2005).

Aziz-Zadeh and colleagues (2006) used fMRI and found that when observing specific types of actions (with the hand, mouth and leg) and processing actions related to these specific body parts ("grab the pen", "push the pedal") recruit shared neural areas (premotor areas). Based on the fMRI-data effector-specific (hand, mouth, and leg) activation was found in the left hemispheric premotor region, where mirror neurons are found, in both settings. These theories may support the embodied semantics hypothesis of modal theories, such as Barsalou's PSS theory: conceptual representation accessed during language processing partially overlaps with the sensorimotor representation of that concept.

The nexus of the mirror neuron theory and modal theories is *simulation theory* (Gallese and Goldman, 1998), according to which we do not just observe others, but we internally represent

[21] Amodal representations in these convergence zones are implicit in the sense that mechanisms define linking rules, however, the contents are modality-specific states.

the actions and emotional states of others, that is, we take the perspective of the other person. This process may have evolutionary causes, for example, being able to react faster to environmental stimuli, and thereby we get prepared for an adequate action.

Friedemann Pulvermüller's (2003) book *The Neuroscience of Language* bridges neuroscience and linguistics within the framework of modal theories. According to Pulvermüller the neural representation of a word activates distinct brain regions (e.g., occipital lobe, motor cortex, somatosensory cortex, etc.) in a modality-specific manner (visual, motor, tactile, etc. brain areas depending on the contents of the word). His conception is consistent with modality-specific approaches, which assume multimodal perceptual symbols.

The multimodal view of language representation in the cortex has been also supported by more subtle evidence recently: Pulvermüller and colleagues (2005) used TMS over the motor region of the left hemisphere of right-handed participants. Participants performed lexical decision task during transcranial magnetic stimulation. Test words were divided into two categories: (1) words that refer to activity with the leg (e.g., *kick*) and (2) words that refer to activity with the hand (e.g., *pick up*). Pulvermüller and colleagues found a significant interaction between the category of words and the locus of stimulation (leg or hand area): lexical decisions were faster if the leg area was stimulated during the reading of leg-related words, and the same logic was true for hand-related words.

Their results suggest that the stimulation of premotor and motor areas affect the processing of words whose contents refer to actions and are related to these areas. This finding suggests that language-related and action-related systems of the left hemisphere share overlapping structures. Thus, such results could disconfirm modular theories of language and the existence of amodal symbols. However, one could question the status of modality-specific representations in the conceptual hierarchy; it may still be the case that motor representations are closely associated to the abstract representation of words, hence epiphenomenal.

Refined versions of the modality-specific account can also be found in neuroscience. For example, Pascual-Leone and Hamilton (2001) claim that perception is not strictly modular and pyramid-like, as it was assumed previously, but sensory modalities function not independently from one another. Thus, cortical regions do not implement strictly modality-specific processing, but rather they can be modulated by information or signs coming from other modalities.

This conception was supported by the following experiment: participants with normal vision were blindfolded for five days, while they performed tactile and auditory spatial discrimination tasks (Pascual-Leone and Hamilton, 2001). It was shown in the fMRI-images that activation in the visual cortex increased during the implementation of refined motor finger-responses to the auditory and tactile stimuli. When blindfolding was removed, visual cortex activation vanished after 12–24 hours. The finding of this experiment is similar to the previous well-known observation that the visual cortex is active in blind people.

Taken together, the experiment of Pascual-Leone and Hamilton shows that the visual cortex processed tactile and auditory information as a result of visual deprivation. It is further speculated that novel neural plastic connections could not have established so fast between tactile/auditory cortical regions and the visual area. This finding might show that the visual region contains pre-existing cross-modal connections, which are activated in the case of a deficit of the primary function. Further, it might be the case that the brain is not organized into modality-specific areas, as it was speculated previously, but rather the visual cortex, for example, can be conceived of as a *metamodal* structure, which can also process tactile and auditory stimuli.

In other words, the visual cortex is not only active when it is processing visual stimuli coming from the eyes but also in other perceptual settings. This is also supported by the case of Esref Armagan, a Turkish congenitally blind painter, who can paint true-to-life pictures (Pascual-Leone, 2005). His visual cortex is active during painting, as in the case of people with normal vision. Vision – according to the standard view – is the depiction of objective reality through our eyes. However, this conception does not seem plausible given the case of Esref. Esref constructed pictures in his visual cortex with the help of information coming from other modalities.

Amedi and colleagues (2002) demonstrated using fMRI that there is a region within the lateral occipital complex (LOC), more precisely LOtv – lateral occipital tactile-visual region, which is activated to objects irrespective of modality of perception; that is, this area is activated when we are seeing the object and also when we are touching it. This result bolsters the metamodal theory mentioned earlier. Both visual and tactile information and modalities activate this region, however, auditory activation did not case an equally robust effect as visual or somatosensory activation. This difference is explained with the assumption that auditory information does not contribute to geometrical information of an object to the same degree as visual or tactile information. Based on the results of the experiment, LOTv is responsible for the geometrical shape of objects irrespective of modality. Importantly, LOtv is hypothesized to reflect a highly abstract representation.

Amedi and colleagues (2004) stimulated the visual cortex of blind people (V1) using rTMS (repetitive transcranial magnetic stimulation), while participants performed a higher semantic task. rTMS is a non-invasive method which induces weak electric currents using magnetic field. This stimulation, which causes a “virtual lesion” in a specific brain region by causing activity in that region of the brain, allows studying the functioning of the brain and the peripheral nervous system. This method can also be used to cure central and peripheral medical conditions. The review of Devlin and Watkins (2007) is a good summary of language-related TMS experiments.

Amedi és colleagues found using TMS that blind people performed poorly as opposed to people with normal vision on verbal tasks, such as the one in which they heard nouns, and they had to say a relevant verb to it. Thus, results show that the visual cortex subserves higher cognitive functions in blind people, such as semantic processing.

Wilkins and Wakefield (1995, in Hungarian: 2003) investigate the emergence of modality-independent representations from an evolutionary perspective. The parieto-occipital-temporal region/junction (POT) processes intermodal information in the brain; this area is responsible for the integration of motor, tactile, and visual information. According to the language evolutionary scenario of Wilkins and Wakefield, such abstract representations in the POT area underlie language and served the basis for the emergence of language. The POT is hypothesized to be evolutionary the unique storage of modality-independent abstract representations. Wilkins and Wakefield argue that POT is responsible for the ability of abstraction of features, which is the basis for later linguistic lexicalisation. This abstraction processes cannot be associated to any of the modalities.

According to the metamodal organization theory of the brain, numerous neural operators/networks are competing to perform certain tasks. These are metamodal brain centres, which are used and formed by sensory modalities. Neuro-scientific studies, which demonstrate that a cortical region is recruited to subserve another function, cannot be considered as cross-modal plasticity, but rather as evidence for an efficiently functioning metamodal cortical operator network. The metamodal theory of the brain claims that cortical regions are defined by computations rather than dominant sensory input modalities.

Non-representational approaches: the system theory of Maturana and Varela

Constructivism has many variants within psychology (for an extensive review, see Bodor, 2002). However, the constructivism of Maturana and Varela is different from other constructivist conceptions in the sense that the principal unit of scientific psychology is the individual, the brain, and the level of the cell, rather than the societal sphere.

The radical constructivist model of Humberto R. Maturana and Francisco Varela intends to dismiss naïve realist thinking from the sciences. Radical Constructivism is an epistemological theory, whose principal claim is that cognition is a constructional process, and that the correlate of cognition, reality, is the product of this process.

Traditional theories are realist, objectivist, or positivist as opposed to radical constructivism, which is relativist. Radical constructivism is a type of radical subjectivism, which is the anti-pole of radical objectivism (positivism). Radical constructivism dismisses the idea that our knowledge is a depiction of an objective, ontological reality, hence radical.

Radical constructivism does not deny reality, it just emphasizes that our statements about it are completely based on our experiences (cf. Schmidt, 1991, 35). In other words, our knowledge is not the "true" picture of *real*ity. Radical constructivism claims that it is impossible to determine to what extent our knowledge matches ontological reality. The function of cognition is not to explore the ontological reality but to organize experiential reality because ontological reality falls outside the world of cognition.

Radical constructivism is radical also in the sense that it extends the concept of cognition to the domains of perception, emotion, and behaviour. Cognition in Maturana's system theory applies also to organisms without a nervous system, such as bacteria, which react to certain changes of the environment.

Radical constructivism is a holistic and monistic model because it claims that humans do not live in isolation *in* the world, but rather they exist *with* the world in unity, hence holistic. Our body and self also belong to the world. It is monistic in the sense that material and soul are not dissociated. Damasio (1996) also argues for monism on neurobiological grounds.

The central notion of the biological system theory of Maturana and Varela is the concept of self-organization, *autopoiesis*, which is a Greek compound that Maturana invented to describe the concept of self-organization ("autos" + "poiein"). According to Maturana and Varela, organisms are continuously self-organizing systems; they call this self-organizing process autopoietic organization. Autopoietic systems produce the components that they are composed of. The continuous production of these components is crucial for biological sustainment.

Living organisms are molecular self-production systems with closed dynamics; yet, they are open in terms of permeability of molecules. Self-organization is not a characteristic of systems but rather it is their basic principle. Self-organizing processes that take play in the molecular space happen without any external influence. Maturana calls this process *structural coupling* because by this process change is induced between components of the system.

Such a structural change can take place either between the organism and its environment or within the organism (at higher levels of development). Structural changes are evoked by the environment but they are not guided by it. Structural couplings instigate the organism to actions. Structural change as a result of physical stimuli in the system can be inter alia either the response of perception or of the immune system (accident is not considered one). Structural coupling is the basis of development and learning.

Autopoietic systems are autonomous in their environment as a result of their organisational closure. Organisational closure refers to the notion that living organisms are closed to information. That is, living systems do not have an input or output; a novel conception, which cannot be found in either amodal or modal representational approaches. Self-organizing systems do not have an input condition system, which would deterministically specify what should happen (cf. Pléh, 1998, 103). The system contains the information which it requires, and no data are received from the environment. Information is considered as an internal cognitive construct, representation as a notion is dismissed from the radical constructivist theory. The notion input/output is constructed by the observer. The concept of an observer is also a cognitive construct, just like the concepts object, environment, or self-consciousness.

The structure-determined nature of autopoietic systems refers to the fact that structural changes within systems are limited. Not only living organisms as structure-determined systems can be considered as closed, but also the nervous system is a closed system. The nervous system is a closed system of neurons, which are in constant interaction with one another. Every relative neural activity leads to another relative neural activity (Maturana, 1991, 98).

However, living systems are materially-energetically open, so that they can interact with their environment (cognitive environment) and other living systems (Schmidt, 1991, 22). Events that cause structural changes in autopoietic systems but do not alter their organization are considered as disturbances. These disturbing factors are perturbations from the perspective of the system because they disturb the cognitive processes of the subject. Perturbations form and correct constructions. Perturbations, however, cannot be considered detrimental because real detrimental effects are so destructive that they destroy organism.

Thus, this biological radical constructivism dismisses the idea of internal representations because they depict an external reality according to the traditional approach. Knowledge in the radical constructivist paradigm is the ability of the organism to adapt to the environment, which is the experiential reality.

Radical constructivism is close to connectionist approaches (e.g., Rumelhart and McClelland, 1986); however, these conceptions shall not be detailed in the present paper. Yet, the major aspect of these theories should be mentioned here briefly: modelling cognition is impossible within the representational theory, thinking does not have syntax, there are no symbols, and linguistic levels are not dissociated.

The critique of Radical Constructivism

A major critique of radical constructivism is the following: since radical constructivism makes an *empirical* statement that reality and scientific theories are constructs on physical, chemical, and biological grounds, therefore it follows from this argumentation that radical constructivism itself is also a scientific construct; in other words, it is *empirically* "hollow". This critique seems plausible, further it also seems reasonable that radical constructivism is not falsifiable in terms of Popper. The answer to this critique from the radical constructivist camp is the following (Schmidt, 1991): radical constructivism interprets empirical knowledge in terms of radical constructivism, rather than in terms of realism. Empirical knowledge is understood as inter-subjective operational knowledge within the cognitive niche; this is an operational knowledge, whose function is to manage the adequate interaction between living organisms. In this interpretation, radical constructivism just claims that we (or any adequate theory) cannot access reality objectively via the traditional methods because objective reality is outside the domain of cognition. The theory of radical constructivism is not an adequate theory of ontological reality either but rather it is an epistemology. Taken together, the theory does not contradict itself.

Radical constructivism – seemingly being nihilist relativism – dismisses numerous scientific categories[22]. The question arises how we can proceed in the absence of traditional terminology. Does radical constructivism have an explanatory force? In response to this critique: radical constructivism supports and is consistent with other theories, such as Darwin's evolution-theory (from the perspective of *autopoiesis* the point in evolution is to preserve adaptation), further it elaborates on the relationship between action and perception. Language is put in another perspective: language has primarily orientational function (and is not descriptive). Language serves ultimately the preservation and sustainment of *autopoiesis*. Knowledge is understood as ability rather than as a competence: knowing is tantamount to operate adequately. Radical constructivism, thus, substitutes the "old" questions, and postulates processes instead of categories.

The interpretation of linguistic semantics in the paradigms

According to the traditional conception our knowledge is stored in amodal symbols (Fodor, 1975; Newell and Simon, 1972). This theory claims that semantic representations are independent from perceptual and sensory representations (Schwanenflugel and Shoben, 1983). The other camp, modal theories claim that modality-specific representations can implement conceptual processing instead of amodal symbols (e.g., Barsalou, 1999). It is crucial to know that other conceptions have also emerged recently, for example, Rogers and McClelland (2004), who assume statistical representations. Yet others, for example, Burgess and Lund (1997) or Landauer and Dumais (1997) conceive of knowledge as grounded in linguistic context-vectors; this conception does not use amodal symbols when modelling meaning, rather it conceptualizes meaning as a distribution of linguistic forms. Linguistic representations are linguistic forms according to this conception, and not amodal symbols – just like in Barsalou's (1999) system. In the following, I shall elaborate on the question of linguistic semantics in amodal *versus* modal, and non-representational theories.

[22] To name a few: objectivity, representation, stimulus, proposition, denotation, prototype, linguistic meaning, amodal symbol, self, ego, consciousness, the existence of an observer, mind, identity, etc. Churchland's (1981) eliminative materialism already envisioned such an eliminative approach in science.

The question of linguistic semantics in amodal and modal theories

In amodal theories, linguistic meaning is stored in amodal symbols. Conceptual processing is similar to linguistic processing in amodal theories: amodal symbols – analogously to words – are processed *sequentially*. Conceptual representation is different from linguistic semantics. Linguistic semantics is stored in a unimodal storage. There is not sufficient direct evidence for the existence of amodal linguistic semantics.

Fodor's externalist amodal atomism (1998) denies holism, conceptual analysis, proto-type theory, *inferential role semantics*, and lexical semantics. This approach is consistent with Radical Constructivism; however, Radical Constructivism is not externalist.

Fodor's atomism is externalist because the contents of atomistic concepts is contingent on the external environment. According to the externalist semantics, the meaning of a sentence is not solely composed of subjective interpretation, as it is claimed by Radical Constructivism. The usually cited example is the concept of water: water as it is found in nature partially determined our concept of 'water'. Linguistic meaning in Fodor's atomism is equivalent to the concept, which is the atomistic content. The atomistic content cannot be structured, and it bears no conceptual relationship to other concepts.

Fodor's main argument for atomism is that the prototype theory does not explain certain concepts, such as PET FISH: according to the constitutional theory of concepts and the prototype theory, the concept PET FISH should be composed of the merge of the stereotypes of PET and FISH. However, this hypothesis does not seem to give the real stereotype, which is 'gold fish'. Fodor goes to argue along the same lines that if NOT A CAT was a concept, then we could not associate a stereotype to it. This logic applies also to decomposable idioms, such as *kick the bucket*. The stereotypes of *kick* and *bucket*, do not give the 'die' meaning.

However, in my view, this approach seems to miss the fact that new concepts or new uses of concepts can emerge through metonymical or metaphorical transfer rather than compositionally. For instance, we do understand the abstract/metaphorical meaning of 'grab' without compositionality, but instead based on our knowledge of concrete grabbing. Likewise, we can make sense of 'blue stockings' without having a prototype.

Certain idioms could serve as good psycholinguistic test items for Fodor's criticism of the prototype theory, for example, those that are of the same type as PET FISH, such as mole

(Hungarian *anyajegy*, *literally: *mother sign*), glucose (Hungarian *szőlőcukor*, *literally *grape sugar),* ‘blue stockings’ (Hungarian *kékharisnya*), ‘yellow fever’ (Hungarian *sárgaláz*) etc. The Hungarian examples, especially the first two, are decomposable compounds in Hungarian. Compositional contrast-examples, such as (Hungarian *anyagyilkos* the person who kills his/her mother, ‘matricide’) or (Hungarian *szőlőtőke* ‘vine-stock’) could serve as comparable experimental controls. Fodor’s criticism (adopted to the Hungarian data), according to which the meaning of ‘mole’ (*anyajegy*) is not the merge of the stereotypes of the concepts ‘mother’ (*anya*) and ‘sign’ (*jegy*), is legitimate. It would be a strong piece of psycholinguistic evidence, if *szőlő* (‘grape’) would not prime *szőlőcukor* (‘glucose’), yet it would prime *szőlőtőke (vine-stock)*. If, however, we found priming in both conditions, then the minimal interpretation would be that orthographic priming is at play, rather than conceptual priming.

Gergely and Bever (1986) investigated verbs regarding this question. According to the decomposition hypothesis, we understand verbs via their abstract semantic structure. So, for example, the conceptual structure of ‘kill’ is more complex than that of ‘see’: *kill* [[x] CAUSE [BECOME] [Y (dead)]], *see* [[x] PERCEIVE(see) Y]]. Based on Fodor’s conceptual atomism, we would not expect a processing difference between the two types of verbs.

The research of Gergely and Bever questioned whether subjectively explored relations between words are a function of the semantic distance between words. Their results do not support the semantic decomposition approach, i.e., subatomic linguistic semantics. In their opinion, the underlying structure of semantic representations cannot be explored based on intuitive inter-word relations.

Since linguistic semantics is inherently amodal, this poses a challenge for modal theorists. Modal theories sometimes substitute linguistic semantics with conceptual representation, which is equated with simulations. Yet, other modal theories propose also lexico-semantic representations. In modal theories, the representation of abstract concepts is also modality-specific. Language understanding happens through the construction of perceptual symbols, which are refreshed in the course of later access and linguistic specification. Barsalou’s *simulation* concept (Barsalou, 1999) resembles and approximates the simulation theory proposed by Gallese and Goldman (1998).

Paivio’s (1986, 2007) Dual Coding theory should be addressed here briefly. This theory assumes that there are two sub-systems (representational codes) underlying conceptual processing: the first system is linguistic in nature, and the other one is grounded in the modalities. The linguistic system processes language, while the other system is responsible for the processing of modal representations. As opposed to modality-specific theories, such as PSS, the Dual Coding theory claims that both sub-systems implement deep conceptual processing. PSS theory assumes that only mental simulation falls under the domain deep conceptual processing. Another specific difference between Dual Coding theory and PSS is their approach to the representation of abstract concepts: Dual Coding theory assumes that abstract concepts are grounded in the linguistic code, while modality-specific theories (e.g., PSS) hypothesize mental simulation in the representation of abstract concepts.

The classic version of amodal theories does not clearly explain the representation of certain concepts that cannot be expressed in terms of feature lists; for example, Wittgenstein's example of 'game' is such a concept: there is no salient *feature* that is true for each and every game. Further, there are no clear-cut criteria as to how we could define the concept of game because some games are played for fun, some are played for money, some games are played by many people in team, yet other games are played by two people, and there are games which are played alone. Further, we know of games where a time limit is defined, and there are games without time pressure. Interestingly, in the absence of a clear system of criteria speakers can still use this concept and construct ad hoc meanings.

In conclusion, it does not seem plausible that a feature list is activated when processing or extending the use of the game concept. Fodor (1988) therefore argues for the indefinability of concepts. He considers this as evidence for the existence of an amodal atomistic representation of concepts. Wittgenstein claims that the meaning of a linguistic symbol can be expressed with its use.

The indefinability argument is further bolstered by a closer examination of colour concepts and the concept of 'pain'. Let us take the concept of pain first. The closest concept to it is probably 'bad feeling' or 'suffer', although these associations do not render the core meaning or the essence of the concept. Colour concepts behave similarly because they cannot be decomposed into semantic features. These thought experiments intend to demonstrate that the classical theses of the amodal view, such as semantic network or *frame* do not seem plausible. A definition of the concept of pain is possible with the help of non-linguistic contents, for example by equating the concept with neuro-physiological processes or subjective experiences of such processes, or memories. The other “solution” leads to tautology: we experience pain when we are in pain. What it amounts to is that it is difficult to define the concept of pain with other linguistic symbols, or postulate a feature list to the concept.

The ‘pain’ example fits into Fodor’s (1998) theory of conceptual atoms: the environmental grounding of this concept is probably the experience of tissue damage, which triggers a neuro-physiological process, which serves the basis of the nomological locking process in fodorian sense. What would Fodor say about the *nomological locking* of metaphors? To illustrate, how are we nomologically locked to the metaphorical concept of $\text{PAIN}_{\text{abstract}}$? We are aware that this metaphorical concept cannot be decomposed into constituents either. How are metaphors nomologically locked then in Fodor’s theory?

The question is how speakers arrive at the metaphorical concept $\text{PAIN}_{2(\text{abstract})}$ via the atomistic concept $\text{PAIN}_{1(\text{concrete})}$ in terms of Fodor’s theory. Lakoff and Johnson (1980, 1999) for example propose that abstract concepts are structured by concrete concepts, which are based on concrete sensorimotor experiences. It can also be the case that we have two distinct ‘pain’ concepts with different meanings and representation. The nomological locking of abstract concepts is still under-researched, therefore this topic has been mentioned only tangentially.

Finally, let us take a look at some problematic points of modal theories:

(i) We understand language in certain tasks by mental simulation processes (see PSS, Barsalou, 1999). To what extent do these evoked neural mental simulations overlap with those sensorimotor brain regions that are activated when we are not processing language? A second question is whether sensorimotor representations are directly activated when processing language in certain tasks, or indirectly through the access of abstract mediating representations? (Which would be the abstract-logical meaning)? If abstract representations are also co-activated, then are these activated in parallel or consecutively? Is a concept the same as the sensorimotor activation evoked by the concept (cf. sensory reductionism), or conceptual representation only partially overlaps with sensorimotor activation?

(ii) Mirror neurons can be considered as strong evidence supporting modal theories. However, if we take modal theories and the mirror neuron theory seriously, then we can come to the conclusion that *observation* is equivalent to the internal (unconscious and automatic) simulation of an *observed action*. We can adopt this theory to the understanding of language describing intentional actions. What it amounts to is that understanding an action verb, such as grasp involves the recruitment of mirror neurons. However, the question arises at this point whether mirror neurons are essential parts of the representation of actions (or language describing these actions). Based on Gergely Csibra (2005), an alternative explanation is that mirror neurons may operate to anticipate actions following the observed action, rather than operate in the simulation of the observed action (*prediction hypothesis*). According to this hypothesis, the activation of mirror neurons is epiphenomenal rather than inherent in the simulation of the observed action. It is also conceivable that only the semantics of action verbs, such as *grasp* or *run*, is based on mirror neurons; other types of linguistic expressions may be processed differently. This begs the following questions:

(iii) Because our concrete and abstract knowledge is tied to distinct brain systems, is it possible that our abstract knowledge is represented not solely in a modality-specific manner? This neuro-scientific alternative is consistent with the Dual Coding theory (Paivio, 1986, 2007) and other linguistic context theories (e.g., Burgess and Lund, 1997; Landauer and Dumais, 1997), but it can also serve as an argument for the existence of amodal representations.

(iv) A general critique against modal theories is that the neuro-scientific results, which seem to support modality-specific theories, can be attributed to the task demand nature of the experiments, or to post-hoc processes. According to this standpoint, participants are engaged in tasks which require mental simulation, such as visualisation. In other words, the task demand involves the construction of imagery, e.g., a semantic similarity task. Therefore, “it is not surprising” to see the activation of isolated modality-specific cortical areas on the fMRI scans as a function of verb category.

The strongest response to this critique, which attributes modality-specific activation to associations evoked by the artificial task demand nature of the experiments, is found in the neuro-psychological literature: lesion studies can show that damage to an isolated brain area can result in the selective loss of a cognitive function, which also co-occurs with a linguistic deficit. Such damage can be, for example, a lesion in an effector-specific area, which causes a linguistic-conceptual deficit as well.

(v) Numerous modality-specific theories claim that every perceptual symbol is tied to a corresponding (modality-specific) brain region (Barsalou, 1999). However, numerous studies have demonstrated that, for example, neurons in the visual cortex can be modulated by non-visual stimuli (Ghazanfar and Schroeder, 2006; Pascual-Leone és Hamilton, 2001). According to this view, these neurons cannot be considered visual or unimodal in the broader sense because they can be modulated by input from other modalities. The metamodal theory of the brain by Pascual-Leone and Hamilton (2001) solves this problem by positing the view that brain areas execute computations. The metamodal view defines brain areas by the computations they implement and not by input modalities.

(vi) Modality-specific theories have to answer the question about the differences between neural activations elicited in a concrete observational setting (e.g., the perception of a cat), an imagined setting (thinking about a cat) and the neural activation elicited by language (processing the word *cat*)? Current behavioural and neuro-scientific studies report only about an overlap between these representations.

Linguistic semantics in the Maturana model

If structural coupling exists between two autopoietic systems, then a consensual zone also emerges between them; this builds the basis of communication. Communication is understood as information constructions within this consensual zone. The prerequisite of communication is at least the presence of two organisms and a human-environment system. Organisms have to master the language use (the use of signs) during their ontogenesis for efficient communication. Language signs are seen as the subjective uses of signs in an autopoietic system; these subjective signs do not have an objective meaning, they rather indicate meaning through their use. The observer masters the uses of language through ontogenesis and through the interaction with the environment. Language does not describe the outer world. Neither does it convey information. Rather, its function is the orientation of the conversational partner in their cognitive zone/niche. Subjective language use (the use of signs) is grounded contextually in situations.

Information is a cognitive construct, which is constructed by the observer, the individual. The essence of communication is to affect another autopoietic system with the use of (linguistic) signs. In this interpretation, communication can be understood also at the cellular level.

In this model, during language understanding the observer constructs subjective contents, which are activated by linguistic signs. These signs are not representations but relative neural activations. There is no extra-linguistic reality, there is only a cognitively constructed reality.

Relative neural activations can only be interpreted contents. In what sense are these activations *interpreted*? Interpretation refers to modal processing; it does not refer to meaning association because there is only interpreted linguistic sign in language; a modally uninterpreted sign does not exist from the perspective of the observer. However, no meaning is associated yet to this linguistic sign. The radical constructivist semiotic triangle is relativized as follows: extra-linguistic objective reality does not exist from the perspective of the organism. Further, there is no linguistic (cognitive) sign that conveys information (in the sense of stimulus). Linguistic meaning is always a subjectively constructed relative neural activity rather than a representation. Linguistic signs motivate the observer for interpretation. Linguistic signs are composed of modally interpreted contents.

The radical constructivist conception about knowledge also deters from the traditional approach: according to the radical constructivist conception, the function of knowledge is to be able to act adequately in a situation and the function of linguistic knowledge is to sustain autopoiesis. Radical constructivist semantics is consistent with Wittgenstein's late usage-based approach about language (Schmidt, 1991).

According to the radical constructivist approach, there is nothing that can be substituted, or *re*presented because we construct reality entirely. Yet, the classic conception about representation claims that mental representations are isolated neural activations with *clear-cut boundaries*. This aspect is supported by radical constructivists because they do not deny that certain environmental effects elicit neural activations with clear-cut boundaries, which are tied to specific brain regions.

The neuro-fuzzy logic by Lofti Zadeh (1965) is consistent with the radical constructivist semantics. The approach, which is usually referred to as *fuzzy*-logic, dismisses the traditional structuralist, positivist, categorical and analytical conceptions. Instead of these, the concepts of uncertainty and probability are introduced. For example, instead of decomposing the concept YOUNG [-OLD] into semantic features, the *neuro-fuzzy* approach suggests that the categories 'young' and 'old' are 'opaque', and that they should be conceived of as continuums. Their meaning is highly context-dependent and subjective: 'young' can refer to a teenager or to a 35-

year old woman. Furthermore, judgements of other people also differ subjectively because some people may see a person as old, yet others would say that that person is relatively young. In other words, the concept ‘adult’ is graded rather than dichotomous. Stereotypes and prototypes in cognitive linguistics handle *fuzzy*-categories relatively efficiently.

Summary

The present paper reviewed representational and non-representational cognitive theories with a special focus on linguistic semantics. Specifically, the classical amodal view, Fodor’s atomism, Barsalou’s modal perceptual symbol systems theory and Maturana’s non-representational system theory were detailed. The question of linguistic semantics was interpreted in these paradigms.

It is crucial to clarify the different uses of the concept of amodality in the different theories. (i) Amodality can refer to a predicate-/proposition-/statement-like representational form (‘A is behind B’), or (ii) it can refer to an abstract bundle of features of a concept (symbol) (the amodal symbol of *cat*). (iii) Third, the symbol manipulative mechanisms of the mind can be interpreted as amodal. According to this interpretation, the brain processes the input along abstract rules, e.g., Damasio’s convergence zones in the brain, the hierarchical organization of script-like knowledge, etc. The important question related to amodality is whether it refers to a *mechanism* (a rule) or a *representational content*. Likewise, the concept of *representation* can refer to a content in the sense of ‘substitute’, or to a brain mechanism, e.g., a neural associative or transformational rule.

Another question is where the boundary lies between amodal and modality-specific representations? Let us think of a spatial scene, which can be described by an abstract amodal proposition, e.g., ‘A is behind B’. If, however, A is situated behind B in occlusion (A cannot be seen because it is occluded), then is it the case that this aspect is represented also in an abstract manner in this proposition? We can think of further cases, such as an entity is faded, or that the two entities are 10 cm from each other, etc. How many such abstract functions, such as BEHIND are represented in the mind? What determines these functions?

The mirror neuron theory and the simulation paradigm support the modality-specific representational view of knowledge representation. Mirror neurons play a pivotal role in language evolution (Arbib, 2005) and language acquisition (imitation learning). However, they do not disconfirm the existence of amodal symbols or modular linguistic semantics.

There is no direct empirical evidence to confirm modal theories, or to support amodal symbols. The question about the existence of amodal symbols remains unanswered even to the proponents of the modal camp (cf. Barsalou et al., 2003, 87). Likewise, the question as to what direction cognitive sciences will take is unknown too: will modal theories defeat classical cognitivism, or a third paradigm, such as the non-representational neuro-science will substitute for representational approaches?

Evidence supporting modal theories cannot be considered strong (Machery, 2006), and experimental results about conceptual atomism are contradictory. The general ideological critique against amodal symbols is based on the principle of parsimony: in terms of the principle of cognitive economy the amodal representational level is redundant, if other mechanisms (e.g., modality-specific systems) can also explain conceptual processing.

Further interesting fields of investigation for modality-specific representations include beyond the visual and motor domains other modalities as well, such as auditory, tactile, gustatory, or olfactory. The question arises in this context whether, for example, processing concrete and abstract (metaphorical) expressions describing auditory (*ring*), tactile (*velvet*), gustatory (*honey*) or olfactory (*jasmine*) contents necessarily activate modality-specific representations. The question of cross-modal integration comes into picture here: the sentence *The wine has a velvet body* evokes two different modal representations (gustatory and tactile domains are merged).

Modality-specific theories should also be mentioned in connection with linguistic relativism at the level of the central nervous system: the question, which arises in this context, is whether motor areas (areas that are activated to verbs encoding motion) of speakers of a non-satellite-languages is distinct from or richer in representation? Satellite-languages, such as English, Chinese, or Hungarian direction of motion and manner of motion are encoded separately (Talmy, 2000a, 2000b); for example, in Hungarian the verbal prefix encodes direction of motion: *Andrea bement a házba* (Andrea in(to)-go[3rd-sing-PAST]the house-into). In non-satellite languages, such as Korean direction of motion is encoded by the verb. Wu and colleagues (2008) showed using fMRI that perception of direction and manner of motion are tied to two distinct neural regions in the case of English speakers. It would be worthwhile repeating the experiment with speakers of non-satellite languages. Potential differences would indicate the effect of language structure on the nervous system.

Maturana and Varela devised their cognitive theory on biological grounds. Their theory dismisses the notion of representations. Despite this difference, modal and non-representational theories are not far from each other because both substitute for traditional categories with neural processes: they dismiss amodal symbols and the psychological and neural reality of traditional linguistic semantics. The main theses of Radical Constructivism, such as the elimination of representations and amodal symbols, however, cannot be easily tested directly with present-day neuro-imaging methods.

In my view, the dismissal of representations in the broader sense is premature because there are implicit rules in the brain that function as representations, such as those representations in convergence-zones. However, representations in the classical narrow sense, that is in the sense of 'substitute', are eliminated in the Radical Constructivist paradigm. In my opinion, conceptual amodality cannot be dismissed that trivially because it is possible that a concept, such as 'cat' has an amodal representation in a higher convergence zone, which ignites perceptual simulations (the simulations of different tokens of cat). Radical Constructivism is consistent with connectionist approaches and *neuro-fuzzy* theories.

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3.2. Thesis 2: A corpus-linguistic investigation of the strong version of the Embodiment Hypothesis

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The Automatic Identification of Conceptual Metaphors in Hungarian Texts: A Corpus-Based Analysis

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Abstract

The present study is a corpus-based analysis of literal versus metaphorical language use. Previous corpus linguistic works have focused on the linguistic characteristics of the metaphorical expressions. The main question of the present paper is whether the automatic identification of certain conceptual metaphors could be successful taking the embodiment hypothesis as a starting point. 12 widespread conceptual metaphors were selected from Lakoff & Johnson (1980) and the metaphor index in Kövecses (2002), where consistent mapping was observed between a concrete (source) domain and an abstract (target) domain. According to our hypothesis, a metaphoric sentence should include both source-domain and target-domain expressions. This assumption was tested relying on three different methods of selecting target-domain and source-domain expressions: a psycholinguistic word association method, a dictionary method and a corpus-based method. The results show that for the automatic identification of metaphorical expressions, the corpus-based method is the most effective strategy, which suggests that the concept of source and target domains is best characterized by statistical patterns rather than by psycholinguistic factors.
Keywords: embodiment hypothesis, conceptual metaphors, association, corpus-based, automatic identification

1. The Theory of Metaphor

1.1 The Cognitive Theory of Metaphor

In everyday language use the term *metaphor* is held to be a figure of speech which refers to an analogy between two entities or concepts (e.g., *Achilles was a lion*). In cognitive linguistics, in contrast, metaphor is first of all a conceptual process, thus metaphorical relations are taken to be conceptual mappings, which characterize not only our language use but also our everyday life, thought and behavior (Lakoff & Johnson, 1980). According to the cognitive linguistic view, conceptual metaphors refer to the understanding of an abstract concept, also called the *target domain*, in terms of a concrete concept of which we can have direct sensory experience, namely the *source domain*. This underlying association between the two domains is held to be systematic in both language and thought.

The hypothesis that the representation of abstract concepts in the mind/brain is grounded in the representation of concrete knowledge, which in turn is grounded in our bodily experience of the world, is the main statement of the **embodiment theory** in cognitive linguistics (Gibbs, 2006; Kövecses, 2002; Lakoff & Johnson, 1980, 1999). For example, people universally think and talk about the abstract concept of "time" with the help of "space", the terms of which are acquired through our interaction with the environment (*before, after, under, in* etc.). Consequently, we can argue that the concept of "time" is structured by the concept of "space" which means that there is a TIME IS SPACE conceptual metaphor in our mind.

This hypothesis is supported by psycholinguistic experiments: it has been shown, for instance, that sensory-motor experiences influence the interpretation of metaphorical expressions on "time" (Boroditsky & Ramscar, 2002) which means that during the understanding of metaphors people do physical *motion simulation*, i.e. they imagine the actions or events described by metaphorical expressions (Gibbs & Matlock, 2008). However, other experiments did not find evidence for the necessity of conceptual metaphoric mappings in comprehension of metaphorical expressions (Keysar et al., 2000; Szamarasz, 2006). The problem whether in natural language use abstract concepts are independent of concrete concepts still remains an open question.

1.2 The Statistical Learning Theory

Another approach referring to the nature of abstract knowledge is the **statistical learning theory**, which argues that people acquire and structure their abstract concepts with the help of the statistical properties of language (Burgess & Lund, 1997; Landauer & Dumais, 1997). This means that novel linguistic symbols are directly abstracted from known symbols without the interference of metaphorical processes or embodied schemes.

The two theoretical approaches do not necessarily exclude one another since it is conceivable that our abstract knowledge exploits both sources mentioned above. According to this integrative point of view (Andrews et al., 2005, 2007), both the attributive and distributive properties of words play an important role in symbol grounding. Attributive properties are non-linguistic physical attributes associated with a word, while distributive factors refer to common occurrences of a word with other linguistic elements.

Based on our discussion so far, the present paper investigates whether the automatic extraction of conceptual metaphors in large corpora could be successful taking the embodiment hypothesis as starting point, and along with this, whether which strategy is the most effective: the psycholinguistic word association method or the corpus-linguistic method based on statistical patterns.

2. Metaphor and Corpus Linguistics

2.1 Corpus-Based Research on Metaphor

Corpus-based studies of metaphorical language use have already pointed out the inadequacy of the cognitive theory and also the defects of psycholinguistic experiences. These critics claim that the theoretical and experimental research neglect the linguistic attributes of metaphorical expressions, and they do not use natural data but fictitious examples, which might be misleading in some cases. For example, Deignan (2008) demonstrates that according to corpus-linguistic results the conceptual metaphor AN ANGRY GROUP OF PEOPLE IS A WILDFIRE is more likely to occur than the metaphor ANGER IS THE PRESSURE OF HEATED FLUID IN A CONTAINER, even though it is the latter that is ubiquitously listed in works in cognitive theory. Observed metaphorical patterns (Stefanowitsch, 2006) and collocations (Deignan, 2005, 2008) also have characteristic grammatical features. Similarly, Deignan (2005) demonstrates that in metaphoric usage the words have less grammatical liberty compared to their literal occurrences. For example, the words belong to the source domain in the metaphorical mapping tend to denote actions and properties, and thus they occur mainly as verbs and adjectives. These results show that the logical relations between concrete entities are not simply mirrored in abstract language use but undergo some kind of change. This fact supports the so-called *blending theory* (Fauconnier & Turner, 2002), which contends that during metaphoric language use people create a mixed or blended domain that has a proper structure and relations, and thus proper linguistic features.

Taking all the evidence into account, it is clear that the conceptual theory of metaphor alone is not able to explain all the phenomena found in texts.

2.2 Methodological Problems in Automatic Conceptual Metaphor Identification

The default method of metaphor annotation is *manual processing*: based on their linguistic intuitions, researchers mark expressions that they perceive as metaphorical in a given corpus. Since this method is very labor-intensive and time-consuming, it is worth experimenting with at least partly automated techniques, such as *searching a corpus for expressions belonging to the source domain* (e.g., Deignan, 2008) or to *the target domain* (Stefanowitsch, 2006) and manually checking the extracted sentences for metaphoricity. Finally, it is also possible to search the corpus for sentences containing characteristic words from *both the source and the target domains* of a given conceptual metaphor (e.g., Martin, 2006). The disadvantage of this method is that in this way we can test only predetermined metaphorical mappings, and, in contrast to the technique used by Stefanowitsch (2006), the recovery of novel metaphors is precluded. However, it has the advantage of a higher level of automation in the annotation process allowing the processing of larger corpora. It is this latter strategy that our study attempts to enhance.

The first step of any of the above three (semi-) automated methods is that expressions that are likely to characterize either the source domain or the target domain of a given metaphor type need to be collected. However, the identification of the linguistic cues that may characterize a particular domain is not a straightforward question. A problem facing automatic metaphor annotation is that, in general, the domains of conceptual mappings discussed in the cognitive literature are associated with concepts rather than specific linguistic forms. Our paper undertakes to address this issue by testing three different methods of compiling word lists characterizing the source versus the target domains of a set of conceptual metaphors. The first two methods rely on experimental psycholinguistic evidence and on lexicographic data, while the third approach is based on the manual analysis of a reference corpus. In addition to the practical import of the results for corpus analysis, the experiments also shed light on the language theoretical issue discussed in Section 1. If either of the first two methods proves to be more successful, we have some support for the embodiment hypothesis. If, however, the third method leads to the best results, the statistical approach to metaphor proves to be more plausible.

3. The Study: Automatic Identification of Metaphors

The main question addressed by the present study is, therefore, whether the automatic identification of certain conceptual metaphors is feasible taking the concept of source-to-target domain mapping as a starting point.

The experiment involved the following phases:

- A set of conceptual metaphors were selected from the cognitive linguistic literature.
- A corpus was compiled using a variety of text types.
- Word lists characterizing the source and the target domains of the selected conceptual metaphors were compiled using three different methods. This resulted in three separate sets of source-target word lists.
- Sentences containing at least one source-domain word and at least one corresponding target-domain word were automatically extracted from the corpus. The three sets of word lists were used in separate runs.
- The results were manually checked for precision and recall.

3.1 Resources and Methods

3.1.1. The Conceptual Metaphors

12 widespread conceptual metaphors were selected from Lakoff & Johnson (1980) and the metaphor index in Kövecses (2002). The criteria for the selection process were the following:

- The metaphor had to be general enough to be found in many types of texts,
- The domains had to be suitable for providing associations in a psycholinguistic experiment, and
- There had to be a mapping from a concrete source domain to an abstract target domain.

Based on the above, the following 12 conceptual metaphors were chosen:

1. ANGER IS HEAT
2. CHANGE IS MOTION
3. CONFLICT IS FIRE
4. CONTROL IS UP
5. CREATION IS BUILDING
6. MORE IS UP (LESS IS DOWN)
7. POLITICS IS WAR
8. PROGRESS IS MOTION FORWARD
9. RESOURCES ARE FOOD
10. THE MIND IS A MACHINE
11. THEORIES ARE BUILDINGS
12. TIME IS MONEY

3.1.2. The Corpus

The corpus was compiled observing two criteria: a variety of genres should be represented; and the texts should be accessible for research purposes in four different languages. The genres include modern fiction from digital libraries, popular science articles from the National Geographic magazine and movie subtitles, the latter of which was included as a representation of quasi-spoken language. The criterion of multilingual availability was needed in view of future plans of creating a multilingual parallel corpus (Hungarian, English, Spanish and Italian) with metaphor annotation. As the analysis has only been completed for the Hungarian texts, the results described in this paper apply to the Hungarian corpus. The sizes of the Hungarian texts from the different genres are shown in Table 1.

