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FIGURES OF LANGUAGE IN COGNITIVE SCIENCE IN THE LIGHT OF FIGURATIVE LANGUAGE PROCESSING IN THE BRAIN

PhD Thesis

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Acknowledgements

Abstract

In the past two decades the cognitive neuroscience of language processing has been expanding at an unprecedented pace, for a large part thanks to novel brain imaging technologies. Even though metaphors are highly frequent in everyday language and crucial in scientific reasoning, processing models and experimental results are inconsistent. Profound questions are still open such as the role of the right hemisphere in their comprehension, or whether there is a dedicated neural substrate for figures of speech. The experimental part of the present work attempts to resolve some of the contradictions by controlling the numerous variables suspected to pose a processing load on the right hemisphere, such as the effects of novelty, sentential context, imageability, and emotional valence and arousal. According to the results metaphors levy classical left hemispheric language areas, and require no specialized computations. Studies showing right hemispherical involvement could have observed poetic and/or contextual effects. In the second part, I propose a metaphor comprehension model based on abstract conceptual substitution, with an attempt to integrate the semantic and pragmatic aspects of metaphor processing. The extra cognitive effort necessary for metaphor comprehension is discussed in a relevance theory based framework, where I suggest two key pragmatic roles for metaphors: (1) covering up meaning in socially risky situations by letting the hearer make inferences, hence making meaning negotiable; and (2) highlighting meaning by creating analogies and mappings utilizing their expressive power. Finally, in a neural model of scientific endeavor, the cognitive dispositions (e.g., hemispheric preferences) of researchers are proposed to translate into various schools of scientific research programs via inventive metaphors. Thought-as-language might be preferred over thought-as-vision, or vice versa, by researchers whose personal brain architecture favors one work method over the other. In conclusion I suggest that instead of trying to resolve the ever debates of cognition between competing approaches, they could be reinterpreted as products of the human mind, and could be integrated into a unified epistemological system.

Keywords: metaphor, cognitive neuroscience, right hemisphere, pragmatics, abstract-concrete, history of science

Abbreviations

BAIS	bilateral activation, integration, and selection model
BOLD	blood-oxygen-level-dependent
CSC	coarse semantic coding theory
DVF	divided visual field paradigm
EEG	electroencephalography
ERP	event-related potential
fMRI	functional magnetic resonance imaging
GNW	Global Neuronal Workspace model
GSH	graded salience hypothesis
LH	left hemisphere
LHD	left hemisphere damage
LIFG	left inferior frontal gyrus
MEP	motor-evoked potential
ms	milliseconds
PARLO	production affects reception in left only model
PET	positron emission tomography
RH	right hemisphere
RHD	right hemisphere damage
TMS	transcranial magnetic stimulation

Notation

The notation follows conventions that are widely adhered to in cognitive science (cf. Fodor, 2008).

SMALL CAPITALS: Names of concepts (the word 'dog' expresses the concept DOG).

Italics: Semantic values construed broadly to include meanings, senses, referents and the like (the word 'cat' refers to *cats*; the word 'cat' means *cat*; the word 'cat' expresses the property of *being a cat*).

'Single quotes': Expressions that are mentioned rather than used (the word 'dog' applies to dogs).

"Double quotes": Quotes of ideas from specific authors.

1 Introduction

Metaphorical language has been enthralling scholars of various eras and disciplines, however their nature has been mostly an enigma. Intriguingly, its workings seem to stretch the relationship between the signifier and the signified. Some authors, like Fónagy (1999), suggested that metaphors contradict one of the basic ideas of Saussure, the linearity of linguistic expression. The Fregean tradition of compositionality – the basis is modern logical semantics, suggesting that meaning can be derived from the meaning of constituents plus compositional rules – is also challenged by the broad interpretability of metaphorical expressions. On the other hand, such a linguistic ambiguity can have a crucial role in communication. For example, indirect speech creates a situation where delicate social situations (sexual offers, bribing, etc.) can be negotiated under the veil of the two possible alternative meanings (Pinker, Nowak, & Lee, 2008).

Other authors, like Dan Sperber and Deirdre Wilson (2008), question the status of metaphors as independent linguistic entities, and suggest that they are not more than examples of the general phenomena of broadening meaning. They consider the literal-figurative distinction unnecessary. Many computational linguists, expressing a criticism of a more syntactic nature, agree. Such a distinction might not be a useful one to explore the inner organization of language from a frequency and usage based perspective, where meaning is carried – at most – in the structural relations of language.

The above concerns highlight that metaphors could seem marginal from the perspectives of both pragmatics and syntactics of language, and might be primarily relevant at a semantic level. This matter of scope could be one of the reasons why metaphors became recently a central issue in cognitive linguistics that has moved away from syntax (and generative grammar) towards semantics (via construction grammars). The relevance of classical left hemispherical language areas has been brought into question as well, when concepts were proposed to require some kind of perceptual, embodied processing (Lakoff & Johnson, 1999). As a consequence, linking metaphor comprehension to right hemisphere language functions has stirred much enthusiasm. Such results fueled the assumption that metaphors require "extra linguistic" processing outside of classical left hemispherical language areas. However,

experiments delivered many more questions than answers so far.

Studying the neural underpinnings of figurative meaning is crucial not only to the better understanding of everyday communication, but also to scientific language. Metaphors might play a central role in establishing novel models and analogies; they can influence generations of researchers, create rival scientific schools, and foster traditions of knowledge transfer. As Mithen (1996) emphasized, metaphors might have been a crucial tool for the cross talk between domains of intelligence during the genesis of the modern human mind. Accordingly the cognitive neuroscience of metaphors could be highly informative regarding the nature of mappings across knowledge domains, from scientific to everyday contexts.

2 The psycholinguistics of metaphors

2.1 Linguistic and conceptual interpretations

The idea that metaphors constitute an independent linguistic category originates from Aristotle's Poetics (335BC / 1952). He described them as ornaments of language that sign talent, since they tell about the recognition of similarities among things in the world. In all four types of metaphors a word stands instead of another one (Aristotle, 335 BC / 1952): "Metaphor consists in giving the thing a name that belongs to something else; the transference being either from genius to species, or from species to genus, or from species to species, or on grounds of analogy." The most eloquent metaphors are based on analogies, for example, *old age : life = evening : day*, therefore evening may be called 'the old age of the day'. In other words, such figures of language derive their meaning from the analogies and comparisons lurking in the background.

Aristotle's (322 BC / 1952) comparison account was not challenged seriously for two millennia. Bréal (1898/1900) raised the idea that metaphor is not merely a rhetorical and poetic device, but a widely used, general phenomenon, and one of the most important instruments of linguistic change. Also viewing metaphor as an omnipresent principle of language Richards (1936/1965) proposed that it is not simply a substitution of a word with another one, but there is interplay between the meanings of the two constituents. For example in the expression 'Odysseus is a lion' the *tenor*, 'Odysseus', is the underlying idea or the subject, to which the *vehicle* 'lion' metaphorically refers to, and lends some of its attributes. During a comparison,

overlapping features emerge, constituting the *ground* of the metaphor. It was Black (1962) who suggested that the ground is established on a conceptual level, not between words, and figurative meaning is a result of an interaction, not a comparison. This has been a clear break away from Aristotle, establishing the theoretical direction of the interactionists.

Lakoff and Johnson's (1980a) cognitive metaphor theory transformed the field profoundly. On the one hand, there was a culminating dissatisfaction with models proposing the primacy of literal language, and the ensuing truth-value analysis. On the other hand, there was an emerging desire to integrate language and cognition in a comprehensive framework. By bringing the literal-metaphorical boundary into question, Lakoff and Johnson have not only reframed the relationship between language and categorization (Lakoff, 1987). They claimed that their embodied cognition framework challenges Western philosophy's classical mind-body distinction as well (Lakoff & Johnson, 1999), although, it worth to note that, to a large extent, it is a neo-empiricist rephrasing of the romantic ideas of a Western thinker, Giambattista Vico (Nuessel, 2006).

According to model of Lakoff and Johnson (1980a, 1999) not single concepts, but conceptual domains are referenced to each other via systematic mappings (which was considered to be a feat of world view metaphors and the like in classical stylistic theory). For example, everyday expressions, such as 'his reasoning fell apart' or 'the hypothesis had no foundation' or 'the model constituted of strong building blocks', can be grouped together under the same conceptual metaphor THEORIES ARE BUILDINGS. The source domain (BUILDING), that is more concrete and relatively straightforward to imagine, is mapped onto the more abstract and less easy to conceptualize target domain (THEORY). Mappings are thought to be asymmetrical, with BUILDINGS lending some of their properties to THEORIES, but not the other way around. Since mappings are always partial it is a matter of analysis to determine which elements of the source domain are mapped onto which elements of the target domain (Kövecses, 2005).

Vastly extending their theory Lakoff and Johnson (1980b) proposed that even the conceptual system is organized in a metaphorical manner, and that abstract concepts acquire an inner structure and meaning only via mappings. The large proportion of metaphors involving domains referring to bodily functions gave birth to the idea of embodied cognition that suggests that physical experiences (and their

neural substantiations) serve as the basis of all cognition. Distinguishing between the mind and the body is not meaningful, they argue, since there is only one unified, embodied system (Lakoff & Johnson, 1999). Conceptual metaphors can be divided into complex and primary metaphors. The latter are suggested to be mappings grounded in physical experience (e.g., the expression 'warm smile' is routed in the childhood contingency between physical warmth and a kind smile), which combine into complex conglomerates not referring to bodily experiences directly. For example the complex metaphor THEORIES ARE BUILDINGS is a compound of the primary metaphors PERSISTING IS REMAINING ERECT and STRUCTURE IS PHYSICAL STRUCTURE (Grady, 1997).

However, it is not entirely clear as to whether conceptual structure is an inherent property of every individual physical experience, or it is an independent dimension. Advocates of the strong version of embodiment would probably pick the former, however Gentner's (1983) structure mapping theory offers the latter alternative. Perhaps distantly inspired by Aristotle, it draws on the intimate relationship between analogies and metaphors. Instead of the mappings between elements, it emphasizes the transfer of complete relational structures between knowledge domains. As a result, the distinction between similes and metaphors is slightly diminished, since they both involve lending, although different kinds of, inner relational systems.

Cognitive metaphor theory has received much criticism (Fónagy, 1999; Jackendoff & Aaron, 1991; Murphy, 1996, 1997), inter alia because it did not perform well in the description of the conceptual system or figurative language either (McGlone, 2007). It does not attempt to give an explanation of why mappings are partial, why those specific elements are transferred and not others, why one source domain can be mapped to several different target domains and one target domain can have several source domains structuring it, and exactly what processing steps and what specific neural networks instantiate them. At the same time, only a small proportion of the numerous metaphor theories (for reviews see Fónagy, 1999; Nuessel, 2006) try to give an exact account of linguistic processing.

2.2 On-line metaphor processing

According to the classical comparison theory (Aristotle, 322 BC / 1952) metaphors of the 'X is a Y' formula ('Odysseus is a lion.') are literally false

categorization statements that need to be transformed into 'X is like a Y' comparison statements ('Odysseus is like a lion.'). They were considered to be denotative violations, describing things in a manner that is not true. As a consequence they require sequential processing, since they can be comprehended only after a transformation into literally true comparisons (Grice, 1975; Searle, 1979). In terms of truth-value, the literal and the metaphorical interpretations are mutually exclusive, because it cannot be true that Odysseus is *like* a lion, if Odysseus *is* a lion in fact. This necessitates the refusal of the first literally false categorical interpretation, and the acceptance of the comparison (Keysar, 1989).

Despite the theoretical considerations, reading time experiments could not confirm the differences between literal and metaphorical sentences, which would be a direct consequence of serial processing (Inhoff, Lima, & Carroll, 1984; Ortony, Schallert, Reynolds, & Antos, 1978). Moreover, if a proposition can be true both literally and metaphorically, sentence comprehension takes less time when both meanings are available (e.g., "Simon is a magician" both in terms of his profession and his financial talent), compared to when only one meaning is active (Keysar, 1989). Therefore, it does not seem to be necessary to discard the literal meaning in order to arrive at the metaphorical one, which seems to be automatically available (Glucksberg, Gildea, & Bookin, 1982).

Based on such findings Glucksberg and Keysar (1990) proposed a parallel processing model, where it is not necessary to transform the proposition into a comparison, but it can be understood directly as a categorization. In their view the metaphorical term refers to a whole ad hoc category, and labels it as a prototypical category member. For example, Simon would be a *magician* in the figurative, financial sense, if he were placed in the ad hoc category EFFECTIVE IN A TRICKY WAY, labeled by its most prototypical member, 'magician'. Proponents of the parallel processing view showed experimentally that metaphors (or similes) are not processed like literal comparisons, but like category assertions (Glucksberg, McGlone, & Manfredi, 1997), and that comprehending a metaphor involves highlighting specific relevant, and suppressing irrelevant features (Gernsbacher, Keysar, Robertson, & Werner, 2001; Glucksberg, Newsome, & Goldvarg, 2001). It is important to note that even though both senses are accessed parallel, interpretation depends strongly on context (Gibbs, 1994).

Bowdle & Gentner's (2005) in their career of metaphor hypothesis attempt to

integrate the comparison and categorization perspectives. Novel metaphors do require a transformation into a simile and a comparison in order to allow for the matching of the conceptual domains and, to establish the structure of systematic mappings. Eventually, as a result of extensive use and gradual conventionalization, novel metaphors become familiar, and a mere categorization is sufficient. During the course of familiarization the source domains acquires a secondary, abstract sense that can be used as a category. Even though proponents of the category assertion view repeatedly showed that their model can provide better explanation of experimental findings (McGlone & Manfredi, 2001; Pierce & Chiappe, 2009), the debate has not been settled yet.

Experimental work on metaphor comprehension has been growing steadily, but results or often inconclusive, and many further questions concerning processing steps and neural underpinnings are still open. The development of novel experimental techniques has transformed the field of metaphor research as well. Since reading time differences are not always informative of underlying processes, the emphasis has moved towards neuroscience. In the following section I am going to provide a critical review of the currently available studies on metaphor research. The two main questions in the field have been the right cerebral hemisphere's role, and the processing steps specific to metaphor comprehension.

3 Right hemispherical language: figuratively strong

Following the discovery of speech related brain areas in the left hemisphere (LH) during the course of the 19th century (Broca, 1861; Wernicke, 1874), language comprehension and production seemed to be under the control of the LH (Geschwind, 1970; Luria, 1970), and the right hemisphere (RH) has been often referred to as the 'mute' hemisphere (e.g., Sperry, 1985). Undoubtedly, the likelihood of an abiding aphasia is much higher following left hemisphere damage (LHD) than right hemisphere damage (RHD). According to classical clinical language test batteries speech comprehension seemed intact after RHD, and complaints of altered language skills by RHD patients and their relatives seemed unfounded.