Text types	Number of text words
National Geographic	68,997
Subtitles	32,148
Fiction	208,384
Total	**309,529**

Table 1: The content of the corpus.

The texts were converted to plain text format with UTF-8 character encoding. The part-of-speech tagger *Hunpos* (Halácsy et al., 2007) was used to tag the Hungarian texts. Hunpos was chosen because it is a Hidden Markov Model-based open source part-of-speech tagger, which can tag any language once it has been trained on a pre-tagged corpus. As the next step, the tagged corpus was converted to XML format, which was our working format for metaphor identification.

3.1.3. The Baseline Corpus

In order to obtain an estimate of the performance expected from an automatic metaphor annotation method a baseline corpus was constructed on which human inter-annotator agreement was measured.

The baseline corpus was created by extracting 10% (approximately 30,000 words) of the entire corpus in which each genre was represented in the same proportion as in the main corpus. The baseline corpus was independently annotated for metaphors by two human annotators.

The manual annotation followed a pre-defined procedure. The procedure was based on the criteria defined by Pragglejaz (2007). For example, classical idioms, i.e., fixed collocations which are not decomposable (e.g., *pop the question*), "dead metaphors" or those which are metaphorical only in etymological sense (e.g., the word *depression*) were not classed as metaphorical. A rule was further defined for each type of conceptual metaphor. For example, in the case of the MORE IS UP conceptual metaphor we applied the following rules: "Every expression with a 'quantity' meaning which can be visualized as moving along a vertical scale, e.g., *price, lease, temperature,* should be annotated as a potential target domain expression. Every sentence which contains the word *csúcs* ('top') e.g., *csúcsteljesítmény* ('top performance'), *csúcstechnológia* ('peak technology') should be annotated as metaphorical."

At the first attempt, inter-annotator agreement was only 17%. After refining the annotation instructions, we made a second attempt, which resulted in an agreement level of 48%, which is still a strikingly low value. These results indicate that the definition of "metaphoricity" is problematic in itself.

Some typical sources of disagreement between the annotators are the following:

- In the absence of a statistical measure of semantic distance, it was difficult to draw the line between words directly referring to a concept belonging to the source domain and those indirectly referring to it. For example, in the case of the conceptual metaphors ANGER IS HEAT or CONFLICT IS FIRE, the source domain should be an expression referring to a sort of "heated thing". However, in some cases, one or the other annotator included words indirectly suggesting the presence of heat, such as *kiolt* ('extinguish'), *kihűl* ('get cold') etc. Another case in point is the phrase *a memória élesítése* ('the sharpening of one's memory'), which may or may not be an instance of the conceptual metaphor THE MIND IS A MACHINE, depending on whether the annotator is prepared to accept the indirect association between machines and acts of sharpening.
- A second source of discrepancies was the fuzzy nature of the boundary between ambiguous words having an

established abstract sense and metaphorical uses of unambiguous words. For example, the expression *eljutottam a mai napig* ('I've gotten to this day') may or may not represent a CHANGE IS MOTION metaphor depending on whether the Hungarian verb *jut* (literally: get somewhere, reach a place by moving the entire body) is taken only to denote physical movement or to be ambiguous. The verb *alapul* ('be founded on something'), which is derived from the noun *alap* ('foundation') is similarly problematic since, although *az elmélet alapjai* ('foundations of the theory') is a good example for THEORIES ARE BUILDINGS, the verb derived from the concrete noun can only have an abstract sense. The question is, therefore, how far we should go in diachronic or morphological analysis when making a decision of metaphoricity.

• The level of inter-annotator agreement was further lowered by discrepancies in the classification of metaphorical expressions. Consider the following example from the novel *The Master and Margarita*: *az öreg előbb* ***megdöntötte*** *mind az öt* ***bizonyítékot****, és aztán, mintegy magamagából csúfot űzve, ő maga* ***felállított*** *egy hatodikat.* ('the old man first **demolished** all five **arguments** and then, as if mocking himself, **constructed** a sixth of his own'). This phrase were classified by one of the annotators as a THEORIES ARE BUILDINGS metaphor, while the other considered it to pertain to a CREATION IS BUILDING type. Similarly, it is difficult to make an informed decision on whether the following example contains a CHANGE IS MOTION or a PROGRESS IS MOTION FORWARD metaphor, neither of which appear to be an intuitively correct choice: *a járvány végigsöpört szülővárosukon* ('the epidemic swept through their hometown').

3.1.4. The Compilation of the Word Lists

For the automatic identification of metaphors, we searched the corpus for sentences containing one or more words characterizing the source domain and one or more words representing the target domain of a given conceptual metaphor. Three different methods of compiling the word lists were tested: a) word association experiment, b) dictionary of synonyms, and c) reference corpus.

The first method is based on the assumption that the expressions people associate with a key word for the source domain and a key word for the target domain can provide a lexical profile for a given metaphor type. The word associations were collected in an online experiment. 138 students from the Budapest University of Technology and Economics participated in the experiment. One key word for each source and target domain (e.g., *anger, building, change, up, war*) appeared on the screen one at a time in randomized order and the participants had one minute to type words they associated with the key word. When the minute was up, the keyword disappeared and participants were instructed to click a button when they were ready for the next key word.

The lists obtained in the association experiment were normalized: multiword expressions, proper names and antonyms were filtered out, abbreviations were completed, and finally, the words were stemmed by the Hunmorph open source morphological analyzer (Trón et al., 2005).

For each of the 12 conceptual metaphors, the resulting two word association lists (one containing associations provided for the source domain, and another providing associations for the target domain) were taken to constitute the metaphor's lexical profile.

For the second method, the word lists obtained from the association experiment were expanded with the synonyms listed for the association words in the *Magyar szókincstár* [Hungarian Word Thesaurus] (Kiss, 2007). Dialectal, slang and obsolete expressions were omitted. Compared to the association list, the size of the word lists substantially increased (see Table 2). For the third – corpus-based – method, the word lists for each source and target domain were extracted from the manually annotated baseline corpus. Due to the low level of inter-annotator agreement obtained for the baseline corpus, the union of sentences annotated as metaphorical by the two annotators were used for compiling the corpus-based lists of source and target domain words.

Method / Words	Psycho-linguistic	Synonyms	Corpus-based
Source domain	1239	6348	126
Target domain	674	5094	120

Table 2. Number of words in source- and target-domain lists compiled by the three methods.

3.1.5. The Annotation Process and its Verification

Based on the three sets of word lists, the XML test corpus was automatically annotated producing three files in which the sentences were marked with tags showing the type of conceptual metaphor the system identified. Each of the three annotation versions were then verified manually using the graphical interface of the GATE application (Cunningham et al., 2002). Because of time constraints, the manual verification was completed for 10% of the test corpus, where the different genres were represented in the same proportion as in the entire corpus. In this sub-corpus, a total of 155 sentences were identified as metaphorical by two human annotators.

3.2 Results

The results of the three methods were quantified by the *precision* and *recall* measures (Table 3). Precision shows the proportion of the sentences correctly tagged as metaphorical by the automatic system, while the recall measure shows the percentage of metaphorical sentences successfully identified by the system. The F-measure is the weighted harmonic mean of these values, i.e. the final indicator of the system's performance.

Method	Recall	Precision	F-measure
Association	3.8%	7.5%	5.6%
Dictionary	18.1%	4.5%	11.3%
Corpus	31.3%	55.4%	43.3%

Table 3: Results of the three methods.

The results reveal that the association method covered substantially fewer metaphorical sentences containing both a source and a target expression than the other two methods. This psycholinguistic method also performed very poorly in terms of precision. When the association word lists were expanded with synonyms, recall somewhat improved but only at the cost of a decline in precision. The corpus-based method was very clearly the most successful of the three strategies. Taking all our results into account, we must contend that the hypothesis that the co-occurrence of psycholinguistically typical source domain and target domain words in a sentence is a good predictor of metaphoricity receives no empirical support. Exploiting the statistical properties of texts leads to considerably better but still not satisfying results.

3.3 Problem Cases

It is clear from the above discussion that deciding whether a sentence is metaphorical or not is far from being a straightforward task. The general experience of our experiments is that if certain elements are difficult for a human language user to find in a text, then the automatic identification of these words also brings poor results. One problem is that in several cases we must look beyond a single sentence. The manual annotation identified several sentences that were metaphorical but did not contain words from both the source and the target domains, i.e. they were problematic with regard to recall. There were sentences in which a word denoting a concrete action in its literal interpretation (source domain) referred to a metaphorical event, which could only be deduced from the extra-sentential context.

In other cases, the metaphoricity of the sentence was signaled by a single word which incorporated both the source and the target meaning.

Precision values were lowered by the frequent occurrence of sentences which contained both a source and a target expression but were not metaphorical. A typical example is given below: ***Mérnökök és vezetők tanakodnak kisebb csoportokban a 23 emelet magas fúrótorony tövében.*** ('Small groups of engineers and **managers** are discussing their options at the base of the 23-storey **tall** oil-rig.')

The word *manager* is a target-domain expression and the adjective *tall* is a source-domain expression for the metaphor CONTROL IS UP but the two words are conceptually unrelated in this particular sentence.

4. Conclusions

The present paper investigated the automatic identification of conceptual metaphors using corpus-linguistic analyses, and found that the concept of source and target domains is best characterized by statistical patterns rather than by psycholinguistic factors. Since the main objective of our study was to find the most effective way of automatically identifying conceptual metaphors in natural texts, we did not carry out a detailed grammatical analysis of the examples or explore the possible connection between the type of texts and the type of metaphors occurring in them. However, it seems that our research supports previous results of corpus-linguistic analyses, in particular those regarding collocations and the linguistic form of metaphorical expressions. This is also confirmed by the fact that, while the lists compiled on the basis of the association experiment had a very weak predictive force, the targeted selection of the words characteristic to conceptual domains brought the best result, which means that not every association suggests metaphoricity but only the common co-occurrences of certain words and expressions. For example, in Hungarian the co-occurrence of the verb *pazarol* ('waste') and the noun *idő* ('time'), or the verb *gerjeszt* ('induce') and the noun *harag* ('anger') within a single sentence almost always signals a metaphor.

Our analyses also found several examples highlighting the importance of grammatical form: for example, in the case of the conceptual metaphor RESOURCES ARE FOOD, according to the reference corpus method the source domain is represented mainly by verbs (*fogyaszt* 'consume', *felfal* 'devour', *táplál* 'feed'), while the majority of words collected in association experiment are nouns (*edény* 'dish', *fagylalt* 'ice cream', *reggeli* 'breakfast' etc.). This observation supports the results obtained by Deignan (2005) showing that for the majority of metaphorical expressions, words referring to the source domain are verbs or adjectives. The author argues that this is because in metaphorical language use people try to describe abstract entities, thus they take words denoting behaviors, features or actions from the concrete source domains. Of course, the confirmation of these hypotheses requires a more comprehensive analysis of the metaphors found so far. Our plans for the future involve the expansion of the reference corpus and the extraction of a larger word list for source and target domains. At the same time, we intend to analyze the English, Spanish and Italian versions of the texts, and to compare the results with the Hungarian data, since cross-linguistic analyses might reveal important factors in the conceptual nature of metaphorical expressions.

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Appendices: Appendix A describes the workflow. Appendices B and C contain extra material that are not included in the abstract.

<u>Appendix A</u>: A Description of the Workflow of the Web-survey

12 widespread conceptual metaphors were selected from Lakoff & Johnson (1980)[24] and the metaphor index in Kövecses (2002)[25]. Criteria for the selection process were the following:

1. the metaphor had to be general enough to be found in many types of texts,
2. domains had to be suitable for providing associations in a survey, and
3. mapping had to be present from a concrete domain to an abstract domain.

Based on the above, the following 12 conceptual metaphors were chosen:

1. ANGER IS HEAT
2. CHANGE IS MOTION
3. CONFLICT IS FIRE
4. CONTROL IS UP
5. CREATION IS BUILDING
6. MORE IS UP (LESS IS DOWN)
7. POLITICS IS WAR
8. PROGRESS IS MOTION FORWARD
9. RESOURCES ARE FOOD
10. THE MIND IS A MACHINE
11. THEORIES ARE BUILDINGS
12. TIME IS MONEY

This conceptual metaphor list was uniformly used when collecting associations and identifying metaphorical linguistic expressions in the corpora in order to collect comparable data.

The first phase was to assemble the Lexical Profiles (LP) of the metaphors in the Conceptual Metaphor List.

1. Collection of associations with a web-survey.

Aim: Collection of word associations that will later provide a lexical profile for each of the metaphors in the CML. For each of these 12 conceptual metaphors, two word association lists

[24] Lakoff, G. & Johnson, M. (1980) Metaphors We Live By. Chicago: University of Chicago Press.

[25] Kövecses, Z. (2002) Metaphor: A Practical Introduction. Oxford: Oxford University Press.

(one containing associations provided for the source domain, and another providing associations for the target domain) will constitute the metaphor's LP.

Altogether 25 target words were tested in the survey, each metaphor in the CML providing two target words (the source and the target domain). Both the target and source domains of 12 metaphors would naturally yield 24 target words, but given that UP occurs twice as a source domain, and since we also included the metaphor LESS IS DOWN - the complement of MORE IS UP – to the list, we overall tested 25 target words.

The Web-survey.

The collection of word associations was carried out online in php on the server of the Budapest University of Technology and Economics (Department of Cognitive Science). PHP is a general-purpose scripting language that is suited for web development. It can also be embedded in HTML.

Participants: 138 university students who participated in the survey for course credit.

The survey consists of three parts, which are the following:

1. **General information**
   Here participants may
   - provide their personal data (name, age, gender),
   - choose a password that ensures the possibility of re-entering the program after taking a break
   - enter their course or personal university identity codes (may be useful for keeping account of students who have completed the survey)
2. **Instructions**
   Instructions of the web survey appear on the screen.
3. **The survey**
   Target words (25) appear on the screen one at a time in random order. Participants are required to enter their association separated by ENTER in the box below the target word. Participants have one minute for each target word.

1. General information.

Fieldnames for providing data:

- Name
- Age
- Gender (choose)
- Password
- Code

2. Instructions

Text of the instructions:

In the following survey, you will see words appearing on the screen, one at a time. When a word appears, type anything that comes to your mind upon encountering the word in question.

You have one minute for each word. Use this time to enter all the things that you think of when coming across the target word!

Separate your entries by pressing ENTER between your entries.

There are no right or wrong answers, you don't have to think hard, you may write down anything that comes to your mind.

Example:

STRAWBERRY

Summer

red

sweet

fruit

raspberry

milkshake

ice-cream

seed

strawberry

carnival

Press NEXT to continue!

[NEXT]

3. The survey.

The 25 test words individually appeared on the screen during the survey.

1. anger
2. building (N)
3. building (V)
4. change
5. conflict
6. control
7. creation
8. down
9. fire
10. food
11. heat
12. less
13. machine
14. money
15. more
16. motion
17. motion forward
18. politics
19. progress
20. resources
21. the mind
22. theory
23. time
24. up
25. war

2. Preparation of data obtained in the word association survey for further analysis.

Merge word associations obtained for each target word by target word.

Select final list of words for each target word according to the following guidelines:

- Correct spelling mistakes.
- Delete punctuation marks.
- Omit proper names.

- Omit opposites of target word. (e.g. if the words *below*, *down,* or *beneath* appear in the list for the target word UP, omit them from the final list due to their opposite meaning)
- Omit words belonging to paired domain. (e.g. if the word *fire* occurs in the list for the target word ANGER, omit from the final list because *fire* belongs to the source domain -HEAT- of the respective metaphor, ANGER IS HEAT)
- Merge synonyms.
- Identify lemmas.
- Omit entries that only appear once.

These new final lists were used when identifying metaphorical linguistic expressions in the corpora. The lexical profile of each conceptual metaphor in the CML constituted two final lists, one where the target word had been its source domain (**source list**), and another where the target word had been its target domain (**target list**).

In the next phase of the project, metaphors were searched for and annotated in the GATE software (http://gate.ac.uk/download/index.html) based on the word associations. A description and a user guide of the GATE software is found here: http://gate.ac.uk/documentation.html.

Examples for annotated metaphors can be seen in APPENDIX B. Metaphoric words are underlined for easier notice. These concrete words indicated metaphoricity.

Appendix B: The following table summarizes the conceptual metaphors that we investigated. Next to each conceptual metaphor there are some examples listed that we gained from the Hungarian corpus.

Conceptual metaphor	***Examples***
more is up	felmelegedés ('heat up')
control is up	felsőbbrendű szellem ('superior spirit', literally: 'high'), magas tenor ('high tenor'), magas férfihang ('high voice of a man')
change is motion	hosszú volt az út ('the road has been long', in the metaphorical sense), gyermekcipőben jár ('is going still in child's shoes'), végigsöpört ('spread through'), felett eljárt az idő ('time has gone/passed over something/someone'), nem megy túl jól ('is not going well'), megugrottak a költségek ('the expenses have jumped high')
progress is motion forward	előrevihet minket az úton ('can lead us further on the way')
less is down	lelohad a szerelem ('love diminishes', literally: 'down')
anger is heat	lobbanékony helytartó ('impulsive governor', literally: 'inflame', fire suggests heat), a vita hevében ('the heat of the argument')
creation is building	leraktam barátságunk alapjait ('laid the foundation of our friendship')
theories are buildings	a genetika alapjai ('the basics of genetics'), az evolúcióelméleten alapul ('is based on evolution theory'), tudományosan megalapozott ('theoretically grounded')
the mind is a machine	hogyan működik a tudattalan ('how the unconscious works'), a szem nem működik ('the eye doesn't work')
conflict is fire	ember életét oltotta ki ('extinguished human life'), erre tüzelted a népet ('put fire on something')
resources are food	az autó sokat fogyaszt ('the car consumes a lot'); Ideje mind céltudatosabban új üzemanyagot keresni a mohó emberiség számára. ('It's time to step up the search for the next great fuel for the hungry engine of humankind.')
politics is war	Amit eredetileg a kényszer eszményi fegyverének szánhattak, azt ma pajzsként akarják használni, hogy a szabad társadalom megvédhesse magát önmagától. ('What was originally proposed as perhaps the ideal weapon of coercion is now being sought as a shield to protect free society from itself.')
time is money	nem pazarlom az időmet ('not wasting my time')

3.3. Thesis 3: A psycholinguistic investigation of the strong version of the Embodiment Hypothesis at the interface of argument structure and semantics.

Fekete, I., Pléh, Cs. (2011). Bidirectional and Unidirectional Comitative Constructions in Hungarian: a Psycholinguistic Investigation at the Interface of Argument Structure and Semantics, *Acta Linguistica Hungarica*, Vol. 58. (1–2), 3–23.

Errata for the article above:

The ANOVA statistics for the experiments are missing from the article 'Fekete, I., Pléh, Cs. (2011). Bidirectional and Unidirectional Comitative Constructions in Hungarian: a Psycholinguistic Investigation at the Interface of Argument Structure and Semantics, *Acta Linguistica Hungarica*, Vol. 58. (1–2), 3–23'. The ANOVA statistics are reported in the Hungarian article (reference below) as well as here. In this errata, the ANOVA statistics are added.

The Hungarian version of the article above is: Fekete, I., Pléh, Cs. (2011). „Ne viccelődj a rendőrökkel": egy- és kétirányú társas viszonyok a nyelvben [Don't Fool around with the Cops": Unidirectional and Bidirectional Comitative Relations in Language], *Magyar Pszichológiai Szemle* [Hungarian Journal of Psychology], Vol. 66. (4), 559-586.

In the following, ANOVAs are reported for the three experiments:

Experiment 1:

ANOVA was conducted on the region of anaphors. The interaction was not significant [$F(1, 61) = 0.739$, $p = 0.393$]. There was a main effect of verb type [$F(1, 61) = 4.673$, $p = 0.035$], but there was no main effect of number (singular/plural) [$F(1, 61) = 0.808$, $p = 0.372$].

Experiment 2:

ANOVA was conducted on the region of anaphors. The interaction was not significant [$F(1, 59) = 0.042$, $p = 0.839$]. There was no main effect of verb type [$F(1, 59) = 0.038$, $p = 0.845$], and there was no main effect of verb number either [$F(1, 59) = 0.656$, $p = 0.421$].

Experiment 3:

ANOVA was conducted on the region of anaphors. The interaction was not significant [$F(1, 71) = 2.550$, $p = 0.115$]. There was no main effect of verb type [$F(1, 71) = 0.947$, $p = 0.334$], but singular verbs were read significantly faster [$F(1, 71) = 11.792$, $p = 0.001$].

Acta Linguistica Hungarica, Vol. 58 (1–2), pp. 3–23 (2011)
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BIDIRECTIONAL AND UNIDIRECTIONAL COMITATIVE CONSTRUCTIONS IN HUNGARIAN: A PSYCHOLINGUISTIC INVESTIGATION AT THE INTERFACE OF ARGUMENT STRUCTURE AND SEMANTICS*

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Abstract: This paper explores how bidirectional and unidirectional comitative constructions are processed at the level of argument structure. Bidirectional comitative constructions describe events where the two actors undergo the same effect described by the predicate (e.g., *John was kissing with Mary*), whereas unidirectional comitative constructions describe events in which one of the actors is the agent, and the other one is the patient (e.g., *John was messing with Mary*). In particular, we used the self-paced reading paradigm to determine if the two constructions access distinct mental representations. The findings suggest that distinct mental representations are activated automatically by bidirectional and unidirectional verbs during online language comprehension.

Keywords: comitative-instrumental suffix, argument structure, self-paced reading, sentence processing, anaphora resolution

1. Introduction

How are verb meanings processed? Two competing but not mutually exclusive approaches to verb representation are as follows (i) language users draw inferences from thematic roles of arguments (e.g., Dowty 1991), or (ii) they understand events in terms of non-linguistic mental models (i.e., routinely imagining the scene encoded in the sentence,

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e.g., Zwaan–Radvansky 1998). The first approach is based on the assumption that verbs are represented as complex semantic templates. The second approach claims that language understanding recruits modality-specific information. Experimental studies have shed light on the nature and time course of the processing of thematic roles and argument structure (Adams et al. 1998; Carlson–Tanenhaus 1988; Dowty 1991; Goldberg 1995; Levin 1993; MacDonald et al. 1994; Mitchell 1987; Prichett 1992; van Gompel–Pickering 2001). For example, Mitchell (1987) found that verbs automatically project their argument structures; *the doctor* is read slower after an intransitive verb, such as *sneezed*, than after a transitive verb, such as *visited*:

(1) (a) After the child had sneezed the doctor prescribed a course of injections.
 (b) After the child had visited the doctor prescribed a course of injections.

The effect is due to a clause boundary in (1a) based on the argument structure of the verb in the first clause. Taken together, these studies suggest that thematic and argument structures are computed automatically when the verb meaning is activated to construct a schematic representation of the event described. It is commonly accepted, however, that thematic roles and syntactic arguments do not solely constitute verb meanings. For example, recent studies have suggested that language users compute sentential meaning via non-linguistic mental simulation (Richardson et al. 2003; Zwaan et al. 2004). One theoretical framework of this line of research is proposed by Zwaan and Radvansky (1998) who claim that language comprehenders use situation models (mental models) which are integrated mental representations of the events described.

The current study raises the question whether there is empirical evidence for the psycholinguistic reality of distinct mental representations for bidirectional and unidirectional comitative constructions (for an overview of comitative constructions, see Rákosi 2003). Bidirectional (comitative) constructions describe events where the two actors undergo the same effect described by the predicate (e.g., *John was kissing with Mary*), whereas unidirectional (instrumental-like) constructions describe events in which one of the actors is the agent, and the other one is the patient (e.g., *John was messing with Mary*). If thematic roles are immediately processed when the verb is encountered, as previous findings show, then differences in reading times should emerge. Given that there is a semantic difference between the two constructions in terms of the thematic status of the second arguments, we expect readers to be sensitive to this distinction based on Mitchell (1987), who showed that readers automatically project argument structure.

Hungarian, which has a relatively free word order, allows us to investigate word-order effects, too. Here, the question arises, for example, how a conjoined-NP subject is interpreted ('the girl with the boy'). Do readers have a tendency to parse such a chunk as a symmetrical construction? It is also possible to test whether anaphors referring to either or both of the actors of a unidirectional or bidirectional construction are read differently. The rationale for this hypothesis is that there may emerge a difference in the processing of surface and deep anaphora (Sag–Hankamer 1984; Pléh 1989; 1998; Pléh–MacWhinney 1987). We also expect readers to be sensitive to the resolution of these two types of anaphors.

The linguistic background of this speculation is the distinction between surface and deep anaphora proposed by Hankamer and Sag (1976). In this paper, we address each of the questions raised above. The studies in this paper focus on the representation of relational information (who did what to whom) in the mental model.

2. Mental models

The question arises if verb meanings and sentential meaning include information about events beyond thematic features (participant slots). Recent research has found, for example, that language comprehension routinely recruits perceptual-motor simulations (Glenberg–Kaschak 2002; Kaschak–Glenberg 2000; Stanfield–Zwaan 2001; Zwaan et al. 2004). Mental simulation as a possible mechanism has been postulated to describe the dynamic non-linguistic processes going on during language comprehension: the comprehender mentally simulates the situational content of utterances. The situational content can involve perceptual, motor, affective and social inferences and simulations. This level of processing is the situational level; the other two are the lexical and the propositional levels.

In our case, mental simulation refers to mental processes that capture symmetry and asymmetry at this non-linguistic representational level. This is a situation model which encodes the scenario described by the predicate. The comprehender presumably pictures a social scene, a microworld with two agents who are either equal partners in terms of their involvement in the action, or are in an asymmetric relationship. Mental simulation is hypothesized to play a crucial role because the encoding of symmetrical and asymmetrical events involve higher semantics.

Mental models are psychological representations of situations. A mental model is an internal representation of a situation in which objects or concepts are linked to other objects or concepts. They were first proposed by the Scottish psychologist Kenneth Craik (1943), who postulated that the mind constructs these models of reality (a "small-scale model" of external reality) for the anticipation of events, or to reason. These models are constructed in working memory in present-day terminology.

Mental models can emerge from perception, discourse comprehension, or imagination (Johnson-Laird 1983; Marr 1982). An important aspect of mental models is that their mental structure corresponds to the real structure of what they represent. However, they are more abstract than mental images. The theory of mental models refutes the assumption that humans employ a kind of propositional logic when making inferences about the events of the world.

Zwaan and Radvansky (1998) claim that people typically identify at least five dimensions of situations: time, space, causation, intentionality, and protagonists. Many studies have investigated protagonists and objects in anaphor resolution tasks. The various components of the situation model are separate (*ibid.*), and they can be primed individually. Boroditsky (2000), for example, found that the use of a temporal reference perspective can be primed by a spatial reference perspective (ego moving or object moving). Thus, if people had just verified a sentence describing a spatial scenario that used a particular frame of reference (ego moving or object moving), they tended to interpret a temporal expression in terms of the corresponding frame of reference. Her results demonstrate priming of a structural aspect of the situation model that is postulated to be shared between the spatial and temporal dimensions.

The comprehension of the two aforementioned comitative constructions is hypothesized to take place in the situation-model. The comprehender presumably builds a corresponding mental model of a scene with two actors. This model of comprehension goes beyond the propositional level (the latter as proposed, e.g., by Kintsch 1998). The purpose of such an experiment is to investigate how conceptual-level representations are mapped onto the syntactic–semantic level. We suppose that mental models play a central role in representing states of affairs and social actions, such as bidirectional and unidirectional events.

Mental models can facilitate inferences drawn from linguistic descriptions. Anaphoric inferences provide a ground to investigate implicitly if mental models are generated during online sentence comprehension. We expect readers to resolve surface anaphors faster than deep anaphors because deep anaphors access non-linguistic representations, while surface anaphors are resolved purely at the linguistic (syntactic) level.

In the following, three experiments are presented that investigate the effect of word order (Experiment 1 vs. Experiment 2) and the effect of adjuncthood (Experiments 1, 2 vs. Experiment 3) on the interpretation of bi- and unidirectional comitative constructions. We refer to optional arguments as adjuncts in the present paper. Cross-sentential anaphoric processing was investigated in each of the conditions in the three experiments.

3. The experiments

3.1. Experiments 1 and 2

3.1.1. Participants

In Experiment 1, 62 Hungarian students, in Experiment 2, 30 Hungarian students participated for course credit.

3.1.2. Materials and design

40 experimental probes and 20 filler probes were constructed. The experimental probes contained 20 bidirectional comitative probes and 20 unidirectional comitative probes (see Appendix A). Each probe consisted of two sentences. The first sentence described an event with two actors, the second sentence described another one whose content was related to that of the first sentence. The second sentence always contained an anaphor (singular/plural), which was a verb (Hungarian is a **pro-drop** language,[1] see É. Kiss 2002). The second sentences were the same across the categories of the variable verb type (bidirectional/unidirectional). Test verbs were pairwise matched for syllabic length and lemma frequency[2] so that the lemma frequencies of the unidirectional verbs were higher (mean lemma frequency of unidirectional verbs: 4633.6; mean lemma frequency of bidirectional verbs: 1880.9). The lemma frequencies can be seen

[1] Certain classes of pronouns are omitted when they are pragmatically inferable (pronoun-dropping).

[2] The lemma frequencies were obtained from the MOKK web-based frequency database: http://mokk.bme.hu/resources/webcorpus/index_html (Halácsy et al. 2004; Kornai et al. 2006).

in Appendix B. The two agents in the test sentences were chosen as neutral and equal in terms of the relationship, to control for any effect this could impose on the processing.

The experimental verbs were tested on directionality in a metalinguistic judgement study: 8 raters judged whether the critical verbs were unidirectional or bidirectional; their task was to determine whether the meaning of the sentences remains the same if the order of the agents are changed. Each matched verb pair had the same number of syllables. Appendix B shows the verb stimuli with their lemma frequencies. In each matched-pair the test sentences were exactly the same up to the point of the critical verb. The second sentence (the continuation) was exactly the same in a matched-pair.

3.1.3. Procedure

The task was self-paced word-by-word reading with a stationary window display (Just et al. 1982) using E-Prime psychological software. Each trial began with a fixation cross on the centre of the screen. Participants pressed the spacebar to reveal each word of the sentence. As each new word appeared in the sentence, the preceding word disappeared. The amount of time the participant spent reading each word was recorded as the time between key-presses. After the final word of each item, a statement appeared to which participants were invited to react (e.g., "The girl was messing with the boy" TRUE/FALSE): participants pressed one of two keys to respond "yes" or "no". No feedback was given for correct responses. Participants were asked to read sentences at a natural rate, but to read as quickly and accurately as they could, and to make sure that they understood what they read. They were told that the time they took to answer the question was not measured. Before the main experiment, two practice probes and questions were presented in order to familiarize the participant with the task. A session was 10 minutes long on the average.

In Experiment 1, mean reading times were analysed (i) in the region of verbs (the last word) in the first sentences of experimental trials, as well as (ii) in the region of the anaphors (the first word) in the second sentences of experimental trials. The first dependent variable (i) tested whether conjoined-NP subjects were interpreted as bidirectional constructions. Our hypothesis was that sentences with this word order (NNV) would be interpreted faster with bidirectional verbs than with unidirectional ones. The second dependent variable (ii) measured if singular and plural anaphors were resolved differently after bidirectional and unidirectional constructions.

In Experiment 2, the verbs separated the two arguments in the critical sentences. Mean reading times were analysed (i) in the region of verbs (the third word) in the first sentences of experimental trials and in the region of the second arguments after the verb, as well as (ii) in the region of the anaphors (the first word) in the second sentences of experimental trials. Reaction time measurement in the first sentences of experimental trials (i) tested whether bidirectional and unidirectional constructions were processed differently at the level of argument structure. Our intuitive hypothesis was that sentences with this word order (NVN) would be interpreted faster with unidirectional verbs than with bidirectional ones. The second dependent variable (ii) measured if singular and plural anaphors were resolved differently after bidirectional and unidirectional constructions.

3.1.4. Results and discussion

In both of the experiments the incorrect trials were removed from the analysis, and the mean of median reading times were taken. Figure 1 illustrates the difference in reading times between comitative (bidirectional, e.g., 'The girl with the boy partied') and instrumental(-like) (unidirectional, e.g., 'The girl with the boy bantered') constructions in Experiment 1 (NNV-setting). It can be seen that comitative constructions were read significantly faster than instrumental(-like) ones ($t(61) = -2.625$, $p < 0.05$).

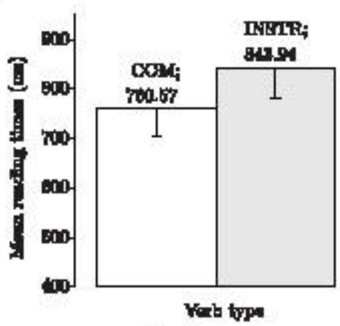

Fig. 1

Main effect of verb type in Experiment 1 (standard error is indicated)

Presumably, the sentence-initial NP and the second NP are taken to be a conjoined Subject-NP [$NP1_{human}$ + NP2('with')$_{human}$ + V(past)]. This interpretation couples with the comitative: 'the girl and the boy' = 'the girl with the boy' (Dimitriadis 2008; Rákosi 2003).

Singular anaphoric verbs were processed significantly faster after comitative constructions than (the same ones) after instrumental-type constructions[3] ($t(61) = -2.120$, $p < 0.05$):

Table 1

The processing times of the anaphoric verbs in Experiment 1

Anaphor type	Mean (ms)	Std. dev.
COM_plural	708.38	245.78
COM_singular	**711.94**	314.73
INSTR_plural	749.14	315.92
INSTR_singular	**793.06**	320.27

The general ease in the processing of anaphoric verbs after comitative constructions is presumably due to the ease of the processing of comitative constructions in the previous sentence, given word order NNV. The difference between the processing of plural anaphors in the two conditions is not significant ($t(61) = -1.163$, n.s.). Plural anaphors were read significantly faster after comitative constructions than singular anaphors after instrumental (unidirectional) constructions ($t(61) = -2.253$, $p < 0.05$): e.g., 'The girl with the boy partied. They hooked up...' vs. 'The girl with the boy bantered. She broke into a smile.'

All in all, the differences in the resolution of anaphors show us that comitative and instrumental constructions are processed differently. The specific difference in the mental models is, however, left unanswered. Suffice it to say that the evidence is interpreted as supporting Kehler's (2002) hypothesis that the processing patterns observed in pronoun processing reflect more general cognitive inference processes underlying the establishment of discourse coherence. It may, however, well be the case that the difference in anaphor resolution only reflects the ease or difficulty with which language users bind the subject-antecedent to the anaphor.

[3] Only four-syllabic anaphors were included in the analysis in order to control for the effect of word length.

The ease or difficulty is contingent on the type of the construction the antecedent is embedded in.

Experiment 2 differed from Experiment 1 in that it changed the word order of Experiment 1 to NVN. Hence, the critical verbs were presented between the two NPs. In accordance with our expectations, there were no differences in reading times between the two types of verbs ($t(29) = -0.222$, $p < 0.826$, n. s.). This is due to the fact that the critical verbs were counterbalanced on lemma frequency and syllabic length. Furthermore, the critical verbs in the NVN-setting were read 200–300 ms faster than in the previous experiment where they were presented in the last position of the sentence. The slower reading times in the region of the critical verbs in Experiment 1 reflect sentence integration costs, whereas in the present experiment only the first NP and the critical verb were encountered but not the second NP. Figure 2 illustrates that in the NVN-setting the second arguments were read significantly faster after instrumental(-like) verbs (unidirectional verbs) ($t(29) = 2.538$, $p < 0.05$).

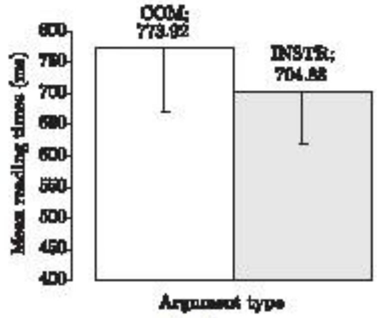

Fig. 2

Mean reading times of the arguments after the critical verbs in Experiment 2 (standard error is indicated). Mean reading times reflect reading time data in the region of the nouns

This difference in the reading times of the second NPs can be explained by the psycholinguistic distinction between arguments and adjuncts. We speculated that the difference in processing times is due to the status of the second NPs (arguments or adjuncts), rather than to the semantics of the preceding verbs. This question is taken up in Experiment 3, in which only two-argument verbs are tested (verbs that take two syntactic arguments). The following table shows the mean reading times of the second NPs by item (NVN-setting).

Table 2

A comparison of the reading times of the NPs after the critical verbs in Experiment 2

Verb pairs	RT of the NP after the verb (ms)	*t*	*p*
bulizott 'partied' – kikezdett 'made a pass at'	770.17 – 530.40	2.073	.047
sétálgatott 'walked' – incselkedett 'joshed'	702.67 – 540.78	1.965	.059
találkozott 'met' – csipkelődött 'japed'	781.48 – 654.05	1.267	.215
tegeződött 'theed' – szimpatizált 'liked'	1315.08 – 908.42	2.908	.007
párbajozott 'duelled' – foglalkozott 'dealt'	98958 – 943.70	0.274	.786
énekelt 'sang' – ordított 'shouted'	1010.67 – 1062.45	−0.315	.755
csókolózott 'kissed' – együttérzett 'sympathized'	598 – 734.35	−1.396	.173
verekedett 'fought' – csúfolódott 'mocked'	1316.65 – 1209.62	0.623	.538
borozott 'drank wine' – törődött 'cared for'	957.25 – 866.07	0.671	.508
mulatozott 'racketed' – gúnyolódott 'jested'	1104.22–1185.81	−0.613	.545

3.2. Experiment 3

Experiment 3 was constructed to eliminate adjuncts. Therefore, in this experiment only such verbs were used that neccesarily take two arguments at the syntactic level (such as *mess with*). The major focus was on the reading times of the second arguments of these unidirectional and bidirectional comitative verbs as well as the resolution of the anaphors. The experimental sentences were presented in NVN-order, as in Experiment 2.

We hypothesized that there would be a reading time difference in the region of the second arguments, which is not due to the nature of the status of the NP (adjuct or argument). This hypothesis was based on the assumption that unidirectional constructions (NVN) are similar to SVO-constructions, and thus they are comprehended more easily than comitative NVN-constructions. Our second hypothesis concerned the resolution of the anaphors (anaphoric verbs): we assumed that the binding of a singular anaphor to the subject is easier when the subject is the agent of a unidirectional construction, since the agent of these constructions is a "better agent" in terms of agenthood. Semantically, the crucial difference between the agents of (i) *Mary hit John* and (ii) *Mary spoke with John* is that in former sentence (i) the agent is more active; Mary is the initiator of the action, whereas (ii) does not necessarily entail the same degree of involvement of Mary in the action. We speculate that this difference will have an effect on the resolution of anaphors referring to these agents.

3.2.1. Participants

72 Hungarian students participated in this study. Nobody was excluded for performing under 75% of overall accuracy.

3.2.2. Materials and design

40 experimental probes and 20 filler probes were constructed. The experimental probes contained 20 bidirectional comitative probes and 20 unidirectional comitative probes. The actors in the sentences were the same as in the previous two experiments, and the filler sentences were also identical. Each probe consisted of two sentences. The logic of this experiment was basically the same as in the previous experiments: the first sentence described an event with two actors, the second sentence described another one whose content was related to that of the first sentence. The second sentence always contained an anaphor (singular/plural), which was a verb. A pair of experimental trials can be seen here: **bidirectional**: *A pék összefogott a patikussal. Megkötötték a szerződést./Megkötötte vele a szerződést.* 'The baker joined forces with the apothecary. They made a contract./He made a contract with him.' and **unidirectional**: *A pék leszámolt a patikussal. Verekedtek./Verekedett vele.* 'The baker squared accounts with the apothecary. They were fighting./He was fighting with him.' The new experimental verbs were tested on directionality in a metalinguistic judgement study. Appendix C shows the experimental verbs.

3.2.3. Procedure

The procedure of Experiment 3 was identical to the previous experiments.

3.2.4. Results and discussion

Comitative arguments (COM, arguments after comitative verbs) were read slower than instrumental-like (INSTR) arguments ($t(71) = 1.985$, $p < 0.05$) (see Figure 3, overleaf).

It should, however, be noted that the difference in reading times in the region of the second NPs could be a spill-over effect from the previous word (the critical verbs). Instrumental-like verbs were read significantly

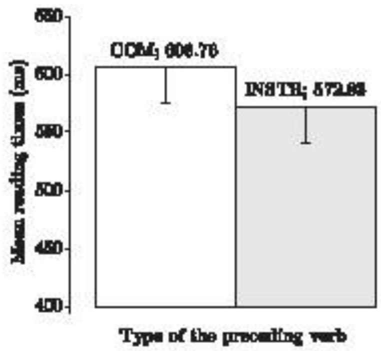

Fig. 3

Main reading times of arguments in Experiment 3 (standard error is indicated). Mean reading times reflect reading time data in the region of the nouns

faster than comitative verbs ($t(71) = 5.807$, $p < 0.01$). (The spill-over region is the NP after the critical verbs.) The following table summarizes the mean of median reading times in the region of the critical verbs.

Table 3

The processing times (ms) of the critical verbs (word 3) in Experiment 3

Verb type	Mean	Std. dev.
COM_verbs	565.55	215.03
INSTR_verbs	503.99	194.73

Figure 4 illustrates the processing times of the anaphoric verbs. Singular anaphoric verbs were read significantly faster after an instrumental construction than after a comitative construction ($t(71) = 2.648$, $p < 0.01$).