Today, however, the RH seems to be involved in a wide variety of language functions (e.g., Van Lancker Sidtis, 2006). According to a comprehensive meta-analysis, it is sensitive to contextual effects (Vigneau et al., 2011), and it appears to be

essential in tasks involving communicational pragmatics (Pléh, 2000; Van Lancker, 1997), such as understanding indirect requests (Brownell & Stringfellow, 1999; Foldi, 1987; Stemmer, Giroux, & Joanette, 1994; Weylman, Brownell, Roman, & Gardner, 1989), jokes (Bihrle, Brownell & Gardner, 1986; Brownell, Michel, Powelson, & Gardner, 1983; Coulson & Williams, 2005; Coulson & Wu, 2005; Marinkovic et al., 2011; Shammi & Stuss, 1999), irony (Eviatar & Just, 2006) and sarcasm (Kaplan, Brownell, Jacobs, & Gardner, 1990), or resolving lexical ambiguity (Burgess & Simpson, 1988; Faust & Chiarello, 1998). Metaphors, posing unique linguistic demands, also have been proposed to be processed by the RH.

3.1 Lateralization and metaphor

Metaphorical expressions were among the first materials that shed light on the RH's linguistic competencies. In their pioneering experiment Winner and Gardner (1977) asked LHD and RHD patients to choose one out of four pictures that fits best a given metaphorical expression – and also explain their choice afterwards. For example the expression 'He has a heavy heart' was accompanied by four images: a crying person (figurative sense), a person carrying a huge heart in his hands (literal sense), a huge weight (referring to the adjective), and a red heart (referring to the noun). RHD patients chose more literal depictions, while LHD patients more figurative ones, just as the healthy control group. Intriguingly, LHD patients later gave more literal, while RHD patients more figurative explanations, despite their previous choice. Their primary results were later replicated in a similar picture naming task (Kempler, Van Lancker, Merchman, & Bates, 1999), and in an experiment where the patients' visuo-spatial deficits were controlled for, ensuring that it did not interact with the finding (Rinaldi, Marangolo, & Baldassari, 2004).

RHD patients' impairment in metaphor comprehension was observed in purely linguistic tasks as well. When choosing the two most similar out of three presented words ('straight', 'honest', 'ruler') LHD patients chose the metaphorically related ('honest'), but RHD patients picked the literally related word ('ruler') more often (Brownell, Simpson, Bihrle, Potter, & Gardner, 1990). Researchers later turned towards other factors that could interact with figurative language processing, such as novelty. Van Lancker and Kempler's (1987) experiment found that RHD patients experienced difficulties with familiar idioms, while LHD patients had problems with novel literal expressions. Eventually, cumulating neuropsychological evidence led to

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the RH theory of metaphor. Proponents of the theory suggest that an intact RH is necessary to understand figures of speech, and that specifically it is involved in computations related to metaphorical language.

Advances in neuroimaging enabled the study of the neural correlates of language comprehension in healthy individuals with no brain injury. A ground breaking PET experiment by Bottini et al. (1994) found the RH taking part in processing figures of speech in healthy individuals. They presented their participants sentences containing metaphors, literal expressions, and (orthographically plausible) non-words. Metaphors were novel in order to avoid observing the automatic processing of fixed formulae. During a lexical decision task (whether the sentence contained a non-word) all correct sentences were processed by the LH; when contrasting literal sentences with metaphorical ones, a RH advantage was evident in prefrontal regions, middle temporal gyrus, and precuneus. Their results later were confirmed by several divided visual field (DVF) studies (Anaki, Faust, & Kravetz, 1998; Faust, Ben-Artzi, & Harel, 2008; Faust & Mashal, 2007; Mashal, & Faust, 2008; Schmidt, DeBuse, & Seger, 2007), and neuroscience experiments involving fMRI, TMS, and EEG source localization (Ahrens et al., 2007; Arzouan, Goldstein, & Faust, 2007; Diaz, Barrett, & Hogstrom, 2011; Mashal, Faust, & Hendler, 2005; Mashal, Faust, Hendler, & Jung-Beeman 2007; Pobric, Mashal, Faust, & Lavidor, 2008; Sotillo et al., 2005; Stringaris et al., 2006; Yang, Edens, Simpson, & Krawczyk, 2009).

At the same time, several groups were unable to show RH advantage (Chen, Widick, & Chatterjee, 2008; Eviatar & Just, 2006; Faust & Weisper, 2000; Kacinik & Chiarello, 2007; Lee & Dapretto, 2006; Mashal & Faust, 2010; Mashal, Faust, Hendler, & Jung-Beeman, 2009; Rapp, Leube, Erb, Grodd, & Kircher, 2004, 2007; Stringaris, Medford, Giampietro, Brammer, & David, 2007), and some have been arguing for bilateral processes (Coulson & Van Petten, 2007; Schimdt & Seger, 2009). Taken together, new data sometimes supported, sometimes challenged the RH metaphor theory. Experiments nevertheless strongly hinted that the RH's sensitivity to linguistic materials is in fact not specific to figurativeness, and it is influenced by a variety of factors.

3.2 Novelty: salience, coarse coding, & difficulty

In general, RH metaphor processing has not been attributed to its affinity for

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figurative language per se, but to its sensitivity to novel, unusual, and unfamiliar meaning (Chiarello, 1991; Beeman, 1998; Giora, 2003; St. George, Kutas, Martinez, & Sereno, 1999). One highly influential theory is the graded salience hypothesis (GSH) (Giora, 1997, 2003). Instead of a figurative-literal division of labor between the cerebral hemispheres, this framework proposes that the LH codes highly salient meanings, and the RH codes non-salient meanings. Saliency depends on a number of semantic factors, such as being coded in the mental lexicon, conventionality, frequency, familiarity and prototypicality. Conventional metaphors have a highly salient figurative meaning, and as a result are processed by the LH ('tie the knot'). In turn, the literal sense of idioms ('tie the knot' – 'rope') is low in saliency and is processed by the RH, as shown by an fMRI study (Mashal, Faust, Hendler, & Jung-Beeman, 2008). In the case of novel metaphors the non-salient figurative meaning is comprehended only after the refusal of the highly salient (literal) meaning, and this kind of serial processing is reflected in slower comprehension (Giora, 1997, 1999; Giora & Fein, 1999). This hypothesis gained much popularity, but cannot account for some experimental results, such as the one by Blasko and Connine (1993), who found that only mildly apt novel metaphors are processed serially, and figurative meaning is available promptly (and parallel) for highly apt novel metaphors.

Another highly influential framework is Beeman's (1998; Beeman et al., 1994; Jung-Beeman, 2005) coarse semantic coding theory (CSC), predicting lateralized language comprehension differences based on neural organization. The asymmetric architecture of the microcircuitry of the hemispheres yields narrow semantic fields in the LH that code information in a fine grained manner and quickly reach a specific solution. The RH has broader semantic fields that code in a coarse manner and as a result activates a broad array of distant associates. In other words, regardless of figurativeness the RH is expected to process new, unusual expressions, and the LH to process conventional ones, such as idioms.

An improved version of CSC theory is the Bilateral Activation, Integration, and Selection (BAIS) model (Jung-Beeman, 2005). Jung-Beeman proposes that three semantic systems in both hemispheres that work together in a precisely coordinated and highly interactive manner. Posterior middle and superior temporal gyri activate, lower frontal gyrus selects, and anterior middle and superior temporal gyri integrate semantic information bilaterally according to the linguistic demands at hand. Fine coding by close linkages in the LH leads rapid to solutions with sharp contours, while

diverse and distant connections in the RH enable a wider range of possible solutions in all three subsystems. In other words, regardless of figurativeness new, unusual expressions fall under the authority of the RH, whereas conventional terms under the LH.