Plural anaphoric verbs were read slower than singular ones in both conditions (plural anaphors, mean: 607.45 ms; singular anaphors, mean: 567.48 ms; $p < 0.01$). We have already noted that singular anaphoric verbs were read faster after instrumental-like constructions (e.g., 'The girl was messing with the boy') than the same verbs after comitative constructions (e.g., 'The girl stayed together with the boy'). However, it is not yet clear from the two mental models why comitative (second)

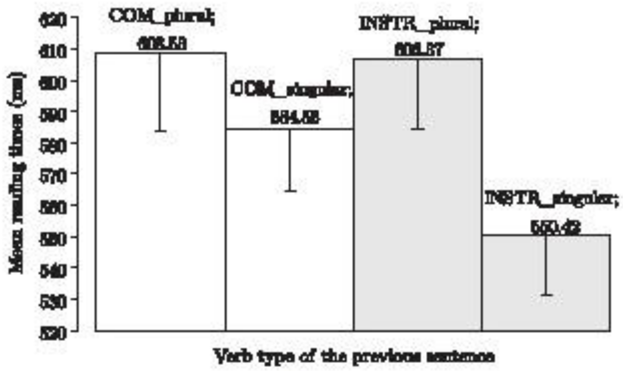

Fig. 4

The processing times (ms) of the anaphoric verbs in Experiment 3 (standard error is indicated)

arguments (NV<u>N</u>) should be read slower. We propose here that asymmetric constructions (e.g., 'The girl was messing with the boy') usually take SVO word order (which is common in Hungarian), and thus more easily comprehended, and this is why singular anaphoric verbs are read faster after an instrumental-like construction (antecedent reactivation is easier) than after a bidirectional comitative construction. Following the logic of this assumption about the ease of processing of a singular anaphor after an instrumental construction, we suggest that it is easier to extract the subject from an instrumental construction than from a comitative one (based on the argument mentioned), because the subject of an unidirectional construction is more salient given the essence of the event encoded.

If antecedent reactivation was purely a syntactically-driven process,[4] then no difference should emerge in the processing of anaphors. Since there is a difference in the processing of singular anaphors after bidirectional and unidirectional constructions, we can conjecture that some other processes also play a role. We propose that the crucial aspect in the mental model is that in a unidirectional construction the first NP (the

[4] This could be described with the following syntactic rule: the antecedent of the anaphoric verb is the first NP/the subject in the first sentence.

subject) is more salient, and thus, reactivated more easily when the singular anaphoric verb is encountered (this is because of the event structure of the action). In other words, the subject of a unidirectional construction is a volitional agent, wheras that of a bidirectional one is a non-volitional (or less volitional) one.

4. Conclusion

Our results show that meaning, specifically relational information, is computed at the level of argument structure. The more complex the structure (NNV), the longer the time to process those structures. An alternative explanation for this effect, however, could be that NNV-constructions are less frequent in Hungarian than NVN-constructions. We have seen that participant roles are activated online during language comprehension. Using Hungarian stimuli again we repeated previous findings that arguments are read significantly faster than adjuncts (Gervain–Pléh 2004). In the NVN-setting processing is easier because in this case the argument structure and the referential context of the verbs are activated (Gervain–Pléh 2004; MacDonald et al. 1994; Prichett 1992).

In Experiment 3, we constructed a set of sentences containing only bidirectional ('The girl stayed together with the boy') and unidirectional ('The girl made a pass at the boy') verbs that take two syntactic arguments. We measured reading times in the region of the second arguments (after the critical verbs) and on the anaphoric verbs (in the second sentences). Comitative arguments were read slower than instrumental arguments; however, we noted that the difference may be attributable to a spillover effect during reading.

We further found in Experiment 3 that singular anaphoric verbs were resolved slower after bidirectional comitative constructions than after asymmetric constructions. We proposed that this shows that symmetric and asymmetric constructions are processed differently. We interpret the difference in the resolution of singular anaphors from a form-based perspective, namely, that a singular anaphoric verb gets more easily connected to its antecedent (the subject of the first sentence), because asymmetric constructions resemble SVO-constructions both in terms of structure and meaning, and the subject NP of unidirectional (asymmetric) constructions is more salient than that of bidirectional ones. (We will argue later that the saliency of the Subject is essentially its prototypicality as an agent.)

The reverse effect (singular anaphoric verbs were processed faster after bidirectional constructions than after unidirectional ones) was observed in Experiment 1: this can be explained by a spill-over effect, namely that unidirectional constructions were processed slower (Exp 1, NNV), and therefore, anaphor resolution is also slower.

Importantly, the difference in the resolution of singular anaphors in Experiment 3 can be explained by **linguistic** (not imagery-based) theories: anaphor resolution is easier after an **agent/patient** (asymmetric) construction than after an **agent/co-agent(partner)** (symmetric) construction, because the agent in the former case is more salient from a semantic point of view (since it is crucial to know who initiated the action, who was the "agentive agent").

Intuitively, the agent of bidirectional constructions is less prototypical for an agent. For example, in the sentence ***Mary was kissing with John***, Mary is less "agentive" than in the sentence ***Mary kissed John***. The latter sentence entails that Mary intentionally instigated the event described by the predicate (kissing), whereas in the former sentence (***Mary was kissing with John***) both of the NPs are in focus. It seems, therefore, that the agent of bidirectional constructions is not a **prototypical volitional agent**. This conception is in accord with Dowty's (1991) fuzzy analysis of proto-agents; he proposed that volitionality is one of the semantic properties in the representation of agents.

We showed earlier (cf. Experiment 1) that the two NPs are taken as a conjoined NP, and interpreted as the agent of the event. It appears that the agent of bidirectional constructions is the two actors of the event because they undergo the same effect in the action (they are walking or kissing together). We propose that semantic information (saliency, volitionality) can be represented in a linguistic format (e.g., [± vol]). A second, still linguistic, explanation can be that bidirectional constructions are represented mentally as NP+NP-constructions. This approach claims that these constructions are redescribed semantically into a synonymous construction, such as ***Mary and John were kissing***. This approach suggests that the transformation of NVN into NNV takes time. One could also argue that bidirectional constructions, instead of having only one agent, have two agents that are equal participants in the event. Under either explanation, the results show that the linking of agent to the Subject position is harder after a bidirecional construction.

A third explanation for the anaphor-binding advantage in the agent/patient condition is that the agent of an agent/patient construction is more activated and available in the situational model, thus, more easily reactivated at the point of the anaphor. This approach (the **situational** or **simulational** account) explains the difference of reading times of the anaphors in terms of non-linguistic mental models (situation models; Zwaan–Radvansky 1998).

Taken together, both the linguistic-propositional (form-based) and the situational account can explain the pattern of results in our experiments. The **hybrid model** of text comprehension claims that the situational model is only one of the factors influencing linguistic processing. (The **eliminative model**, on the other hand, proposes that any comprehension process is finally based on the situational model.) Further research is needed to be able to opt for one of these models. We could only show with the methodology at hand that a fine-grained semantic distinction is represented during language comprehension. However, we could not demonstrate exactly at which level this distinction is represented, and what information goes exactly into the linguistic, syntactic and propositional representation. It may well be the case that thematic roles, which are heavily loaded semantically, disambiguate the bi- vs. unidirectional readings, rather than situation models. We believe that the subtle semantic difference between the agent status of uni- and bidirectional constructions ([± vol]) is finally represented in the mental model (situational model) in a non-linguistic format.

An alternative conception of the hybrid model is that the thematic representation is a (formal-linguistic) description and simplification of the situational representation. What this amounts to is that thematic representations are equivalent to the elements of non-linguistic situational models. They are the ultimate theoretical constructs of situational models. This approach, therefore, is at odds with the view that thematic roles and situational models are qualitatively different.

Future research should focus on the question of the saliency of the subject. It may be the case that certain verbs require the agent to be "more agentive" (asymmetric verbs) than others (symmetric verbs). The question of agency is as follows: is there a difference in the representation of *Mary kissed John* (volitional agent) versus *Mary was kissing with John* (non-volitional agent)? A self-paced reading experiment should shed light on the reactivation of Subject-antecedents in both cases. We expect antecedent reactivation (the binding of the Subject-NP) to be faster in the volitional agent case (*Mary kissed John*) because a volitional agent is a more prototypical agent (proto-agent) in terms of the proto-roles proposed by Dowty (1991). In his conception, the NP with the highest number of properties of the Proto-Agent tends to be treated as the Agent in the sentence.

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Appendix A

Stimulus sentences in Experiments 1 and 2 (the sentences were presented in the NNV-setting in Experiment 1; and in Experiment 2 in an NVN-setting).

A lány a fiúval bulizott. Összejöttek másnap.
'The girl partied with the boy. They hooked up the day after.'
A lány a fiúval bulizott. Összejött vele.
'The girl partied with the boy. She hooked up with him.'
A lány a fiúval sétálgatott. Nevetgéltek közben.
'The girl was walking with the boy. They were giggling.'
A lány a fiúval sétálgatott. Nevetgélt közben.
'The girl was walking with the boy. She was giggling.'
A hölgy az úrral találkozott. Elmosolyodtak.
'The lady met up with the gent. They broke into a smile.'
A hölgy az úrral találkozott. Elmosolyodott.
'The lady met up with the gent. She broke into a smile.'
A hentes a fűszeressel tegeződött. Összebarátkoztak később.
'The butcher was on friendly terms with the grocer. They became friends afterwards.'
A hentes a fűszeressel tegeződött. Összebarátkozott vele.
'The butcher was on friendly terms with the grocer. He became friends with him.'
A szakács a pékkel párbajozott. Elfáradtak.
'The cook duelled with the baker. They got tired.'
A szakács a pékkel párbajozott. Elfáradt.
'The cook duelled with the baker. He got tired.'
A pék a patikussal énekelt. Elcsendesedtek.
'The baker was singing with the pharmacist. They quieted down.'
A pék a patikussal énekelt. Elcsendesedett.
'The baker was singing with the pharmacist. He quieted down.'
A lány a fiúval csókolózott. Átkarolták egymást.
'The girl was kissing with the boy. They gave each other a hug.'
A lány a fiúval csókolózott. Átkarolta őt.
'The girl was kissing with the boy. She gave him a hug.'
A zöldséges a virágárussal verekedett. Kibékültek másnap.
'The grocer was fighting with the florist. They made it up next day.'

A zöldséges a virágárussal verekedett. Kibékült vele.
'The grocer was fighting with the florist. He made it up with him.'
A kereskedő a halásszal borozott. Megkedvelték egymást.
'The merchant was drinking wine with the fisherman. They came to like each other.'
A kereskedő a halásszal borozott. Megkedvelte őt.
'The merchant was drinking wine with the fisherman. He came to like him.'
A hentes a zöldségessel mulatozott. Hazamentek ezután.
'The butcher racketed with the grocer. They went home afterwards.'
A hentes a zöldségessel mulatozott. Hazament ezután.
'The butcher racketed with the grocer. He went home afterwards.'
A lány a fiúval kikezdett. Összejöttek másnap.
'The girl made a pass at the boy. They hooked up with each other the day afterwards.'
A lány a fiúval kikezdett. Összejött vele.
'The girl made a pass at the boy. She hooked up with him.'
A lány a fiúval incselkedett. Nevetgéltek közben.
'The girl was teasing the boy. They both were giggling.'
A lány a fiúval incselkedett. Nevetgélt közben.
'The girl was teasing the boy. She was giggling.'
A hölgy az úrral csipkelődött. Elmosolyodtak.
'The lady was bantering with the gent. They broke into a smile.'
A hölgy az úrral csipkelődött. Elmosolyodott.
'The lady was bantering with the gent. She broke into a smile.'
A hentes a fűszeressel szimpatizált. Összebarátkoztak később.
'The butcher was fond of the grocer. They became friends later on.'
A hentes a fűszeressel szimpatizált. Összebarátkozott vele.
'The butcher was fond of the grocer. He became his friend.'
A szakács a pékkel foglalkozott. Elfáradtak.
'The cook was dealing with the baker. They got tired.'
A szakács a pékkel foglalkozott. Elfáradt.
'The cook was dealing with the baker. He got tired.'
A pék a patikussal ordított. Elcsendesedtek.
'The baker was shouting at the baker. They quieted down.'
A pék a patikussal ordított. Elcsendesedett.
'The baker was shouting at the baker. He quieted down.'
A lány a fiúval együttérzett. Átkarolták egymást.
'The girl sympathized with the boy. They hugged each other.'
A lány a fiúval együttérzett. Átkarolta őt.
'The girl sympathized with the boy. She gave him a hug.'
A zöldséges a virágárussal csúfolódott. Kibékültek másnap.
'The grocer was mocking the florist. They made it up the day after.'

A zöldséges a virágárussal csúfolódott. Kibékült vele.
'The grocer was mocking the florist. He made it up with him.'
A kereskedő a halásszal törődött. Megkedvelték egymást.
'The merchant was caring for the fisherman. They came to like each other.'
A kereskedő a halásszal törődött. Megkedvelte őt.
'The merchant was caring for the fisherman. He came to like him.'
A hentes a zöldségessel gúnyolódott. Hazamentek ezután.
'The butcher was mocking the grocer. They went home afterwards.'
A hentes a zöldségessel gúnyolódott. Hazament ezután.
'The butcher was mocking the grocer. He went home afterwards.'

Appendix B

The lemma frequencies (MOKK) of the critical verbs in Experiments 1 and 2.

Bidirectional (symmetric) verbs		**Unidirectional (asymmetric) verbs**
14 borozott 'drank wine'	<	15 csipkelődött 'japed'
14381 találkozott 'met'	<	40951 foglalkozott 'dealt'
46 tegeződött 'were on familiar terms'	<	47 incselkedett 'joshed'
122 csókolózott 'kissed'	<	146 gúnyolódott 'japed/jested'
305 sétálgatott 'walked'	<	1040 ordított 'shouted'
119 bulizott 'partied'	<	304 szimpatizált 'liked'
22 mulatozott 'racketed'	<	37 csúfolódott 'mocked'
21 párbajozott 'duelled'	<	80 együttérzett 'sympathized'
66 verekedett 'fought'	<	76 kikezdett 'made a pass at'
3713 énekelt 'sang'		3640 törődött 'cared for'

Appendix C

Bidirectional (symmetric) verbs	**Unidirectional (asymmetric) verbs**
összeházasodott 'got married with'	szakított 'broke up with'
együttmaradt 'stayed together with'	kikezdett 'made a pass at'
elbeszélgetett 'had a chat with'	szimpatizált 'liked'
megismerkedett 'got acquainted with'	törődött 'cared for'
összekülönbözött 'fell out with'	foglalkozott 'dealt with'
összefogott 'joined with'	leszámolt 'got equal with'
összeköltözött 'moved together with'	vesződött 'bothered with'
összebeszélt 'ganged up with'	kivételezett 'favoured'
összeszólalkozott 'came to loggerheads with'	kiszúrt 'picked on'
találkozott 'met up with'	elbánt 'made a score with'

3.4. Thesis 4: A psycholinguistic investigation of the strong version of the Embodiment Hypothesis in the domain of environmental sounds and language I.

Fekete, I. (accepted, 2012): Mi van akkor, ha a macska ugat? Kognitív templátok és a valóság illesztése a nyelvi megértés során [What if the cat is barking? Cognitive templates and the matching of reality during real-time language understanding], *Általános Nyelvészeti Tanulmányok XXV* [General Linguistic Studies].

The following article is the English translation of the above article in press.

What if the cat is barking? Cognitive templates and the matching of reality during real-time language understanding [*]

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Abstract

Sentences such as 'The professor blew the whistle on the students for plagiarizing' include an expression that describes a sound but does not refer to real sound events. Auditory effects on abstract sound-related language is an understudied phenomenon and it is this question that the present study undertakes to shed light on.

In Experiment 1, participants read concrete and abstract sentences while listening to any of the four types of auditory stimulus: for example, a sentence, such as 'The press rang alarm bells' was presented

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either together with the congruent sound (bells), with an incongruent sound (drums), with an unrelated sound (laughter), or without any sound. The task was to make sensibility judgments on the sentences. Results show that the concrete but not the abstract sentences were processed faster in the congruent condition compared to the incongruent condition.

In Experiment 2, another group of participants read sound-related sentences. Critical sound stimuli were presented in synchrony with the verb. The task was to answer a control question after each trial. Sentences in the congruent condition were not processed differently from those in the incongruent condition. Sentences in both the concrete and the abstract sub-samples were processed significantly slower in the unrelated condition compared to the no sound condition. Results suggest that fictive sound events are processed in a shallow manner without access to auditory representations.

Key words: environmental sounds; mental simulation; abstract language; idioms; metaphor

1. Introduction

How do we understand metaphorical sentences that do not refer to concrete sounds in the environment but rather to abstract[26] or 'fictive' sounds, such as *I would lose my job if I blew the whistle on him*; *His words rang true; He roared in delight; He drummed the rules into them; etc*. Do we hear those fictive sounds with our 'mind's ear' even if there is no sound event in the situational context? Put in more formal terms, is there a qualitative difference between auditory representations activated by concrete sound-related language ('blow the whistle') and by abstract language referring to sounds ('blow the whistle on the students'). Auditory representation is distinct from auditory imagery in that it is automatically generated, while auditory imagery is consciously generated. Auditory imagery is „the introspective persistence of an auditory experience, including one constructed from components drawn from long-term memory, in the absence of direct instigation of that experience" (Intons-Peterson 1992: 46). Auditory imagery, therefore, refers to the subjective experience that accompanies our memory when we think about sound events. We aim to test if auditory representations are automatically activated during online language processing. An interesting study that deals with a similar phenomenon in language was conducted by Matlock, Ramscar and Boroditsky (2005) who investigated fictive motion in language, such as the sentence *The road runs along the coast*. We adopted this terminology to describe abstract sounds. It is reasonable to assume that the processing of concrete sound-related language (*The dog is barking*) gives rise to the simulation

[26] The abstract (figurative, non-literal) sentences in the article are sometimes categorized as metaphors, although it could be argued that they are idioms. The terminology does not matter in the current study. Importantly, these sentences do not refer to real sound events, hence fictive.

of the sounds encoded in these sentences because these sentences refer to real auditory phenomena in the world. By extension, it is possible that abstract sentences (whose semantic profile nevertheless does not include the concrete sound event) also exhibit the same effects on the cognitive linguistic assumption that they are processed as metaphorical extensions of concrete sound events (Kövecses, 2002; Lakoff and Johnson, 1980, 1999). No empirical studies that we know of have touched upon the comprehension of metaphorical extension of sound events until now, but previous research, for example, on fictive motion metaphors (Matlock et al., 2005; Talmy, 2000) suggests that sound metaphors might behave similarly. However, in principle it is equally plausible that the abstract meaning is directly accessed and the literal sound is not activated. This is the question that we aim to answer in the present study.

The broader theoretical approach, according to which we expect sound stimuli to affect linguistic processing, and linguistic stimuli to activate sound representations is the theory of Perceptual Symbol Systems as advocated by Barsalou (1999) and the paradigm of Simulation Semantics (Bergen, 2007; Zwaan and Madden, 2005). Barsalou (1999) claims that the simulated event evoked by the linguistic representation also contains auditory experiences (auditory experiential traces), e.g., the experience of hearing the engine roar as a consequence of the processing of the concept 'engine'. Simulation Semantics also emphasizes that language understanding involves the recruitment of modality-specific information (which is a previously stored perceptual experience).

We argue and will show in line with the theory of Perceptual Symbol Systems and the framework of Simulation Semantics that sound representations are not just associations from linguistic representations, but rather they are auditory representations that are unfolded by the process of *mental simulation*. However, the concept of mental simulation should be distinguished from other kinds of association because mental simulation requires by definition that the association should be indispensable for the full understanding of the sentence.

One function of mental simulation is to prepare for action (Barsalou, 1999; Glenberg and Kaschak, 2002). The theory of mental simulation proposes that language users construct modality-specific simulations of the perceptual and motor content of experiences described by the linguistic input. On the basis of these simulations and situation models detailed inferences are drawn about the situational content of utterances (Barsalou, 1999; Bergen, 2007; Narayanan, 1997).

By abstract representation we, the authors mean a conceptual process by which less real concepts or ideas, such as *power*, *democracy*, or *whistleblowing* (‘reporting of wrongdoing’), are derived from the usage of literal concepts. Mental simulation effects for abstract representations can be interpreted in the framework of the Cognitive Metaphor Theory (Kövecses, 2002; Lakoff and Johnson, 1980, 1999) which claims that we understand abstract domains in terms of more concrete representations. Cognitive metaphor theorists assume that concepts are embodied in the sense that they are grounded in perception and action. What it amounts to is that conceptual features (e.g., visual, acoustic, motor) are hypothesized to be stored in modality-specific areas of the brain and are assumed to be activated during the processing of abstract language. However, there are several other accounts of how abstract concepts may be represented by simulation, such as simulation by concrete situational and introspective experiences (Barsalou and Wiemer-Hastings, 2005), or emotional affective states (e.g., Winkielman, Niedenthal & Oberman, 2008). According to the Cognitive Metaphor Theory, image schemas provide sensory-motor grounding for abstract concepts. It should be noted that the different accounts about abstract conceptual representation are not mutually exclusive. Pecher, Boot, and Van Dantzig (2011), for example, argue that situations are also needed to fully represent abstract meaning.

Specifically, the strong version of the embodiment view (Kövecses, 2002; Lakoff and Johnson, 1980, 1999) holds that language understanding is *directly* grounded in embodied representations, i.e., listeners tap into their experiential knowledge when they process language. In other words, the strong embodiment view, which is usually also referred to as Radical Embodiment, holds that modality-specific representations are inherent part of conceptual representations (i.e., they are conceptual features), which entails that word meanings are built from sensory-motor experiences, which are necessarily activated during language use.

However, in discord with the strong embodiment view, numerous studies have shown that embodied information only receives enough activation when language is processed deeply (Louwerse and Jeuniaux, 2008). Such findings have given rise to a distinction between shallow vs. deep levels of processing (Barsalou, 1999). The shallow processing account can be conceived of as a refutation of the strong embodiment view, since it shows that language processing does not necessarily invoke modality-specific information.

As a resolution to the anomaly between the strong embodiment view and other conflicting conceptions, the Language and Situated Simulation theory of conceptual processing (LASS, Barsalou, Santos, Simmons & Wilson, 2008), which is compatible with the shallow vs. deep processing accounts, proposes that comprehenders first access the linguistic meaning, and then they simulate the situational content of the utterance. According to this approach, mental simulations are post-hoc activations in the nervous system, and do not constitute part of the linguistic meaning. Comprehenders first access the word form which sends activations to other associates in a spreading activation manner (Anderson, 1983; Neely, 1991). The spreading activation theory has methodological implications too, because different effects can emerge as a function of stimulus onset asynchrony (SOA). SOA refers to the time interval between the onset of the prime stimulus and the onset of the target stimulus.

In contrast with the Cognitive Metaphor Theory (Kövecses, 2002; Lakoff and Johnson, 1980, 1999), another alternative to metaphor comprehension has also been proposed, for example, by Gernsbacher and Robertson (1999) and Keysar (1994) who claim that metaphor comprehension involves the suppression of irrelevant concrete attributes and the enhancement of attributes that support the metaphorical meaning. For example, understanding the metaphor *My lawyer is a shark* involves the activation of the metaphorical shark-properties, such as 'vicious' or 'tenacious', while the literal shark-properties, such as 'fast swimmer', 'has fins', 'lives in the ocean', or 'has sharp teeth' are suppressed. Thus, this theory predicts that during the understanding of fictive sound metaphors, such as 'whistleblowing' the concrete sound representation (of blowing a whistle), the concrete concept ('whistle'), or at least its literal lexical associate (*whistle*), is suppressed.

Again, contrary to the Cognitive Metaphor Theory, Vigliocco et al. (2004) highlight that semantic representation is independent from sensorimotor representations. In line with this conception, recent proposals have also claimed that modality-specific activations are not strictly necessary for linguistic meaning but are needed for fully grounding a concept; they contribute only to the *covert* meaning of words (Boulenger, Mechtouff, Thobois, Broussolle, Jeannerod & Nazir, 2008; Jeannerod, 2008). The covert meaning incorporates implicit modality-specific information about that word, while the *overt* (dictionary) meaning of a word contains lexico-semantic information. The two "meanings" are represented in two distinct, but interacting systems in the brain. In the case of words referring to auditory phenomena this knowledge would involve, for example, the ability to distinguish two near synonyms, such as *snort* and *grunt* or *stammer* and *stutter*. In other words, the covert meaning of the word 'bark' is the barking sound itself.

We adopt Jeannerod's (2008) position, and assume that sound generation for concrete linguistic labels is crucial for recovering the covert meaning of words referring to auditory phenomena. There are subtle differences between the words mentioned earlier that can only be captured by the reactivation of auditory representations. Similarly, the linguistic meanings of *oboe*, *tuba*, *horn*, and *clarinet* are not sufficient for the referential binding of the linguistic labels to the corresponding sounds. This, of course, does not mean that we cannot have a concept of an *oboe* without having a representation of the sound it produces. The thought experiment with musical instruments is intended to illustrate why language users might simulate the sounds encoded in the sentences.

Previous behavioural and neuroscientific studies have focused on concrete language describing sounds (e.g., Ballas, 1993; Bussemakers and De Haan, 2000; Chiu and Schachter, 1995; Cummings, Čeponiene, Koyama, Saygin, Townsend, Dick, 2006; Cummings, Čeponiene, Dick, Saygin, Townsend, 2008; Friedman, Cycowicz, Dziobek, 2003; Kaschak, Madden, Therriault, Yaxley, Aveyard, Blanchard, 2005, Kaschak, Zwaan, Aveyard, Yaxley, 2006; Kemmerer, Castillo, Talavage, Patterson and Wiley, 2008; Kiefer, Sim, Herrnberger, Grothe, Hoenig, 2008; Orgs, Lange, Dombrowski, Heil, 2006, 2007; Schön, Ystad, Kronland-Martinet, Besson, 2010; Stuart and Jones, 1995; Van Petten and Rheinfelder, 1995).

Although language describing abstract sounds is hitherto underexplored in the literature, a number of studies indicate that specific sounds do affect the processing of concrete language describing these sounds, and *vice versa* (concrete sound-related language can activate sound representations). For example, an electrophysiological study on sounds and language by Van Petten and Rheinfelder (1995) shows that conceptual relationships between spoken words and environmental sounds influence the processing of both types of representations. In their study, an N400 effect was found to sounds preceded by inconsistent words, for example, the sound of helicopter rotor preceded by the word 'dog' instead of 'helicopter'. The N400 is a negative ERP component that is related to semantic processing and elicited to unexpected word or other meaningful stimuli. In the study by Van Petten and Rheinfelder, words preceded by related sounds elicited smaller N400 components than those preceded by unrelated sounds. When testing conceptual relatedness effects, it is usually found in N400 studies that the amplitude of N400 is reduced to related stimuli: the less familiar the stimulus, the larger the N400.

Along these lines, Schön et al. (2010) have recently reported a relatedness-effect at an early time window in the event-related brain potentials for both sound-word and word-sound pairs presented sequentially. Their results suggest that sounds and words are processed conceptually similarly on the level of the nervous system.

Similarly, Orgs et al. (2006) observed priming for sounds and words in response latency and event-related brain potentials. Reaction times were shorter when an environmental sound was followed by a related word. Both word and sound stimuli produced an N400-effect for unrelated compared to related trials. In the word/sound condition an N400-effect for unrelated trials started as early as 200 ms post stimulus. These findings can be considered as evidence for the hypothesis that the conceptual processing of environmental sounds is similar to the processing of words (if words are presented in the auditory modality).

The famous Stroop-effect (Stroop, 1935) was also observed in the auditory domain. In the original visual colour-word interference or "Stroop" task, a colour word is presented in an incongruent colour ink and the participant has to identify the colour of the ink. It is found that reaction time is slowed relative to a control (nonword) presentation of that colour. Thus, participants cannot ignore the irrelevant information. Presumably, two colour names are activated at a prespeech stage, but the name arising from the printed word must be suppressed for the correct response.

Stroop analogues in the auditory domain have been documented, for example, in the interaction between pitch and word meaning (high and low) (McClain, 1983; Walker and Smith, 1984), and between the ear of presentation and word meaning (left or right) (MacLeod, 1991; Pieters, 1981). For instance, McClain (1983) demonstrates the inability to ignore the semantic content of a spoken word when pitch categorization is the task. Essentially, participants are hindered in the incongruent condition, when they hear the words 'high' or 'low', which indicates that the meaning of tone-related words interact with the perception of tones, given a simultaneous setting. Auditory analogues of the Stroop task therefore point to an intimate connection between non-linguistic representations and their linguistic labels.

Kemmerer, Castillo, Talavage, Patterson and Wiley's (2008) fMRI study shows, for example, that specific types of verbs activate the corresponding brain areas during a semantic similarity task. Five classes of verbs were tested, including Speaking Verbs (e.g., *shout*, *mumble*, *whisper*). Importantly, this class of verbs elicited activation in the auditory cortex while the subjects performed the semantic similarity task. This result supports the hypothesis of Perceptual Symbol Systems, according to which conceptual knowledge is grounded in sensorimotor systems. The results, however, do not rule out the alternative that these brain activations are artefacts of the similarity judgement task, and would not be recruited during normal language use. Therefore, the findings do not lend support to the strong version of the Embodiment Hypothesis which claims that modality-specific information is an inherent part of conceptual representations.

It may be the case that language users have a dictionary meaning for ‘cry’, ‘shout’, ‘scream’, and ‘shriek’ (overt meaning) but it appears implausible that the mental system operates exclusively with such *amodal* symbols during language use. Further, it appears to be difficult or even impossible to capture the meaning of these words without accessing any auditory representation.

All the studies mentioned above emphasize that semantic representation and sensorimotor processing have a common neuronal substrate, and that mental simulation is fundamental to language comprehension. The studies, however, do not agree unanimously over the role of embodied representations: the critical question is whether non-linguistic representations are necessary for conceptual processing, or if they are just consequences or post-hoc elaborations of linguistic processing (sometimes referred to as later/secondary cognition), as suggested, for example, by the LASS theory (Barsalou et al., 2008). Crucially, the time course and neural locus of activation determine whether embodiment effects reflect post-conceptual strategic processes, such as imagery, or if they are conceptual features.

Recent neuroimaging (fMRI) and electrophysiological research by Kiefer et al. (2008), for example, confirms that acoustic features constitute the conceptual representation of sound-related concepts. Kiefer and his colleagues measured event-related brain potentials while participants performed lexical decisions on visually presented words. Results show that words that denote objects for which acoustic features are highly relevant (e.g., ‘telephone’) rapidly ignite cell assemblies in the posterior superior and middle temporal gyrus (pSTG/MTG) that are also activated by listening to real sounds. Importantly, activity in the left pSTG/MTG had an early onset of 150 ms, which suggests that the effect has a conceptual origin rather than reflecting late post-conceptual imagery because pre-lexical processes, such as visual word recognition, operate in this time-window. In other words, the results of Kiefer et al. (2008) support the strong version of the Embodiment theory (e.g., Lakoff and Johnson, 1980, 1999) in that they show that the understanding of language referring to auditory phenomena is grounded in auditory representations.[27] It would be worthwhile investigating abstract sound-related language in the same way and compare it to literal language.

[27] The results of Kiefer et al. (2008), however, can be interpreted in four ways based on Mahon and Caramazza (2008): (1) the word ‘telephone’ directly activates the auditory system, with no intervening access to abstract conceptual content; (2) the word ‘telephone’ directly activates the auditory system and in parallel activates abstract conceptual content; (3) the word ‘telephone’ directly activates the auditory system and then subsequently activates an abstract conceptual representation; and finally, (4) the word ‘telephone’ activates an abstract conceptual representation and then activates the auditory system.

Language-to-sound priming is understood as the sound-evoking capacity of linguistic stimuli. Importantly, the relationship between sounds and language may not be unidirectional, but rather bidirectional. Therefore, we define sound-to-language priming as a priming effect from sounds to language. The two experiments in this study, which both use the priming protocol, investigate the nature of this two-way connection between linguistic stimuli and sound representations in both the concrete and the abstract domains.

All the experiments mentioned above focus only on the connection between concrete language and sounds. The present paper investigates whether the processing of metaphorical sentences (including idioms), such as *The reporter* *blew the whistle* *on doctors for malpractice* are also affected by *specific* sounds, such as 'blowing the whistle', or 'ringing a bell', and crucially, whether these sentences activate auditory representations.

The major aim of our research is to assess whether fictive sound sentences evoke sound representations and, if so, under what circumstances this phenomenon occurs. The hypotheses we put forward are tested through the emergence or absence of the so-called congruency-effect: congruent sounds, which match the verb, facilitate (or inhibit) linguistic processing as opposed to incongruent sounds, which mismatch the verb.

Based on previous research (Kaschak et al., 2005, 2006; Bergen, 2007), we know that, depending on the congruency of the stimuli, the modality (intra- or cross-modal) and the course of presentation (whether stimuli are presented simultaneously or sequentially), different effects emerge in experiments exploring sounds and concrete language. The two experiments described in the present study both use a cross-modal paradigm with the sentences presented in a written form. The stimulus presentation sequence varies between the experiments, as is detailed below.

2. Experiment 1 – sound-to-language priming

2.1. *Paradigm*

The goal of the experiment was to determine whether specific sound stimuli affect linguistic processing of concrete and abstract sentences describing sound events. Participants read concrete and abstract sentences encoding specific sounds on the computer screen while at the same time listened to a sound stimulus. Participants' task was to make sensibility judgements on the sentences. The sensibility judgement task was chosen to minimize the processing burden, and thus avoid any potential artefacts, i.e., artificial processing (meta-)strategies when interpreting the sentences. For example, an explicit relatedness judgement task, in which participants compare sound stimuli to sentences, would induce such strategies.

Four categories of sounds were selected for the experiment: congruent sounds match the sound described by the verb, incongruent sounds come from the same semantic field as the verb but do not match the sound described by the verb, semantically unrelated sounds are taken from a semantic field distinct from that of the verb, and a no sound condition. The incongruent category was introduced because we assumed that within-category items (incongruent) and category-external items (unrelated) might exert different effects on processing. This assumption is bolstered, for example, by an electrophysiological reading study by Federmeier and Kutas (1999) which showed that within-category items elicited a smaller N400 than category-external items, even though both kinds of unexpected items are equally inappropriate and implausible.

We would like to see if participants' processing of the sentences is affected by the sound-conditions, that is, by the category of the sounds they hear. Provided that the sound stimuli are processed before the critical linguistic stimuli in the sentences, which we can assume in this case, congruent sounds are expected to have a priming effect. We further hypothesize that unrelated (category-external) sounds will have an inhibitory effect on sentence processing relative to the no sound condition based on previous research demonstrating that unrelated items "disrupt" processing only given a long SOA (see Neely, 1991, for a review; Plaut and Booth, 2000). These effects are expected to emerge for both the set of concrete and the set of abstract sentences.

2.2. *Method*

2.2.1. *Participants*. Seventy-seven students from the Budapest University of Technology and Economics participated for course credit (*Mean age*: 22.5, *Age range*: 17–32; 33 female and 44 male participants). All participants were native Hungarian speakers with self-reported normal hearing sensitivity bilaterally and normal or corrected to normal vision.

2.2.2. *Stimuli*. 24 critical sentences and 36 filler sentences were constructed (24 of the filler sentences were semantically anomalous, not encoding any sound event, e.g., 'The pencil fainted during the concert', and 12 were semantically anomalous, also describing a sound event, e.g., ‘The contact lens sang a song’). The critical verbs, which were in the past tense, were always embedded in the middle of the sentences. This word order was chosen because it is considered to be neutral in Hungarian, although verbs can also be put at the end of sentences in Hungarian for emphasis. Nevertheless, the neutral tone can be preserved if verbal prefixes are not dislocated. So, for example, a sentence, such as ‘The water boiled (literally: *up-boiled) in the dish’ is equally neutral in Hungarian as the sentence ‘The water in the dish boiled (*up-boiled)’ given the ‘up’-prefix is not dislocated.

Sentences required an affirmative response, that the sentence made sense, in half the trials, and a negative response in the other half. The test texts were complete sentences rather than single words or phrases, since non-literal language can only be tested embedded in sentence context.

The critical sentences were 12 concrete and 12 abstract sentences that encoded sounds (e.g., ‘The wolf was howling in the woods’ and ‘The name of the teacher rang a bell to the student.’). The critical sentences were categorized by 8 raters as being either concrete or abstract. None of the sentences was ambiguous in terms of abstractness.

The critical sentences and their corresponding sounds can be seen in the Appendix (APPENDIX). The environmental sounds comprised living (animal sounds, human sounds) and manmade (musical instruments, sounds of machines) objects, such as the sounds of ‘lion’, ‘airplane’, ‘laughter’, ‘whip’, ‘siren’, ‘boat horn’, etc. The sounds were wave files[28] (used by Marcell, Borella, Greene, Kerr & Rogers, 2000). The sampling rate of the sounds was 44.1 kHz with 16-bit quantization.

The four sound conditions were: (1) congruent sounds, (2) incongruent sounds, (3) unrelated sounds, and (4) no sound. For example, as the sentence *A sajtó kongatta a vészharangot* (‘The press rang alarm bells’) was read by the participants, some participants heard a congruent sound (bell ringing), some heard an incongruent sound from the same semantic category (drums), and others heard an unrelated sound from a different semantic category (laughter). In the fourth sound condition participants did not hear any sound at all.

We wanted to eliminate the potential use of participant strategies (sensitization to sound types) and to reduce error variance associated with between-participant designs. For example, it can be the case that the embodiment effect under investigation is subtle and large inter-

[28] The sound files can be downloaded from the following web page: http://www.cofc.edu/~marcellm/confrontation%20sound%20naming/zipped.htm

participant variances may contaminate the data. Therefore, we manipulated the Sound Conditions within participants so that differences in strategies could not explain the results.

The assignment of items (sentences) to conditions (Sound Conditions) was randomised within each participant, so that the proportion of sentences in both the four Sound Conditions and the two Sentence Type conditions (concrete/abstract) was kept fixed throughout each experimental session. In other words, every participant read an equal number of sentences in every Sound Condition and Sentence Type Condition, while at the same time the number of concrete or abstract sentences in every Sound Condition was also counterbalanced. This type of counterbalancing was used to avoid block effects (list effects) associated with incomplete counterbalancing procedures (e.g., the use of pseudo-randomly organized counterbalance lists). Half of the trials came with sound stimuli, and half of them were presented without any sound in a randomised manner in every experimental session.

2.2.3. *Procedure*. Participants were first presented with an instruction screen. They were asked to read the sentences appearing on the computer screen and press the ENTER key if they thought the sentence made sense or the SPACE key if they did not think the sentence made sense. They were also instructed not to pay attention to the sounds they would hear during the sentences. Participants were informed that they were taking part in a study in which it is tested how environmental sounds affect the reading of sentences in general. Each participant was tested individually in one session lasting approximately 12 minutes. Participants first completed a practice phase, in which they were familiarized with the logic of the experiment. One trial consisted of a sentence and a sound. The sentence appeared in the centre of the computer screen in synchrony with the sound. The sentences appeared one after the other with a fixation cross appearing between trials for 1000 ms. The sounds were presented binaurally and continuously using E-Prime until the subject responded by pressing either of the two keys. There was no limit on response time, i.e., subjects could spend as much time reading the sentences and making their sensibility judgements as they wished: however, subjects were asked to respond to the sentences as quickly as possible. The trials were randomised across participants.

2.3. *Results and discussion*

The practice trials and the filler items were excluded from the analyses as were the erroneous trials. Participants made accurate judgements in 90 percent of trials overall. The mean of the median reading times of the critical sentences was taken. The data of 2 participants were excluded from the analyses (overall accuracy under 75%), thus the statistical analyses were carried out on the data of 75 participants.

Mean reading times were analyzed in a participant-based 2*4 mixed ANOVA model with Sentence Type (two levels) and Sound Condition (four levels) as within-participants factors. Missing values were replaced by series means. For the entire sample, the results show a significant main effect of Sentence Type,[29] $F(1, 157) = 85.004$; $p < 0.001$. The main effect of Sound Condition was marginally significant, $F(3, 155) = 2.624$; $p = 0.053$. The interaction (Sentence Type*Sound Condition) was not significant, $F(3, 155) = 0.458$; $p = 0.712$; n.s. Planned post-hoc testing was performed using the Least Significant Difference test (LSD) to test the four levels of Sound Condition (congruent, incongruent, unrelated, and no sound). Only the congruent-unrelated comparison yielded significance ($p = 0.011$): unrelated sounds (*Mean*: 2288.27 ms, *SE* = 137.38) inhibited processing relative to the congruent sound condition (*Mean*: 2124.20 ms, *SE* = 136.52).

The concrete and the abstract sub-samples were also tested *separately*. Subsequent univariate analyses of variance show that there is a significant main effect of Sound Condition in the concrete domain, $F(3, 67) = 4.277$, $p = 0.008$, but not in the abstract domain, $F(3, 72) = 0.639$, $p = 0.592$, n.s. Figure 1 illustrates the mean reading times of the concrete and the abstract sentences in the four conditions:

[29] Abstract sentences were read significantly slower than concrete sentences. This result is due to the fact that abstract sentences were longer than concrete sentences. We did not control for sentence length as we were not interested in comparing reading times of the concrete sentences with those of the abstract ones.

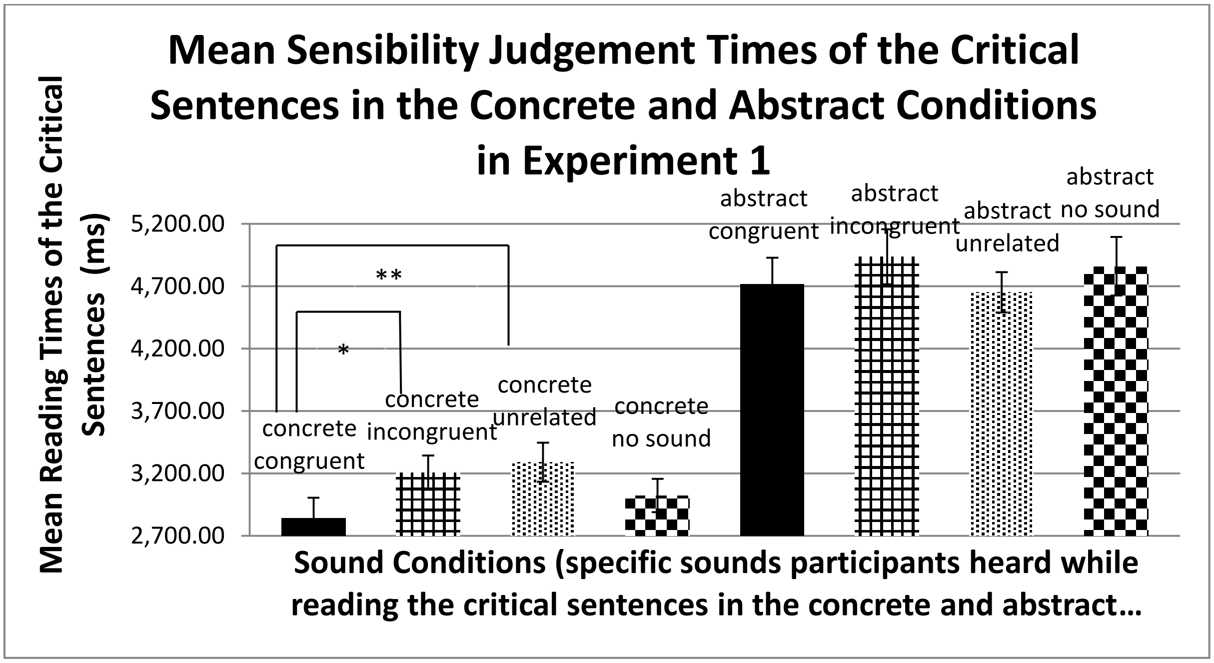

Figure 1. Results of Experiment 1 are shown in terms of Mean Reading Times (sensibility response times) in ms (plotted on the ordinate) as a function of Sound Condition (plotted on the abscissa). The columns represent mean reading times of the concrete and the abstract sentences in the four sound conditions. Concrete sentences in the congruent sound condition were processed significantly faster than those in the incongruent condition. Concrete sentences in the congruent sound condition were processed significantly faster than those in the unrelated condition. The error bars represent standard errors of the mean. Asterisks indicate levels of significance (* p < .05, ** p < .01, *** p < .001). An absence of linking bars indicates that the comparison in question was not significant.