Contrary to the GSH it is not the whole expression's salience (its frequency, codedness, familiarity, etc.) that determines hemispheric processing, but the extent to which the constituents' semantic fields overlap. The semantic field of a word is consisted of its semantic features and its associates. Words that are category members, but not associated (e.g., arm-nose) activate the RH's systems that have a special sensitivity to category relatedness. Words that are category members *and* associated (e.g., arm-leg) activate the LH's systems – because they have more overlapping semantic features (Chiarello, Burgess, Richards, & Pollock, 1990). Thus, in case constituents of expressions are not category members their semantic feature overlap seem to be mainly driven by associations.

Although both the GSH and the CSC predict RH processing for novel expressions (having no salient meaning, and being not associated), even frequent expressions – with not associated constituents – can evoke RH activations. When researchers compared familiar noun noun phrases (e.g., 'lake house') with their unfamiliar reversals (e.g., 'house lake') in an fMRI study, they observed activations at the right temporoparietal junction (Graves, Binder, Desai, Conant, & Seidenberg, 2010). The phrases used in the experiment might not be coded in the mental lexicon, but their overall saliency should be still relatively high, meaning that it is possible to disentangle the two theories, what is going to be crucial for Thesis point I.

In case it is solely novelty that matters when it comes to lateralized language processing, novel literal language also should be processed by the RH. However, for the time being, there is only one study that explored novel literal language with regard to hemispheric processing. In an experiment combining the DVF and event-related potential (ERP) technique, Davenport & Coulson (2013) compared novel literal sentences (so called literal mapping condition: 'At one time, this movie house was a cathedral.') and conventional literal sentences (last word used in a conventional meaning: 'It scared him to be alone in the cathedral.') that were matched for cloze probability. Cloze probability is a measure of the probability of the sentence final word appearing in the given context. It has been observed that it strongly influences the amplitude of the N400 (Kutas & Hillyard, 1984), a negative going brain wave

peaking around 400 milliseconds (ms), associated with semantic comprehension and memory retrieval (Kutas & Hillyard, 1980; Kutas & Federmeier, 2011). They found a late right lateralized frontal positivity for novels, and a temporal processing pattern that fitted the GSH better than the CSC. However the results were complicated by an apparent greater ease of processing of novels in the LH, indicated by a reduced N400, that contradicts the GSH.

Moreover, novelty does not seem to be processed identically across literal and metaphorical language. In an ERP study Coulson and Van Petten (2002) compared high- and low-cloze literal with matched low-cloze (novel) metaphorical sentences. They found that the observed late positivity had an anterior focus for novel literals, but a posterior focus for novel metaphors. This suggests that literal and figurative language is processed differently in some respect. Later, Coulson and Van Petten (2007) used the same stimulus material in a DVF version of their ERP experiment, and found larger N400s for novel metaphors, indicating a greater processing effort, but did not register significant hemispheric differences. Only a handful of other studies attempted to compare novel metaphorical and novel literal language, but they yielded rather contradictory results. In a DVF experiment Schmidt, DeBuse, and Seger (2007) used the stimulus material from the study of Bottini et al. (1994) including novel literal ('The boy used a plastic bag as a rain hat') and novel metaphorical sentences ('The close friends were a bag of toffees'), and extended them with conventional literal sentences ('The children's' shoes were covered in dirt'). Although the authors claimed that all novel sentences, but not the conventional ones, evoked a RH processing advantage, their results are dubious, as they have found no interaction between conditions and hemispheric presentation. Diaz, Barrett and Hogstrom (2011) presented familiar (i.e. conventional) and novel, both metaphorical and literal sentences in an fMRI study. In grouped contrasts novel expressions (literal and metaphorical together) relative to familiars activated RH regions; and metaphorical sentences (familiar and novel together) relative to literal ones activated also the RH. Yet, the results are not uncontroversial, since relative to familiar literals, novel literals elicited left inferior frontal gyrus (LIFG) activations, and novel metaphors did not differ from them. The latter finding contradicts both the GSH and the CSC. These experiments hint that novel metaphors might not be processed identically with novel literal expressions, perhaps including the matter of lateralization, but results are inconclusive.

One possible explanation is that novelty is a demanding linguistic dimension; some researchers even suggested that the RH joins language processing once LH resources are not sufficient for comprehension because of difficulty (e.g., Bookheimer, 2002). Based on ERP measurements some groups also found a gradual processing demand: novel metaphors require more effort than conventional metaphors that in turn require more than literal expressions (Arzouan et al., 2007; Lai, Curran, & Menn, 2009). An fMRI experiment involving novel metaphors concluded that RH activity increase is more of a function of the specific task at hand and its difficulty than figurativeness per se – conventional and even novel metaphors evoked activations primarily in the LH (Yang et al., 2009). RH metaphor processing has been linked to difficulty in brain-damaged patients as well (Monetta, Ouellet-Plamondon, & Joanette, 2004). In order to clarify the interplay between figurativeness, familiarity, and difficulty, the fMRI experiment of Schmidt and Seger (2009) compared literal sentences ('The computers at my house are new') with easy familiar metaphors ('Freedom is a breath of fresh air'), easy unfamiliar metaphors ('A shadow is a piece of night'), and difficult unfamiliar metaphors ('A smile is an ambassador'). This manipulation enabled the comparison based on conditions, not merely on task. Difficult unfamiliar metaphors relative to easy unfamiliars activated the LIFG and right middle frontal gyrus – areas in both hemispheres. Although all unfamiliar metaphors elicited stronger BOLD signal change in the right inusla, this area was activated by every metaphor. Additionally, familiar metaphors activated the right middle frontal gyrus and the right inferior frontal gyrus, whereas they were expected to tax primarily LH areas. Taken together, neither difficulty evoked only RH, nor familiarity only LH activations, and predictions based on these factors were not strongly supported.

In a highly relevant study Cardillo, Watson, Schmidt, Kranjec, & Chatterjee, (2012) investigated the process of familiarization. They presented their participants novel metaphors repeatedly in an fMRI study. As a consequence, the expressions gradually became familiar, but interestingly activity decreased in the left posterior middle temporal gyrus and bilateral inferior frontal gyrus. Even though everyday conventionalization probably takes many more encounters in natural language, LH areas seemed to be more involved in processing the novelty of unfamiliar metaphors.

In conclusion, understanding novel metaphors seems to be influenced by a number of semantic variables, and its mechanisms have repeatedly proved to be

challenging to tackle. Novel metaphors might not be processed identically with novel literals, what contradicts the GSH and the CSC theories. However, the BAIS could provide an explanation given that there are various subtasks that are carried out by the two cerebral hemispheres in an unpredicted pattern. Difficulty cannot be excluded to play a role in RH activations, but results are not decisive. Paradoxically, familiarization might depend on bilateral and LH regions, irrespective of overall novelty. Further experiments seem inevitable, but an additional option is to try to find patterns in existing data. For example a recent meta-analysis of imaging studies on figurative language by Bohrn, Altmann, & Jacobs (2012), metaphors in general, relative to literal expressions, activated left frontotemporal regions, but when only novel metaphors were contrasted with conventional ones, significant clusters emerged in the RH. This is an important finding because it supports the stance that RH processing advantage is not related to figurativeness, but to novelty, and confirms the GSH and the CSC theories as well.

3.3 Sentence complexity, context, & pragmatics

There are a number of linguistic variables that also can influence hemispheric processing, such as sentential, contextual, and pragmatic processing. Surprisingly certain studies were not able to show RH effects even with novel metaphors (Mashal & Faust, 2010; Mashal et al., 2009; Shibata, Abe, Terao, & Miyamoto, 2007), or even found LH priming (Faust & Weisper, 2000). One possible explanation is that sentence processing generally taxes LH resources (for reviews see Chiarello, 2003; Faust, 1998), what might have overridden effects of novel figurative language (cf. Mashal et al., 2009).

Another possibility is that sentence processing is a complex task not lateralized exclusively to the LH, and RH level sentence processing masked metaphor related RH effects. The Production Affects Reception in Left Only or PARLO model (Federmeier, 2007) is based on the observation that the two hemispheres apply qualitatively different strategies to deal with sentential information (Federmeier & Kutas, 1999; Federmeier, Mai, & Kutas, 2005). As a result of its strong feedback connections and a concomitant increased interactivity between processing levels, the LH creates top-down expectancies to actively predict likely upcoming material, while in the lack of such strong feedback the RH is integrating the already available material into a comprehensive whole in a more bottom-up fashion. Therefore, higher sentence

predictability could enhance LH processes, and lower predictability RH processes. Novel linguistic material probably requires bottom-up RH computations.

Measures of sentential predictability (and processing difficulty) such as cloze probability or sentential constraint are rarely controlled for in experiments on figures of speech. Cloze probability is the predictability of the last word of a sentence, based on the preceding sentence context. Sentential constraint is high when a sentence has one high probability completion, and it is low when it has several low probability completions. Therefore there are two kinds of low-cloze sentences: 1) weakly constrained sentences, and 2) strongly constrained sentence with a not preferred ending. While cloze probability is influencing the N400 (Kutas & Hillyard, 1984), sentential constraint the post-N400-positivity (Federmeier, Wlotko, Ochoa-Dewald, & Kutas, 2007). When cloze probability was controlled for, studies combining the ERPs with the DVF paradigm found no marked RH effects for metaphors, but bilateral processing (Coulson & Van Petten, 2007; Kacinik & Chiarello, 2007). Thus, RH effects could have been a result of sentence predictability in several experiments.

When RH's language functions are studied, communicational pragmatics and context are key questions. Context can have effect at various levels on language comprehension (Kutas, 2006). Sometimes context is referred to as minimally as a prime word preceding a target word, but it could be problematic to draw a straight line even between sentential and discourse effects. On the other hand linguistic expressions longer than a single sentence require processing additional to syntax in order to link sentences. Context in this latter sense is a good approximation of at least one aspect of pragmatic processing: reading between the lines that allows inferring the intended meaning across sentences. Not surprisingly, contextual understanding has been also linked to RH processing (Ferstl, Neumann, Bogler, & von Cramon, 2008; St. George, Kutas, Martinez, & Sereno, 1999; Vigneau et al., 2011; Xu, Kemeny, Park, Frattali, & Braun, 2005). Priming effects were found only for congruent contexts in the LH, but both for congruent and incongruent contexts in the RH (Faust & Chiarello 1998). In general the RH seems to be able to sustain a broader range of possible interpretations, either in order to revise/repair interpretation (Chiarello, 1991), or in order to integrate previous, or yet to come distant information during discourse, or both.

More importantly, contextual effects, in a broad sense, could have masked RH metaphor effects in fMRI studies, where activations could have cancelled each other

across conditions, and/or could have tilted overall processing towards the RH in DVF studies (e.g. Schmidt et al., 2007). The results of Diaz & Hogstrom's (2011) fMRI study point towards this interpretation, since they found that prime sentences preceding metaphorical sentences exercised a stronger influence on the RH than figurativeness by itself.

Pragmatics is the study of the use of language for communication – not specifically phonemes or grammar, but the way intended meaning is conveyed via linguistic means, inference, world knowledge, and the discourse as a whole (Pléh, 2000; Van Lancker, 1997). Although it is not entirely clear whether pragmatics is a separate brain and/or knowledge domain, or whether it is decomposable into a number of subdomains as Sperber and Wilson (2002) argue, it seem to tax RH and frontal brain areas (Pléh, 2000). Some of the tasks utilized in previous studies (e.g., in Mashal et al., 2005, 2007: "Silently decide whether words are metaphorically related") could have posed subtle pragmatic demands. Metaphors in general are also likely to serve pragmatic functions in natural language (which is going to be addressed in Thesis point III). The above considerations raise the possibility that pragmatic aspects, not semantic features evoked RH computations in at least some of the previous studies.

3.4 Conclusions

Based on the above considerations there seem to be two main issues in current metaphor research. The first is the role of processing novelty/conventionality. One kind of operationalization, leaning towards the GSH, is familiarity, a prominent constituent of saliency. Note that even conventional metaphors can be novel for children or second language learners, but usually it is taken for granted that conventional expressions are familiar and novel expressions are not. Another way to look at novelty is leaning towards CSC, conceptualizing it as a kind of semantic distance based associative strength. Again, it is possible for some conventional expressions to be constituted of distantly associated words, as it is in the case of noun noun phrases (as in Graves et al., 2010) and also compound words. This unique feature of compound words was utilized to contrast the GSH and CSC in the paper related to Thesis point I. For example, conventional noun noun compound word metaphors (e.g. chair-leg) require LH processing according to the GSH, because they have a salient figurative meaning, but RH processing according to the CSC since the constituents are not closely associated.

The second issue with metaphor processing is the great variety of linguistic factors influencing RH processing. Both of the two studies related to Thesis points I & II aimed at exploring hemispheric differences in metaphor comprehension, while controlling for factors known to tax the RH. Expressions were presented without context to eliminate the effects of sentential and/or contextual-pragmatic processing. Previous research reporting RH advantage for metaphor production might have been confounded with these and further factors including emotions (Ferstl, Rinck, & Von Cramon, 2005; Schwartz, Davidson, & Maer, 1975) and visual imagery (Just, Newman, Keller, McEleny & Carpenter, 2004). The first study looked at spatial processing patterns using fMRI measurements, and the second at behavioral-temporal processing in a DVF paradigm using an eye-tracker. The results suggest that when potentially confounding factors are controlled for there is no evidence for RH computations (in terms of BOLD signal change), or a RH processing advantage (in terms of reaction times and response accuracy). Further on the comparable reaction times for novel metaphors and novel literal point towards: (1) no processing difficulty is evident for novel metaphors, and (2) dropping of an initial salient and/or literal meaning of novel metaphors is not likely either.

4 The science of metaphors: an alternative account

4.1 Semantics of category assertions

Based on the results of the papers of Thesis points I & II metaphor comprehension seem to involve computations beyond processing salience or associatedness. Processing low salience does not seem to be a unique RH feat, and the BAIS (Jung-Beeman, 2005) seem to better account for the findings. On the other hand, metaphor comprehension needs higher level explanations than the BAIS offers. Several models, including the cognitive metaphor theory (Lakoff & Johnson, 1980; 1999) do not seriously attempt to outline comprehension stages. Serial processing (Grice, 1975; Searle, 1979) does not seem to be a valid account (Gibbs, 1994). Even though the career of metaphor hypothesis (Bowdle & Genter, 2005) suggests that at least novel metaphors are understood via serial processing, the results related to Thesis point II do not support such a claim. Slow reaction times for novel metaphors did not reflect a literal-figurative differentiation, since novel literals were processed equally slow.