Figure 6. ***Mean Sensibility Judgement Times of the Critical Sentences in the Concrete and Abstract Conditions in Experiment 1 (Chapter 3.4.)***

Importantly, as predicted, participants reacted faster to concrete sentences in the congruent condition (*Mean*: 2844.23 ms, *SD* = 1339.83) than in the incongruent condition (*Mean*: 3206.24 ms, *SD* = 1147.89), as revealed by a significant difference between the congruent and the incongruent conditions in the concrete sub-sample (p = 0.016). Similarly, participants read concrete sentences faster in the congruent condition than in the unrelated sound condition (unrelated sound condition *Mean*: 3289.89 ms, SD = 1303.92, p = 0.002), which is compatible with our prediction that congruent sounds facilitate processing. However, there were no significant differences in the abstract sub-sample, which is inconsistent with our hypothesis. This finding shows that, since specific sounds do not influence abstract linguistic processing, specific sound representations are semantically not related to abstract sound-related language. In other words, abstract sentences in the present experiment are “frozen”, as shown, for example, by the idiom *kick the bucket* ‘TO DIE’, which does not activate the concepts ‘KICK’ or ‘BUCKET’.

Contrary to our prediction, we did not obtain a significant difference between the unrelated and the no-sound conditions for either concrete or abstract contexts. Irrelevant sounds, such as those in the unrelated condition, do not affect attention functions that would alter linguistic processing. The findings show that, given a long SOA, sounds only have an effect on linguistic processing if they are related to the semantics of the sentences.

3. Experiment 2 – language-to-sound priming

In Experiment 1, we have not provided any evidence that auditory experiential traces are *necessarily* and *automatically* evoked as a result of linguistic processing. Experiment 2 therefore is designed as a self-paced reading paradigm to eliminate the long stimulus onset asynchrony (SOA). This modification is crucial to rule out expectancy priming, which is a controlled process that operates at a long SOA (500 ms), or the possibility that sounds affect only word recognition. A second modification was that we employed the control question technique instead of the sensibility judgement task of the previous experiment because in the former case abstract sentences are read as naturally as concrete sentences and do not necessarily yield longer reading times than concrete sentences, thus, embodiment effects may be easier to unravel. This observation was based on our previous experimental results where the reading of abstract sentences required conscious effortful thinking in the sensibility judgement condition as opposed to the control question condition. Also, the superficial control question technique discourages participants to use post-conceptual auditory imagery strategies. The third modification was that we constructed five-word sentences from the sentence stimuli of Experiment 1 and put the verbs at the end of the sentences.

With respect to abstract sentences our working hypothesis is that during the understanding of metaphors, such as ‘blow the whistle on the students’ the concrete scenario need *not* be recreated along with the auditory component, that is, ‘blowing the whistle’, because the auditory representation in the mental model of the event described by the phrase is irrelevant to the abstract meaning. We base the assumption that abstract sentences are expected to be processed directly via their abstract meaning on the fact that sentences in the abstract condition are conventional sound-metaphors. This prediction is compatible with the Career of Metaphor Hypothesis by Bowdle and Gentner (2005) which claims that there is a shift from comparison processing in the case of novel metaphors to categorization processing in the case of conventional metaphors. In the light of the literature, this assumption is in agreement with alternative accounts to metaphoric representation, such as Vigliocco et al. (2004) or the conception that level of processing determines the activation of embodied representations (Louwerse and Jeuniaux, 2008), but it is clearly inconsistent with the strong embodiment approach (Lakoff and Johnson, 1980, 1999). This hypothesis for abstract sentences can be operationalized in our experiment as the absence of a congruency-effect (an insignificant congruent vs. incongruent comparison) in the abstract domain.

As for the concrete sentences, we hypothesize that sound representations are activated during reading. This hypothesis is consistent with previous research on sounds and concrete words, such as Kemmerer et al. (2008), Kiefer et al. (2008), Orgs et al. (2006), Schön et al. (2010), or Van Petten and Rheinfelder (1995). We expect the congruency-effect to emerge for concrete sentences. Another question to ask is whether these activations result from the ability of isolated lexical or phrasal items (such as ‘blow the whistle’) to prime sound representations, or else they are the product of sentence-level processing. Bergen (2005), for example, found that lexical items, such as verbs or nouns can trigger simulations. If differences in RT patterns between concrete and abstract sentences were found, then that would indicate that sentential processing (or metaphoric processing *per se*) evokes sound representations, rather than isolated lexical items.

All in all, our hypothesis is that if the perceptual symbol (sound representation) is necessarily and automatically activated, then results should yield a congruency-effect (a significant difference between congruent and incongruent items) because the brain will register the discrepancy. If, however, sound stimuli prime only semantic categories, then no congruency-effect should emerge in a simultaneous cross-modal presentation setting because the brain will treat both sounds as belonging to the same semantic category. The former statement is consistent with the strong version of the Embodiment Hypothesis (e.g., Lakoff and Johnson, 1980, 1999), while the latter is consistent with shallow processing accounts (e.g., Barsalou, 1999; Louwerse and Jeuniaux, 2008).

3.1. *Paradigm*

A new group of participants were recruited. Participants were presented first with an instruction screen which said that they would read sentences in a self-paced manner, and that they could not return to previously read word material. On each trial, participants read concrete and abstract sound-related sentences one word at a time (“static window”, i.e., central presentation) in a self-paced reading paradigm. We used the self-paced reading paradigm because we wanted to measure the reading times of the critical verbs. The sound stimuli were taken from the sound conditions of Experiment 1. The participants’ task was to read the sentences word-by-word, and after reading the last word of each sentence they had to answer a control question related to the sentence they have just read. The control questions were presented in the form of statements that participants had to answer by either pressing a ‘yes’ or a ‘no’ key. For example, after reading the sentence ‘The press rang the alarm’ participants received the false statement ‘the press was optimistic’ (for which they had to press the ‘no’ key). In synchrony with the last word (i.e., the critical verb), a sound stimulus was played in both ears, that is, the perception of the sound and the verb occurred within the same episode, reducing the SOA to zero. Similarly to Experiment 1, participants were instructed not to pay attention to the sound stimuli. The cover story was that the study investigated how environmental sounds could distract readers.

Four categories of sounds were presented: congruent sounds (which matched the sound encoded by the verb), incongruent sounds (which did not match the sound encoded by the verb; these were taken from the semantic field of the verb), unrelated sounds (which came from a different semantic field), and a no sound condition. Sentence Type (concrete/abstract) and Sound Condition were within-participants factors.

3.2. *Method*

3.2.1. *Participants*. Eighty-three Hungarian university students (*Mean age*: 22.23, *Age range*: 18–31) of the Budapest University of Technology and Economics participated for course credit. As in Experiment 1, four sound conditions were presented: congruent sounds, incongruent sounds, unrelated sounds, and no sounds. All participants were native Hungarian speakers with self-reported normal hearing sensitivity bilaterally and normal or corrected to normal vision.

3.2.2. *Stimuli*. The sentences and the sound stimuli of Experiment 1 were used with minor changes: five-word sentences were constructed in which the critical verb appeared as the last word, for Hungarian allows verb-last word order. Further sets of new filler sentences (40 fillers) were introduced which also contained sound events. Half of the trials came with sound stimuli, and half of them were presented without any sound in a randomised manner in every experimental session. The same counterbalancing procedure was used as in Experiment 1 (cf. 2.2.2.) in order to preclude the use of strategies and reduce inter-participant error-variance.

3.2.3. *Procedure*. Participants were presented first with an instruction screen which informed them that they would read sentences one word at a time by pressing a key (SPACEBAR) when they were ready to move to the next word, but they could not return to previously read words. The instructions went on explaining that at the end of the sentences, that is, on the point of the last word, they would hear a sound; participants' task was to read the sentences and answer a control question after each sentence. The control questions, which were statements related to the contents of the critical sentences, were constructed as simple as possible. For instance, participants read the control question 'the bomb exploded on a truck' ('yes' or '<u>no</u>') after the sentence 'the bomb exploded in the school'. A practice phase was included before the test trials in which participants received feedback about their responses. A fixation cross preceded each trial for one second. The trials were randomised across participants.

3.3. *Results and discussion*

The practice trials were excluded from the analyses as were the filler items. Erroneous trials – where the wrong answer was given to the control question – were also excluded from the analyses. The data of four participants were discarded (overall accuracy under 75%). The overall accuracy rate for the critical trials was 92 percent. The means of the median reading times of the critical verbs were taken.

Mean reading times were first analyzed in a participant-based 2*4 mixed ANOVA model with Sentence Type (two levels) and Sound Condition (four levels) as within-participants factors. The analysis for the entire sample showed a significant main effect of Sentence Type, $F(1, 145) = 30.097$, $p < 0.001$, and also a significant main effect of Sound Condition, $F(3, 143) = 8.848$, $p < 0.001$. The interaction (Sentence Type*Sound Condition) was also significant, $F(3, 143) = 4.485$, $p = 0.005$.

LSD post-hoc tests were carried out for the entire sample. Sentences, more specifically, the critical verbs in the unrelated sound condition (*Mean*: 786.26 ms, *SE*: 26.29) were read significantly slower than those in the no sound condition (*Mean*: 681.73 ms, *SE*: 21.47), $p < 0.001$. Incongruent sounds (*Mean*: 764.36 ms, *SE*: 28.41) inhibited processing relative to the no sound condition ($p < 0.001$). Similarly, sentences in the congruent sound condition (*Mean*: 756.66 ms, *SE*: 30.58) were read significantly slower than those in the no sound condition ($p = 0.002$). These findings may indicate that sounds distract readers irrespective of sound stimulus type in a simultaneous setting. Most importantly, however, there was no difference between reading times in the congruent and the incongruent sound conditions ($p = 0.673$, n.s.). The results for the two sub-samples (concrete and abstract) are summarized in Figure 2.

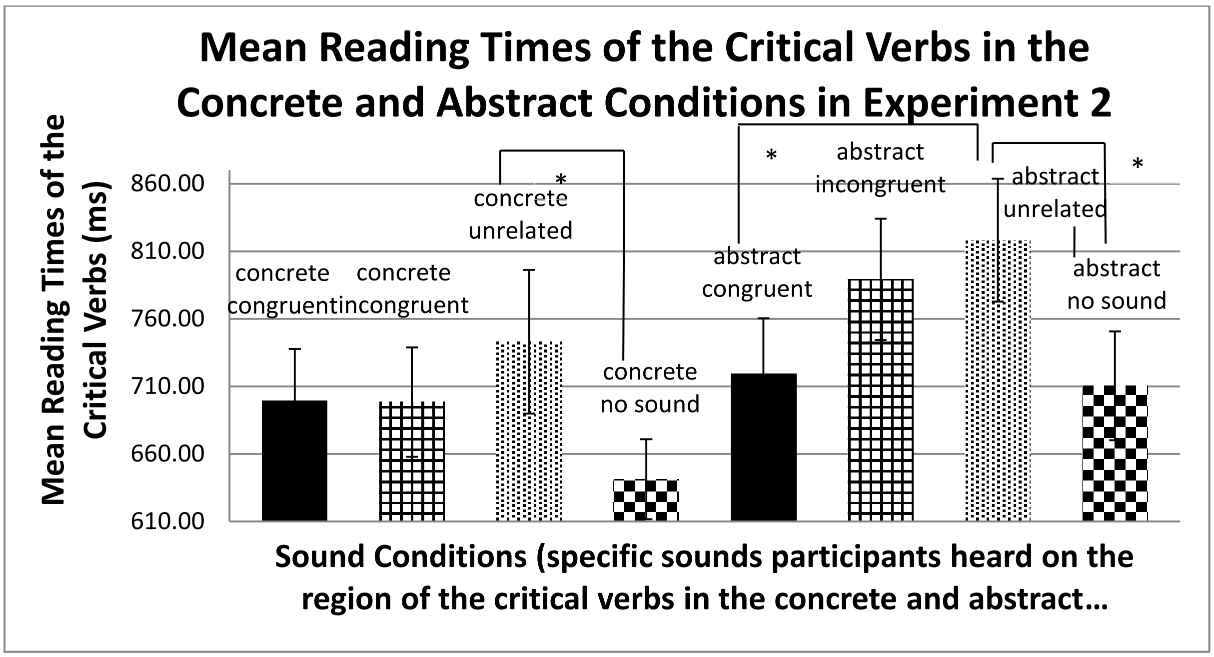

Figure 2. Results of Experiment 2 are shown in terms of Mean Reading Times in ms (plotted on the ordinate) as a function of Sound Type (plotted on the abscissa). Congruent sounds are those that match the meaning of the verb (e.g., a 'barking' sound after the sentence 'the dog was barking'). Incongruent sounds were taken from the same semantic category as the verb (e.g., the sound of a cat meowing with the sentence 'the dog was barking'). Unrelated sounds are out-of-category sounds. Mean Reading Time refers to the mean reading time of the critical verbs. For both the set of concrete and the set of abstract sentences, reading times in the unrelated condition were significantly slower than those in no sound condition. The error bars represent standard errors of the mean. Asterisks indicate levels of significance (* $p < .05$, ** $p < .01$, *** $p < .001$). An absence of linking bars indicates that the comparison in question was not significant.

Figure 7. ***Mean Reading Times of the Critical Verbs in the Concrete and Abstract Conditions in Experiment 2 (Chapter 3.5.)***

In order to explore the two sub-samples, follow-up univariate analyses were carried out to test the concrete and abstract sub-sets separately. Only significant comparisons are listed here (cf.

Figure 2). For the concrete sub-sample, the main effect of Sound Condition was not significant, $F(3, 67) = 1.943$, $p = 0.131$. The unrelated-no sound comparison yielded significance ($p = 0.023$). For the abstract sub-sample, there was a significant main effect of Sound Condition, $F(3, 65) = 2.952$, $p = 0.039$. The congruent-unrelated ($p = 0.012$) and the unrelated-no sound ($p = 0.019$) comparisons yielded significance. The significant slow-down in reading in the unrelated condition for both sub-sets indicates that unrelated sounds passively influence processing under a short SOA condition. Importantly, the congruent-incongruent comparisons did not reveal any significant differences in either concrete or abstract contexts.

Neither the analysis for the entire sample, nor the analyses for the sub-samples confirmed that sound representations are activated. It should also be noted that none of the concrete or the abstract congruent-incongruent item-comparisons yielded significance, which indicates that the absence of the congruency-effect is not due to some of the verb stimuli contaminating the results (e.g., some verbs that do not routinely evoke any sound representations). As referred to earlier in the present article, auditory conceptual features have been shown to be activated within the very short time window of 150 ms after stimulus onset for concrete sound-related words (Kiefer et al., 2008). Because the congruency-effect was not revealed in the time-window of more than 600 ms in our experiment, the absence of the congruency-effect points to the conclusion that no auditory conceptual features are routinely evoked in shallow linguistic processing. Rather, shallow linguistic processing accesses lexico-semantic information only. The 600 ms time-window rules out that auditory *conceptual* features are activated in a delayed manner, i.e., after having seen the critical verb. According to this hypothesis the target site (time-window) of the congruency-effect is derived from *post-conceptual* processing. Our finding indicates that activation of auditory conceptual features should occur before or in parallel with lexical retrieval.

This result is compatible with spreading activation theories (e.g., Anderson, 1983; Neely, 1991) and distributed network theories of semantic content (McRae, de Sa & Seidenberg, 1997). Category-external items (unrelated sounds) inhibit processing relative to category-internal items (congruent, incongruent, or no sounds), given a short SOA.

Data are consistent with the shallow level processing account (Barsalou, 1999), according to which not all cognitive tasks utilize simulation (auditory mental simulation).[30] In other words,

[30] Lexical decision, synonym judgements, orthographic discrimination judgements, recognition tasks, etc. require shallow processing, whereas, for example, semantic similarity judgements utilize deep processing. What it amounts to is that situated simulations are modulated by task conditions (Louwerse and Jeuniaux, 2008).

semantic representation is still possible without access to auditory representations (Vigliocco et al., 2004).

These results are clearly inconsistent with Radical Embodiment approaches (strong embodiment accounts) which claim that auditory representations are necessarily and directly recruited. Therefore, cognitive simulation in the auditory domain is not fundamental to language processing.

4. General discussion

In Experiment 1, we investigated whether specific sounds affect linguistic processing. A significant difference between the congruent and the incongruent conditions was observed in the concrete sub-sample but not in the abstract domain. Subjects processed concrete sentences faster in the congruent condition compared to the unrelated condition, indicating that congruent sounds have a facilitatory effect on linguistic processing given the unrelated condition as the baseline and the long SOA.

The simplest explanation for the priming effect in the congruent condition in Experiment 1 is that the sounds were processed before the critical verbs were encountered, since the sounds appeared in synchrony with the sentences in each trial, while the critical verbs were the third words in the sentences.

It can be observed that for both concrete and abstract sentences, the difference between the unrelated and the no sound conditions was not significant, which indicates that irrelevant sounds *per se* do not impair or facilitate linguistic processing. The reason for this finding could be that ambient distraction does not normally influence reading, e.g., listening to music or being exposed to environmental sounds while reading a newspaper does not disrupt linguistic processing. In one study, conducted by Carter (1969), the increased amount of simultaneous auditory distraction, such as school sounds, did not significantly affect the reading performance of either brain-injured or non-brain-injured participants. Along these lines, Tucker and Bushman (1991) showed that reading comprehension remained constant while participants listened to rock and roll music.

However, in Experiment 1 sounds may have only facilitated word recognition. In other words, sounds might have simply activated the linguistic representation that primed the recognition of the corresponding verbs and in turn facilitated reading times of the sentences. This question was taken up in Experiment 2, where the sound-language interface was explored in a short SOA setting.

The finding that concrete sounds do not affect abstract linguistic labels in Experiment 1 can be explained by dissociative representations of specific sounds and abstract conceptual representations. Other psycholinguistic studies have also shown that people do not necessarily analyse the literal meanings of idioms during the understanding of figurative phrases (e.g., Gibbs, Nayak, Cutting, 1989), such as our abstract sound-related sentences, which can account for the absence of transfer from specific sounds to abstract idiomatic language.

In Experiment 2, we measured reading times on the region of the critical verbs. Sound stimuli were superimposed on the critical verbs. We found that unrelated sounds inhibited processing compared to the no sound condition both for concrete and abstract contexts. However, the results of Experiment 2 may appear to be at odds with the results of Experiment 1, since congruence is expected to have a priming effect. The explanation for the different RT-profiles lies in the fact that Experiment 2 employed a task in which participants were *simultaneously* exposed to an auditory and a visual representation (SOA=0) as opposed to Experiment 1 with its long SOA. Previous research has also demonstrated (e.g., Plaut and Booth, 2000) that inhibition emerges only at a long but not short SOA.

The finding that unrelated sounds inhibited processing can be accommodated with previous results. Bussemakers and De Haan's (2000) experiments, for instance, show a similar pattern: congruent and even incongruent real-life sounds presented simultaneously with pictures lead to faster reaction times to the pictures compared to the unrelated condition (with category-external sounds). However, these results were obtained in a visual categorization task in which participants categorized pictures (animal or not animal) while passively listening to the sounds. Experiment 2, in contrast, employed a reading paradigm in which participants had to read sentences word-by-word.

In line with the RT profile of Experiment 2, DiGirolamo, Heidrich and Posner (1998) demonstrated in an event-related brain potential study that similar temporal and spatial patterns emerge for both the congruent (e.g., the word BLUE in blue ink) and the incongruent (e.g., the word RED in blue ink) Stroop-condition. These two conditions diverged from a neutral condition (e.g., the word KNIFE in blue ink) in an early time window of 268 ms. However, incongruent items disrupt processing at a later time window, as in our Experiment 1. The function of this inhibition is to resolve competition. Anderson and Spellman (1995) and Anderson (2003) also suggest that retrieval only inhibits related traces if they interfere with retrieval.

In Experiment 2, we have demonstrated that related sounds (congruent or incongruent items) do not affect linguistic processing differently from the no sound condition when sounds and linguistic stimuli are presented in the same episode (SOA=0). However, unrelated sounds hinder processing compared to the no sound condition because they prime category-external items.

The fact that the two experiments yielded different RT-patterns for the sound conditions can be explained with differences in SOA and task demand. In Experiment 1 sounds were presented at sentence onset, that is, before participants read the relevant phrase. Therefore, the congruency-effect in the concrete sub-sample is presumably due to expectancy priming, a slower process which operates from 700 ms onwards (Neely, 1977).

In contrast, in Experiment 2 the sounds and the critical verbs were presented in a temporal overlap. Our results can be explained based on Neely (1977) who demonstrates that an activated semantic node proceeds to activate linked semantically related nodes within an early time window: unrelated targets (bird – rake) were inhibited at a SOA of 400 ms. This is a fast-acting involuntary process which explains the inhibition in the unrelated sound condition and the non-significant comparison between the congruent and the incongruent conditions. The inhibitory power of unrelated sounds in this setting can therefore be explained with the short SOA.

Thus, the results of our two experiments can be conceptualized in a common framework proposed by Becker (1980) in which there is a shift from facilitation dominance of incongruent items at short SOAs to inhibition at long SOAs. However, the absence of the facilitatory power of incongruent (or congruent) sounds in Experiment 2 (cf. non-significant incongruent-no sound comparison in Experiment 2) can also be explained by the hypothesis that two sensory channels are recruited simultaneously in the presence of sounds (passive listening), and therefore attentional resources are divided unwillingly as opposed to the no sound condition. We also observed an absence of facilitation of congruent sounds relative to the no sound condition in Experiment 1, whose cause could be the relatively long SOA in Experiment 1 where the priming effect presumably dissipates.

The present findings provide additional evidence supporting the perception-language interface in the auditory domain. The results do not underscore the theoretical argument that the comprehension of abstract language is always affected by concrete representations (Kövecses, 2002; Lakoff and Johnson, 1980, 1999). As far as can be concluded from the results of Experiment 2, it is possible that the effects reflect fast-acting automatic shallow comprehension processes, as suggested by Barsalou (1999). Experiment 2 supports this conclusion as it provides evidence for language processing without accessing auditory representations. The results of Experiment 2, however, do not support the *strong* version of the Cognitive Metaphor Theory (strong embodiment), according to which abstract and concrete language understanding is grounded in the perceptual modalities. The superficial types of control questions used in Experiment 2 make participants amend their reading strategies to match the task demands, i.e. answering the control question correctly, thus, participants were probed implicitly regarding the auditory aspect of the sentences. If, however, "sound-provoking" control questions were applied, such as 'there was a jingling sound' ('yes' or 'no'?) to the critical sentence 'The silver spurs clattered', then different effects may emerge on the region of the critical verbs because this new task demand probably alters the reading styles of participants, and the new reading strategies will tap into deeper non-linguistic information, such as auditory imagery. In this case readers will probably generate auditory representations and draw inferences from it, rather than skimming over the sentence in a superficial manner. Nevertheless, the "superficial" type of control questioning was chosen deliberately in Experiment 2 in order to preclude artefacts, i.e., the explicit retrieval of auditory representations, while testing simple sentence understanding.

In sum, the two experiments presented in this paper extend our understanding of the interface between environmental sounds and language in the following directions: specific sounds influence linguistic behaviour (Experiment 1) in the concrete domain, and that sound simulation is not fundamental to language processing (Experiment 2).

It remains unclear from the results of the present research whether there is a direct or indirect connection between auditory and linguistic representations. For example, it could be that there is an intermediate level of representation: sounds activate a semantic node (e.g., an amodal representation), which in turn activates the linguistic representation. This approach contends that linguistic meaning is not directly grounded in sound representations.

The questions of whether sounds affect linguistic processing and whether linguistic processing affects sound perception cannot be seen as two approaches to the same process. Boroditsky (2000), for example, found that spatial representations primed their consistent temporal schemas, whereas there was no transfer from the domain of time to the domain of space, indicating that – although space and time share structured relational information on-line – this sharing is asymmetric. We have also found that the two-way connection between sounds and language is asymmetric: although sound stimuli affect linguistic processing in the concrete domain (Experiment 1), language processing does not routinely activate sound representations either in the concrete or the abstract domain (Experiment 2).

5. Conclusions

In Experiment 1, we sought to answer the question of whether specific environmental sounds (e.g., 'barking') affect concrete and abstract sound-related linguistic processing. Of particular interest was whether fictive sound sentences, such as *Researchers blow the whistle on malpractice*, an event that does not contain any sounds at all are also affected by concrete sound representations. The processing of the concrete but not the abstract sentences was influenced by the passive hearing of specific sounds. Reading times of concrete sentences were the fastest when participants listened to sound stimuli that were congruent with the sounds described by the sentence, and the slowest when they heard incongruent sound stimuli (congruency-effect). These results show that visual sentence processing is not only affected by non-specific auditory stimuli (auditorily invoked white noises) as demonstrated by Kaschak et al. (2006), but also by the processing of specific sounds.

In Experiment 2, we eliminated the long SOA condition of Experiment 1 by presenting the sound stimulus together with the verb instead of over the course of the whole sentence. It has been shown that SOA is a good predictor of congruency-effects: the congruency-effect emerges at a long SOA (Experiment 1) for the concrete sub-sample, while no facilitation-inhibition emerges given a short SOA (Experiment 2) either for concrete or abstract contexts. Crucially, again, no category-internal effect of auditory information on abstract language processing was confirmed. This experiment thus demonstrated that sound-related language does not routinely evoke sound representations.

Taken together, the findings of Experiment 2 are interpreted in the shallow processing account proposed by Barsalou (1999): language processing does not necessarily and automatically utilize simulation, but rather linguistic processing is contingent on lexico-semantic information. The results thus do not lend support to the strong version of the Embodiment hypothesis (e.g., Lakoff and Johnson, 1999), according to which language processing and semantic representation is dependent on accessing modality-specific representations. Contrary to the Embodiment position, the theoretical import of our study is that concrete or abstract semantic sound-related representation is possible without access to auditory representations. Our findings also extend the Cognitive Metaphor theory to the domain of environmental sounds and towards fictive sounds.

Future research might fruitfully explore the following questions: (1) what is the role of suppression (if any) in auditory representations? For example, comparing affirmative and negative phrases encoding fictive sounds, does the negated sentence *Her name doesn't ring a bell* engage auditory mental simulation similarly to the affirmative? Also, can different task-instructions inhibit or induce mental simulations? (2) The specificity of mental simulations is a very interesting question that would be worth pursuing further: do different kinds of concrete ‘ringing’ sounds recruit different samples of subtle auditory representations? (3) One could ask if there is a difference in the time course of activation of auditory representations triggered by concrete and abstract sentences in a task in which auditory representations are active.

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APPENDIX

The critical sentences in Experiment 1 and 2 can be seen below. Experiment 1 used the first 10 sentences from both concrete and abstract samples, Experiment 2 used 12 sentences in the form of 5-word sentences. The English translations may not always render the meaning of the abstract sentences, only their general senses. The underlined verbs in the sentences encode the sounds that are given in the congruent condition (the names of the objects/animals/musical instruments are given).

Abstract sentences (fictive sound event)	*congruent condition*	*incongruent condition*	*unrelated condition*
A sajtó kongatta a vészharangot. ‘The press rang the alarm.’	gong	drums	laughter
A diáknak zakatolt az agya a tanulástól. ‘The student’s brain was fried from studying too much.’	train	truck	cow
A betörő végigzongorázta az összes belépési kódot a házba. ‘The burglar keyed in every number combination to enter the house’	piano	violin	frog
A miniszterelnök összetrombitálta az ország vezetőit. ‘The prime minister blew the horn to summon the leaders of the country.’	trumpet	flute	lion
A verebek azt csiripelték, hogy fizetésemelés várható. ‘The birds were chirping about a salary rise.’	chirp	crow	airplane
A kormány beharangozta az új programot. ‘The government rang the bell to announce the new program.’	bell	whistle	horse
Az egyetemista lebőgött a vizsgán. ‘The student put up a bad show in the exam.’	cow	horse	siren
A bróker szétkürtölte a csőd hírét. ‘The broker sounded the horn to announce the news about the bankruptcy.’	horn	drums	cat
A titkárnő világgá kukorékolta a titkot. ‘The secretary disclosed the secret.’	rooster	duck	helicopter

A tanár neve ismerősen csengett a diáknak. 'The name of the teacher rang a bell to the student.'	bell	twang	pig
A korrupciós bomba felrobbant tegnap. 'The corruption bomb exploded yesterday.'	explosion	crash	harmonica
A ninjának felforrt a vére. 'The ninja was boiling with anger.'	boiling	frying pan sizzling	ice drop
Concrete sentences (concrete sound event)	*congruent condition*	*incongruent condition*	*unrelated condition*
A macska nyávogott a kertben. 'The cat was meowing in the garden.'	cat	bark	piano
A diák zongorázott a szobában. 'The student was playing the piano in the room.'	piano	violin	bark
A fiú dobolt a garázsban. 'The boy was playing the drums in the garage.'	drums	guitar	cat
A ló nyerített az istállóban. 'The horse was neighing in the stable.'	horse	cow	guitar
A lány trombitált a zeneiskolában. 'The girl was playing the trumpet in the music school.'	trumpet	flute	helicopter
Az oroszlán bőgött az állatkertben. 'The lion was roaring in the zoo.'	lion	elephant	airplane
A bácsi horkolt a vonaton. 'The old man was snoring on the train.'	snore	hiccup	rooster
A helikopter rotorja berregett a mező felett. 'The rotor of the helicopter was humming over the meadow.'	helicopter	airplane	owl
A kisgyerek sírt a bölcsőben. 'The baby was crying in the cot.'	cry	laugh	car
A farkas vonyított az erdőben. 'The wolf was howling in the woods.'	wolf	dog	train

A bomba <u>felrobbant</u> az iskolában. ‘The bomb exploded in the school.’	explosion	crash	harmonica
A víz <u>felforrt</u> az edényben. ‘The water boiled in the dish.’	boiling	frying pan sizzling	ice drop

3.5. Thesis 4: A psycholinguistic investigation of the strong version of the Embodiment Hypothesis in the domain of environmental sounds and language II.

Fekete, I., Babarczy, A. (submitted, 2012): A psycholinguistic analysis of 'fictive' sound events.

A psycholinguistic analysis of 'fictive' sound events[*]

Abstract

Sentences such as 'The professor blew the whistle on the students for plagiarising' contain an expression that describes a sound but does not refer to an actual sound event. The present study undertakes to explore the effects of auditory stimuli on the processing of such abstract sound-related language.

Two experiments were conducted that investigate the effect of sound stimuli on language processing. The experiments differed only in the timing of critical sound stimuli presentation. In Experiment 1, participants read concrete and abstract sentences in a self-paced manner while listening to any of the four types of auditory stimulus: for example, a sentence, such as 'The press rang alarm bells' was presented either together with the congruent sound (bells), with an incongruent sound (drums), with an unrelated sound (laughter), or without any sound. Sound stimuli were presented before the critical verbs. The task was to answer a control question after each trial. Results show that sound stimuli did not affect the processing of sentences.

In Experiment 2, another group of participants read the same sound-related sentences. Critical sound stimuli were now presented in synchrony with the verb. Sentences in both the concrete and the abstract sub-samples were processed significantly slower in the unrelated condition compared to the no sound condition. However, sentences in the congruent condition were not processed differently from those in the incongruent condition. Results suggest that fictive and concrete sound events are processed in a shallow manner without access to sound representations.

Key words: environmental sounds; mental simulation; abstract language; idioms; metaphor

1. Introduction

How do we understand metaphorical sentences that do not refer to concrete sounds in the environment but rather to abstract[31] or 'fictive'[32] sounds, such as *I would lose my job if I blew the*

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[31] The abstract (figurative, non-literal) sentences in the article are sometimes categorized as metaphors, although it could be argued that they are idioms. The terminology does not matter in the current study. Importantly, these sentences do not refer to real sound events, hence fictive. By abstract representation, we, the authors mean a conceptual process by which less real concepts or ideas, such as power, democracy, or whistleblowing ('reporting of wrongdoing'), are derived from the usage of literal concepts.

whistle on him; *His words rang true; He roared in delight; He drummed the rules into them; etc*. Do we hear those fictive sounds with our 'mind's ear' even if there is no sound event in the situational context? Put in more formal terms, is there a qualitative difference between the auditory representations activated by concrete sound-related language ('blow the whistle') and those activated by abstract language referring to sounds ('blow the whistle on the students').

It is reasonable to assume that the processing of concrete sound-related language (*The dog is barking*) gives rise to the simulation of the sound events encoded in these sentences because these sentences refer to real auditory phenomena in the world.

By extension, it is possible that the processing of abstract sound-related sentences also exhibits the same effects. No empirical studies that we know of have touched upon the comprehension of abstract sound-related language until now, but previous research, for example, on fictive motion sentences (Matlock et al., 2005; Talmy, 2000) suggests that sound-related expressions might behave similarly. However, in principle it is equally plausible that the abstract meaning is directly accessed and the literal sound is not activated.

The broader theoretical approach, according to which we expect sound stimuli to affect linguistic processing, and linguistic stimuli to activate sound representations is the theory of Perceptual Symbol Systems as advocated by Barsalou (1999) and the paradigm of Simulation Semantics (Bergen, 2007; Zwaan and Madden, 2005). Barsalou (1999) claims that the simulated event evoked by the linguistic representation also contains auditory experiences (auditory experiential traces), e.g., the experience of hearing the engine roar as a consequence of the processing of the concept 'engine'. Simulation Semantics also emphasizes that language

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[32] An interesting study that deals with a similar phenomenon in language was conducted by Matlock, Ramscar and Boroditsky (2005) who investigated fictive motion in language, such as the sentence *The road runs along the coast*. We adopted this terminology to describe abstract sounds.

understanding involves the mental simulation of modality-specific information, which is a previously stored perceptual experience.

One function of mental simulation is to prepare for situated action (Barsalou, 1999; Glenberg and Kaschak, 2002). The theory of mental simulation proposes that language users construct modality-specific simulations of the perceptual and motor content of experiences described by the linguistic input. On the basis of these simulations and situation models detailed inferences are drawn about the situational content of utterances (Barsalou, 1999; Bergen, 2007; Narayanan, 1997). We seek to answer the question whether sound representations are also activated as a result of sound-related language processing.

In support of the theory of Perceptual Symbol Systems, Kemmerer and colleagues' (2008) fMRI study showed, for example, that specific types of verbs activate the corresponding brain areas during a semantic similarity task. Five classes of verbs were tested, including Speaking Verbs (e.g., *shout*, *mumble*, *whisper*). Importantly, this class of verbs elicited activation in the auditory cortex while the subjects performed the semantic similarity task. This result supports the hypothesis of Perceptual Symbol Systems, according to which conceptual knowledge is grounded in sensorimotor systems. The results, however, do not rule out the alternative that these brain activations are artefacts of the similarity judgement task, and would not be recruited during normal language use.

Mental simulation effects for abstract representations can also be interpreted in another framework[33], the Cognitive Metaphor Theory (Kövecses, 2002; Lakoff and Johnson, 1980,

[33] However, there are several other accounts of how abstract concepts may be represented by simulation, such as simulation by concrete situational and introspective experiences (Barsalou and Wiemer-Hastings, 2005), or emotional affective states (e.g., Winkielman, Niedenthal & Oberman, 2008). It should be noted that the different accounts about abstract conceptual representation are not mutually exclusive. Pecher, Boot, and Van Dantzig (2011), for example, argue that situations are also needed to fully represent abstract meaning. Since these accounts are not central to the discussion of the present paper, the literature review will not detail them further.

1999), which claims that we understand abstract domains in terms of more concrete representations. Cognitive metaphor theorists assume that concepts are embodied in the sense that they are grounded in perception and action. What it amounts to is that conceptual features (e.g., visual, acoustic, motor) are hypothesized to be stored in modality-specific areas of the brain and are assumed to be activated during the processing of abstract language because they provide sensory-motor grounding for abstract concepts.

Specifically, the strong version of the embodiment view (Kövecses, 2002; Lakoff and Johnson, 1980, 1999) holds that language understanding is *directly* grounded in embodied representations, i.e., listeners tap into their experiential knowledge when they process language. In other words, the strong embodiment view holds that modality-specific representations are inherent part of conceptual representations (i.e., they are conceptual features), which entails that word meanings are built from sensory-motor experiences, which are necessarily and automatically activated during language use.

In support of the strong embodiment view theory (e.g., Lakoff and Johnson, 1980, 1999), recent neuroimaging (fMRI) and electrophysiological research by Kiefer et al. (2008), for example, confirms that acoustic features constitute the conceptual representation of sound-related concepts. Kiefer and his colleagues measured event-related brain potentials while participants performed lexical decisions on visually presented words. Results show that words that denote objects for which acoustic features are highly relevant (e.g., ‘telephone’) rapidly ignite cell assemblies in the posterior superior and middle temporal gyrus (pSTG/MTG) that are also activated by listening to real sounds. Importantly, activity in the left pSTG/MTG had an early onset of 150 ms, which suggests that the effect has a conceptual origin rather than reflecting late post-conceptual imagery because pre-lexical processes, such as visual word recognition, operate in this time-window. In other words, the results of Kiefer et al. (2008) show that the understanding of language referring to auditory phenomena is grounded in auditory representations.[34] It would be worthwhile investigating abstract sound-related language in the same way and compare it to literal language.

In contrast to the Cognitive Metaphor Theory (Kövecses, 2002; Lakoff and Johnson, 1980, 1999), another alternative to metaphor comprehension has also been proposed, for example, by Gernsbacher and Robertson (1999) and Keysar (1994) who claim that metaphor comprehension involves the suppression of irrelevant concrete attributes and the enhancement of attributes that support the metaphorical meaning. For example, understanding the metaphor *My lawyer is a shark* involves the activation of the metaphorical shark-properties, such as 'vicious' or 'tenacious', while the literal shark-properties, such as 'fast swimmer', 'has fins', 'lives in the ocean', or 'has sharp teeth' are suppressed. Thus, this theory predicts that during the understanding of fictive sound metaphors, such as 'whistleblowing' the concrete sound representation (of blowing a whistle), the concrete concept ('whistle'), or at least its literal lexical associate (*whistle*), is suppressed.

Similarly to the suppression theory (Gernsbacher and Robertson, 1999; Keysar, 1994), the Career of Metaphor Hypothesis by Bowdle and Gentner (2005) also claims that concrete representations do not contribute to the semantics of conventional metaphors. The idea is that there is a shift from comparison processing in the case of novel metaphors to categorization processing in the case of conventional metaphors. This theory predicts that conventional metaphors, such as 'whistleblowing', are comprehended directly, without access to concrete

[34] The results of Kiefer et al. (2008), however, can be interpreted in four ways based on Mahon and Caramazza (2008): (1) the word 'telephone' directly activates the auditory system, with no intervening access to abstract conceptual content; (2) the word 'telephone' directly activates the auditory system and in parallel activates abstract conceptual content; (3) the word 'telephone' directly activates the auditory system and then subsequently activates an abstract conceptual representation; and finally, (4) the word 'telephone' activates an abstract conceptual representation and then activates the auditory system.

representations because these concrete representations are irrelevant to the abstract meaning of these metaphors.

In line with the Career of Metaphor theory, recent proposals have also claimed that modality-specific activations are not strictly necessary for linguistic meaning but are needed for fully grounding a concept (Boulenger, Mechtouff, Thobois, Broussolle, Jeannerod and Nazir, 2008; Jeannerod, 2008). In the case of words referring to auditory phenomena modality-specific information would involve, for example, the ability to distinguish two near synonyms, such as *snort* and *grunt* or *stammer* and *stutter*. In other words, part of the modality-specific representation of 'bark' is the barking sound itself. We assume that sound generation for concrete linguistic labels is crucial for recovering the modality-specific content of words referring to auditory phenomena.

Again, contrary to the predictions of the strong embodiment view, numerous studies have shown that embodied information only receives enough activation when language is processed deeply (Louwerse and Jeuniaux, 2008). Such findings have given rise to a distinction between shallow vs. deep levels of processing (Barsalou, 1999). The shallow processing account can be conceived of as a refutation of the strong embodiment view, since it shows that language processing does not necessarily invoke modality-specific information. Lexical decision, synonym judgements, orthographic discrimination judgements, recognition tasks, etc. require shallow processing, whereas, for example, semantic similarity judgements rely on deep processing. That is, situated simulations appear to be modulated by task conditions (Louwerse and Jeuniaux, 2008).

Sanford and Sturt (2002) reviewed the literature on shallow processing and concluded that in some situations language processing is not thorough or detailed because it is not worth the cognitive effort of processing what is irrelevant to the discourse context. Similarly to the shallow processing account, the “Good Enough” approach (Ferreira et al., 2009) contends that language understanding is not necessarily complete but it is simply “good enough” for the understander’s purposes. The depth of processing is influenced by circumstances, such as ambiguity, relevance, discourse context, or task demand, and under certain circumstances shallow processing is sufficient (Ferreira et al., 2002; Louwerse and Jeuniaux, 2008). A famous example of shallow representation is the Moses Illusion (Erickson and Matteson, 1981), which demonstrates that people do not notice the error in the question *How many animals of each kind did Moses put on the ark?* (it was Noah). Erickson and Matteson suggest that Moses is not in focus, therefore it does not undergo a thorough analysis.

It is crucial to distinguish shallow processing referring to the level of processing and the depth of encoding, as in memory research (Craik and Lockhart, 1972), from shallow processing describing the quality of representations activated (Ferreira et al., 2002, 2009). In Craik and Lockhart’s model when words are processed, for example, for sound (Does the word rhyme with X?) or other physical properties (Is the word in capital letters? What shape, size, colour is the word? How many vowels does the word contain?), the task involves shallow processing.

The control question task is considered to involve deep processing in the sense of Craik and Lockhart (1972) because it requires semantic analysis in contrast to structural and phonemic tasks. Craik and Lockhart associated depth of processing with recall performance: the deeper the level of processing, the more retrievable and lasting the memory traces will be. We are going to adopt recent accounts of shallow processing instead of Craik and Lockhart’s conception because they newer accounts conceive of shallow versus deep processing at the level of semantic processing. So, for example, according to these newer conceptions semantic processing can be both shallow and deep.

Recent definitions of shallow processing (Barsalou, 1999; Ferreira et al., 2002; Louwerse and Jeuniaux, 2008; Sanford and Sturt, 2002) are seemingly at odds with Craik and Lockhart's approach because these newer accounts propose underspecified, incomplete representations formed during language comprehension in certain tasks involving semantic processing. Shallow processing is now defined as a partial semantic analysis giving rise to these incomplete representations, which are good enough for the communicative situation. Crucially, while the control question task requires deep processing in the sense of Craik and Lockhart, it can in theory involve shallow but "good-enough" processing in the sense of Ferreira et al. (2002).

Some evidence for varying levels of semantic analysis is provided by Stewart et al. (2007), who tested the processing of ambiguous pronouns under both shallow and deep processing conditions. For instance, the sentence *Paul lent Rick the CD before he left for the holidays* is ambiguous regarding the antecedent of *he*. In their experiments, under the shallow processing condition, comprehension questions requiring a yes/no answer probed the information content of sentences without requiring the resolution of the anaphor (e.g., *Did Paul lend Kate the CD?*), while under the deep processing condition similar yes/no comprehension questions were employed but these required the resolution of the anaphor (e.g., *Who left for holidays? Rick or Paul?*). The results reveal that reading times for the pronoun were significantly faster in the shallow processing condition than in the deep processing condition, i.e., participants did not try to resolve the ambiguity unless they expected to be tested on it.

As a resolution to the anomaly between the strong embodiment view and other conflicting conceptions, the Language and Situated Simulation theory of conceptual processing (LASS, Barsalou, Santos, Simmons & Wilson, 2008), which is compatible with the shallow vs. deep processing accounts, proposes that non-linguistic representations are situated simulations, which are the basis of conceptual representations but which are not always and necessarily activated during language processing. This approach is consistent with the observation that comprehenders first access the word form which sends activations to other associates in a spreading activation manner (Anderson, 1983; Neely, 1991). The spreading activation theory has methodological implications too, because different effects can emerge as a function of stimulus onset asynchrony (SOA). SOA refers to the time interval between the onset of the prime stimulus and the onset of the target stimulus.

Sound-related language has been explored by several behavioural and neuroscientific studies, all focusing on concrete language describing sounds (e.g., Ballas, 1993; Bussemakers and De Haan, 2000; Chiu and Schachter, 1995; Cummings, Čeponiene, Koyama, Saygin, Townsend, Dick, 2006; Cummings, Čeponiene, Dick, Saygin, Townsend, 2008; Friedman, Cycowicz, Dziobek, 2003; Kaschak, Madden, Therriault, Yaxley, Aveyard, Blanchard, 2005, Kaschak, Zwaan, Aveyard, Yaxley, 2006; Kemmerer, Castillo, Talavage, Patterson and Wiley, 2008; Kiefer, Sim, Herrnberger, Grothe, Hoenig, 2008; Orgs, Lange, Dombrowski, Heil, 2006, 2007; Schön, Ystad, Kronland-Martinet, Besson, 2010; Stuart and Jones, 1995; Van Petten and Rheinfelder, 1995).

Although language describing abstract sounds is hitherto underexplored in the literature, a number of studies indicate that specific sounds do affect the processing of concrete language describing these sounds, and *vice versa* (concrete sound-related language can activate sound representations). For example, an electrophysiological study on sounds and language by Van Petten and Rheinfelder (1995) shows that conceptual relationships between spoken words and environmental sounds influence the processing of both types of representations. In their study, an N400 effect was found to sounds preceded by inconsistent words, for example, the sound of helicopter rotor preceded by the word ‘dog’ instead of ‘helicopter’. The N400 is a negative ERP component that is related to semantic processing and elicited to unexpected word or other meaningful stimuli. In the study by Van Petten and Rheinfelder, words preceded by related sounds elicited smaller N400 components than those preceded by unrelated sounds. When testing conceptual relatedness effects, it is usually found in N400 studies that the amplitude of N400 is reduced to related stimuli: the less familiar the stimulus, the larger the N400.

Along these lines, Schön et al. (2010) have recently reported a relatedness-effect at an early time window in the event-related brain potentials for both sound-word and word-sound pairs presented sequentially. Their results suggest that sounds and words are processed conceptually similarly on the level of the nervous system.

Similarly, Orgs et al. (2006) observed priming for sounds and words in response latency and event-related brain potentials. Reaction times were shorter when an environmental sound was followed by a related word. Both word and sound stimuli produced an N400-effect for unrelated compared to related trials. In the word/sound condition an N400-effect for unrelated trials started as early as 200 ms post stimulus. These findings can be considered as evidence for the hypothesis that the conceptual processing of environmental sounds is similar to the processing of words (if words are presented in the auditory modality).

All the studies mentioned above emphasize that semantic representation and sensorimotor processing have a common neuronal substrate, and that mental simulation is fundamental to language comprehension. The studies, however, do not agree unanimously over the role of embodied representations: the critical question is whether non-linguistic representations are necessary for conceptual processing, or if they are just consequences or post-hoc elaborations of linguistic processing (sometimes referred to as later/secondary cognition, imagery, or post-perceptual processing). Crucially, the time course and neural locus of activation determine whether embodiment effects reflect post-conceptual strategic processes, such as imagery, or if they are conceptual features.

Based on previous research (Kaschak et al., 2005, 2006; Bergen, 2005, 2007), we know that, depending on the congruency of the stimuli, the modality (intra- or cross-modal) and the course of presentation (whether stimuli are presented simultaneously or sequentially), different effects emerge in experiments exploring sounds and concrete language. Kaschak and colleagues (2005), for example, asked participants to listen to and make sensibility or grammaticality judgments on sentences that described motion in a particular direction (e.g., “The car approached you”). Participants simultaneously viewed dynamic black-and-white stimuli that produced the perception of movement in the same direction as the action described in the sentence (i.e., towards you) or in the opposite direction as the action described in the sentence (i.e., away from you). Both sensibility and grammaticality responses were faster to sentences presented simultaneously with a visual stimulus depicting motion in the opposite direction as the action described in the sentence, an effect usually referred to as mismatch-advantage. The mismatch-advantage arises because perceiving motion in one specific direction engages neurons that respond to motion in that direction (Mather, Verstraten, & Anstis, 1998). Because these neurons are engaged by the visual stimulus, they are less activated in constructing a simulation of events in which the action moves in the same direction.

The two experiments described in the present study both use a cross-modal paradigm with the sentences presented in a written form. The stimulus presentation sequence varies between the experiments, as is detailed below. Language-to-sound priming is understood as the sound-evoking capacity of linguistic stimuli. Importantly, the relationship between sounds and language may not be unidirectional, but rather bidirectional. Therefore, we define sound-to-language priming as a priming effect from sounds to language. The two experiments in this study, which both use the priming protocol, investigate the nature of this two-way connection between linguistic stimuli and sound representations in both the concrete and the abstract domains.

All the experiments mentioned above focus only on the connection between concrete language and sounds. The present paper investigates whether the processing of metaphorical sentences (including idioms), such as *The reporter blew the whistle on doctors for malpractice* are also affected by *specific* sounds, such as 'blowing the whistle', or 'ringing a bell' (Experiment 1), and crucially, whether these sentences activate auditory representations (Experiment 2).

The major aim of our research is to assess whether fictive sound sentences evoke sound representations. The hypotheses we put forward are tested through the emergence or absence of the so-called congruency-effect: congruent sounds (e.g., that of a dog), which match the verb, facilitate or inhibit linguistic processing as opposed to incongruent sounds, which mismatch the verb (e.g., that of a cat). In the two experiments we use the control question technique in a task where “good-enough” representations are sufficient to give a correct answer (Ferreira et al., 2002, 2009).

As for the concrete sentences, we hypothesize that sound representations are activated during reading. This hypothesis is consistent with previous research on sounds and concrete words, such as Kemmerer et al. (2008), Kiefer et al. (2008), Orgs et al. (2006), Schön et al. (2010), or Van Petten and Rheinfelder (1995). We expect the congruency-effect to emerge for concrete sentences. Specifically, we expect a match-advantage in a *consecutive* setting where sounds are presented before critical verb stimuli (Experiment 1), while we hypothesize a mismatch-advantage (reverse facilitation effect) to emerge in a *simultaneous* setting (Experiment 2). We assume in terms of a mismatch-advantage that language stimuli in the congruent sound condition are read slower than in the incongruent condition based on hypothetical shared processing (domain-specific) and/or attentional (domain-general) resources (e.g., Kaschak et al., 2005; Bergen et al., 2012).

With respect to abstract sentences our working hypothesis is that during the understanding of metaphors, such as 'blow the whistle on the students' the concrete scenario need not be recreated along with the auditory component, that is, 'blowing the whistle', because the auditory representation in the mental model of the event described by the phrase is irrelevant to the abstract meaning. We base this hypothesis on the assumption that abstract sentences are expected to be processed directly via their abstract meaning as the sentences in the abstract condition are conventional sound-metaphors.

This prediction for abstract sentences is compatible with the Career of Metaphor Hypothesis by Bowdle and Gentner (2005) which claims that conventional metaphors are not comprehended in terms of concrete representations as opposed to novel metaphors. Second, this assumption is also in line with Gernsbacher and Robertson (1999) and Keysar (1994) who propose that concrete attributes are suppressed during the comprehension of metaphors because they do not contribute to the semantics of these abstract expressions. This assumption is also in agreement with the Good-Enough Approach (Ferreira et al., 2002, 2009) and the conception that level of processing determines the activation of embodied representations (Louwerse and Jeuniaux, 2008), but it is clearly inconsistent with the strong embodiment approach (Lakoff and Johnson, 1980, 1999) which does not take into account the level of processing as a variable. This hypothesis for abstract sentences can be operationalized in our experiment as the absence of a congruency-effect (a not significant congruent vs. incongruent comparison) in the abstract domain in a simultaneous sound stimulus setting in Experiment 2, while we expect a classic priming effect in Experiment 1 where sounds are presented before critical verbs.

2. Experiment 1 – sound-to-language priming

2.1. *Paradigm*

The goal of the experiment was to determine whether specific (environmental) sound stimuli affect linguistic processing of concrete and abstract sentences describing sound events. Participants read seven-word concrete and abstract sentences encoding specific sounds on the computer screen in a self-paced reading paradigm while at the same time listening to a sound stimulus. Their task was to answer superficial control questions related to the sentences but unrelated to the semantics of the verb. Control questions were presented to participants in the form of statements, e.g., 'The girl was playing the trumpet at home' (yes/no). Participants were expected to press 'no' in this case because the test sentence mentioned that the girl was playing the trumpet in a music school.

The control question technique was employed to minimize the processing burden, and thus avoid any potential artefacts, i.e., artificial processing (meta-)strategies when interpreting the sentences. For example, an explicit relatedness judgement task, in which participants compare sound stimuli to sentences, would induce such strategies and hence would involve deep processing. A sensibility judgement task, for instance, would also incur extra processing costs for abstract sentences based on our observations in our previous experiments in which the reading of abstract sentences required conscious effortful thinking in the sensibility judgement condition as opposed to the control question condition. Also, the superficial control question technique discourages participants to use post-conceptual auditory imagery strategies.

Four categories of sounds were selected for the experiment: congruent sounds match the sound described by the verb (e.g., 'bark'), incongruent sounds come from the same semantic field as the verb but do not match the sound described by the verb (e.g., 'meow'), semantically unrelated sounds are taken from a semantic field distinct from that of the verb (e.g., 'whistle'), and a no sound condition. Incongruent and unrelated sounds can also be distinguished based on semantic similarity measures (see APPENDIX). Based on this semantic distance, we expect incongruent sounds to be competitors of congruent items for being closely related associates.

The incongruent category was introduced because we assumed that within-category items (incongruent) and category-external items (unrelated) might exert different effects on processing than unrelated items. This assumption is bolstered, for example, by an electrophysiological reading study by Federmeier and Kutas (1999) which showed that within-category items elicited a smaller N400 than category-external items, even though both kinds of unexpected items are equally inappropriate and implausible.

We would like to see if participants' processing of the sentences is affected by the sound-conditions, that is, by the category of the sounds they hear. Provided that the sound stimuli are processed before the critical linguistic stimuli in the sentences, which we can assume in this case, congruent sounds are expected to have a priming effect relative to incongruent sounds. We further hypothesize that unrelated (category-external) sounds will have an inhibitory effect on sentence processing relative to the no sound condition based on previous research demonstrating that unrelated items "disrupt" processing only given a long SOA (see Neely, 1991, for a review; Plaut and Booth, 2000). These effects are expected to emerge for both the set of concrete and the set of abstract sentences.

2.2. *Method*

2.2.1. *Participants*. Thirty-four students from the Budapest University of Technology and Economics participated for course credit (*Mean age*: 22.06, *Age range*: 18–34). All participants were native Hungarian speakers with self-reported normal hearing sensitivity bilaterally and normal or corrected to normal vision.

2.2.2. *Stimuli*. 24 test sentences of seven words each and 40 filler sentences were constructed. In the test sentences, the critical verb, which was in the past tense, was the fifth word of the sentence and was followed by an adjunct phrase such as ‘yesterday evening’. The arguments of the verb preceded the verb and unequivocally signalled its meaning regarding abstractness. This word order is natural in Hungarian. For example, the Hungarian sentence *a lány a konyhában játszott* (literally: ‘the girl in the kitchen played’) sounds completely neutral and conveys the meaning that the girl was playing in the kitchen.

12 concrete and 12 abstract 7-word test sentences were used that encoded sounds (e.g., ‘The wolf was howling in the woods yesterday evening’ and ‘The name of the teacher rang a bell to the student.’). In a pilot experiment, the critical sentences had been categorized by 8 raters as being either concrete or abstract. None of the sentences was ambiguous in terms of abstractness. With one exception, critical verbs were taken from the same frequency range.

The control questions were simple statements that referred to the contents of the test sentences. For example, after reading the sentence ‘The press rang the alarm’ participants received the false statement ‘the press was optimistic’ (for which they had to press the ‘no’ key). Sentences required an affirmative response, that the sentence made sense, in half the trials, and a negative response in the other half. The test texts were complete sentences rather than single words or phrases, since non-literal language can only be tested embedded in sentence context. Filler sentences were of equal length and of comparable syntactic complexity but they did not contain sound-related verbs. These sentences were also presented with sound stimuli (unrelated sound stimuli) so that the proportion of sentences with sounds and without sounds was kept constant throughout the experiment.

The critical sentences and their corresponding sounds can be seen in the Appendix. The environmental sounds comprised sounds made by living (animal sounds, human sounds) and manmade (musical instruments, sounds of machines) objects, such as the sounds of ‘lion’, ‘airplane’, ‘laughter’, ‘whip’, ‘siren’, ‘boat horn’, etc. The sounds were wave files[35] selected from a list compiled by Marcell, Borella, Greene, Kerr & Rogers (2000). The sampling rate of the sounds was 44.1 kHz with 16-bit quantization.

The four sound conditions were: (1) congruent sounds, (2) incongruent sounds, (3) unrelated sounds, and (4) no sound. For example, as the sentence *A lány a zeneiskolában trombitált éveken keresztül*. (‘The girl was playing the trumpet in the music school for years.’) was read by the participants, some participants heard a congruent sound (trumpet), some heard an incongruent sound from the same semantic category (flute), and others heard an unrelated sound from a different semantic category (swords). In the fourth sound condition, participants did not hear any sound at all.

The assignment of sentences to sound conditions was counterbalanced across participants, so that every participant read an equal number of sentences in every Sound Condition and Sentence Type Condition, while at the same time the number of concrete or abstract sentences in every Sound Condition was also counterbalanced. This type of counterbalancing was used to avoid block effects (list effects) associated with incomplete counterbalancing procedures (e.g., the use of pseudo-randomly organized counterbalance lists). Half of the trials came with sound stimuli, and half of them were presented without any sound in every experimental session.

2.2.3. *Procedure*. Participants were first presented with an instruction screen. They were asked to read the sentences one word at a time and then the questions appearing on the computer screen and press the ENTER key if they thought the answer to the question was yes and the SPACE key if

[35] The sound files can be downloaded from the following web page: http://www.cofc.edu/~marcellm/confrontation%20sound%20naming/zipped.htm

they thought the answer was no. They were also instructed not to pay attention to the sounds they would hear during the sentences. Each participant was tested individually in one session lasting approximately 10 minutes.

Participants first completed a practice phase, in which they were familiarized with the structure of the experiment. They received feedback about their responses in the practice phase. One trial consisted of a sentence and a sound. The words of the sentence appeared in the centre of the computer screen and the sound was presented through headphones for 750ms starting with the onset of word 3. The value of the SOA was motivated by previous experiments (e.g., Simpson and Burgess, 1985). The control question appeared after the last word of the sentence. There was no limit on response time, i.e., subjects could spend as much time reading the sentences and answering the questions as they wished: however, subjects were asked to respond to the sentences as quickly as possible. The trials were randomised across participants.

2.3. *Results and discussion*

The practice trials and the filler items were excluded from the analyses as were the erroneous trials. Participants gave accurate responses in 96 percent of trials overall (minimum: 83% maximum: 100%). The mean of the median reading times of the words of the critical sentences was taken. Crucially, reading times on words 5, 6, and 7 were analysed. No participant was excluded from the analyses for poor overall performance. Missing values, where neither of the responses of the participant was accurate in a category, were replaced by series means in SPSS. This occurred only once, so altogether 3 data points were replaced.

First, the average time between sound offset and verb onset was calculated based on the reading time data. The mean of median reading times of word 3 (*Mean*: 388 ms) and word 4 (*Mean*: 427 ms) were added: 815 ms. Given that sounds were presented continuously from the onset of word 3 for 750 ms, it can be estimated that sound stimuli stopped 65 ms before the offset of word 4 on average. This observation, however, does not affect the long SOA setting of the experiment. The following two tables illustrate the mean reading times and standard deviations of the words in the sound conditions in the concrete and abstract conditions separately:

Sound Condition	**word 5 (concrete)**	**word 6 (concrete)**	**word 7 (concrete)**
congruent	461 ms (186.00)	466 ms (123.02)	472 ms (162.70)
incongruent	462 ms (206.69)	439 ms (123.74)	441.50 ms (175.99)
unrelated	448 ms (284.17)	454 ms (127.51)	449 ms (209.98)
no sound	417.50 ms (152.70)	424 ms (149.01)	454 ms (200.65)

Table 1. Mean Reading Times of the Critical Verbs and the Spill-over in the Concrete Context in Experiment 1 (milliseconds and standard devitations are indicated)

Sound Condition	**word 5 (abstract)**	**word 6 (abstract)**	**word 7 (abstract)**
congruent	512.00 ms (221.23)	473.00 ms (123.46)	496.50 ms (185.65)
incongruent	484.50 ms (258.80)	459.50 ms (172.74)	497.00 ms (216.99)
unrelated	506.50 ms (201.61)	479.00 ms (189.36)	468.00 ms (169.43)
no sound	469.00 ms (169.65)	431.50 ms (132.55)	479.00 ms (170.63)

Table 2. Mean Reading Times of the Critical Verbs and the Spill-over in the Abstract Context in Experiment 1 (milliseconds and standard devitations are indicated)

Mean reading times were first analyzed in a participant-based 2*4 repeated measures ANOVA model with Sentence Type (two levels) and Sound Condition (four levels) as within-participants factors. For the entire sample, the analyses of reading times on word 5 (the critical verb) revealed a significant main effect of Sentence Type,[36] $F(1, 33) = 6.339$; $p = 0.017$, Wilks' Lambda = 0.839. The main effect of Sound Condition was not significant, $F(3, 31) = 1.929$; $p = 0.145$, Wilks' Lambda = 0.843. The interaction (Sentence Type*Sound Condition) was not significant either, $F(3, 31) = 0.436$; $p = 0.728$, Wilks' Lambda = 0.959. The spill-over region (words 6 and 7) was also analysed.

Analyses on the point of word 6 also returned a significant main effect of Sentence Type, $F(1, 33) = 11.219$, $p = 0.002$, Wilks' Lambda = 0.746, however there was no main effect of Sound Condition, $F(3, 31) = 0.460$, $p = 0.712$, Wilks Lambda = 0.957, and the interaction was not significant either, $F(3, 31) = 1.969$, $p = 0.139$, Wilks Lambda = 0.840.

Analyses on the point of word 7 likewise returned a significant main effect of Sentence Type, $F(1, 33) = 4.910$, $p = 0.034$, Wilks' Lambda = 0.870, however there was no main effect of Sound Condition, $F(3, 31) = 0.219$, $p = 0.882$, Wilks Lambda = 0.979, and the interaction was not significant either, $F(3, 31) = 0.700$, $p = 0.559$, Wilks Lambda = 0.937. Taken together the findings for the entire sample on the three regions of interest, only the main effect of Sentence Type was significant. Subsequent analyses of variance were conducted for the concrete and the abstract sub-samples *separately*.

One-way analyses of variance revealed that there was no significant effect of Sound Condition on word 5 in the concrete domain, $F(3, 31) = 1.319$, $p = 0.286$, Wilks' Lambda = 0.887, or the abstract domain, $F(3, 31) = 1.010$, $p = 0.401$, Wilks' Lambda = 0.911.

Reading times were also analysed on the regions of words 6 and 7 in the concrete and abstract sub-samples. One-way analyses of variance revealed that there was no significant effect of Sound Condition on word 6 in the concrete domain, $F(3, 31) = 0.859$, $p = 0.473$, Wilks' Lambda =

[36] Abstract sentences were read significantly slower than concrete sentences, which is a well-known phenomenon. We did not control for sentence length as we were not interested in comparing reading times of the concrete sentences with those of the abstract ones.

0.923, or the abstract domain, $F(3, 31) = 2.154$, $p = 0.114$, Wilks' Lambda = 0.828. Similarly, there was no significant effect of Sound Condition on word 7 in the concrete domain, $F(3, 31) = 0.450$, $p = 0.719$, Wilks' Lambda = 0.958, or the abstract domain, $F(3, 31) = 0.547$, $p = 0.654$, Wilks' Lambda = 0.950.

These results show that sound stimuli do not affect language processing for either of the two domains. Our results demonstrate that, since specific sounds do not influence linguistic processing, specific sound representations are semantically not related to abstract sound-related language. In other words, abstract sentences in the present experiment are "frozen", as shown, for example, by the idiom *kick the bucket* 'TO DIE', which does not activate the concepts 'KICK' or 'BUCKET'.

We did not obtain a significant difference between the unrelated and the no-sound conditions for either concrete or abstract contexts. Irrelevant sounds, such as those in the unrelated condition, do not affect attention functions that would alter linguistic processing.

3. Experiment 2 – language-to-sound priming

In Experiment 1, we have not provided any evidence that auditory experiential traces are *necessarily* and *automatically* evoked as a result of linguistic processing. Experiment 2 therefore is designed to eliminate the long stimulus onset asynchrony (SOA). This modification is crucial to rule out expectancy priming, which is a controlled process that operates at a long SOA (500 ms), or the possibility that sounds affect only word recognition.

Our predictions for Experiment 2 were that abstract sentences do not activate sound representations, hence we do not assume a congruency-effect to emerge in the abstract sub-sample, while we hypothesize the congruency-effect to emerge in the concrete sub-sample.

3.1. *Paradigm*

A new group of participants were recruited. On each trial, participants read concrete and abstract sound-related sentences one word at a time ("static window", i.e., central presentation) in a self-paced reading paradigm as in Experiment 1. In synchrony with the critical verb a sound stimulus was played in both ears, that is, the perception of the sound and the verb occurred within the same episode, reducing the SOA to zero. Sentence Type (concrete/abstract) and Sound Condition were within-participants factors.

3.2. *Method*

3.2.1. *Participants*. Thirty-five Hungarian university students (*Mean age*: 22.74, *Age range*: 18–34) of the Budapest University of Technology and Economics participated for course credit, fulfilling the same criteria as did those who took part in Experiment 1.

3.2.2. *Stimuli*. The sentences and the sound stimuli of Experiment 1 were used. Half of the trials came with sound stimuli, and half of them were presented without any sound in a randomised manner in every experimental session. The same counterbalancing procedure was used as in Experiment 1 (see 2.2.2.) in order to preclude the use of strategies and reduce inter-participant error-variance.

3.2.3. *Procedure*. Participants were presented first with an instruction screen which informed them that they would read sentences one word at a time by pressing a key (SPACEBAR) when they were ready to move to the next word, but they could not return to previously read words. The instructions went on explaining that at the end of the sentences they would have to answer a forced-choice control question after each sentence. A practice phase was included before the test trials as in Experiment 1. A fixation cross preceded each trial for one second. The trials were randomised across participants.

3.3. *Results and discussion*

The practice trials were excluded from the analyses as were the filler items. Erroneous trials – where the wrong answer was given to the control question – were also excluded from the analyses. The data of one participant was discarded because of measurement error; therefore, the analyses were carried out on the data of 34 participants. The overall accuracy rate for the critical trials was 95 percent (minimum: 83% maximum: 100%). The means of the median reading times of the critical verbs and the following two words were taken. The regions of words 5, 6 and 7 were analyzed. Three data points were replaced by series means.

Mean reading times were first analyzed in a participant-based 2*4 repeated measures ANOVA model with Sentence Type (two levels) and Sound Condition (four levels) as within-participants factors. The analysis for the entire sample revealed significant main effects of Sentence Type on the regions of word 5, $F(1, 33) = 5.505$, $p = 0.025$, and word 6, $F(1, 33) = 21.137$, $p < 0.001$, showing that sentences were read slower in the abstract context than in the concrete condition. However, there was no main effect of Sentence Type on the region of the last word (word 7), $F(1, 33) = 0.001$, $p = 0.980$. No interactions (Sentence Type*Sound Condition) were revealed on any of the three word regions. A significant main effect of Sound Condition was yielded only sentence-finally, on the region of word 7, $F(3, 31) = 4.033$, $p = 0.016$. Therefore, Fisher LSD post-hoc tests were carried out for the entire sample only on this region.

For the entire sample on the region of word 7, reading times in the congruent condition did not differ from those in the incongruent condition ($p = 0.232$). Sentences in the congruent and incongruent sound conditions were both read faster than sentences in the unrelated sound condition (p = 0.079, marginally significant, and p = 0.021, respectively). This result indicates that the effect of inhibition cuts across the semantic category boundary (i.e., semantic categories are primed), rather than category-internally across specific exemplars (i.e., category-internal sounds are equally compatible with processing as the sound encoded by the verb).

Sentences in the congruent sound condition were read slower than those in the no sound condition (p = 0.010). Unrelated sounds significantly inhibited processing relative to the no sound condition (p = 0.004). The concrete and the abstract sub-samples were analyzed separately on the three regions of interest (see below). The results for the two sub-samples (concrete and abstract) on the points of words 5 and 7 are summarized in Figures 1 and 2.

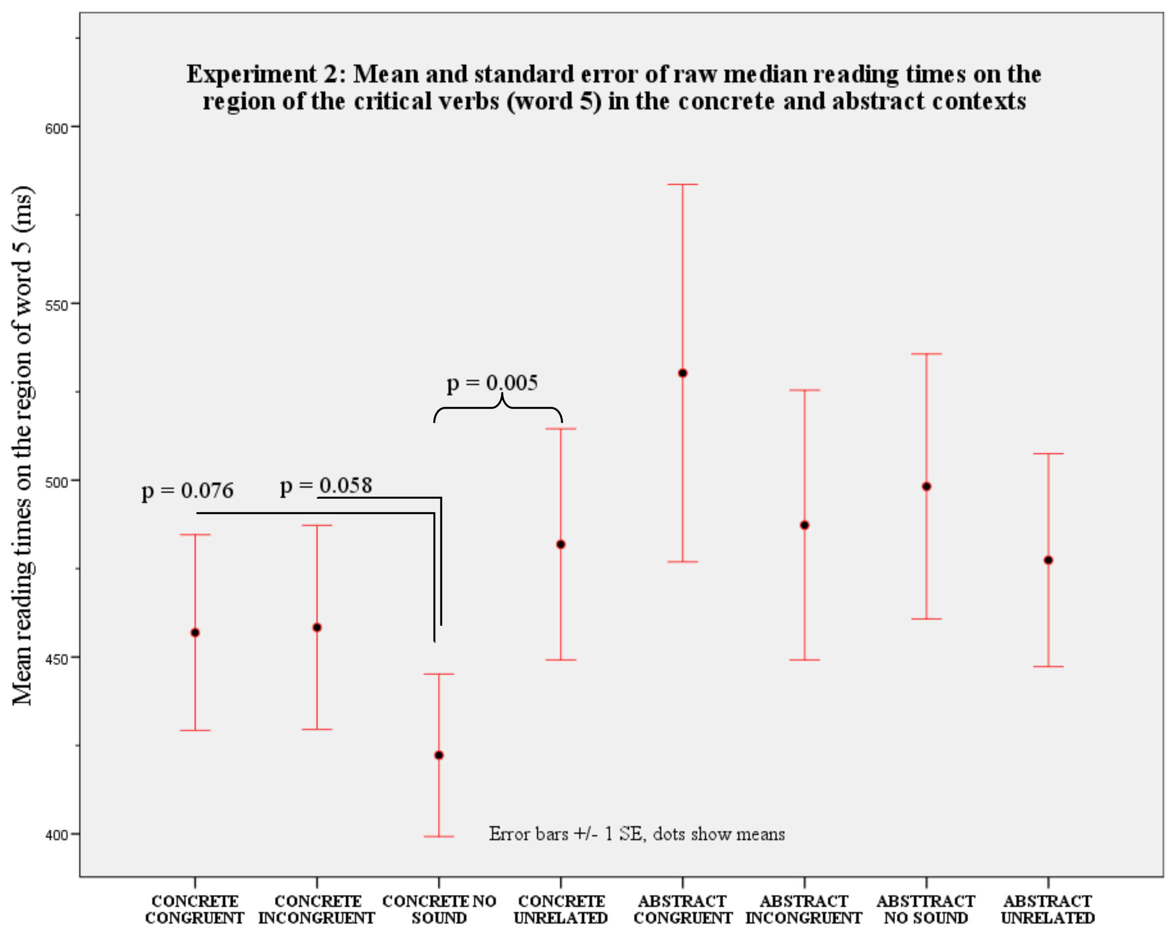

Figure 1. Mean and standard error of raw median reading times on the region of word 5 in the concrete and abstract contexts

Results of Experiment 2 are shown in terms of Mean Reading Times in ms (plotted on the ordinate) as a function of Sound Type (plotted on the abscissa) on the region of word 5 (the critical verb). For the set of concrete but not the set of abstract sentences, reading times in the unrelated condition were significantly slower than those in the no sound condition. The error bars represent standard errors of the mean. Absence of linking bars indicates that the comparison in question was not significant.

Figure 8. *Mean and standard error of raw median reading times on the region of word 5 in the concrete and abstract contexts in Experiment 2 (Chapter 3.5.)*

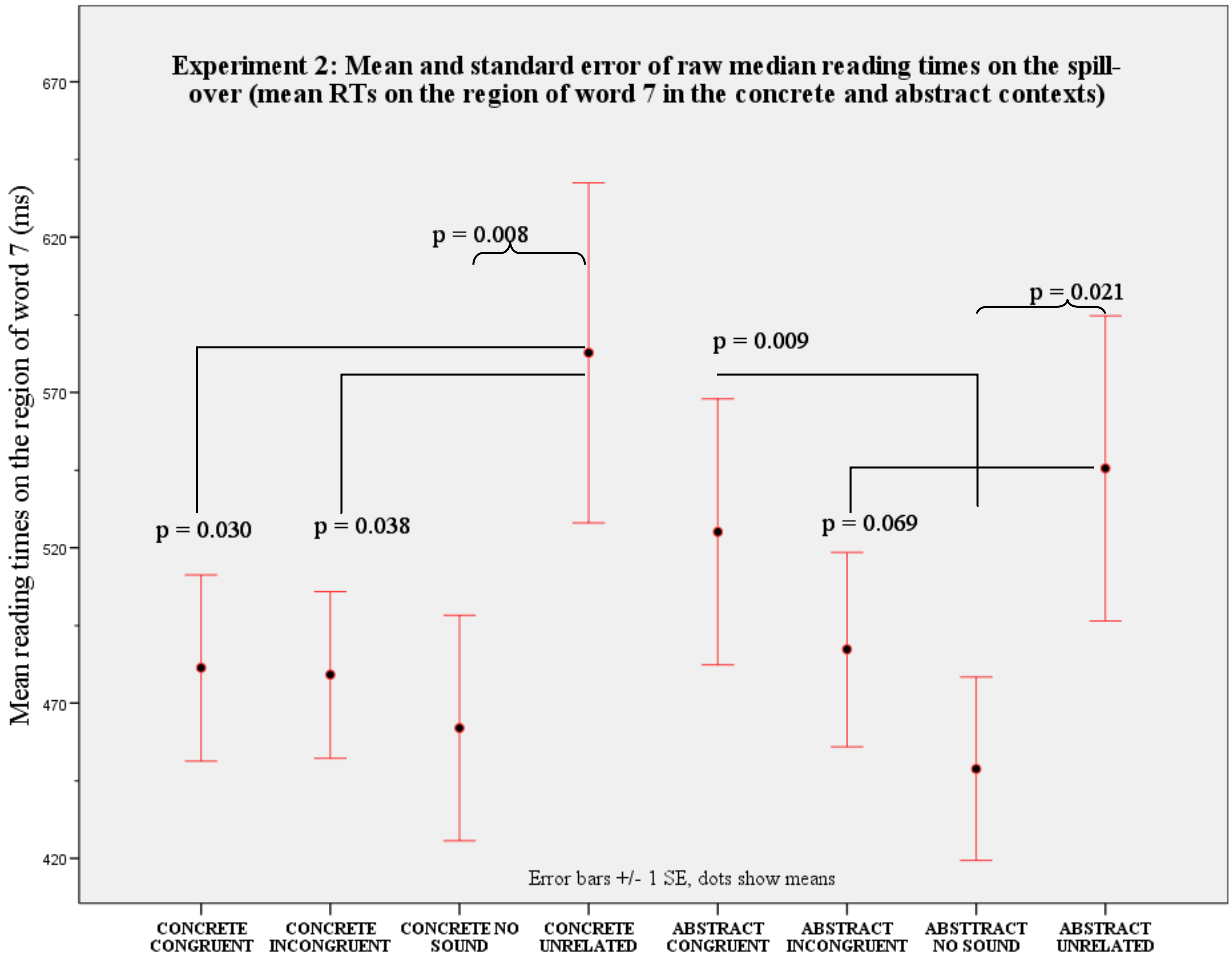

Figure 2. *Mean and standard error of raw median reading times on the region of word 7 in the concrete and abstract contexts*

Results of Experiment 2 are shown in terms of Mean Reading Times in ms (plotted on the ordinate) as a function of Sound Type (plotted on the abscissa) on the region of word 7 (the final word). For both the set of concrete and the set of abstract sentences, reading times in the unrelated condition were significantly slower than those in no sound condition.

Figure 9. *Mean and standard error of raw median reading times on the spill-over region (word 7) in Experiment 2 (Chapter 3.5.)*

For the concrete sub-sample, the effect of Sound Condition on the point of word 5 (the critical verb) was marginally significant in the omnibus ANOVA, $F(3, 31) = 2.807$, $p = 0.056$, Wilks' Lambda = 0.786. LSD post-hoc tests showed that the unrelated (*Mean*: 481.85 ms, *SD*: 190.5) - no sound (*Mean*: 422.24 ms, *SD*: 133.93) comparison was highly significant ($p = 0.005$), which indicates that unrelated sounds inhibit processing relative to the no sound condition. Similarly, the congruent (*Mean*: 456.90 ms, *SD*: 161.32) - no sound and the incongruent (*Mean*: 458.37 ms, *SD*: 168.32) - no sound comparisons yielded significance ($p = 0.076$ and $p = 0.058$, respectively), which indicates that category-internal sounds also distract readers irrespective of sound stimulus type in a simultaneous stimulus onset setting. Most importantly, however, there was no difference between reading times of the verbs in the congruent and the incongruent conditions ($p = 0.937$).

Further repeated-measures one-way ANOVAs were carried out on the spill-over (carry-over) regions of the verb. There was no effect of Sound Condition from the omnibus ANOVA in the concrete context on the next region of interest, which is the point of word 6, $F(3, 31) = 1.600$, $p = 0.209$, Wilks' Lambda = 0.866. However, there was a marginally significant effect of Sound Condition on the region of the next word (word 7) in the concrete context, $F(3, 31) = 2.499$, $p = 0.078$, Wilks' Lambda = 0.805. LSD post-hoc tests revealed that the congruent (*Mean*: 481.31 ms, *SD*: 174.56) – unrelated (*Mean*: 582.72 ms, *SD*: 319.08), the incongruent (*Mean*: 479.10 ms, *SD*: 156.40) - unrelated, and the unrelated - no sound (*Mean*: 461.97 ms, *SD*: 211.92) comparisons yielded significance ($p = 0.030$ and $p = 0.038$, $p = 0.008$, respectively), which indicates that unrelated sounds inhibit processing relative to category-internal items and the no sound condition, while category-internal items do not affect processing differently from the no sound condition on this point. This finding shows that category-internal items are of different cognitive status than category-external ones. Again, importantly, the congruent – incongruent comparison was not significant ($p = 0.917$). Taken together the findings in the concrete sub-sample, the absence of the hypothesized mismatch-advantage ($RT_{incongruent} < RT_{congruent}$) in a simultaneous stimulus onset setting (i.e., no congruency-effect) shows that no specific perceptual symbol (sound representation) is activated during this reading task, but rather category-external items, such as those in the unrelated condition inhibit processing.

For the abstract sub-sample, there was no significant effect of Sound Condition either on the region of word 5 or word 6, $F(3, 31) = 0.684$, $p = 0.569$, Wilks' Lambda = 0.938, and $F(3, 31) = 0.090$, $p = 0.965$, Wilks' Lambda = 0.991, respectively. However, there was an effect of Sound Condition on the region of the last word of the sentence, on word 7, $F(3, 31) = 3.165$, $p = 0.038$, Wilks' Lambda = 0.766. The congruent – no sound ($p = 0.009$), the unrelated - no sound ($p = 0.021$), and the incongruent – unrelated ($p = 0.069$, marginally significant) comparisons yielded significance: the sentence-final words in the congruent sound condition (*Mean*: 525.09 ms, *SD*: 249.87) were read slower than those in the no sound condition (*Mean*: 448.85 ms, *SD*: 171.98), reading in the unrelated sound condition (*Mean*: 545.63 ms, *SD*: 286.52) was inhibited relative to processing in the no sound condition or the incongruent sound condition (incongruent, *Mean*: 487.24 ms, *SD*: 182.22).

The inhibitory aftereffect on the spill-over, i.e., the inhibitory power of congruent sounds relative to the no sound condition in the timeframe of word 7 in the abstract sub-sample may be due to the fact that the concrete sound representation is incompatible with the idiomatic meaning of the abstract sentence yet the verb primarily encodes that meaning. Importantly, this effect emerged only in the abstract context because in the concrete context the concrete sound representation is compatible with the semantics of the verb.

Again, crucially, the congruent – incongruent comparison was not significant ($p = 0.260$), which provides compelling evidence against a mismatch-advantage in a simultaneous stimulus onset setting either in the abstract or concrete sub-sample. In the context of the present study, the unrelated sound can be considered to be the “mismatch” condition.

The critical finding of this experiment, that is the significant slow-down in reading in the unrelated condition for both sub-sets on word 7 indicates that unrelated sounds passively influence processing under a short SOA condition, and that this effect is not over until the end of sentence. The inhibitory power of unrelated sounds in contrast to congruent or incongruent sounds shows that sound stimuli are recognized and affect lexical processing by the activation of semantic categories, rather than being tied to processes, such as specific sound simulation.

Our data are consistent with the shallow level processing account (Barsalou, 1999), according to which not all cognitive tasks utilize simulation (auditory mental simulation). In other words, semantic representation is still possible without access to auditory representations.

These results are clearly inconsistent with Radical Embodiment approaches (strong embodiment accounts) which claim that auditory representations are necessarily and directly recruited. Therefore, cognitive simulation in the auditory domain is not fundamental to language processing.

4. General discussion

In Experiment 1, we investigated whether specific sounds affect linguistic processing at a long SOA (750 ms). No significant differences between the congruent and the incongruent conditions were observed in either the concrete or the abstract domains. The simplest explanation for the absence of the congruency-effect in Experiment 1 is that, although sounds were processed before the critical verbs were encountered, sounds could not exert their effect.

The finding that concrete sounds do not affect abstract language in Experiment 1 can also be explained by dissociative representations of specific sounds and abstract conceptual representations. Other psycholinguistic studies have also shown that people do not necessarily analyse the literal meanings of idioms during the understanding of figurative phrases (e.g., Gibbs, Nayak, Cutting, 1989), such as our abstract sound-related sentences, which can account for the absence of transfer from specific sounds to abstract idiomatic language.

In Experiment 2, we measured reading times on the region of the critical verbs in a short SOA setting (SOA = 0): sound stimuli were superimposed on the critical verbs. We found that unrelated sounds inhibited processing compared to the no sound condition for both concrete and abstract contexts. However, the results of Experiment 2 may appear to be at odds with the results of Experiment 1, since congruence is expected to have a priming effect. The explanation for the different RT-profiles lies in the fact that Experiment 2 employed a task in which participants were *simultaneously* exposed to an auditory and a visual representation as opposed to Experiment 1 with its long SOA. Previous research has also demonstrated (e.g., Plaut and Booth, 2000) that inhibition does not emerge at a short SOA.

The finding that unrelated sounds impair processing may first seem to be in conflict with previous results because there is evidence that ambient distraction does not normally influence reading, e.g., listening to music or being exposed to environmental sounds while reading a newspaper does not disrupt linguistic processing. In one study, for example, conducted by Carter (1969), the increased amount of simultaneous auditory distraction, such as school sounds, did not significantly affect the reading performance of either brain-injured or non-brain-injured participants. Along these lines, Tucker and Bushman (1991) also showed that reading comprehension remained constant while participants listened to rock and roll music. Our finding that unrelated sounds impair processing is due to the fact that unrelated items were superimposed on the verbs in a short time-frame where semantics-critical lexical processes operate rather than presented continuously during the whole linguistic material.