A further model specifying the comprehension of nominal metaphors, proposes a semantic feature suppression and enhancement procedure. The category assertion view or class-inclusion theory (Glucksberg 2003; Glucksberg, & Keysar, 1990) takes important steps towards flashing out the processing steps, however, there are some serious theoretical concerns with this framework as well (cf. Gibbs, 1992). Glucksberg's proposal is that parallel processing of figurative and literal senses originates from the dual reference of metaphors. The expression 'my lawyer is a shark' contains the word 'shark' that can refer simultaneously to a basic level of abstraction, a *marine creature* (a subordinate category), and to a higher level of abstraction, *predatory creature* in general (a superordinate category). Such ad hoc categories, lacking a lexical entry or a specific name, can borrow one from their most prototypical category member. Therefore the name 'shark' would stand for the category of *predatory creatures* instead of merely the concept SHARK. This account suggests that in order to interpret metaphors accurately, features belonging to the superordinate category that are relevant to the ground of the metaphor (*cruel, aggressive*) have to be highlighted, while the inappropriate ones (*swims well, has a cartilaginous spine*) have to be suppressed (Gernsbacher et al., 2001; Glucksberg, et al., 2001).

However, the theory leaves some important questions open. First, it is not clear why we need to create a whole novel category (*predatory creature*), once we would like to make a reference to a *specifically shark kind of predatory creature* only? The concern is: how come that the LAWYER is not in interaction with the rest of the category members, such as a LYNX, or perhaps with category members also classified recently as *predatory creatures*, for example the lawyer's AUNT? Categories bring a number of constraints with them, even if they are organized prototypically, which have consequences not considered thoroughly by the theory. Conversely, the extension (and/or explanation) of a metaphor usually does not follow a – hypothetical ad hoc – category, but rather the metaphor vehicle itself broadening the figure into a comparison or an analogy based on the concept SHARK (and not the category *predatory creatures*, or its other members).

Secondly, it is not obvious why SHARK would be the prototypical category member of *predatory creatures*. The prototypical exemplar of predators is most probably a culturally and geographically varying construct – but this metaphor works in landlocked countries as well. If the question is reversed, namely what superordinate

category 'shark' is prototypically exemplifying, it might be simply *marine creature* or *predator* – but these referents would not even be figurative senses. These superordinate categories could be characterized by physical properties[*] (*gills, hunting*, etc.), not relevant for the figurative meaning. Of course shark could be simply exemplify a highly specific, yet ad hoc superordinate category of *very aggressive, cruel, vicious predatory creatures*. In this case 'shark' would not represent a real ad hoc category, but would refer to a very narrow, *very sharky* novel category, containing the relevant non-physical properties. This kind of categorization would leave taxonomy behind for the sake of dispositions, but it is not clear what is the gain or cognitive reality of such categories. Are not the 'very sharky' properties simply describing SHARKS? Why do we need a category of *metaphorically very shark-like things*? Or *only very vicious things*?

And it leads to a third problem: which one of the several possible senses of 'shark' is going to be selected as the ground of the metaphor in various potential contexts? As the categorization theory is not specifying why a certain categorization is selected above another possible one, it fails to account for the different senses a metaphor can have (e.g., 'That swimmer is a shark' or 'Those drivers are sharks' etc.). Would this mean that in another context the word 'shark' having a slightly different sense becomes a prototypical member a slightly different category? Since a word can appear in infinitely numerous contexts, this constraint would eventually lead to the problem of infinitely numerous superordinate ad hoc categories assigned to a concept. In fact there is a hidden contradiction here. If we need a superordinate ad hoc category for every metaphor, and take into consideration the vast amount of metaphors and their high frequency, most superordinate categories should be ad hoc. By having many more super- than subordinate categories, we would run out of words of (subordinate) prototypical category members quickly. A word's meaning would be dissolved in an infinite amount of possible, superordinate senses, with its subordinate sense blurred. Categories would not serve as categories anymore, since their inflation would not allow them to structure and group semantic and world knowledge.

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[*] Semantic attributes are usually referred to as 'features' by proponents of the category assertion view (Glucksberg, 2003) and the BAIS (Jung-Beeman, 2005), and 'properties' by Sperber and Wilson (2008). I am going to use the latter as it is somewhat more abstract.

4.2 Inverse containment

One way out from the above concerns is through one of the central properties of concepts, the abstract-concrete dimension. The conceptual analysis suggested by the category assertion view, that is, labeling an ad hoc category with one of its prototypical members, already somehow relates to an abstract sense. It takes the superordinate category to represent a higher level of abstraction, and the subordinate a lower level of abstraction. However, this is problematic, since high-level categories do not necessarily mean abstract properties. Having *gills*, or a *spine* are not abstract, but physical properties, although they characterize FISH and VERTEBRATES, respectively. It is true that such categories have less concrete physical properties, making them more abstract, but this is a relative difference only. Correspondingly, low-level categories do not necessarily represent concrete properties – one specific dog can be much more *playful* than all other dogs, and the specific instances of literary tools are all quite abstract. Sub- and superordinate do not cut across categories the same way as the abstract-concrete, but the category assertion theory seems to take superordinate categories for abstractness. However, for metaphors the abstract sense is the relevant, not the concrete, irrespective of categorization (in the context of 'lawyers' the idea that SHARKS are *merciless*, not that they have *cartilaginous spine*).

Category assertion builds on the classical empiricist model of the conceptual system, which persuaded constructing complex, high level abstract concepts from some kind of basic, elementary (e.g. perceptual), concrete sets of concepts. Abstract categories allegedly contain concrete categories and category members (LIVING contains ANIMAL that in turn contains SHARK). This theory has received considerable criticism, and Fodor (2008) effectively showed that it was untenable. According to classical containment theories, more specific concepts are of greater numbers, and are pulled together by higher level, more abstract concepts – large bubbles of abstract concepts contain the smaller, more concrete, more tangible bubbles of concepts. However, this gives rise to the X-problem, and Fodor (2008) deems this as one of the major arguments against the analytic notion of concepts. The problem is that there is no such X that would correspond to the formula 'color + X → red', only 'red' itself, therefore the reasoning is circular. Every concept carries an indeterminable individual concrete essence and therefore cannot be defined. Containment theories propose a *'concrete + X → abstract'* scheme that should look like 'red + X → color'. However, (by chance?), Fodor himself turned it upside down with his 'color + X → red'

example, transforming it into *'abstract + X → concrete'*.

Actually the inversion opens up an exciting opportunity to (re)interpret conceptual primitives. We might not need to look for sensual concepts, or for basic level concepts, but not even for metaphysical ones – as has been proposed earlier without much explanatory value. Instead we could turn exactly towards the other end, to the most abstract concepts as building blocks. It is 'inverse' not just as compared to the philosophical tradition, but also to folk psychology and folk biology, where families contain the genera, which contain species, etc. Abstractness could become an atomistic conceptual primitive that should, could, or need not to be defined, and concreteness could carry the informational surplus. The reversal of the original model would be: large bubbles of specific terms include the atoms of abstract concepts. Inverse containment could solve the X-problem. Going back to the example above, we could set aside defining COLOR, leaving it open to include any new colors we encounter, and RED would carry something unique and specific besides being an abstract idea – a kind of *color*. Therefore, more specific terms would be defined by the abstract ones and not vice versa, that is, again *'abstract + X → concrete'*, where X is labeling the unique properties of the concept at hand. Abstract concepts would be vague, and concrete concepts would be dense, containing all relevant properties from physical to abstract, from taxonomical to category specific, from perceptual to dispositional. The empiricist description of the conceptual system, that is, viewing abstract concepts as containing concrete ones, was rendered an impossible endeavor, perhaps, because it is the units that might be abstract, and not the other way around.