The finding that unrelated sounds inhibited processing can be well accommodated with previous results. Bussemakers and de Haan (2000), for instance, showed a similar pattern: congruent and even incongruent real-life sounds presented simultaneously with pictures lead to faster reaction times to the pictures compared to the unrelated condition (with category-external sounds). However, these results were obtained in a visual categorization task in which participants categorized pictures (animal or not animal) while passively listening to the sounds. Our experiment 2, in contrast, employed a reading paradigm in which participants had to read sentences word-by-word.

In line with the RT profile of our Experiment 2, DiGirolamo, Heidrich and Posner (1998) demonstrated in an event-related brain potential study that similar temporal and spatial patterns emerge for both the congruent (e.g., the word BLUE in blue ink) and the incongruent (e.g., the word RED in blue ink) Stroop-condition. These two conditions diverged from a neutral condition (e.g., the word KNIFE in blue ink) in an early time window of 268 ms. Unrelated items in our Experiment 2 similarly disrupt processing because they prime category-external items. In Experiment 2, we have also demonstrated that related sounds (congruent or incongruent items) do not affect linguistic processing differently from the no sound condition when sounds and linguistic stimuli are presented in the same episode (SOA=0). Anderson and Spellman (1995) and Anderson (2003) suggest that retrieval only inhibits related traces if they interfere with retrieval. However, incongruent items do not interfere with processing because they are in the same semantic field in contrast to unrelated sounds which hinder processing because they fall outside the semantic field of the verb.

Our results of Experiment 2 can be explained based on Neely (1977) who demonstrated that an activated semantic node proceeds to activate semantically related nodes within an early time window: unrelated targets (bird – rake) were inhibited at a SOA of 400 ms. This is a fast-acting involuntary process which explains the inhibition in the unrelated sound condition and the non-significant comparison between the congruent and the incongruent conditions. The inhibitory power of unrelated sounds in this setting can therefore be explained with the temporal overlap of verbal and sound stimuli. This scenario is consistent with shallow processing approaches (Barsalou, 1999; Louwerse and Jeuniaux, 2008) as well as the Good-Enough Approach of language processing (Ferreira et al., 2002, 2009).

It is in theory possible that sound stimuli may not be identified before the button pushes or before lexical access and decision[37]. Therefore, sound stimuli would not be able to affect semantic processing and decision. The hypothesis that lexical access or button pushes may bypass and happen earlier than sound identification is possible in theory; however, incongruent sounds did not affect processing in either of the critical time windows (words 5, 6, and 7) in contrast to unrelated sounds. A recent study by Stockall and colleagues (2004) attributes the point of lexical access to the M350 magneto-encephalograph component peaking around 300–400 msec. Since the M350 component is believed to reflect word retrieval, and sound recognition has been shown to appear earlier (Guillaume et al., 2006), therefore it is implausible that recognition of sound stimuli lags behind word retrieval.

We analysed the post-critical region too because it may be the case that the target site (time-window) of the congruency-effect is derived from *post-conceptual* processing. Because the

[37] It may be the case that sound stimuli differ in terms of their identification times, i.e., the minimum amount of time presentation for the sound to be identified. For example, certain sounds may be easier to identify than others because of characteristics of onset dynamics or waveforms (*uniqueness points of identification*). In other words, the time frames or uniqueness points for critical sound identification may differ. Guillaume and colleagues (2006), for example, showed that rhythmic sounds, such as watch alarm, bubbles in water, tapping water, frog, coin, broken glass,or poured water are recognized earlier (160 ms) than non rhythmic sounds (239 ms), such as dog barking, clarinet, rooster, girl shout, flute, guitar, whistling, police siren, cough, etc. The present experiment deliberately did not control for or test this possible confound because the critical difference between category-internal and category-external (unrelated) sounds makes the assumption unwarranted that sound stimuli do not affect semantic processing. Rather, unrelated sounds did affect processing *in-situ* (on the region of word 5) as well as in a *delayed* manner (on word 7).

congruency-effect was not revealed on the region of the critical verbs or later in the sentence in a delayed manner, therefore the absence of the congruency-effect points to the conclusion that no auditory conceptual features are routinely evoked under shallow linguistic processing.

Our results are compatible with spreading activation theories (e.g., Anderson, 1983; Neely, 1991) and distributed network theories of semantic content (McRae, de Sa & Seidenberg, 1997). Category-external items (unrelated sounds) inhibit processing relative to category-internal items (congruent, incongruent, or no sounds), given a short SOA. These results provide evidence that categorical information is extracted from sound stimuli as they are processed and instantly spreads to neighbouring concepts within the semantic network. The semantic network consists of a pool of conceptual and perceptual features in this semantic space, with closer neighbours sharing a greater number of features (Rogers and McClelland, 2004).

The present findings provide additional evidence supporting the perception-language interface in the auditory domain in that it shows that category-external sounds inhibit the retrieval of sound-related verb meaning. The results do not underscore the strong version of the theoretical argument proposed by the Cognitive Metaphor Theory that the comprehension of abstract language is always affected by concrete representations (Kövecses, 2002; Lakoff and Johnson, 1980, 1999).

As far as can be concluded from the results of Experiment 2, the effects reflect fast-acting automatic shallow comprehension processes, as suggested by Barsalou (1999), without accessing auditory representations. The results are therefore compatible with the LASS theory (Barsalou et al., 2008) mentioned earlier which claims that there are multiple systems to represent knowledge: linguistic forms in the brain's language systems and situated simulations in the modal systems. The effects revealed in our findings reflect the operation of the former one. In the LASS framework, linguistic forms and situated simulations interact continuously. Importantly, the

LASS theory proposes that when a word is encountered, the language system becomes engaged immediately before situated simulations to categorize the linguistic form: associated linguistic forms are generated. Our results are consistent with this prior activation of the language system. The effects in our Experiment 2 show that in this early stage of processing, linguistic associated, such as incongruent items are generated which are compatible with the categorical knowledge. Crucially, word associations are sufficient to produce arrive at a correct interpretation in conceptual tasks and the use of deeper modality-specific knowledge is not necessary, such as the generation of sound representations.

The superficial types of control questions used in our experiments make participants adjust their reading strategies to match the task demands, i.e., answering the control question correctly, thus, participants were probed implicitly regarding the auditory aspect of the sentences. If, however, "sound-provoking" control questions were applied, such as 'there was a jingling sound' ('yes' or 'no'?) to the critical sentence 'The silver spurs clattered', then different effects may emerge on the region of the critical verbs because this new task demand would probably alter the reading styles of participants, and the new reading strategies will tap into deeper non-linguistic information, such as auditory imagery. In this case readers will probably generate auditory representations and draw inferences from it, rather than skimming over the sentence in a superficial manner. Nevertheless, the "superficial" type of control questioning was chosen deliberately in order to preclude artefacts, i.e., the explicit retrieval of auditory representations, while testing simple sentence understanding.

In sum, the two experiments presented in this paper extend our understanding of the interface between environmental sounds and language in that sound simulation is not fundamental to language processing. This finding is consistent with the Career of Metaphor Hypothesis (Bowdle and Gentner, 2005) and the Good-Enough Approach of language processing (Ferreira et al., 2002, 2009). Our results of the two experiments show that both concrete and abstract sound-related expressions are processed in a shallow manner in the sense of Barsalou (1999) and Louwerse and Jeuniaux (2008).

Further, the questions of whether sounds affect linguistic processing and whether linguistic processing affects sound perception cannot be seen as two approaches to the same process. Boroditsky (2000), for example, found that spatial representations primed their consistent temporal schemas, whereas there was no transfer from the domain of time to the domain of space, indicating that – although space and time share structured relational information on-line – this sharing is asymmetric. We have found in Experiment 1 that sound stimuli do not affect language processing, and that language processing does not routinely activate sound representations (Experiment 2).

5. Conclusions

In Experiment 1, we sought to answer the question of whether specific environmental sounds (e.g., ‘barking’) affect concrete and abstract sound-related linguistic processing. Of particular interest was whether fictive sound sentences, such as *Researchers blow the whistle on malpractice*, an event that does not contain any sounds at all are also affected by concrete sound representations. The processing of concrete or abstract sentences was not influenced by the passive hearing of specific sounds.

In Experiment 2, we eliminated the long SOA condition of Experiment 1 by presenting the sound stimulus together with the verb instead of in a temporal asynchrony. The congruency-effect did not emerge either at a long SOA (Experiment 1) or a short SOA setting (Experiment 2) either for concrete or abstract contexts. Crucially, no category-internal effect of auditory information on abstract language processing was confirmed. The two experiments demonstrated that sound-related language does not routinely evoke specific sound representations, but rather semantic categorical knowledge is elicited in a non-specific manner, i.e., priming only semantic categories.

Taken together, the findings of both Experiments 1 and 2 are interpreted in the "Good-Enough" processing framework (Ferreira et al., 2002, 2009) and the shallow processing account proposed by Barsalou (1999) and Louwerse and Jeuniaux (2008). According to the shallow processing account, language processing does not necessarily and automatically utilize modality-specific simulation, but rather linguistic processing is contingent on lexico-semantic information. The results thus do not lend support to the psychological reality of the strong version of the Embodiment hypothesis (e.g., Lakoff and Johnson, 1999), according to which language processing and semantic representation is dependent on accessing modality-specific representations. Rather, the effects reflect the immediate and superficial but "good-enough" activation of associated linguistic forms (linguistic system) without the activation of deeper modality-specific representations (simulation system), the main finding of our study, which is compatible with the two-system LASS theory (Barsalou et al., 2008). The theoretical import of our study therefore is that concrete or abstract semantic sound-related representation is possible without access to auditory representations. The absence of the congruency-effect for abstract sentences are consistent with the Career of Metaphor Hypothesis put forward by Bowdle and Gentner (2005) according to which conventional metaphors are directly represented without links to concrete representations.

Future research might fruitfully explore the following questions: (1) what is the role of suppression (if any) in auditory representations? For example, comparing affirmative and negative phrases encoding fictive sounds, does the negated sentence *Her name doesn't ring a bell* engage auditory mental simulation similarly to the affirmative? Also, can different task-instructions inhibit or induce mental simulations? (2) The specificity of mental simulations is a very interesting question that would be worth pursuing further: do different kinds of concrete ‘ringing’ (telephone, bell, etc.) or ‘horn’ (boat, automobile, brass musical instrument, etc.) sounds recruit different samples of subtle auditory representations? (3) One could ask if there is a difference in the time course of activation of auditory representations triggered by concrete and abstract sentences in a task in which auditory representations are active.

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APPENDIX

The critical sentences in Experiments 1 and 2 can be seen below. The English translations may not always render the meaning of the abstract sentences, only their general senses. The underlined verbs in the sentences encode the sounds that are given in the congruent condition (the names of the objects/animals/musical instruments are given). Sound and verb stimuli in the concrete and abstract contexts are comparable because the same verbs were used in both concrete and abstract contexts. Linguistic devices in the three sound categories refer to the denominations of sound sources (e.g., truck, train, etc.) or to actions (e.g., glass break, frying pan sizzling, etc.). Verb frequencies were computed from the Hungarian National Corpus (MNSZ, http://corpus.nytud.hu/mnsz/). The first number refers to the occurrences of the verb forms in past tense in the corpus, the second one (in brackets) refers to the averaged occurrence per 1 million word.

Abstract sentences (fictive sound event)	***congruent sound***	***incongruent sound***	***unrelated sound***	*verb frequency*
1.) A sajtó a vészharangot kongatta választás előtt. 'The press rang the alarm before the election.'	gong (church bell)	drums	water dripping	35 (0.19)
2.) A diáknak az agya zakatolt vizsga után. 'The student's brain was fried after the exam.'	train	truck	organ	80 (0.43)
3.) A betörő a kódokat végigzongorázta még otthon. 'The burglar keyed in every number combination to the house yet at home.'	piano	violin	glass break	9 (0.05)
4.) A miniszterelnök a vezetőket összetrombitálta sajtótájékoztató előtt. 'The prime minister blew the horn to summon the leaders before the press conference.'	trumpet	flute	swords	9 (0.05)
5.) A madarak valami fizetésemelésről csiripeltek értekezlet közben. 'The birds were chirping about a salary rise during the meeting.'	bird chirp	crow	motorcycle	15 (0.08)
11.) A nő biológiai órája ketyegett házasság után. 'The woman's biological clock was ticking after marriage.'	clock tick	typewriter	sheep	79 (0.42)
7.) Az egyetemista a vizsgán lebőgött tanárai előtt. 'The student put up a bad show in the exam in front of his teachers.'	cow	horse	police siren	3 (0.02)
8.) A bróker a csődöt szétkürtölte a médiában. 'The broker sounded the horn to announce the news about the bankruptcy in the media.'	horn	drums	lawn mower	8 (0.04)
9. A titkárnő mindent világgá kukorékolt új munkahelyén. 'The secretary disclosed every secret at her new workplace.'	rooster	duck	boat horn	71 (0.38)
12. A játékos a bírót leugatta meccs közben. 'The football player barked something to the referee during the match.'	dog bark	cat	banjo	7 (0.04)
6. A korrupciós bomba tegnap felrobbant a bíróságon. 'The corruption bomb exploded at the court yesterday.'	explosion	crash	harmonica	798 (4.25)
10. A ninjának a vére felforrt küzdelem előtt. 'The ninja was boiling with anger before the fight.'	boiling	frying pan sizzling	ice drop	95 (0.51)
Concrete sentences (concrete sound event)	***congruent sound***	***incongruent sound***	***unrelated sound***	
8.) A hajó a kikötőben kürtölt indulás előtt. 'The boat sounded the horn in the harbour before departure.'	horn	drums	lawn mower	22 (0.12)
2.) A fiú a szobában zongorázott a barátnőjének. 'The student was playing the piano in the room for his girlfriend.'	piano	violin	glass break	160 (0.85)
12. A kutya a kertben ugatott szakadó esőben. 'The dog was barking in pouring rain in the garden.'	dog bark	cat	banjo	163 (0.87)
4.) A madarak a fán csiripeltek a kertben. 'The birds were chirping on the tree in the garden.'	bird chirp	crow	motorcycle	15 (0.08)

5.) A lány a zeneiskolában trombitált éveken keresztül. 'The girl was playing the trumpet in the music school for years.'	trumpet	flute	swords	52 (0.28)
6.) A tehén az istállóban bőgött fél délelőtt. 'The cow was booing in the stable from the morning.'	cow	horse	police siren	160 (0.85)
10.) A vonat a hídon zakatolt utasokkal tele. 'The train was clattering on the bridge full of passengers.'	train	truck	organ	80 (0.43)
9.) A kakas a templomban kukorékolt egész reggel. 'The rooster was crowing in the church the whole morning.'	rooster	duck	boat horn	71 (0.38)
1.) A lelkész a harangot kongatta istentisztelet után. 'The priest sounded the church bell after the ceremony.'	gong (church bell)	drums	water dripping	35 (0.19)
11.) Az óra a szobában ketyegett egész éjjel. 'The clock was ticking in the room the whole night through.'	clock tick	typewriter	sheep	79 (0.42)
7.) A bomba az iskolában felrobbant tegnap délután. 'The bomb exploded in the school yesterday afternoon.'	explosion	crash	harmonica	798 (4.25)
3.) A víz az edényben felforrt a konyhában. 'The water in the dish boiled in the kitchen.'	boiling	frying pan sizzling	ice drop	95 (0.51)

Semantic distance measures

Semantic distance measures based on the **Jiang & Conrath's** (1997) similarity measure of semantic relatedness were obtained in **WordNet::Similarity** (http://marimba.d.umn.edu/). The Jiang & Conrath measure (jcn) was chosen for relatedness estimation because this measure has been shown to be superior to the others (Budanitsky and Hirst, 2006). The value of this measure ranges from zero (completely unrelated) to one (identical). The idea is that words in similar contexts are close. Congruent-incongruent pairs comprise sound events that are conceptually close, while congruent-unrelated pairs are semantically distant relative to congruent-incongruent ones, as shown by the Jiang & Conrath measures in the table below. Congruent-incongruent pairs may be semantically dissimilar, yet conceptually close. Semantic distance measures are crucial because it may be the case that environmental sounds are organized mentally according to latent features and not necessarily according to taxonomic semantic categories. The underlined words were used as linguistic devices to compute the Jiang & Conrath values in cases where multi-word terms did not return a value. Category-internal semantic distances (congruent-incongruent pairs, *Mean* jcn = 0.21, *SD* = 0.14) are significantly closer than category-external relationships (congruent-unrelated, *Mean* jcn = 0.05, *SD* = 0.03), $t(12.240) = 4.100$, $p = 0.001$. This analysis confirmed our intuitive hypothesis about the status of incongruent and unrelated sounds (that incongruent sounds are semantically closer).

congruent - incongruent semantic distance	***congruent - unrelated semantic distance***
sound of a gong (church bell) - drums (jcn 0.0934)	sound of a gong (church bell) - water dripping (jcn 0)
train - truck (jcn 0.1685)	train – organ (jcn 0)
piano - violin (jcn 0.3562)	piano - glass break (jcn 0.0862)
trumpet - flute (jcn 0.2556)	trumpet – swords (jcn 0.0872)
bird chirp - crow (jcn 0.2418)	bird chirp – motorcycle (jcn 0.0787)
clock tick - typewriter (jcn 0.0883)	clock tick – sheep (jcn 0.0650)
cow - horse (jcn 0.3121)	cow - police siren (jcn 0.0487)
horn - drums (jcn 0.1593)	horn - lawn mower (jcn 0)
rooster - duck (jcn 0.1394)	rooster - boat horn (jcn 0.0526)
dog bark - cat (jcn 0.5374)	dog bark - banjo (jcn 0.0596)
explosion (explode) - crash (jcn 0.1357)	explosion (explode) - harmonica (harp) (jcn 0.0604)
boiling - frying pan sizzling (jcn 0.0788)	boiling - ice drop (jcn 0.0482)

4. GENERAL DISCUSSION AND CONCLUSIONS

The general aim of this thesis was to shed light on the following questions: Does the strong version of the Embodiment Hypothesis hold? Are sensori-motor representations/experiences *necessary* and *automatically* activated for concrete and abstract language processing? The answers to these questions are not only technically pertinent (i.e., how language processing works) but they are also theoretically relevant because a more general question can be answered via the investigation of language processing: are modality-specific representations conceptual features, or not? In other words, by conceptual feature we mean that a modality-specific representation is an inherent part of a conceptual representation (e.g., Lakoff and Johnson, 1999). The other alternative is that modality-specific activation in linguistic tasks is only *supportive* and *epiphenomenal* rather than necessary (e.g., Mahon and Caramazza, 2008).

Hungarian, the language of testing throughout the studies in this thesis, is different from English in many respects, however, no crucial differences in performance were expected which would alter the result profile. I am going to elaborate on and confirm this point when discussing the corpus-linguistic study, as some degree of difference between English and Hungarian was observed. The studies tied to the Thesis points (Chapter 3.) strived to employ versatile methods of linguistics and psychology in approaching the research problem of whether the strong version of the Embodiment Hypothesis holds. By applying psycholinguistic methods, research questions inaccessible to theoretical and corpus-linguistic methods can be tapped. It has been implied that psycholinguistic techniques are superior to the corpus-linguistic method when it comes to psychological reality. In Chapter 3.1., the research question was first taken up from a theoretical angle, in Chapter 3.2., from a corpus-linguistic point of view, and in Chapters 3.3., 3.4. and 3.5., from a psycholinguistic perspective.

It is evident that keeping only to one type of evidence or method constrains the way results are interpreted. The corpus-study with its close but *indirect* approximation of psychological reality and the psycholinguistic experiments with their inadequacy to infer to the *format* of representation or *time course* of processing all point to the conclusion that other methods are needed to investigate the topic. Thus, further research should extend the current research program by employing neuroimaging and neuropsychological methods to investigate the psychological reality of the strong version of the Embodiment Hypothesis.

It has been demonstrated that there are alternative theories of the Embodiment Hypothesis, and that embodiment effects can be explained by other theories else than the CMT (cf. Chapters 1.2., 1.5., 3.1., 3.3., 3.4., and 3.5.). These alternative theories include *inter alia* the Structural Similarity View (Gentner et al., 2001), the weak version of the Embodiment Hypothesis (Murphy, 1996), the “Good-enough” approach of language processing (Ferreira et al., 2002, 2009), the shallow processing account (Barsalou, 1999; Louwerse and Jeuniaux, 2008, reviewed also by Sanford and Sturt, 2002), and the Career of Metaphor theory (Bowdle and Gentner, 2005).

A famous pragmatic theory, Relevance Theory (Sperber and Wilson, 1986/2005), is a well-known candidate to the CMT. However, this theory has not been dealt with in the context of the present thesis because the assessment of this theory lies outside the scope of the dissertation. Further, it has been suggested in the thesis that embodiment effects in general are hard to interpret (e.g., Dove, 2009; Mahon and Caramazza, 2008), which tames the interpretability of Embodiment theories.

The review article tied to Thesis 1 aimed to demonstrate the tension between amodal and modal theories. It was shown that the existing evidence cannot distinguish between amodal and modal theories, and that embodiment effects are compatible with modal theories too. The dissertation took therefore this position and interpreted the empirical results from this perspective. The weak version of the Embodiment Hypothesis, which prompted the psycholinguistic studies tied to Theses 3 and 4, was claimed not to be able to distinguish between the weak version and the negation of the Embodiment Hypothesis in terms of predictions on the level of psycholinguistic experiments presented in this dissertation. Therefore, I followed the principle of parsimony and concluded the results as the negation/disconfirmation of the strong version of the hypothesis as a minimal statement.

A corpus-based analysis of literal versus metaphorical language use in Chapter 3.2. aimed to investigate the strong version of the Embodiment Hypothesis based on corpora. The main question, which was taken up in Chapter 3.2., was whether the automatic identification of certain conceptual metaphors could be successful taking the strong version of the Embodiment Hypothesis. It was hypothesized in this corpus-linguistic article that a metaphoric sentence should include both source-domain and target-domain expressions.

Three major theoretical approaches to text-based metaphor identification have been explored, the methods of which are combined to perform a comprehensive analysis of metaphorical language use: (1) Qualitative linguistic analysis, (2) Statistical analysis (Latent Semantic Analysis), and (3) the Psycholinguistic approach. A common ground in all the three approaches is that metaphorical processing is defined as a conceptual mapping from a source domain to a target domain. An expression is considered metaphorical if the two domains can be shown to be distinct.

In the Qualitative linguistic analysis (1) (Steen, 2002 and the Pragglejaz Project) after the propositional structure of the sentence is identified, the sentence is broken down into a series of predicate-argument relations. Vague or ambiguous terms are explicated. Next, a situation model, which is the likely mental representation of the situation described, is constructed for the sentence. The predicates and arguments of the propositional structure are classified according to whether they designate an element of the situation model

- directly (literal use) or
- indirectly (metaphorical use)

A linguistic expression designates an element directly if the conceptual domain of the given expression (source) and the conceptual domain of the designated element (target) are identical. Conversely, a linguistic expression designates an element of the situation model indirectly if the two conceptual domains can be shown to be distinct. Two domains, however, may be neither clearly distinct nor clearly identical but systematically related – in this case we have an instance of metonymy (e.g., The New York Times may designate the paper, the institution producing the paper or the staff working for the institution).

In the statistical approach (2) (Kintsch 1999, 2000, Goatly 2002) the discrete categories of “same”, “different” and “related” domains are replaced by the notion of semantic distance between domains to avoid the problem of borderline cases. Thus, there are degrees of metaphoricity: strong metaphors are those where the distance between the domains is relatively great, for example, in the case of the metaphor *My lawyer is a shark*, while metonymy will appear towards the weaker end of the scale. The statistical approach further assists qualitative analysis in that it provides an efficient method of measuring the distance between domains on an empirical basis. It is measured through the distributional distance in a linguistic corpus between the expression representing the source domain and the expression representing the target domain (e.g., *lawyer* and *shark*), where distributional distance is defined as the likelihood and size of the overlap between the sets of expressions in the linguistic neighbourhoods of the two test expressions (e.g., *lawyer*’s neighbours are *law courts, solicitor, fee, justice, vicious, greedy, etc.* and *shark*’s neighbours include inter alia *fish, sea, boat, vicious greedy, etc.*).

A number of studies in the Psycholinguistic approach (3) provide support for the theoretical underpinnings of the statistical method by showing that metaphorical processing is not qualitatively different from literal processing; metaphors could indeed be instances of polysemy. Two conclusions can be drawn: (i) literal meaning does not have priority over metaphorical meaning in processing (figurative interpretations do not take longer to process) and (ii) metaphor comprehension is not optional. A corpus study of the context effects of metaphors conducted by Martin (2006) shows that Metaphor is less likely to occur if the preceding context contains literal uses of the vehicle, which confirms the statistical approach (2), and further supports psycholinguistic findings of inhibition/priming. It also justifies the context-based Pragglejaz method of resolving problem decisions.

Elements of the three approaches were used to construct a metaphor corpus. Some typical source and target domains of metaphor were annotated by hand in two multi-lingual corpora: a literary text and a corpus of texts from international media. Both corpora were constructed specifically for the purpose of metaphor identification. A set of expressions associated with each domain (i.e., its neighbourhood) was built by an experimental method and by Latent Semantic Analysis. In the experiment subjects sitting in front of a computer screen were presented with an expression representing the test domain and were given one minute to type words they associate with the test expression (see Chapter 3.2., Appendix A). For each test domain, words provided by at least 25% of participants were selected as neighbours of the test expression. At the second stage of the analysis the corpora was scanned for sentences containing both an expression associated with the source domain and an expression associated with the target domain.

We conducted a Hungarian corpus analysis on a selection of various texts. We focused on the use of metaphoric language in the texts. The texts included film subtitles (Wasabi; Taxi3; Delicatessen; Un long dimanche; Le Mépris (Contempt Il Disprezzo); Crouching Tiger; Hidden Dragon), *National Geographic* articles, and novels (Mikhail Bulgakov: The Master and Margarita, Karel Čapek: War with the Newts, Th. Mann: Mario and the Magician, Erich Kästner: Lottie and Lisa, The Diary of Anna Frank). The texts were chosen to be available in four languages (English, Hungarian, Italian, Spanish) for the purpose of a potential cross-linguistic comparison in the future. Our test corpus was 10% of these texts.

We focused on the following conceptual metaphors (based on Lakoff's and Kövecses' work): 'anger is heat', 'change is motion', 'conflict is fire', 'control is up', 'creation is building', 'more is up' ('less is down'), 'politics is war', 'progress is motion forward', 'thoughts are food', 'the mind is a machine', 'theories are buildings', 'time is money'. For an extensive list of Hungarian examples, see Chapter 3.2., Appendix B.

We followed three methods: First we used the associations obtained from our internet association survey, and tested the recall and the precision of this method on the corpus (Method 1, psycholinguistic word association norm), second we extended these associations with synonyms from dictionaries (Method 2, dictionary method). Third, we looked at the metaphorical sentences (which were annotated by the raters), and gathered source and target domain words from these sentences to construct a set of new lists. We tested these lists on a new sample of the corpus (Method 3, corpus-based method).

The results can be summarized as follows: there were altogether 155 metaphorical sentences in the corpus, which all belonged to the conceptual metaphors mentioned above. Method 1 found 6 sentences (out of the 155) that contained both a source and a target domain word, while Method 2 found 28 sentences by this logic. Method 1 found altogether 80 sentences, and Method 2 found 617 sentences that contained a source and a target domain word at the same time. Only 18 sentences were rated as metaphorical (Method 1), and with Method 2 only 89 sentences were judged as metaphorical.

The manual construction of source and target domain words (Method 3) yielded better results: 42 metaphoric sentences were found to contain both a source and a target domain word out of the 75 (that contained both a source and a target domain word). In the light of some problem cases and the low performance of Method 1 and 2 we can conclude that (i) the absence of source and/or target domain words does not necessarily show that there is no metaphor, (ii) the presence of both source and target domain words may not necessarily be indicative of a metaphor either (overgeneralization of the parser, see results), (iii) Conceptual Metaphors are sometimes not explicit about the target domains.

Taken together, it can be concluded that certain metaphors can be found based on these methods, yet others cannot. The present results *may* indicate the implausibility of the source-target theory, *but could in theory also show that the source-target theory cannot be grasped adequately with a corpus-linguistic methodology that focuses on source and target domains*. *A limitation of this study is that it cannot directly refute the strong version of the Embodiment Hypothesis because this hypothesis can in theory be consistent with our corpora-based observation that metaphors do not group together along source and target domain words.* All in all, results demonstrated that the corpus-based method is the most effective strategy. What it amounts to is that source and target domains are best characterized by statistical patterns rather than by psycholinguistic factors.

This corpus-study also allowed for a comparison of metaphor use in English and Hungarian, which was one of the rationales behind this study. This rationale is relevant to the strong version because universalism on the level of conceptualization may be consistent with the strong version of the hypothesis. It is evident that different languages show differences in the number and in the intension and extension of abstract concepts in given domains of experience (e.g., emotion, interpersonal interaction), which could be ascribed to cultural differences.

A number of abstract domains of knowledge have been identified that are expressed in the different languages (for instance, psychological states, see *Appendix B* in Chapter 3.2.). Each domain has been analysed in terms of the number of different words available, and extensive comparisons have been carried out in order to determine whether translation equivalents of abstract words across languages are mapped onto the same concrete domains.

It can definitely be concluded that no significant differences can be observed at the conceptual level of metaphors between Hungarian and English. In other words, all of these conceptual metaphors are available in both languages. This observation is best illustrated by the English translations of the Hungarian examples in Chapter 3.2., Appendix B. This is due to a common perceptual apparatus (e.g., MORE IS UP), common experience with everyday phenomena (e.g., CONFLICT IS FIRE) and universal physiological perceptions (e.g., ANGER IS HEAT), as well as due to a shared cultural knowledge (e.g., POLITICS IS WAR, TIME IS MONEY). For example, both Hungarian and English use the metaphor MORE IS UP when they speak about temperature: *felmelegedés* (HEAT IS UP). Theories are conceptualized as buildings in both languages: just like English, Hungarian predominately uses the concept of *foundation* or the *ground* of a theory. However, there are subtle differences in terms of the use of these conceptual metaphors. For example, in Hungarian *gyerekcipőben jár* (‘go in a child’s shoes’) refers to the initial level of development, something that is not fully developed.

Although, in general, there are no significant differences between the two languages with regard to metaphorical mappings, we can find some examples which are metaphorical in one language but not in the other. Take the following phrases from the Hungarian and English translations of the novel *The war with the newts* by Karel Čapek, one of our source texts in the corpus:

Így történt azután, hogy minden nemzet természettudománya megalkotta a maga óriásszalamandráját, és ***ádáz harcot folytatott*** *('furiously fought against') a többi nemzet óriásszalamandrái ellen.* 'So it was that in the end every nation had its own giant newts and **furiously and scientifically criticised** the newts of other nations.'

A tudomány józan világosságában a szalamandrák sokat veszítettek kezdeti nimbuszukból, mely a ***szokatlanság forrásából táplálkozott*** *('fed from the resources of uniqueness').* 'In the cold light of science the salamanders lost much of their aura of **primordial** strangeness and uniqueness.'

While in both examples the Hungarian texts contain a metaphorical mapping, POLITICS IS WAR and RESOURCES ARE FOOD, respectively, the English versions are more literal. This fact, however, does not mean that the English lacks those metaphors but only highlights the subjective preferences of translators. It may also be the case that English abstract vocabulary relies predominantly on Latin concepts which are originally also metaphorical in Latin. For example, the word 'concept' is abstract in English, while in Hungarian it shows metaphorical effects: Hungarian 'fogalom' ('concept') stems from the idea of grasping ('fog'); this etymology evokes the metaphor 'grasping is understanding' which is also present in English. In other words, there are few unique, language-specific metaphors "under the sun".

Our analyses also found several examples highlighting the importance of grammatical form: for example, according to our corpora, the source domains are represented mainly by verbs or adjectives (*fogyaszt* 'consume', *táplál* 'feed', *megy* 'go', *gurul* 'roll', *kitör* 'explode', *magas* 'high', *lobbanékony* 'impetuous, impulsive', etc.), while the words referring to the target domains are usually nouns (*vita* 'argument', *élet* 'life', *tisztelet* 'honour', *szerelem* 'love', *gondolat* 'thought' etc.). This observation supports the results obtained by Deignan (2005) showing that for the majority of metaphorical expressions, words referring to the source domain are verbs or adjectives. The author argues that this is because in metaphorical language use people try to describe abstract entities, thus they take words denoting behaviour, features or actions from the concrete source domains.

In conclusion, there are more parallels than differences between the two languages. We can distinguish between two levels: (i) the level of conceptual metaphors, and (ii) the level of metaphor use. We did not find any cultural differences at the first level between Hungarian and English. The second level refers to the way speakers use conceptual metaphors. For example, the conceptual metaphor MORE IS UP is usually associated with temperature, hence the English expression *heat up*. However, time is not usually related to this metaphor, because neither English nor Hungarian associated time with verticality (e.g., MORE IS UP, LESS IS DOWN), which would follow logically from the conceptual metaphor MORE IS UP. It seems therefore that differences may emerge at the second level. As for time, there are deviations from the conceptual metaphor. Boroditsky (2001), for example, showed that Mandarin also describes time as vertical and that this pattern is deeply seated in Mandarin speakers when they use language. Our finding that deviations arise at the second level is more consistent with the strong version of the hypothesis.

However, it is crucial to underscore that a corpus-study may best indicate the scarcity or abundance of conceptual metaphors but it cannot directly assess the predictions of the strong version. Cross-linguistic differences may just show that different cultures use language differently and that cultural and environmental factors shape their representations. However, this all cannot yet disconfirm the strong embodiment view because there may be a common pattern behind cultural variance: they all use the same conceptual metaphor but that metaphor is surfaced differently (Boroditsky, 2001).

This corpus-based conclusion is regarded as a *weak refutation of the strong version of the Embodiment Hypothesis* because it may be the case that embodiment effects do not explicitly surface in corpora but rather they can be tapped in psycho- and neuroscientific experiments. For example, a usage-based hypothesis assumes that source-domain words are not necessary to be present in metaphors because linguistic structures have undergone cognitive routinization and may not show metaphoric effects. In other words, psycholinguistic data reflects online language use *directly*, whereas corpus-linguistic data only reflects language use *indirectly*. Therefore, we extended the research into the strong version of the Embodiment Hypothesis towards psychological reality and further investigations were carried out using psycholinguistic methods in Chapters 3.3., 3.4. and 3.5.

The experiments in Chapters 3.3., 3.4., and 3.5. all employed the self-paced reading paradigm (introduced by Just et al., 1982), although they tested two different phenomena in language. The connection between the two phenomena is the research question at hand, that is, the investigation of our concrete-abstract knowledge with respect to the activation of non-linguistic (modality-specific) representations. The experiments in Chapter 3.3. addressed the question of the mental representation of uni- and bidirectional social relations in language and those in Chapters 3.4. and 3.5. dealt with the interface of environmental sounds and language.

The effects revealed in the experiments tied to Chapter 3.3. can also be interpreted in terms of *linguistic*/*propositional* theories, and not necessarily in the framework of Embodiment theories, Simulation theories (Bergen, 2007; Zwaan and Madden, 2005), Situation models (Zwaan and Radvansky, 1998), or the CMT. A specific problem with the interpretation of the results is that one cannot infer to the *format* of representation (*amodal* or *modal*). Even if the modal nature could be inferred, it may still be the case that uni- and bidirectionality are represented *non-spatially*.

Given the constraints and limitations to the interpretation of the findings in Chapter 3.3., we can only hypothesize parsimoniously that processing asymmetrical constructions is *cognitively more loaded* than that of symmetrical ones. In terms of this hypothesis, processing an asymmetric construction is a more difficult *cognitive operation* (AGENT, PATIENT) than processing a symmetric one (AGENT, CO-AGENT) because of the processing ease of *co-involvement* or symmetry in the case of symmetric constructions compared to the difficulty of processing asymmetry where the two actors are assigned different thematic roles. This hypothesis is congruent with the assumption that there is a *procedural difference* between the processing of the two constructions. Neuropsychological investigations have also emphasized that thematic role-assignment is impaired in a graded fashion. Manouilidou et al. (2009) showed that Alzheimer patients had the most difficulty with object-experiencer psych verbs (e.g., 'frighten'), while they performed perfectly on canonical agent-patient constructions.

What this former hypothesis amounts to is that we cannot infer to the specific nature of modality-specific representations activated. Moreover, we even cannot infer to the activation of modality-specific representations at all. The minimal interpretation is that a *higher cognitive representation* (cognitive template) is activated *instead of modality-specific representations*. It may also be that this higher *amodal representation* is *not a propositional representation*.

This higher cognitive representation may be a *frame* activated by the verbs which selects an agent and a co-agent or patient. For example, the activity of 'messing with someone', the "messing-frame" requires an agent who messes with another person, the patient, while the activity of 'hooking up with someone', the "hook-up-frame" requires two agents of equal status and involvement in the activity. The fact that they carry out the action together makes this frame easier to process than in the other case. Crucially, differences in processing may be attributable to the different structure of these cognitive templates (frames), rather than to the modality-specific representations implicitly elicited by the verbs and their argument structures.

However, it may be the case that these templates activate modality-specific simulations, such as visual imagery (pictures of the actors), spatial representations (relationship between the actors), motor content ("who did what to whom?" information), etc. These hypothesized frames resemble Barsalou's and Prinz's conception of frames (Barsalou, 1992; Prinz, 2002) or Hampton's (2003) schemas, and they are compatible with modality-specific theories because they can provide the cognitive basis for simulations in the sense of Barsalou (1999).

A procedural difference between symmetric and asymmetric constructions may indicate the difference in retrieving thematic-role information from the two types of frames. Thematic-roles are values or slots added to frames. A thematic-role frame therefore is an action-oriented amodal representation whose role is to identify the thematic roles of the agents and objects involved in an event or action.

Coming back to the impaired assignment of thematic roles in Alzheimer's disease (Manouilidou et al., 2009), Alzheimer's disease may be considered as evidence that thematic role assignment is implemented by amodal representations given the overlapping neural substrate in Alzheimer's disease and semantic dementia (SD) (ATL; anterior temporal lobe). Concerning SD, I have already elaborated on the semantic hub hypothesis of the ATL regions.

It would be interesting to test thematic-role assignment on non-verbal tasks, such as the picture-verification paradigm or with video stimuli to dissociate linguistic representations from amodal non-linguistic representations. In other words, the difference in performance in processing asymmetric and symmetric constructions may be attributable either to a *domain-specific* linguistic amodal representational difference or to a *domain-general* amodal representational mechanism which would surface in a variety of linguistic and non-linguistic tasks. Similar result patterns would point to the direction of a domain-general amodal representation in computing thematic roles.

It is crucial to highlight that the term amodal is used here not in the sense of Newell and Simon (1972) or Minsky (1975), but rather, for example, in the sense of Damasio's *convergence zones* (1989). About the different uses of amodality, see Chapter 3.1. or Fekete (2010). Damasio's convergence zone is a neural control structure which integrates operations performed at other parts of the brain. The integration process is both hierarchical and heterarchical and it is the sum of time-locked neural activations. Importantly, *amodal coding* refers to the idea of *connecting* and *integrating* lower representations to each other or to a higher representation (see Chapters 1.4.2. and 3.1. on Damasio's theory).

In the absence of direct methods, such as EEG, MEG, TMS, or fMRI, no direct conclusion can be made about the *format* (amodal/modal) or *modality* (auditory, visual, tactile, etc.) of representations. EEG recordings could provide a relatively precise time window of the neural flow of mental phenomena. For example, neural activity recorded from EEG less than 200 ms from word onset is usually interpreted as supporting an *automatic* and *inherent* (non-auxiliary) activation of modality-specific information (Pulvermüller et al., 1999). fMRI experiments, on the other hand, could provide precise information about the spatial locus of mental processes.

Patient studies from neuropsychology could unravel the *necessary* aspect of the Embodiment Hypothesis. By necessary, a *non-auxiliary* role of modality-specific representations is meant, i.e., they are inherent parts of conceptual representations. A double dissociation would indicate that the two domains under investigation may share common neural origin and structure, thought there might be independently represented. However, even if some patients should preserve their ability to comprehend concrete or abstract action-related language despite their motor disabilities, this might just indicate that the brain is plastic enough rather than suggesting that the embodiment account is false. In other words, it may be the case that their brain recovers rapidly after a trauma but the original wiring is based on the embodiment principle. TMS studies are capable of producing “artificial brain damage” for a very short time to test the healthy operation of the brain. Thus, by using TMS the plasticity critique can be ruled out.

It should be noted that empirical results should stand the test of the critics of the Embodiment Hypothesis. Mahon and Caramazza (2008), for example, claim that information is first transduced in an abstract format. However, it still debated whether a very fast activation within a time window of 200 ms renders this hypothesis implausible.

In contrast to the problematic interpretability of the findings in Thesis 3, results of the studies in Thesis 4 (Chapter 3.4.) clearly speak against the strong version of the Embodiment Hypothesis in the realm of environmental sounds and linguistic processing. I shall return to this point later in Chapter 5 as to why this proposition can be stated with certainty based on the result profile.

In Thesis 4 (Chapters 3.4. and 3.5.), I sought to answer the question of whether environmental sounds (e.g., ‘the sound of a violin’) affect concrete and abstract sound-related linguistic processing. This topic is particularly interesting and worth investigating because mostly visual and motor processes in language comprehension have been studied intensively. Of particular interest was whether fictive sound sentences (which are abstract), such as *Researchers blow the whistle on malpractice*, an event that does not contain any sounds at all are also affected by concrete sound representations. Concrete sentences, such as *The dog was barking* were also investigated in the interest of a comparison of concrete and abstract language use.

The four experiments tied to Thesis 4 unanimously showed that no facilitation-inhibition emerges given a short SOA either for concrete or abstract contexts. The facilitation-inhibition effect is sometimes referred to as match/mismatch-effect or congruency-effect. This result is counter-intuitive because previous investigations in other domains revealed match/mismatch or congruency-effects in similar tasks (e.g., Kaschak et al., 2005; Richardson et al., 2003; Zwaan et al., 2004).

The critical verbs were either in sentence-final position (Chapter 3.4.) or in position 5 of a 7-word sentence (Chapter 3.5.), while the object of the critical verb appeared before the critical verb. Words 6 and 7 are always some sort of adjunct phrase, like "yesterday evening" (Chapter 3.5.), but the words "bell", as in "ring the bell", or the "alarm" in "sound the alarm" appeared before the critical verbs. This manipulation raises the possibility that modality-specific representations are activated earlier than at word 5. However, the congruency-effect is unlikely to be washed out by the time of the verb because unrelated sounds and incongruent sounds affect processing differently.

The single occurrence of the congruency-effect in one of the four experiments in Thesis 4 (cf. Chapter 3.4.) is attributed to the temporal asynchrony of sound stimulus presentation and lexical processing. In this setting, sound stimuli were presented continuously from sentence onset, while critical verbs were embedded in the middle of the sentence. Apparently, this long SOA setting causes the congruency-effect to emerge, while in the other long SOA setting in Chapter 3.5. no such effect emerges.

The emergence of a congruency-effect in a long SOA setting, however, does not confirm the thesis that modality-specific representations are necessary and automatically activated, rather it just shows that two stimuli are conceptually related.

This finding can at best be consistent with the weak version of the Embodiment Hypothesis, according to which language processing is in close contact with modality-specific representations. However, the emergence of the congruency-effect is the long SOA setting is minimally interpreted as *associative priming* between sounds and linguistic representations.

One explanation for this contradiction could be that the long SOA setting in Chapter 3.5. is not long enough in duration to exert its effect, so that sounds can affect language processing. Either way, it can be concluded that no congruency-effect was observed under a short SOA condition. The study in Chapter 3.5. was conducted with new sentence material because we wanted to examine the spill-over region of the verb as well because in self-paced reading it is common that effects emerge in a delayed manner.

Importantly, to emphasize, no category-internal effect of auditory information on abstract (or concrete) language processing was confirmed in either the ANOVAs or the item-analyses (see the latter analyses in APPENDIX B at the end of dissertation). However, category-external sound stimuli inhibited the processing of sound-related verbs in the same setting given a short SOA (cf., the slow-down in the unrelated sound condition in both the concrete and abstract sub-samples, cf. Chapters 3.4. and 3.5.).

However, the absence of the congruency-effect can in theory also be explained by the hypothesis that everyone activates a different sample of sound stimulus. So, for example, the same verb ‘bark’ would activate different types of barking sounds for different people. Taking Prinz's (2002) proxytype theory, during concept activation, to think about a whistle or dob-bark people put themselves into an imaginative state that resembles their perceiving these sound stimuli. Prinz calls proxytypes representations that we construct in working memory on a given occasion. Proxytypes, which are ‘copies’ of perceptual representations in long-term memory, are context-sensitive and depend on the cognitive need of the situation (p. 149). Crucially, on this account, on every occasion we think about a dog, we activate only a subset of long-term representations tied to the concept of dog from our *standing knowledge* (Prinz). The activation of a proxytype is endogenously controlled and does not depend on the presence of a stimulus. A concept in Prinz's model is a simulation.

Importantly, proxytypes are linked to other proxytypes in long-term memory, which is a *standing knowledge*, a store of these long-term representations. For example, an auditory representation of barking may activate a visual image of a dog via an intermodal link. In other words, a proxytype is embedded in an inter-modal network made of distinct representational features. These proxytypes form the proxytype of dog.

Suppose that reading sound-related language activates proxytypes, then the possibility arises that participants' congruent (or any type of) sound stimuli in the experiment differ from person to person and from situation to situation. What it amounts to is that reading times in the congruent sound condition will not be faster than those in the incongruent or the no sound condition because congruent sounds in the experiment do not specifically match the proxytypes of the participants. Suppose that this thought experiment holds true, then a model-matching phenomenon should be operating in the congruent condition: participants compare their endogenous sound representation (one that they simulate and expect) to the one they hear in the experiment and accommodate that to the exogenous sound stimulus (the one that is presented to them). Such a hypothetical subtle matching-effect may wash out the congruence-advantage.

A similar critique can arise from a radical constructivist view of semantics (Fekete, 2010). Radical constructivist semantics claims that rather than having an objective representation of a concept, a different concept is activated every time we have a thought. This concept may be similar to Prinz's non-default proxytypes, but the idea of different activations in different situations is also found in Barsalou (1999). Prinz solves the issue of difference and concept individuation by saying that there are links connecting active representations to long-term memory networks. For example, there are predicative links, which have functional roles. If a representation is predicatively connected to a memory network, and features in the network are likely to be linked to that representation. Two representations are manifestations of the same concept if they are predicatively tied to the same memory network.

Surprising as it may seem, the absence of the congruency-effect, that is, the absence of specific sound simulation is compatible with modality-specific theories, such as Prinz's theory (2002) or Barsalou's PSS (1999), because they do not insist on the activation of *every possible* simulations. Simulations can be modulated, for example, by attention or task-demand (e.g., Barsalou, 1999; Louwerse and Jeuniaux, 2008; Meteyard and Vigliocco, 2008). This line of thought is also consistent with neuroimaging investigations by Martin (2001) and Martin and Chao (2001), who claim that categorical representations, rather than being stable, are represented in a distributive manner: the conceptual representation of a category is widespread and distributed across modality-specific areas of the brain.

The experiments with environmental sounds demonstrated that sound-related language does not routinely evoke specific sound representations, but rather categorical knowledge is elicited in a non-specific manner. From the perspective of conceptual representations, results revealed in Thesis 4 can also be interpreted similarly to those in Thesis 3: the conceptual representation of a sound-related concept is a modality-neutral amodal representation.

From the perspective of sentence processing, the findings of the experiments in Thesis 4 are interpreted in the shallow processing account proposed by Barsalou (1999) and Louwerse and Jeuniaux (2008): language processing does not *necessarily* and *automatically* utilize simulation, but rather linguistic processing is contingent on lexico-semantic information. A newer and similar account, the so-called "Good Enough" approach (Ferreira et al., 2002, 2009) also claims that language processing is incomplete yet "good enough" and sufficiently detailed. Shallow linguistic processing, which is based on underspecified representations, is sufficient to arrive at a satisfactory ("good-enough") representation.

From the perspective of the principle of cognitive economy, sound simulation seems to be redundant to the comprehension of sound-related language in such shallow tasks as those in the experiments, and second, it is fairly effortful and would slow down processing. Working memory limitations also restrict the activation of complex bundle of features at one time. In terms of Prinz's proxytype theory, only those proxytypes are activated which are required in a given situation. A proxytype which comprises sound representation does/would not add to the meaning of the sentence.

However, our conclusion is discrepant with that of Brunyé et al. (2010), who showed that readers spontaneously simulate implied auditory elements of sentences, such as sound representations. Participants in their study read sentences that implicitly encoded details that could provoke auditory imagery, such as the sentence ‘The engine clattered as the truck driver warmed up his rig’. They read sentences, and then participants performed an unrelated sound categorization task in which they had to decide if sounds were real-life sound stimuli or fake. Results showed that participants were faster to correctly classify sound stimuli as ‘real’ when the sounds had been congruent with a preceding sentence.

These results seemingly demonstrate that readers simulate sound representations even in a shallow task, which does not require mental simulation. However, an important point to consider is that their study used only matching and mismatching sounds (unrelated sounds – probably category-external sounds), while no category-internal mismatching sounds were tested for verification. Second, their results can well be explained in terms of semantic priming, rather than by activation of specific auditory representations. They write that “if readers had not mentally simulated sounds during sentence comprehension, then sound categorization performance would not have varied as a function of whether sounds matched or mismatched those implied by the sentences”. In my opinion, the fact that sound verification is faster after a sentence which implies that sound (compared to that condition when the sound does not match the sentence) does not necessarily mean that that sentence automatically evoked that sound representation. The alternative explanation is that the representational mechanism behind the mismatch-effect could be a model-matching effect. In my opinion, a more parsimonious explanation is that the amodal semantic representation of the verb, which was elicited previously by the sentence, primes the verification of the matching sound, which is consistent with the amodal representation elicited by the sentence. It would be interesting to test if the same effect emerges when linguistic or pictorial stimuli were presented after the sentences instead of sound stimuli.

Third, given that Brunyé and colleagues concluded the automatic activation of sound representations, it would be legitimate by the same token to conclude the same for our result profile, which looks the same (reading times in the matching sound condition is faster compared to that in the mismatching sound condition). Fourth, they use the term auditory imagery referring to sound representations putatively activated. Imagery is retained for consciously generated sound representations, which is obviously not the case in their study given the shallow nature of the task.

My results yielded in Thesis 4 do not support the strong version of the Embodiment hypothesis (e.g., Lakoff and Johnson, 1999), according to which language processing and semantic representation is dependent on accessing modality-specific representations and that modality-specific information is an inherent part of conceptual representations. The theoretical import of the studies in Thesis 4 is that concrete and abstract semantic sound-related representation is possible without access to auditory representations.

Importantly, the theoretical import of the findings above is tenable. However, these results do not necessarily disconfirm the whole paradigm of modality-specific and embodiment theories. For example, it is possible that other types of modality-specific information is activated instead of sound representations, such as visual representations, e.g., the image of a dog when reading 'bark'. In terms of simulation theories, it is therefore conceivable following Barsalou (1999) and Prinz (2002) that *only task- and situation-relevant simulations* are activated, leaving redundant ones (e.g., sound representations) non-activated in certain tasks. The only important stipulation in Barsalou's (1999) theory is that simulations are the basis of conceptual representations, and that a concept is a simulator. This stipulation does not necessitate the activation of every type of possible modality-specific simulation at one time. However, we had expected sound representations to be active during reading taking the *strong* version of the Embodiment Hypothesis instead of taking modality-specific theories *in general*. Crucially, to emphasize again, modality-specific theories would not necessarily predict this scenario to happen, that is, they just require situated simulations instead of activating every possible simulation. However, the strong version of the Embodiment

Hypothesis does require activation of sensory-motor representations, given that the concept is built on those representations.

To sum up the findings of the Thesis points, results of the corpus study point to the direction of abstract knowledge representation based on statistical properties of the language system (Landauer et al., 1998; Burgess and Lund, 1997). This stance is consistent with the findings of the psycholinguistic experiments in Theses 3–4, which showed that meaning representation (e.g., representation of thematic roles or meanings of verbs in Theses 3 and 4, respectively) is possible without relying on embodied representations, such as spatial/modality-specific representations (Thesis 3) or sound representations (Thesis 4). Developmental psychological investigations have also confirmed that children analyse the linguistic input based on statistical properties of the language (Christiansen and Chater, 1999; Saffran et al., 1996).

Our survey on Hungarian concrete and abstract concepts (Fekete and Babarczy, 2007) presented in Chapter 1.2.1. has also demonstrated that the representation of abstract knowledge is contingent on the language system. We found that definability is a better predictor of abstractness in the intermediate and the abstract domains than imageability, whereas imageability is a good predictor of abstractness in the concrete domain (but not in the abstract domain). Definability may therefore play a more important function in the representation of abstract concepts than imageability: abstract concepts, which are less perceivable, can be differentiated more easily based on the language system, as shown by the ease with which abstract concepts can be differentiated.

It is clear that results of this survey just like the corpus study are considered as weak evidence against the strong embodiment view given that definability is an indirect and meta-cognitive measure of the representational mechanism of grounding abstract concepts. However, the ease of defining abstract concepts compared to concrete concepts may tangentially point to the conclusion that embedding abstract concepts in other linguistic symbols is a major and the dominant representational mechanism in the abstract domain compared to the predominantly modality-specific representational mechanism in the concrete domain (Paivio, 1986, 2007), which is shown by the high image-evoking values.

The results of the dissertation can be best conceptualized in a theory which propagates the above-mentioned statistical analysis and embodied representations at the same time (e.g., Andrews et al., 2005, 2007). Importantly, such theories propose that meaning is grounded in linguistic context vectors rather than in amodal symbols. Thesis 1 pointed out the necessity of amodal symbols in the newer sense, for example, in the sense of Bozeat et al. (2000) or Lambon Ralph et al. (2007). It would be useful to term the different senses of amodal differently (e.g., Damasio's convergence zones, Minsky's amodal symbols, or amodal symbols in the semantic hub hypothesis).

Taken together the findings of Theses 1–4, beginning with a review article presenting theoretical arguments through a corpus-study to a series of psycholinguistic experiments, it can be concluded that both the theoretical arguments and the experimental data converge on the *negation* of the strong version of the Embodiment Hypothesis. It has been emphasized at the outset of the dissertation that if any one of the three aspects of the strong version (*automaticity*, *necessity*, and *direct* activation) gets disconfirmed, then the strong version is not tenable. I have opted for confirming or disconfirming the strong version, rather than testing the weak version (cf. Meteyard and Vigliocco, 2008). The reason for this choice is that a direct testing of the weak version requires a comparison of performance as a function of task-demand. For example, a testing of the weak version would involve a series of experiments that only differ in task demand in order to unravel potential differences in result patterns. Second, such a direct testing may also require other techniques, which I did not access to, such as EEG or TMS.

I do not claim to have resolved the issue of whether the strong version holds or to have covered all possible angles, instead I claim that the strong version needs to be refined by taking into consideration a couple of theoretical arguments as reviewed in Thesis 1 and experimental results about real-time processing, for example, as outlined in those studies tied to Theses 3–4.

I would like to sketch some ideas concerning practical implications. The results in the dissertation and further metaphor- and embodiment-related research might have considerable future benefits in the area of *applied psychology*. Some of the main areas of benefit include: pedagogy, psychotherapy in general, metaphor therapy in specific, child therapy, hypnosis, art therapy, Neuro-Linguistic Programming (NLP), coaching, mediation, marriage counselling, advertisements, business, decision psychology, economics, artificial intelligence, foreign-language teaching (ESL), translation studies, and inter-cultural communication.

Metaphors improve the power of communication, assist in gaining insights and understanding a psychological or other type of problem, or they are of significance in the treatment process (see, for example, ‘metaphor therapy’). Regarding the latter, it is important for the therapist or the professional to know what metaphor the client uses and how they could help the client in reframing the subject’s experience. Also, metaphors are highly important in communication with children (see child therapy and psychotherapy) because children frame and convey their experiences through figurative language.

More specifically, metaphors need to be grounded in the sensory modalities, and if the client is using another modality, the therapist has to accommodate to that channel. A tenet of CMT is that metaphors are secondary, i.e., they exist non-linguistically. Patients can restructure their emotions by changing their metaphor system. This can be done by applying new metaphors and maybe also using the sensory modalities to ground the new meaning more efficiently.

Insights gained from metaphor- and embodiment-studies can also be integrated into the artificial intelligence research program. The former can be seen as an enterprise to model the human brain by creating cognizing agents which can think abstractly. The grounding of abstract thinking is one of the hardest issues in cognitive science and definitely the most difficult rationale in artificial intelligence. Advances in the field of psycholinguistically-oriented metaphor research could go a long way toward grounding abstract thinking in robots. By understanding the specific nature and limits of metaphor processing, it would be possible to devise more efficient artificial learning technologies.

Foreign-language teaching methodologies can profit a great deal from psycholinguistic research related to abstract thinking. Improved education strategies can be developed as a result of a deeper understanding of how metaphors work. The questions arise here, for example, whether multimodal presentation is more efficient than just presenting the new concepts and whether embodied grounding of new concepts is a more effective way of learning abstract concepts.

Educators should also pay attention to how metaphors are used in foreign-language classroom situations and how metaphors can facilitate the learning of new concepts. Translation studies could also benefit from the research of abstract thinking, and more specifically, from cross-linguistic comparisons of metaphoric language use (cf. the corpus-study tied to Thesis 2). Such a research program would uncover similarities or dissimilarities in patterns of conceptualization regarding abstract thinking.

Furthermore, greater insight into the origins of motivations of metaphor and the cross-linguistic comparison mentioned above could assist the efficacy of inter-cultural communication too, the design of advertisements, or the improvement of negotiations. Smooth communication promotes harmony between communication partners, groups, or nations in mediation. In this context, the power of metaphor in shaping attitudes and opinions should be highlighted. Lakoff (2008), in his book *The Political Mind*, shows that there are biological explanations behind our moral and political thought processes. Lakoff (1996/2002) goes on to claim that conservatives and liberals have different cognitive models.

All in all, it is worthwhile researching embodiment and pursuing cross-linguistic comparison studies on metaphor. There is an increasing need for interdisciplinary work of psycho- and neurolinguistic approach in understanding metaphors (see, for example, neuro-linguistic programming, NLP). For example, if the links between non-linguistic functions and abstract thinking are to be understood, there will be a need to define behavioural phenomena which allow them to be linked to neurological factors. Based on these principles and the benefits to applied sciences, further interdisciplinary and cross-linguistic work should be done in the field of metaphor and embodiment.

The benefits of the multi-methodological research of the PhD dissertation allowed me to examine the research question from different angles. Taken together these findings, the thesis points of the PhD dissertation do not lend support to the strong version of the Embodiment Hypothesis but rather they are consistent with theories that propagate that modality-specific representations/experiences are *not inherent* parts of semantic/conceptual representations (i.e., they are not conceptual features) and that language processing does not automatically and necessarily involve activation of sensori-motor representations/experiences. Both the corpus-study and the psycholinguistic results provided converging evidence against the *necessary* and *automatic* aspects of the strong version of the Embodiment Hypothesis.

The results presented in this thesis can in theory also be consistent with the weak version of the Embodiment Hypothesis, according to which modality-specific representations are not conceptual features (Boroditsky, 2000; Bowdle and Gentner, 2005; Gentner et al., 2001; Kemmerer, 2005; Murphy, 1996; Szamarasz and Babarczy, 2008). However, the dissertation did not provide *direct* evidence for the weak version of the Embodiment Hypothesis, instead it *disconfirmed* the strong version. Therefore, based on the findings of the dissertation, the negation of the strong version can be concluded. Thus, the CMT framework does not have a cognitive psychological reality, rather it may be well-founded on other grounds. For example, it may be an explanatory theory in historical linguistics or in developmental psychology.

From a theoretical point of view, the CMT and the Embodiment Hypothesis can be defeated on theoretical grounds too (e.g., Dove, 2009; Mahon and Caramazza, 2008). It has also been shown that modality-specific approaches cannot distinguish between modality-specific and amodal theories. Mahon and Caramazza (2008) and Dove (2009) also argue that amodal representations cannot be discarded and that modality-specific theories need to incorporate amodal representations. The role of amodal representations in newer amodal theories is to integrate and organize perceptual experiences and to provide a cognitive basis for them. Importantly, more recent theories which use amodal symbols, for example, Lambon Ralph et al. (2007), Bozeat et al. (2000), or Hampton (2003) are not in conflict with embodiment theories of cognition. On this view of amodality, the linkage of different kinds of modality-specific information is the basis of semantic organization. However, on can ask about the nature of information that is being linked.

In Thesis 1, it has been demonstrated that embodiment effects are inconclusive, therefore they do not necessarily support the strong version of the Embodiment Hypothesis. Further, as I have already mentioned it before, amodal symbols in the newer sense (e.g., Bozeat et al., 2000; Hampton, 2003; Lambon Ralph et al., 2007) should be integrated in cognitive theories.

In Thesis 2, evidence from corpora has been provided that indirectly speaks against the strong version of the Embodiment Hypothesis. The experiments presented in Thesis 3 proved also useful to demonstrate the potential inadequacy of psycholinguistic measures (e.g., the self-paced reading paradigm) in answering embodiment-related questions when interpreting an effect. If, however, no category-internal effect emerges but only a category-specific one, as in the case of the experiments in Thesis 4, then we are allowed to conclude the absence of the embodiment effect.

My main concern in the dissertation has been to test the strong version of the Embodiment Hypothesis with various experimental paradigms (corpus- and psycholinguistic techniques). The conclusion of the theoretical review paper and the results of the experiments unanimously point to the direction of the *disconfirmation* of the strong version of the Embodiment Hypothesis. However, it should be noted that although the results are consistent with the weak version of the hypothesis, they do not *directly* confirm it. The *direct* testing of the weak version of the Embodiment Hypothesis was beyond the scope of the dissertation, therefore the findings of the dissertation are taken to support the view that language comprehension does not necessarily and automatically involve mental simulation of modality-specific information. Importantly, these results just disconfirm two crucial aspects of the strong version (automaticity and necessity), but they do not disconfirm the whole theory of metaphoric structuring according to which reason and abstract thinking is mostly metaphorical.

The experiments tied to Theses 3 and 4 unravel new insights about aspects of the Embodiment Hypothesis. Specifically, the experiments in Thesis 3 investigate the mental representation of uni- and bidirectional constructions (thematic roles) and the experiments in Thesis 4 provide novel experimental data at the interface of environmental sounds and language. Taken together the results of the experiments in these two Theses, it can be concluded that amodal symbols supply a cognitive basis for modality-specific representations, though, crucially, the activation of the latter has not been shown in these experiments. It has also been suggested that these amodal symbols provide the ground for conceptual representations.

Finally, other measures, such as EEG, MEG, fMRI, eye-tracking, neuropsychology, etc. are needed for us to be able to answer embodiment-related questions. Such experiments may shed new light on the circumstances (discourse context, task demand nature, depth of processing, physical environment, individual differences, etc.), neural locus and time course of activation of embodied representations. Neuropsychological investigations with brain damaged patients are also important in answering embodiment-related questions. However, one should bear in mind that theoretical points about the Embodiment Hypothesis are also crucial and should not be regarded as inferior to empirical investigations.

In closing, considering that the dissertation is relevant from a theoretical-linguistic and cognitive linguistic point of view, there is a limitation to practical implications of the results reported in the dissertation. However, the findings presented in this dissertation and the future directions may be most meaningful, for example, to second language teaching methodology and cross-cultural communication. It is therefore possible that modality-specific theories of cognition can be integrated into present-day teaching methods, for example, research presented in Chapters 3.4. and 3.5. are highly relevant to the multi-modal teaching method of word-concepts. The question, which arises here, is whether learning new concepts is facilitated when presented simultaneously in two channels (both visually and auditorily). The corpus-linguistic study and the comparison of metaphor use are also relevant from both an ESL teaching perspective and from a cross-cultural communication perspective. A point to consider is that embodiment theory should be grounded not only in the body but also in the sociocultural context and the social environment. Thus, in order to progress, a culturally determined embodiment approach should emerge, one which adopts a bio-psycho-social approach, e.g., the notion of ‘cultural embodiment’.

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APPENDIX A

1/ Mean ratings of the 296 words used in the study of Fekete and Babarczy (2007) on Abstractness, Imageability, and Definability. Less than 5% of participants were excluded from the analyses for not filling in the questionnaire properly. Analyses were carried out on the data of 366 participants (n=106 on abstractness, n=151 on imageability, and n=109 on definability).

Concepts/Words	Abstractness	Imageability	Definability	Lemma frequency (MOKK[38])	(MNSZ[39])	Translation
ceruza	1.25	1.30	1.76	1358	1833	pencil
zsiráf	1.29	1.62	1.96	845	538	giraffe
kanál	1.30	1.26	1.65	2462	101044	spoon
asztal	1.39	1.34	1.48	12463	27265	table
fürdőszoba	1.40	1.83	2.12	7005	2257	bathroom
vonalzó	1.41	1.38	1.83	491	235	ruler
kutya	1.43	1.30	1.79	33458	18220	dog
seprű	1.44	1.37	1.66	296	72	broom
sétabot	1.49	1.97	2.39	27	32889	walking stick
kávé	1.50	1.70	2.24	6899	1891	coffee
alma	1.52	1.21	1.79	6705	2810	apple
sör	1.53	1.40	2.09	7378	26993	beer
vonat	1.53	1.50	1.83	10473	11865	train
ereszcsatorna	1.54	2.14	2.83	189	60	gutter
szekrény	1.55	1.56	1.82	3849	36505	cupboard
kabát	1.56	1.54	1.83	1601	1735	coat
párduc	1.56	2.07	2.62	839	13269	panther
labda	1.57	1.25	1.69	7662	6059	ball
metró	1.58	1.64	2.40	8817	2493	metro
repülőtér	1.58	2.15	2.38	5252	160	airport
világítótorony	1.59	1.93	2.30	321	213	lighthouse
szőnyeg	1.61	1.58	1.83	2789	61498	carpet
bor	1.62	1.67	2.06	18524	6442	wine
tea	1.62	1.62	2.13	5793	5832	tea
számítógép	1.63	1.69	2.75	29951	4835	computer
egér	1.64	1.54	1.93	5909	3726	mouse
étterem	1.64	1.88	2.18	10331	4772	restaurant
kő	1.64	1.39	1.88	9304	31899	stone
jelzőlámpa	1.65	1.85	2.67	365	2040	traffic light
méz	1.65	1.66	2.24	3999	26609	honey
ágy	1.70	1.32	1.37	8687	20148	bed
háziorvos	1.70	2.25	2.71	3385	2134	family doctor
kémény	1.70	1.72	2.15	2417	5655	chimney
kórház	1.70	2.00	2.11	29288	17622	hospital
úttest	1.71	1.72	2.00	2029	1340	road

[38] MOKK: Média Oktató és Kutató Központ, mokk.bme.hu

[39] MNSZ: Magyar Nemzeti Szövegtár, mnsz.nytud.hu

napilap	**1.72**	**1.99**	**2.37**	5689	8970	gazette
sorompó	**1.72**	**1.60**	**2.19**	925	921	barrier
létra	**1.74**	**1.43**	**1.94**	1417	48534	ladder
könyv	**1.75**	**1.38**	**1.82**	86656	5260	book
rendőr	**1.76**	**1.62**	**2.31**	23384	7290	policeman
árboc	**1.77**	**2.63**	**3.01**	283	331	mast
gerenda	**1.77**	**1.95**	**2.50**	814	1343	beam
ajtó	**1.81**	**1.30**	**1.54**	17654	28973	door
abroncs	**1.83**	**2.56**	**2.98**	846	419	hoop
könyvtár	**1.83**	**2.00**	**2.23**	50842	7207	library
mozi	**1.83**	**1.87**	**2.20**	7822	3722	cinema
toronyház	**1.83**	**2.16**	**2.55**	355	367	high rise
orvos	**1.84**	**1.85**	**2.06**	42492	24758	doctor
padló	**1.85**	**1.81**	**1.83**	2468	400	floor
gyár	**1.86**	**2.09**	**2.52**	9800	10027	factory
lámpa	**1.86**	**1.66**	**1.79**	6421	4243	lamp
rádió	**1.87**	**1.74**	**2.48**	40268	901	radio
utca	**1.87**	**1.74**	**2.33**	50381	60103	street
képernyő	**1.88**	**2.05**	**2.93**	6713	113831	screen
pózna	**1.91**	**2.60**	**2.83**	153	56526	pole
antenna	**1.93**	**2.05**	**2.56**	3305	1822	antenna
főváros	**1.93**	**2.66**	**2.53**	42270	45408	capital
koponya	**1.94**	**2.01**	**2.26**	1411	64976	skull
ablak	**1.95**	**1.30**	**1.58**	19222	26087	window
katona	**1.95**	**1.94**	**2.17**	22625	5279	soldier
kikötő	**1.95**	**1.97**	**2.28**	4029	16291	harbour
láb	**1.97**	**1.46**	**1.50**	7873	6666	leg
madár	**1.98**	**1.52**	**1.77**	11036	36499	bird
hó	**1.99**	**1.82**	**1.93**	19678	15419	snow
barlang	**2.00**	**1.93**	**2.18**	8972	3494	cave
ebéd	**2.00**	**2.05**	**1.84**	10324	6583	lunch
tető	**2.00**	**1.65**	**2.05**	5684	13971	roof
e-mail	**2.01**	**2.58**	**2.74**	75703	3413	e-mail
pázsit	**2.01**	**2.05**	**2.40**	547	830	lawn
peron	**2.01**	**2.41**	**2.74**	626	6121	platform
akasztófa	**2.02**	**2.49**	**2.52**	375	589	gallows
villamos	**2.02**	**1.48**	**2.02**	17777	5661	tram
zenekar	**2.04**	**2.09**	**2.41**	16920	8863	orchestra
sín	**2.05**	**1.66**	**1.86**	915	8743	rail
deszka	**2.06**	**1.68**	**2.21**	1264	2411	board
ruha	**2.06**	**1.74**	**1.83**	8427	3260	clothes
állvány	**2.07**	**2.50**	**2.83**	1311	794	scaffold
ház	**2.08**	**1.41**	**1.55**	73248	95004	house
oszlop	**2.09**	**1.70**	**2.10**	5558	16817	post, column
víz	**2.09**	**1.53**	**1.83**	76873	61494	water
park	**2.10**	**1.80**	**2.33**	25494	325	park
híd	**2.11**	**1.50**	**1.63**	19383	14215	bridge
fa	**2.13**	**1.42**	**1.70**	29399	30683	tree
szoba	**2.13**	**1.98**	**2.21**	23067	3611	room
Hold	**2.14**	**1.72**	**2.28**	16938	5383	Moon
műhold	**2.14**	**2.97**	**3.44**	1286	16207	satellite

szem	**2.15**	**1.46**	**1.64**	34072	6575	eye
színpad	**2.17**	**1.97**	**2.65**	6912	30017	stage
műanyag	**2.18**	**2.84**	**3.33**	18640	2268	plastic
video	**2.18**	**2.30**	**2.65**	4455	1726	video
gyermek	**2.19**	**1.74**	**1.94**	79478	55890	child
temető	**2.19**	**1.81**	**1.88**	6852	21074	cemetery
templom	**2.20**	**1.68**	**2.34**	40758	11926	church
alcohol	**2.21**	**2.51**	**2.54**	8931	3397	alcohol
feleség	**2.21**	**2.64**	**2.48**	9424	32758	wife
gomb	**2.21**	**1.54**	**2.39**	9549	3737	button
talaj	**2.22**	**2.23**	**2.40**	13814	6552	land, ground
fotó	**2.24**	**2.02**	**2.26**	8531	9608	photo
diák	**2.26**	**2.25**	**2.16**	23679	20826	student
folyó	**2.28**	**1.56**	**1.81**	42446	11773	river
színész	**2.32**	**2.79**	**2.61**	11053	12518	actor
fal	**2.34**	**1.63**	**1.70**	22899	27133	wall
kulcs	**2.34**	**1.32**	**1.82**	6661	23493	key
postafiók	**2.35**	**3.34**	**3.55**	728	248	post office box
caravan	**2.39**	**3.04**	**3.22**	7838	35898	caravan
daru	**2.41**	**1.93**	**2.65**	1096	874	crane
erdő	**2.42**	**1.72**	**1.90**	17591	16889	forest
fennsík	**2.42**	**2.95**	**3.08**	733	619	plateau
vendég	**2.42**	**2.86**	**2.72**	53011	24154	guest
füst	**2.46**	**2.17**	**2.59**	5838	7255	smoke
honlap	**2.46**	**2.60**	**3.39**	28822	3736	homepage
eső	**2.48**	**2.03**	**2.05**	22899	12003	rain
mérleg	**2.48**	**1.81**	**2.06**	13753	5543	scales
irat	**2.51**	**2.61**	**3.06**	4541	18872	document
tenger	**2.51**	**1.98**	**2.16**	14674	878	sea
intézmény	**2.54**	**3.52**	**3.74**	93537	11078	institute
baktérium	**2.56**	**3.84**	**3.52**	2482	2376	bacteria
regény	**2.56**	**2.78**	**3.00**	10734	22614	novel
kódex	**2.59**	**2.66**	**3.52**	4244	2469	codex
állampolgár	**2.60**	**3.56**	**3.82**	13986	20989	citizen
tűz	**2.61**	**1.65**	**2.40**	21362	19095	fire
vizsga	**2.63**	**2.66**	**2.83**	32912	8302	exam
ingatlan	**2.64**	**3.13**	**3.47**	27088	60617	real estate
tanfolyam	**2.67**	**3.58**	**3.25**	56202	4496	course
értékpapír	**2.70**	**3.58**	**4.14**	5234	4455	stock
hétvége	**2.73**	**3.25**	**2.28**	3457	1488	weekend
képviselő	**2.73**	**3.28**	**3.50**	39430	5559	congressman
levél	**2.74**	**1.65**	**2.04**	37765	16294	letter
arc	**2.76**	**2.34**	**2.40**	8439	44780	face
szakadék	**2.76**	**2.20**	**2.51**	4469	11154	ravine
felhő	**2.78**	**1.97**	**2.28**	4681	5685	cloud
jelszó	**2.79**	**3.32**	**3.06**	19464	280	password
partvonal	**2.80**	**2.92**	**3.03**	236	574	coastline
tánc	**2.81**	**2.12**	**2.87**	9407	4250	dance
ének	**2.91**	**2.91**	**2.75**	6963	5752	song
éjszaka	**2.92**	**2.08**	**2.06**	17940	12295	night
gép	**2.92**	**2.78**	**3.23**	29538	31990	machine

ajánlat	**2.96**	**3.73**	**3.51**	15783	13637	offer
ébrenlét	**2.97**	**2.94**	**3.18**	557	294	wakefulness
jutalom	**2.97**	**3.09**	**3.18**	3762	5037	award
csökkenés	**2.99**	**3.28**	**3.17**	6484	8306	decrease
láz	**3.01**	**3.61**	**2.82**	4451	95708	fever
vihar	**3.01**	**2.54**	**2.69**	6946	7658	storm
sárkány	**3.05**	**2.43**	**2.74**	5543	42154	dragon
növekedés	**3.06**	**3.20**	**3.23**	24768	8435	increase
ellenőrzés	**3.07**	**3.63**	**3.58**	31292	26664	control
szél	**3.07**	**3.32**	**2.49**	29710	80519	wind
javaslat	**3.08**	**3.90**	**3.74**	49334	40081	proposal
szoftver	**3.08**	**3.87**	**3.97**	31974	2329	software
betegség	**3.09**	**2.77**	**2.94**	34628	19303	illness
korlát	**3.12**	**2.14**	**2.40**	3632	3060	balustrade
csillag	**3.14**	**2.08**	**2.62**	14529	15676	star
vonal	**3.14**	**1.62**	**2.61**	13573	14812	line
vád	**3.16**	**3.97**	**3.59**	4718	14683	accusation
vita	**3.18**	**2.90**	**3.20**	41863	70684	debate
háború	**3.23**	**3.09**	**3.00**	45480	33939	war
figyelmeztetés	**3.25**	**3.45**	**3.53**	4821	3799	warning
cím	**3.29**	**3.69**	**3.27**	41480	56710	address
egészség	**3.33**	**2.98**	**3.53**	12536	8467	health
vereség	**3.36**	**3.26**	**3.31**	3663	9193	defeat
módszer	**3.38**	**4.53**	**4.29**	34677	9754	method
rosszkedv	**3.38**	**2.84**	**3.40**	326	15918	blues
vers	**3.40**	**3.36**	**3.26**	19000	50440	poem
irányítás	**3.42**	**3.71**	**3.48**	7759	11982	guidance
ítélet	**3.42**	**3.89**	**3.93**	13940	92020	judgement
különbség	**3.44**	**3.46**	**3.45**	38473	33260	difference
botrány	**3.48**	**3.48**	**3.84**	5324	16479	scandal
ellentét	**3.50**	**3.23**	**3.61**	3566	17655	opposition
dicséret	**3.52**	**3.28**	**3.64**	2444	2693	praise
ígéret	**3.53**	**3.72**	**3.61**	5184	321	promise
jókedv	**3.54**	**2.64**	**3.48**	1354	2541	cheerfulness
árulás	**3.57**	**4.05**	**4.05**	1022	1534	treason
segítség	**3.57**	**2.97**	**3.34**	17731	508	help
győzelem	**3.65**	**2.96**	**3.23**	8391	18910	victory
ötlet	**3.69**	**3.89**	**3.84**	17312	3468	idea
ok	**3.70**	**4.39**	**3.74**	38911	2035	cause
áldozat	**3.72**	**3.57**	**3.65**	11047	26660	sacrifice
érvelés	**3.73**	**4.00**	**4.30**	2991	4173	argumentation
uralom	**3.74**	**4.05**	**3.95**	4379	4545	reign
próféta	**3.75**	**3.90**	**3.99**	6020	26789	prophet
tragédia	**3.75**	**3.64**	**3.58**	7050	9534	tragedy
szín	**3.78**	**3.49**	**4.10**	40206	11948	colour
konfliktus	**3.79**	**3.44**	**3.72**	8069	11896	conflict
meggyőzés	**3.79**	**4.08**	**4.10**	1035	11125	persuasion
változás	**3.80**	**3.85**	**3.48**	37660	35796	change
reform	**3.82**	**4.35**	**3.94**	9980	17637	reform
siker	**3.82**	**3.42**	**3.54**	17799	2511	success
szegénység	**3.85**	**2.98**	**3.27**	9659	3882	poverty

egyenlőség	**3.86**	**3.65**	**3.70**	4098	2122	equality
elismerés	**3.86**	**3.77**	**4.12**	5716	10714	acknowledgement
elvárás	**3.86**	**4.29**	**4.13**	4818	6460	expectation
jelentés	**3.86**	**4.43**	**4.13**	21570	5460	meaning
düh	**3.87**	**3.19**	**3.39**	2001	3650	anger
nyugalom	**3.87**	**3.20**	**3.52**	7300	75340	calmness
vétség	**3.89**	**4.30**	**4.18**	2651	2063	delinquency
egyetértés	**3.90**	**3.66**	**3.50**	5996	8948	accordance
elnyomás	**3.90**	**4.04**	**4.16**	2119	1656	oppression
jólét	**3.93**	**3.30**	**3.72**	3731	4430	prosperity
megszégyenítés	**3.93**	**4.11**	**4.49**	131	160	to disfigure
megállapodás	**3.94**	**4.19**	**3.89**	44286	5723	agreement
behódolás	**3.95**	**4.48**	**4.42**	234	119	submission
szükség	**3.97**	**3.83**	**3.83**	167425	7743	necessity
egyensúly	**3.98**	**3.63**	**3.94**	9120	6752	balance
nevelés	**3.98**	**4.02**	**4.21**	25618	23600	nurture
érdem	**4.02**	**4.36**	**4.30**	1431	8669	merit
szomorúság	**4.02**	**2.91**	**3.60**	8459	3372	sadness
esély	**4.03**	**4.45**	**3.94**	13041	25376	chance
gond	**4.03**	**3.73**	**3.58**	27575	38827	trouble
dicsőítés	**4.05**	**3.99**	**4.33**	391	219	glorification
veszély	**4.09**	**3.72**	**3.71**	13090	23733	danger
állapot	**4.10**	**4.49**	**4.34**	27453	39841	state
akarat	**4.12**	**3.79**	**4.04**	9246	12320	will, volition
türelem	**4.13**	**3.70**	**3.78**	4252	6637	patience
újrakezdés	**4.13**	**4.44**	**3.74**	917	647	resumption
kapcsolat	**4.17**	**3.25**	**3.69**	49343	626	relationship
csábítás	**4.19**	**3.35**	**4.08**	940	1008	temptation
depresszió	**4.19**	**3.85**	**4.39**	4876	1846	depression
egyenjogúság	**4.19**	**4.58**	**4.22**	701	940	equal rights
megértés	**4.19**	**4.04**	**4.12**	5112	620	understanding
rajongás	**4.19**	**3.64**	**3.96**	675	15738	enthusiasm
hűség	**4.24**	**3.59**	**3.84**	5196	228652	loyalty
megvetés	**4.24**	**4.20**	**4.37**	606	1142	disdain
szimbólum	**4.25**	**3.77**	**3.86**	2908	1123	symbol
érték	**4.26**	**3.99**	**4.16**	34249	52948	value
döntés	**4.28**	**4.17**	**3.75**	50708	68742	decision
hatalom	**4.28**	**3.78**	**3.93**	33625	39759	power
titok	**4.29**	**3.91**	**3.16**	10815	21111	secret
aljasság	**4.30**	**4.30**	**4.50**	324	518	lowness
béke	**4.30**	**3.48**	**3.45**	20924	15071	peace
féltékenység	**4.30**	**3.60**	**4.05**	1783	1107	jealousy
őszinteség	**4.30**	**3.62**	**3.71**	2223	4257	sincerity
harag	**4.31**	**3.47**	**3.76**	3908	4597	anger
elhivatottság	**4.32**	**4.55**	**4.56**	614	447	vocation
halál	**4.32**	**4.05**	**3.18**	37082	45046	death
kétség	**4.32**	**4.42**	**4.39**	5037	1330	doubt
romlottság	**4.33**	**4.26**	**4.29**	227	409	depravity
gyalázat	**4.36**	**4.74**	**4.69**	1026	753	dishonour
gonoszság	**4.37**	**3.43**	**3.86**	3373	992	evil
összefüggés	**4.40**	**4.79**	**4.28**	7742	15172	relationship

hiány	**4.42**	**3.83**	**3.78**	14716	30809	lack, shortage
kultúra	**4.42**	**4.18**	**4.41**	55224	27591	culture
tekintély	**4.42**	**3.95**	**4.51**	2316	10084	authority
szimpátia	**4.43**	**3.89**	**4.02**	1039	20385	sympathy
imádat	**4.46**	**3.83**	**4.17**	348	21318	adoration
barátság	**4.48**	**3.12**	**3.95**	7695	6371	friendship
elmélet	**4.48**	**4.40**	**4.29**	11702	9688	theory
folyamat	**4.48**	**4.75**	**4.41**	56613	40528	process
hangulat	**4.48**	**4.02**	**4.28**	12257	13061	mood
optimizmus	**4.48**	**3.84**	**3.63**	1531	25925	optimism
szemlélet	**4.49**	**4.79**	**4.73**	12435	7889	approach
vonzódás	**4.50**	**3.17**	**4.05**	620	545	affiliation
bűn	**4.51**	**3.88**	**3.68**	21199	15307	crime
öröm	**4.51**	**2.97**	**3.75**	20282	1593	delight
álom	**4.54**	**3.35**	**3.55**	13383	21973	dream
értelem	**4.55**	**4.19**	**4.79**	9771	47910	sense, reason
bizalom	**4.57**	**3.85**	**4.50**	9946	10843	trustfulness
kettősség	**4.58**	**4.89**	**4.62**	2012	3666	duality
vágyakozás	**4.58**	**3.35**	**4.11**	1078	624	yearning
lehetőség	**4.59**	**4.55**	**4.35**	145884	4156	possibility
gyarlóság	**4.61**	**5.07**	**4.95**	208	370	peccadillo
felfogás	**4.63**	**4.75**	**4.56**	7384	6590	approach
tudás	**4.65**	**4.13**	**4.14**	35254	14152	knowledge
probléma	**4.68**	**4.56**	**3.97**	74880	2493	problem
becsület	**4.70**	**3.73**	**4.66**	2313	4299	credit, honour
emlék	**4.72**	**3.55**	**3.77**	6587	23794	recollection
szépség	**4.72**	**3.01**	**3.71**	8590	20358	beauty
alázat	**4.75**	**4.45**	**4.62**	2200	1609	humbleness
felelősség	**4.77**	**4.57**	**4.50**	22615	25825	responsibility
valóság	**4.86**	**4.30**	**4.66**	25941	21122	reality
bölcsesség	**4.88**	**4.33**	**4.36**	6490	9441	wisdom
erény	**4.88**	**4.63**	**4.71**	3297	3797	virtue
félelem	**4.89**	**3.50**	**4.13**	17306	12117	fear
harmónia	**4.90**	**3.95**	**4.65**	4572	2575	harmony
büszkeség	**4.93**	**4.17**	**4.65**	2167	2722	pride
gondolat	**4.99**	**4.40**	**4.29**	25041	33281	thought
elme	**5.01**	**4.72**	**4.61**	5387	4462	mind
átok	**5.03**	**4.65**	**4.07**	3573	3096	curse
áhitat	**5.04**	**5.05**	**5.11**	0	77	piety
szeretet	**5.05**	**3.46**	**4.37**	43324	3742	love
megváltás	**5.06**	**5.23**	**5.07**	3978	1858	redemption
igazság	**5.07**	**4.29**	**4.58**	39644	13365	truth
képzelet	**5.09**	**4.40**	**4.38**	3549	9171	imagination
boldogság	**5.13**	**3.67**	**4.37**	16428	3305	happiness
művészet	**5.16**	**4.06**	**4.41**	21744	8088	art
pokol	**5.18**	**4.44**	**3.89**	5180	399	Hell
élet	**5.22**	**4.54**	**4.75**	174239	155858	life
elmúlás	**5.24**	**4.67**	**4.49**	1528	1534	passing
érzelem	**5.24**	**3.97**	**5.10**	3494	7261	emotion
idő	**5.27**	**4.43**	**5.02**	193386	22652	time
szabadság	**5.31**	**3.89**	**4.18**	33547	3042	freedom

remény	**5.32**	**4.39**	**4.59**	12787	27101	hope
eszme	**5.34**	**5.06**	**4.96**	4048	10330	idea, notion
szerelem	**5.36**	**3.60**	**4.61**	27750	15973	love
lelkiismeret	**5.37**	**4.31**	**4.81**	4775	1483	conscience
hit	**5.59**	**4.36**	**4.39**	36599	20685	faith
sors	**5.71**	**4.99**	**4.94**	12675	32976	fate
MEAN	**3.19**	**3.02**	**3.22**			
	N=116 (10 excluded) n=106	**N = 167 (16 excluded) n = 151**	**N = 112 (3 excluded) n = 109**			
SD	**1.19**	**1.09**	**0.98**			

2/ Mean values, standard deviations (*SD*s) and correlations in the entire word sample and the three sub-samples along the three variables rated by three different groups of participants (*abstractness*, *definability*, *imageability*) in the study of Fekete and Babarczy (2007). Sub-samples were defined as follows: the 70 uppermost/the most abstract concepts, 70 concepts taken from the "geometrical" middle of the entire word sample, and 70 concepts from the lower end of the concreteness scale (the most concrete concepts in the entire word sample).