A concept of a kind, such as SHARK, then, would not belong to a vast number of high level conceptual groupings, but contain all its properties: its superordinate taxonomic category (i.e. *living thing*, *marine creature*, *predator*), its differentia specifica, (i.e. *cartilaginous spine*), and all its properties, both abstract (e.g., *cruel*, *vicious*, and *merciless*) and concrete (e.g., the unique shark-like *fin*). A specific exemplar would contain all additional unique details as well, such as having *specific scars*, being exceptionally *bloodthirsty*, etc.

The reasoning does not fall into the trap of circularity, an argument against containment theories (Fodor, 2008), because one would not need to know RED to define COLOR, and the anchoring of concepts does not need to be a vast list of experiential or logical items. Instead one could be born with some (but certainly finite number of) very abstract concepts, such as LIVING and NOT-LIVING, ANIMATE and

INANIMATE, QUANTITY and QUALITY, CONTAINING and NOT-CONTAINING, etc., which could be enriched by being divided into smaller and smaller units via the encounters the many possible specific kinds. Such an identification of concepts by gradually differentiating specific instances of general domains fits well with the massive modularity hypothesis of Sperber (1994). He proposes that not only perceptual processes are modular (as suggested by Fodor), but cognitive processes as well: the mind constitutes of a vast number of interconnected macro and micro modules. Consequently, concepts can be viewed as modules that, during development, break down into a large number of smaller, specialized modules that represent more specific concepts. The exact neural mechanism is yet to be identified, but a massively modular neural and conceptual system not just allows for, but in fact calls for the inverse containment of abstract properties. It would allow for much less innate concepts than Fodor suggests, given that every case can be divided into subcases.

Abstract meaning could be linked to experience by cues of ostensive-inferential communication (Sperber & Wilson, 1995), and concepts could be clarified, specified, and divided via relevance in the cognitive environment. In other words, abstractness could be the default of the semantic system, and experience could refine specific instances – and not abstract generalizations. For example, the relevant information transmitted via natural pedagogy seems to be primarily abstract. Ostensive communication creates a genericity bias that elicits the expectation of kind relevant information in infants (Csibra & Gergely, 2009; Gergely & Csibra, 2006). Another example is overgeneralization, a phenomenon of language development, when children tend to interpret words in a more general sense than they should be, and as a consequence in a more abstract sense as well. Children could expect word meanings to be broader and more abstract than they are in fact, exactly because the basic perspective might be of a general level, as in using 'ball' for *moon* – which in could be actually a metaphor, if coined by an adult intentionally. Thus overgeneralization could be viewed as an antecedent of metaphorical language, utilizing a concept in a more abstract sense. Although it also could be a mere categorization error independent of abstractness, Fónagy (1999) suggests that child language is tremendously rich with metaphorical expressions, and considerable poetic power.

Chemistry could serve as a good metaphor for inverse containment – one similar to Mill's (1843) notion of *mental chemistry*. Mental chemistry is the idea that

complex ideas are generated, rather than constituted of simpler ones, and since they are more than the mere sum of their constituents they possess qualities not inherent in their elements. Broadening the analogy to the conceptual system in the light of modern physics reveals the following picture. Abstract conceptual properties could be conceived as atoms born out of the inherent parameters or laws of nature. Just as in the periodic table, they could group into families, while their specific properties are not evident based on their neighbors. Note the remote crosstalk to Wittgenstein's (1953/1986) 'family resemblance' implying that categories, represented by certain concepts, just like groups of atoms, should not be expected to be separated by clear boundaries. These innate conceptual atoms are not well differentiated initially; experience is necessary to identify similarities and differences within and between families, but each represent a unique quality. Complex concepts resemble molecules whose identity emerges from the specific constellation of their constituents. Atomic configurations provide an extra flavor of uniqueness to complex concepts (as proposed by mental chemistry), and determine their interactional properties as well. The larger the conceptual molecules are the more concrete they appear, and physical properties could be conceived as atoms from one specific block in the periodic table of concepts that bind to notions when physical characteristic are emphasized or pointed out. Molecules of concepts could be retrieved-attracted via words (i.e., unique labels or licenses), but the correspondence does not need to be either direct or one to one (cf. Fodor, 2008; Sperber & Wilson, 1998). Complex conceptual could combine into proteins of propositions, and eventually tissues of messages via the chemistry of syntax, where function words could serve as the special binding forces between molecules of meaning. According to this view, language is a living organism, an infinitely combinatorial texture of concepts, ideas, messages and narratives, based on a finite number of abstract conceptual atoms, embedded and developed deep in the mind and brain.

4.3 Abstract substitution

Once we look at concepts from the 'upside down' perspective of inverse containment the concerns with category assertion view could disappear. The theory by suggesting a categorization brings along the shortcomings of classical containment. However, inverse containment takes these weighs off the shoulders of metaphors. In order to refer to an abstract sense of a metaphor's vehicle, we would not need to

evoke a new superordinate ad hoc category, to bother with other members of the category, with categories dissolving and inflating, or with explaining the contextual flexibility of metaphorical reference. During the initial semantic analysis, every concrete aspect of the concept could be filtered, and from the remaining abstract properties the contextually most relevant be selected, simply to substitute the original word. The proposition 'My lawyer is a *shark*' would be modified to 'My lawyer is a *merciless being*', without requiring the creation of a novel ad hoc category. The model suggests a quick semantic analysis of concreteness before searching for the appropriate abstract sense of the word. According to Relevance Theory (Sperber & Wilson, 1995) words can be used in numerous senses depending on context, but such an early abstract-concrete shift would be unique to metaphors. Note that Quintilian also suggested a substitution for metaphor comprehension (and that they can play a serious role in thinking), but did not specify an underlying procedure (Nuessel, 2006).

Some metaphors might seem fairly abstract straight away (e.g., 'A fakir's bed is an oxymoron'). However, even in this case some properties are filtered, such as OXYMORON being a *literary tool*, while an even more abstract one, *inherent contradiction* is used for the substitution. This procedure rather seems more to be a 'class-exclusion': the 'fakir's bed' is not a kind of *literary tool*, but it is described in terms of a specific property of the literary tool 'oxymoron', namely *contradiction*. Similarly, the 'lawyer' is not a 'kind of shark', but is described in terms of an abstract, dispositional property of sharks. The point is that metaphor vehicles never refer to their category, but to a unique salient abstract property. If a metaphor vehicle happens to be abstract form the outset, it still refers to a property relatively more abstract than the specific category it belongs to. (And not a relatively concrete property, such as, in the case of OXYMORON, *occurring in poems*.)

The framework outlined above can readily explain metaphor phenomena, such as their irreversibility and their paraphrasability into similes (cf. Glucksberg, 2003). While metaphors are irreversible without changing the ground of the metaphor ('my shark is a lawyer'), similes can be reversed ('The Guggenheim is like a snail shell' into 'This snail shell is like the Guggenheim'). The reason is that concrete properties, such as physical shape, are not filtered in similes. When a metaphor is paraphrased into a literal comparison, the transfer of meaning switches from abstract to concrete. However, because similes are utilized to highlight concrete, physical similarity, they are not paraphrasable into metaphors, hence the asymmetry. Emergent properties can

have a relatively straightforward explanation as well, being novel concrete properties of the metaphor's topic that are inferred from the abstract property, referred to by the vehicle, that was incorporated into the conceptual representation of the topic.