Results show that the most concrete noun in the entire word sample is 'pencil' (*Mean* = 1.25), the most abstract concept is 'fate' (*Mean* = 5.71), the most imageable one is 'apple' (*Mean* = 1.21), and the least imageable is 'redemption' (*Mean* = 5.23). On the definability scale, the easiest concept is 'bed' (*Mean* = 1.37), while the most difficult one is 'piety' (*Mean* = 5.11). The following table illustrates the mean values and *SD*s in the three groups. Minimum and maximum values denote the mean values of those concepts (words) which were rated the least or the most abstract, imageable, or definable along the variables.

	abstractness	*imageability*	*definability*
Mean	**3.19**	**3.02**	**3.22**
SD	**1.19**	**1.09**	**0.98**
Min.	**1.25**	**1.21**	**1.37**
Max.	**5.71**	**5.23**	**5.11**

The following table illustrates Mean Values and *SD*s in the three sub-samples:

the most concrete (the "lower") 70 concepts			the "middle" 70 concepts			the most abstract (the "upper") 70 concepts		
abstract	imag	defin	abstract	imag	defin	abstract	imag	defin
1.75	**1.82**	**2.19**	**3.19**	**3.14**	**3.23**	**4.76**	**4.13**	**4.33**
0.25	**0.39**	**0.46**	**0.49**	**0.74**	**0.65**	**0.67**	**0.72**	**0.64**

The following table summarizes the correlations in the three sub-samples:

the most concrete ("lower") 70 concepts	*imageability*	*definability*
abstractness	**r = - 0.469 (p < 0.001)**	**r = - 0.279 (p < 0.05)**
the "middle" 70 concepts	*imageability*	*definability*
abstractness	**r = - 0.458 (p < 0.001)**	**r = - 0.527 (p < 0.001)**
the most abstract (the "uppermost") 70 concepts	*imageability*	*definability*
abstractness	**r = - 0.282 (p < 0.05)**	**r = - 0.507 (p < 0.001)**

The following tables illustrate again the correlations for the entire sample and for the sub-samples. Also, the correlations with the lemma frequencies are indicated; the two types of lemma frequencies (MOKK and MNSZ) are positively correlated for the entire word sample ($r = 0.481$, $p < 0.001$).

A./ the entire word sample:

Correlations

			Abstr	Imag	Defin	lemmefreq MOKK	lemmafreq MNSZ
Spearman's rho	Abstr	Correlation Coefficient	1,000	,869**	,888**	,055	,013
		Sig. (2-tailed)	.	,000	,000	,343	,820
		N	296	296	296	296	296
	Imag	Correlation Coefficient	,869**	1,000	,939**	-,031	-,057
		Sig. (2-tailed)	,000	.	,000	,597	,327
		N	296	296	296	296	296
	Defin	Correlation Coefficient	,888**	,939**	1,000	-,084	-,110
		Sig. (2-tailed)	,000	,000	.	,149	,059
		N	296	296	296	296	296
	lemmefreqMOKK	Correlation Coefficient	,055	-,031	-,084	1,000	,481**
		Sig. (2-tailed)	,343	,597	,149	.	,000
		N	296	296	296	296	296
	lemmafreqMNSZ	Correlation Coefficient	,013	-,057	-,110	,481**	1,000
		Sig. (2-tailed)	,820	,327	,059	,000	.
		N	296	296	296	296	296

**. Correlation is significant at the 0.01 level (2-tailed).

B./ the 70 most concrete concepts

Correlations

			Abstr	Imag	Defin	lemmefreq MOKK	lemmafreq MNSZ
Spearman's rho	Abstr	Correlation Coefficient	1,000	,469**	,279*	,236*	,150
		Sig. (2-tailed)	.	,000	,019	,049	,217
		N	70	70	70	70	70
	Imag	Correlation Coefficient	,469**	1,000	,846**	-,196	-,190
		Sig. (2-tailed)	,000	.	,000	,104	,116
		N	70	70	70	70	70
	Defin	Correlation Coefficient	,279*	,846**	1,000	-,244*	-,228
		Sig. (2-tailed)	,019	,000	.	,042	,057
		N	70	70	70	70	70
	lemmefreqMOKK	Correlation Coefficient	,236*	-,196	-,244*	1,000	,373**
		Sig. (2-tailed)	,049	,104	,042	.	,001
		N	70	70	70	70	70
	lemmafreqMNSZ	Correlation Coefficient	,150	-,190	-,228	,373**	1,000
		Sig. (2-tailed)	,217	,116	,057	,001	.
		N	70	70	70	70	70

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C./ the 70 “intermediate” concepts

Correlations

			Abstr	Imag	Defin	lemmefreq MOKK	lemmafreq MNSZ
Spearman's rho	Abstr	Correlation Coefficient	1,000	,458**	,527**	-,096	,035
		Sig. (2-tailed)	.	,000	,000	,429	,772
		N	70	70	70	70	70
	Imag	Correlation Coefficient	,458**	1,000	,815**	,075	-,041
		Sig. (2-tailed)	,000	.	,000	,536	,738
		N	70	70	70	70	70
	Defin	Correlation Coefficient	,527**	,815**	1,000	-,008	-,100
		Sig. (2-tailed)	,000	,000	.	,948	,410
		N	70	70	70	70	70
	lemmefreqMOKK	Correlation Coefficient	-,096	,075	-,008	1,000	,383**
		Sig. (2-tailed)	,429	,536	,948	.	,001
		N	70	70	70	70	70
	lemmafreqMNSZ	Correlation Coefficient	,035	-,041	-,100	,383**	1,000
		Sig. (2-tailed)	,772	,738	,410	,001	.
		N	70	70	70	70	70

**. Correlation is significant at the 0.01 level (2-tailed).

D./ the 70 abstract concepts

Correlations

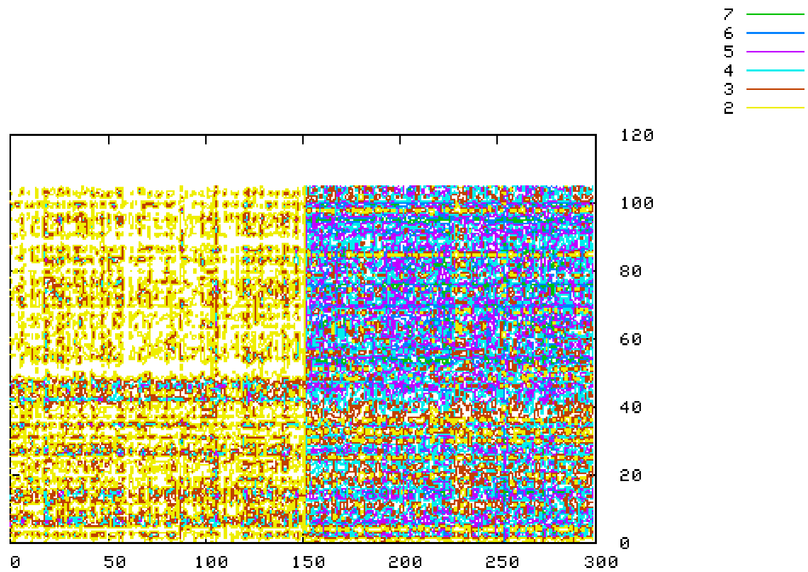
			Abstr	Imag	Defin	lemmefreq MOKK	lemmafreq MNSZ
Spearman's rho	Abstr	Correlation Coefficient	1,000	,282*	,507**	,273*	,059
		Sig. (2-tailed)	.	,018	,000	,022	,627
		N	70	70	70	70	70
	Imag	Correlation Coefficient	,282*	1,000	,629**	-,052	-,091
		Sig. (2-tailed)	,018	.	,000	,670	,455
		N	70	70	70	70	70
	Defin	Correlation Coefficient	,507**	,629**	1,000	-,115	-,126
		Sig. (2-tailed)	,000	,000	.	,343	,299
		N	70	70	70	70	70
	lemmefreqMOKK	Correlation Coefficient	,273*	-,052	-,115	1,000	,589**
		Sig. (2-tailed)	,022	,670	,343	.	,000
		N	70	70	70	70	70
	lemmafreqMNSZ	Correlation Coefficient	,059	-,091	-,126	,589**	1,000
		Sig. (2-tailed)	,627	,455	,299	,000	.
		N	70	70	70	70	70

*. Correlation is significant at the 0.05 level (2-tailed).

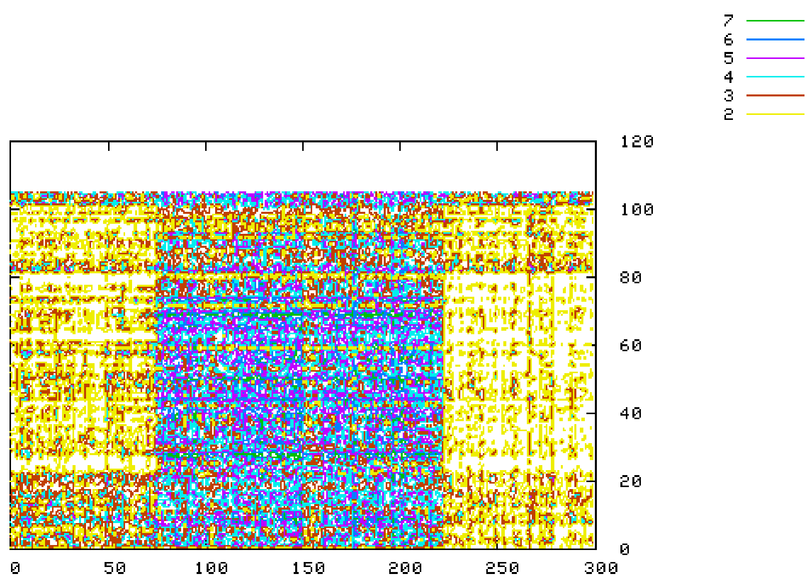
**. Correlation is significant at the 0.01 level (2-tailed).

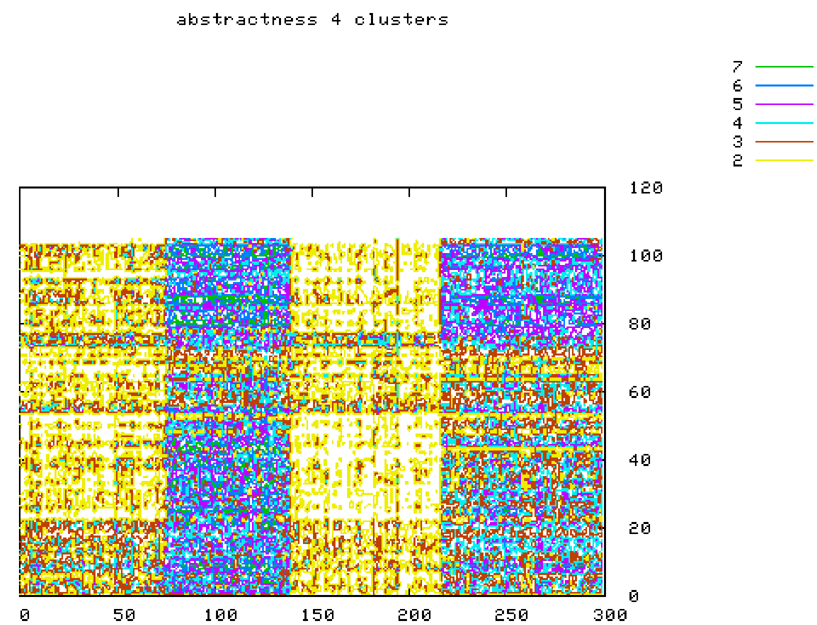
3/ Spectral cluster analyses of the three variables (abstractness, definability, and imageability) in the study of Fekete and Babarczy (2007). The first four analyses show the clusters in the abstractness data points (2, 3, 4 clusters, and the unorganized data points), the second four analyses the definability data points (2, 3, 4 clusters, and the unorganized data points), and the last four analyses the clusters in the imageability data points (2, 3, 4 clusters, and the unorganized data points). Data points were partitioned into clusters using the Fiedler vector.

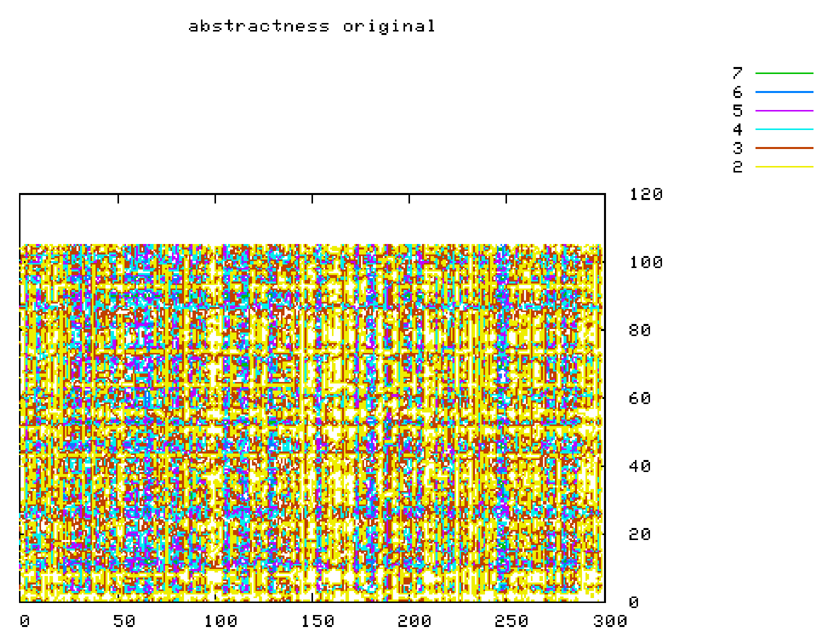
abstractness 2 clusters

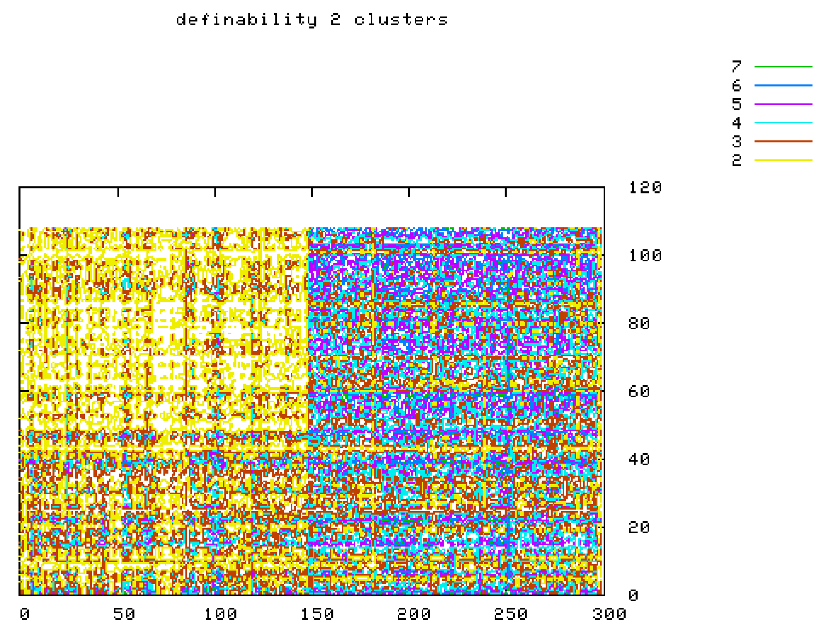


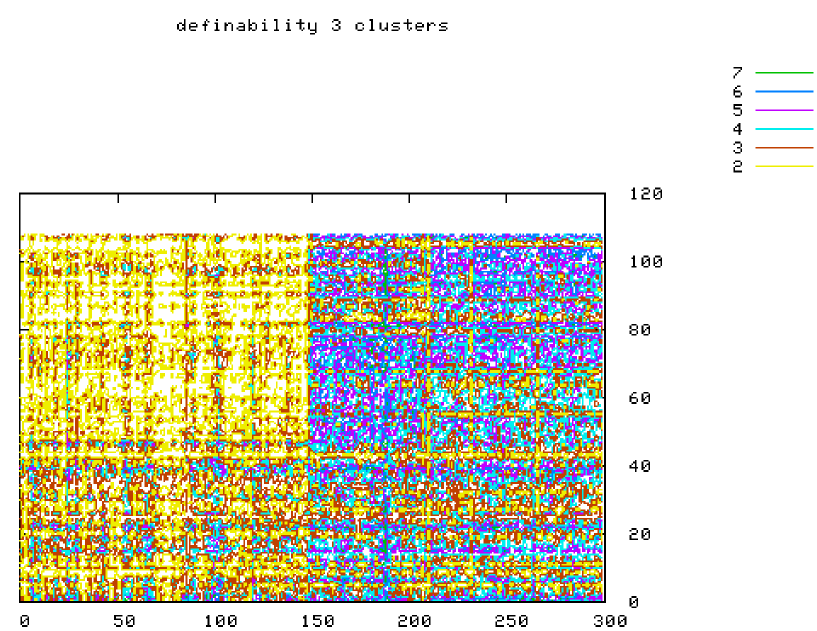
abstractness 3 clusters




abstractness 4 clusters
7
6
5
4
3
2
120
100
80
60
40
20
0
0
50
100
150
200
250
300


abstractness original
7
6
5
4
3
2
120
100
80
60
40
20
0
0
50
100
150
200
250
300


definability 2 clusters
7
6
5
4
3
2
0
20
40
60
80
100
120
0
50
100
150
200
250
300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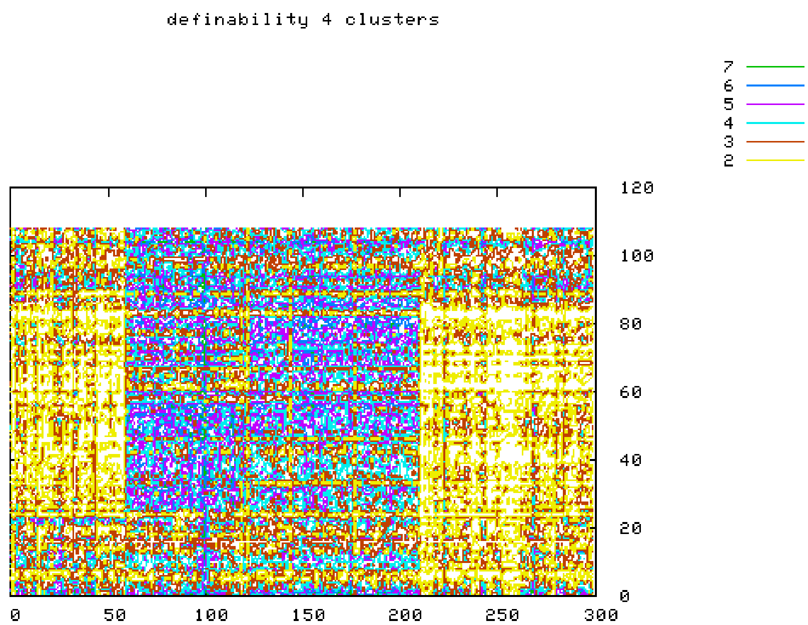
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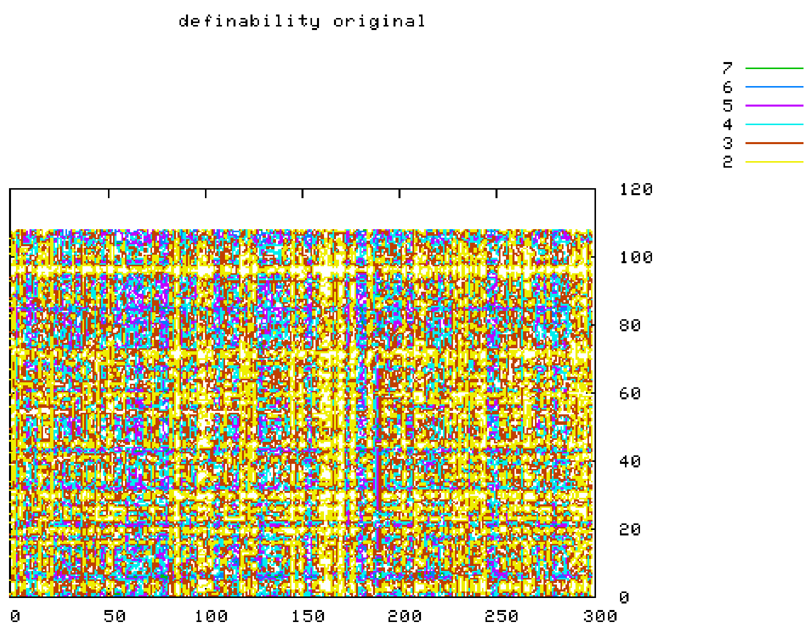
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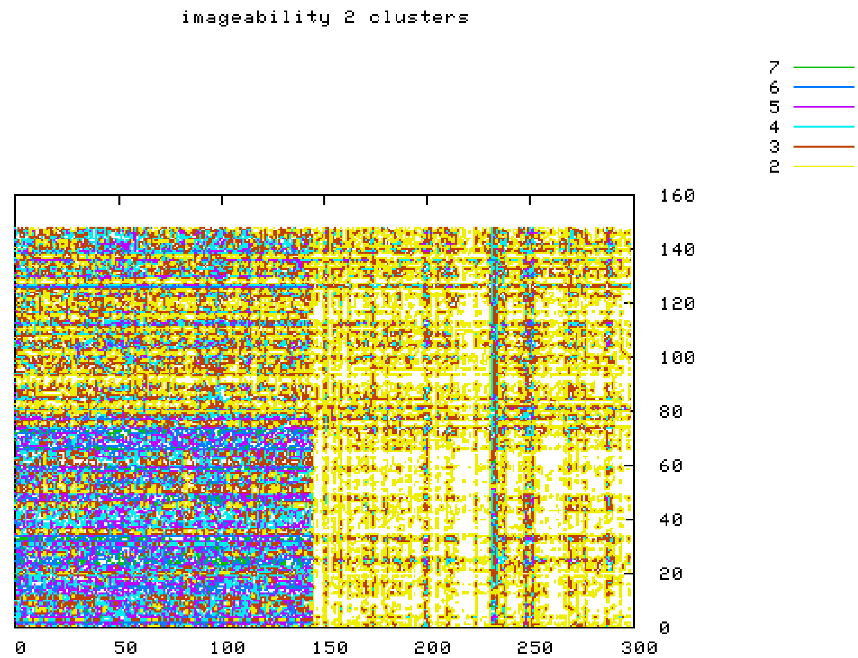
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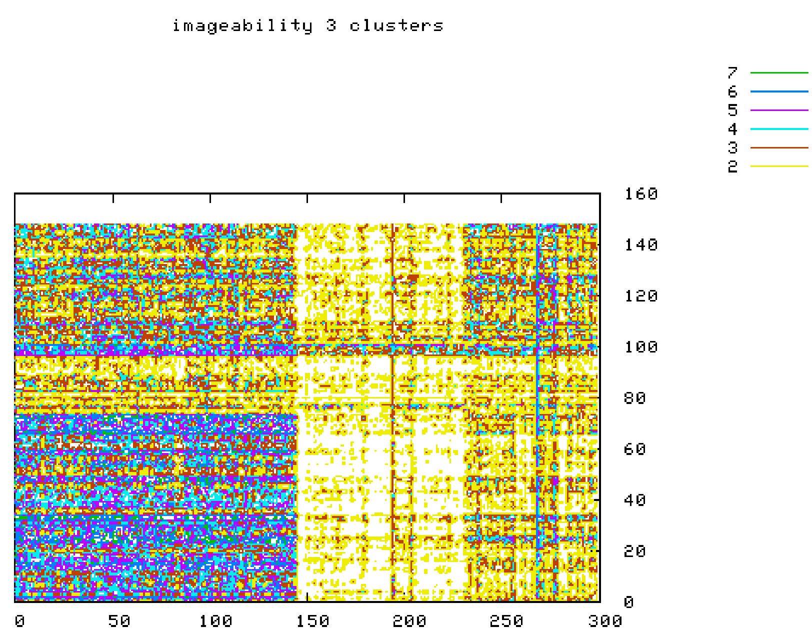
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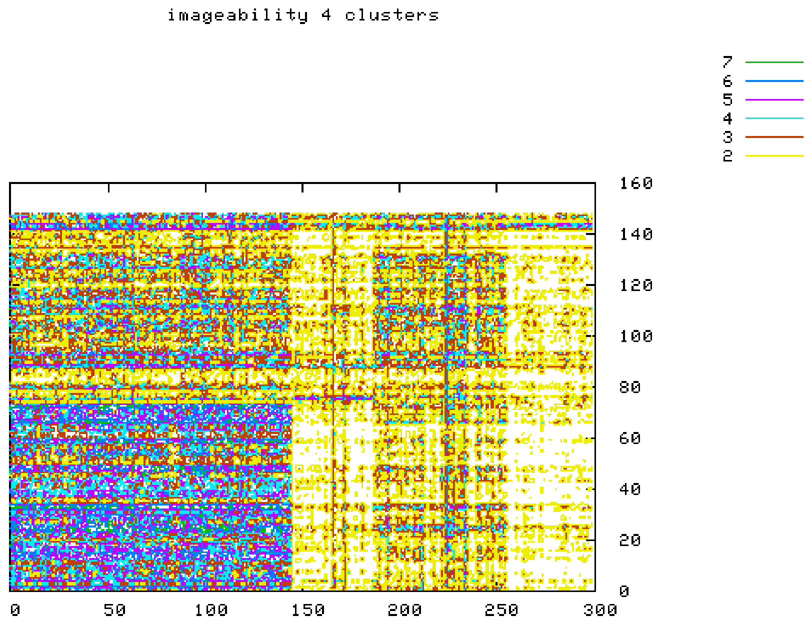
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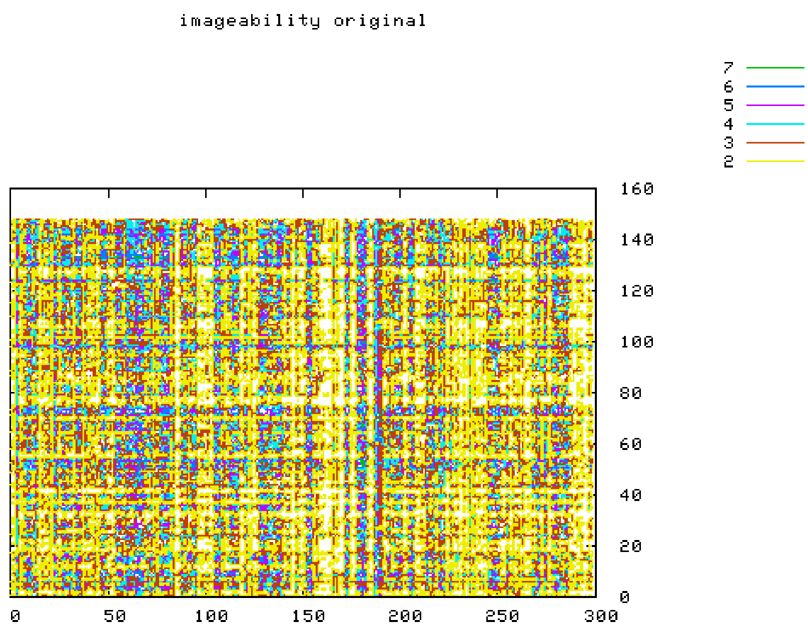
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4./ The original instructions of the web-based questionnaire in the three groups. The translation is below the Hungarian instructions.

Abstractness:

Kedves Résztvevő!

Kérdőívünkkel a magyar szavak tulajdonságait vizsgáljuk, és ehhez kérjük segítségét.

Kérjük, osztályozza az alábbi fogalmakat egy hetes konkrét-elvont skálán. Ha úgy találja, hogy az adott fogalom konkrét, akkor a skálán kisebb értéket jelöljön (1, ha egészen konkrétnak gondolja a fogalmat, pl. *kavics*). Minél elvontabb egy fogalom, annál nagyobb értéket jelöljön (7, pl. *erkölcs*).

Minden oldalon 30 fogalom fog megjelenni. Ezeket, kérjük, egyszerre ítélje meg, és mentse az adatokat a lap alján. A kérdőívet lehetséges részletekben is kitölteni, azaz bármely oldal mentése után meg lehet szakítani a kitöltést, és később – újra bejelentkezve – folytatni, ahol abbahagyta. Kérjük, maradéktalanul ítélje meg a fogalmakat.

Köszönjük a kérdőív kitöltését!

Imageability:

Kedves Résztvevő!

Kérdőívünkkel a magyar szavak tulajdonságait vizsgáljuk, és ehhez kérjük segítségét.

Kérjük, osztályozza az alábbi fogalmakat egy hetes skálán az elképzelhetőségük szempontjából. Ha úgy találja, hogy az adott fogalom könnyen elképzelhető, akkor a skálán kisebb értéket jelöljön (1, ha „nagyon" könnyen elképzelhetőnek gondolja a fogalmat, pl. *kavics*). Minél kevésbé elképzelhető egy fogalom, annál nagyobb értéket jelöljön (7, pl. *erkölcs*).

Minden oldalon 30 fogalom fog megjelenni. Ezeket, kérjük, egyszerre ítélje meg, és mentse az adatokat a lap alján. A kérdőívet lehetséges részletekben is kitölteni, azaz bármely oldal mentése után meg lehet szakítani a kitöltést, és később – újra bejelentkezve – folytatni, ahol abbahagyta. Kérjük, maradéktalanul ítélje meg a fogalmakat.

Köszönjük a kérdőív kitöltését!

Definability:

Kedves Résztvevő!

Kérdőívünkkel a magyar szavak tulajdonságait vizsgáljuk, és ehhez kérjük segítségét.

Kérjük, osztályozza az alábbi fogalmakat egy hetes skálán a definiálhatóságuk szempontjából; vagyis mennyire könnyű vagy nehéz elmagyarázni a jelentésüket. Ha úgy találja, hogy az adott fogalom könnyen definiálható, akkor a skálán kisebb értéket jelöljön (1, pl. *kavics*). Minél nehezebben definiálható egy fogalom, annál nagyobb értéket jelöljön (7, pl. *erkölcs*).

Minden oldalon 30 fogalom fog megjelenni. Ezeket, kérjük, egyszerre ítélje meg, és mentse az adatokat a lap alján. A kérdőívet lehetséges részletekben is kitölteni, azaz bármely oldal mentése után meg lehet szakítani a kitöltést, és később – újra bejelentkezve – folytatni, ahol abbahagyta. Kérjük, maradéktalanul ítélje meg a fogalmakat.

Köszönjük a kérdőív kitöltését!

This is a translation of the instructions for the (definability) questionnaire.

Dear Participant!

This questionnaire investigates some aspects of Hungarian words. We would like to ask for your help by participating in this survey.

Please, rate the following nouns on a 7-point scale in terms of their definability; the task is to decide how easy or difficult it is to explain their meaning. If you think that the concept in question is easily definable, then rate it lower on the scale (e.g., 1 for *pebble*). The more difficult it is to define a concept, the higher you should rate it on the scale (e.g., 7 for *moral*).

30 concepts will appear on every page. Please, rate these concepts at one time, and then save the data below the page. It is possible to return to the questionnaire at other times, that is, you can abort and later resume the filling of the questionnaire after logging in again after you have saved the data below every page. Please, do not leave any of the concepts unrated.

Thank you for your participation!

APPENDIX B

Independent Samples *T*-tests of the Sentence Items in Experiments 1 and 2 in Chapter 3.5.

Analysis by items: independent samples *T*-tests on the means of median RTs (reading times) of words between the **congruent-incongruent** sound conditions in **Experiment 1 (Chapter 3.5.)**. The corresponding sentences can be ordered to the numbers from the table in the appendix of the manuscript.

Sentences	***word 5***	***word 6***	***word 7***
concrete 1.	$t(16) = -0.876$, $p = 0.394$	$t(16) = 0.299$, $p = 0.769$	$t(16) = -0.021$, $p = 0.983$
concrete 2	$t(16) = -0.004$, $p = 0.997$	$t(16) = -0.668$, $p = 0.514$	$t(16) = -0.692$, $p = 0.499$
concrete 3	$t(10.789) = 1.844$, $p = 0.093$	$t(10.396) = 1.755$, $p = 0.109$	$t(14) = 0.745$, $p = 0.469$
concrete 4	$t(15) = 1.164$, $p = 0.263$	$t(15) = 1.516$, $p = 0.150$	$t(15) = 1.365$, $p = 0.192$
concrete 5	$t(8.242) = 0.640$, $p = 0.540$	$t(17) = -0.457$, $p = 0.653$	$t(17) = -0.776$, $p = 0.448$
concrete 6	$t(8) = -0.447$, $p = 0.667$	$t(8) = -0.360$, $p = 0.728$	$t(8) = -0.280$, $p = 0.787$
concrete 7	$t(14) = 0.527$, $p = 0.606$	$t(14) = 1.047$, $p = 0.313$	$t(14) = 0.339$, $p = 0.740$
concrete 8	$t(20) = -1.633$, $p = 0.118$	$t(20) = -3.356$, $p = 0.003$ *	$t(9.666) = -1.745$, $p = 0.113$
concrete 9	$t(14) = 0.826$, $p = 0.423$	$t(14) = 1.406$, $p = 0.182$	$t(14) = 1.735$, $p = 0.105$
concrete 10	$t(11) = -1.147$, $p = 0.276$	$t(11) = -2.483$, $p = 0.030$ *	$t(11) = -1.056$, $p = 0.314$
concrete 11	$t(11) = -0.422$, $p = 0.681$	$t(15) = 0.688$, $p = 0.502$	$t(15) = -0.267$, $p = 0.793$
concrete 12	$t(11) = 0.772$, $p = 0.456$	$t(11) = -0.019$, $p = 0.986$	$t(11) = 1.063$, $p = 0.311$
abstract 1	$t(15) = 0.373$, $p = 0.715$	$t(15) = 0.596$, $p = 0.560$	$t(15) = -0.809$, $p = 0.431$
abstract 2	$t(19) = 0.694$, $p = 0.496$	$t(19) = 1.626$, $p = 0.121$	$t(19) = 1.928$, $p = 0.069$
abstract 3	$t(15) = 1.133$, $p = 0.275$	$t(6.244) = 1.514$, $p = 0.179$	$t(6.836) = 1.756$, $p = 0.123$
abstract 4	$t(17) = 0.493$, $p = 0.629$	$t(17) = 0.852$, $p = 0.406$	$t(17) = -0.015$, $p = 0.988$
abstract 5	$t(9) = 0.227$, $p = 0.826$	$t(9) = -0.250$, $p = 0.808$	$t(9) = -1.420$, $p = 0.189$
abstract 6	$t(10) = -1.277$, $p = 0.231$	$t(10) = 0.058$, $p = 0.955$	$t(10) = 0.572$, $p = 0.580$
abstract 7	$t(12) = -0.888$, $p = 0.392$	$t(12) = 0.292$, $p = 0.775$	$t(12) = -0.978$, $p = 0.348$
abstract 8	$t(8.157) = -0.546$, $p = 0.600$	$t(14) = -0.940$, $p = 0.363$	$t(14) = 1.142$, $p = 0.273$
abstract 9	$t(17) = -0.329$, $p = 0.746$	$t(16) = -0.752$, $p = 0.463$	$t(16) = -1.331$, $p = 0.202$
abstract 10	$t(11) = 0.601$, $p = 0.560$	$t(11) = -0.865$, $p = 0.406$	$t(9) = -1.353$, $p = 0.209$
abstract 11	$t(13) = 0.086$, $p = 0.933$	$t(13) = -0.109$, $p = 0.915$	$t(13) = 0.312$, $p = 0.760$
abstract 12	$t(17) = -0.466$, $p = 0.647$	$t(17) = -0.943$, $p = 0.359$	$t(17) = -1.410$, $p = 0.177$

Analysis by items: independent samples *T*-tests on the means of median RTs of words between the **congruent-incongruent** sound conditions in **Experiment 2 (Chapter 3.5.)**.

Sentences	***word 5***	***word 6***	***word 7***
concrete 1.	$t(16) = -1.538$, $p = 0.144$	$t(16) = -2.061$, $p = 0.056$	$t(16) = -2.104$, $p = 0.052$
concrete 2	$t(14) = -0.906$, $p = 0.380$	$t(14) = -0.613$, $p = 0.550$	$t(14) = -1.124$, $p = 0.280$
concrete 3	$t(17) = 0.411$, $p = 0.686$	$t(17) = 0.615$, $p = 0.547$	$t(17) = 0.887$, $p = 0.387$
concrete 4	$t(16) = 0.578$, $p = 0.571$	$t(16) = 0.718$, $p = 0.483$	$t(16) = 0.530$, $p = 0.603$
concrete 5	$t(14) = -0.577$, $p = 0.573$	$t(14) = -0.067$, $p = 0.947$	$t(14) = -0.928$, $p = 0.369$
concrete 6	$t(13) = -0.434$, $p = 0.672$	$t(13) = 0.967$, $p = 0.351$	$t(13) = 0.543$, $p = 0.596$

concrete 7	$t(15) = 0.309$, $p = 0.761$	$t(15) = 0.740$, $p = 0.470$	$t(15) = 0.448$, $p = 0.661$
concrete 8	$t(21) = -0.305$, $p = 0.763$	$t(21) = 0.004$, $p = 0.997$	$t(13.471) = -0.810$, $p = 0.432$
concrete 9	$t(15) = -1.310$, $p = 0.210$	$t(15) =-0.903$, $p = 0.381$	$t(15) = -0.834$, $p = 0.418$
concrete 10	$t(16) = 1.949$, $p = 0.069$	$t(16) = 1.411$, $p = 0.177$	$t(5.145) = 1.180$, $p = 0.289$
concrete 11	$t(16) = -0.243$, $p = 0.811$	$t(16) = -0.145$, $p = 0.887$	$t(16) = 0.429$, $p = 0.674$
concrete 12	$t(12) = 1.137$, $p = 0.278$	$t(8.500) = 0.823$, $p = 0.433$	$t(9.337) = 1.664$, $p = 0.129$
abstract 1	$t(13) = 0.668$, $p = 0.516$	$t(13) = 0.483$, $p = 0.637$	$t(13) = 0.905$, $p = 0.382$
abstract 2	$t(17) = -1.561$, $p = 0.137$	$t(17) = -0.414$, $p = 0.684$	$t(17) = 0.107$, $p = 0.916$
abstract 3	$t(17) = -1.765$, $p = 0.096$	$t(17) = -0.678$, $p = 0.507$	$t(17) = -0.003$, $p = 0.998$
abstract 4	$t(3.387) = -1.131$, $p = 0.332$	$t(8) = -0.924$, $p = 0.383$	$t(3.502) = -1.455$, $p = 0.229$
abstract 5	$t(12) = 1.028$, $p = 0.324$	$t(9.985) = 1.389$, $p = 0.195$	$t(9.024) = 0.793$, $p = 0.448$
abstract 6	$t(16) = 0.458$, $p = 0.653$	$t(16) = -0.264$, $p = 0.796$	$t(16) = -0.920$, $p = 0.371$
abstract 7	$t(11) = 0.053$, $p = 0.959$	$t(11) = -0.645$, $p = 0.532$	$t(11) = -1.245$, $p = 0.239$
abstract 8	$t(5.007) = -0.732$, $p = 0.497$	$t(4.710) = -2.343$, $p = 0.069$	$t(5.058) = -1.973$, $p = 0.105$
abstract 9	$t(15) = 0.015$, $p = 0.988$	$t(15) = -1.106$, $p = 0.286$	$t(15) = -0.321$, $p = 0.753$
abstract 10	$t(13.122) = 3.578$, $p = 0.003$ *	$t(14) = 1.788$, $p = 0.095$	$t(13.647) = 2.925$, $p = 0.011$ *
abstract 11	$t(16) = 0.517$, $p = 0.612$	$t(16) = -0.536$, $p = 0.599$	$t(16) = -0.243$, $p = 0.811$
abstract 12	$t(15) = 0.958$, $p = 0.353$	$t(15) = 0.904$, $p = 0.380$	$t(15) = 0.377$, $p = 0.712$