Further on, real category assertions do not, in fact, transpose properties they just lend them all. Glucksberg seems to recognize this phenomenon in the case of "literal category assertions". For example, in the case of 'robins are birds' ROBINS inherit all properties of BIRDS (while they have some additional specific properties), what renders a comparison transformation impossible. However, he provides no explanation for why a transformation is possible at all for "metaphorical category assertions" (even if the metaphor's ground changes), what the difference is between the two, or how they are distinguished from one another. It follows then that there should be different processes in the background, but the theory argues just the opposite.

Most problems with the theory stem from the general inclination of metaphor theories to try to give some kind of a literal paraphrase of figurative meaning. This, however, is a program likely to be futile. Why to say something figuratively if it possible to express the very same message literally? Actually, from a Relevance Theoretical (Sperber & Wilson, 1995) perspective cognitive effects should differ in the two cases – metaphor is a kind of loose language use –, and merely choosing one option over the other tells about the speaker's communicative intentions.

Abstract substitution can be carried out also without establishing a complete and systematic structure of conceptual mappings. Metaphor theories emphasizing mappings (Lakoff, & Johnson, 1980a), alignment (Gentner, 1983), or conceptual blending (Fauconnier, & Turner, 1998) seem to start their analysis one step later, after the initial abstract substitution. Sometimes metaphors are extended in a conversation, and when a statement is unpacked in a systematic manner, mappings, analogical alignment, or conceptual blending does seem to be important. It is indeed inviting to enhance the effect of the 'shark' metaphor on the 'lawyer' by explicitly assigning further shark-like properties (*does not let his victim escape*, *persistent*, or even *his walk is such*). On the other hand, systematic mappings, alignment, or blending seem to be complex and consuming processes, and an apt novel metaphor might make sense immediately (Blasko & Connine, 1993). For such an ease of a quick comprehension the simpler substitution procedure seems more plausible, offering a more probable solution than the activation and manipulation of broadly defined conceptual domains.

This view is close to looking at metaphors as a special kind of polysemy, similarly to what has been partially suggested by Murphy (1996, 1997) – adding that metaphors rather than identifying it, probably create structural similarity, and eventually polysemy.

Apprehending metaphor as a kind of abstractive procedure is not without antecedents (e.g., the works of Max Müller, Ernst Leisi, or Hedvig Konrad) yet previous theories considered metaphorical abstraction substantially distinct from conceptual abstraction (Fónagy, 1999). The proposed theoretical framework suggests precisely continuity, while it attempts to embed metaphor comprehension in a broader conceptual, neural, and pragmatic context as well. The latter aspects are discussed in detail in the following sections.

4.4 *The neuroscience of abstractness*

Using concrete concepts in abstract senses as outlined above would also mean that the more concrete a concept is, the more 'dense' it is (the more properties it has), and the more abstract it is, the 'emptier' it is. In terms of brain processing this seems to be supported by the experiment of Huang, Lee, and Federmeier (2010), who showed that two word concrete expressions ('thick book') evoke an additional sustained, negative going, right frontal ERP wave starting in the N400 time window, as compared to abstract expressions ('interesting book'). This is the so called concreteness effect that suggests that concrete words need more computations and perhaps carry more information, as a result of mental imagery, just as proposed by Paivio's (2007) dual coding theory.

Neuroimaging studies seem to corroborate containment on a neural level. Gauthier et al. (1997) contrasted subordinate categories ('pelican') with basic level categories ('bird') both in a visual picture matching and a semantic task, using fMRI. They found that relative to the basic level, the subordinate level evoked much stronger activations in both tasks. In a picture naming fMRI study researchers used words that referred either to the basic level ('donkey' and 'hammer'), or to the domain level ('living' and 'manmade'), and found the fusiform gyrus activated bilaterally for both levels, presumably as a result of processing simple properties, but the perirhinal cortex activated also for the basic level, supposedly as a result of complex conjunction of properties (Tyler et al, 2004). In a PET study Rogers et al. (2006) presented pictures after three kinds of category labels (specific, intermediate, and general), and

participants had to indicate if the pictures matched the words. Areas activated by the specific category labels covered or 'contained' areas activated by the intermediate and general labels. Although these experiments did not address abstractness, but superordinate categories, the more general a concept is (e.g., BIRD), the less specific physical properties it has, granting a relative difference in these experiments. Taken together, a kind of containment seems to be present on a neural level indeed: the lower the semantic category is, the broader the brain activations are.

In the context of metaphor research the ease of processing abstract senses might have shown up in the experiment of Gernsbacher et al. (2001). Participants needed less time to make a decision when a metaphorical prime sentence ('That defense lawyer is a shark.') was followed by a target sentence referring to the superordinate sense ('Sharks are tenacious.') than the subordinate ('Sharks are good swimmers.'). They observed just the opposite pattern for prime sentences that were either literal ('That large hammerhead is a shark.'), nonsense ('His English notebook is a shark.'), or unrelated ('That new student is a clown.'). The intriguing was though that decisions regarding the superordinate sense (being *tenacious*) needed little time for every kind of sentences. Even the relatively time consuming decisions on literal, nonsense, and unrelated sentences in the superordinate condition were faster than the relatively fast decisions in the subordinate (being a *good swimmer*) condition. Thus abstract senses might be more readily available in general.

Motion metaphors are excellent candidates for studying the concrete and abstract aspects of processing. Desai, Binder, Conant, Mano and Seidenberg (2011) designed an fMRI experiment that presented literal action ('The daughter grasped the flowers'), metaphorical action ('The public grasped the idea'), and abstract sentences ('The public understood the idea'). Their results showed that metaphorical action sentences activated a secondary sensorimotor area (in the anterior parietal lobe) that overlapped with the activation elicited by literal action sentences. However, they also activated the left anterior and middle superior temporal sulcus, an area responding to abstract sentences, but not to concrete ones. This hints that they were processed concretely – and abstractly as well.

At the same time, the activation of motor areas is not necessarily a decisive result. Certain approaches claim a kind of somatotopic representation for the semantic system, instantiated in widely distributed neural networks reaching over large brain areas (e.g., Pulvermüller, 2005). The stance might seem radical, but it is not

profoundly distinct from Wernicke's (1874) hypothesis that suggests that sensorimotor representations are part of concepts, and they are stored together in semantic memory. On the other hand, this does not necessarily mean that sensorimotor representations are necessarily required for interpretation. During sentence comprehension both senses of ambiguous words are available around 200 ms after stimulus onset (Gergely & Pléh, 1994; Thuma & Pléh, 1995), but soon afterwards, around 250-300 ms, the incongruent meaning is suppressed (Pynte, Besson, Robichon & Poli, 1996; Seidenberg, Tanenhaus, Leiman & Bienkowski, 1982; Swinney, 1979). Therefore, sensorimotor aspects might be activated briefly – while according to neuropsychological findings sensorimotor activations are neither sufficient nor necessary for semantic processing. In semantic dementia, although sensorimotor functioning is intact, semantic abilities are selectively impaired; patients cannot, for example, name a picture of a chicken as 'chicken', or even as 'bird', but can provide a description of its physical properties (e.g., Patterson, Nestor, & Rogers, 2007). Conversely, apraxia is an impairment of executing object appropriate actions, with no loss of corresponding concepts, meaning that patients, for example, can name and recognize pantomimes with a hammer, but cannot use it to drive a nail in (e.g., Mahon & Caramazza, 2008).

There is also more direct evidence that the brain might represent metaphors in an abstract manner. Metaphorical motion sentences activated more anterior regions of secondary motor areas in the middle temporal gyrus compared to literal motion sentences that in turn activated more posterior parts of the same regions, in accordance with the abstract-concrete organization of the anterior-posterior temporal lobe (Chen et al., 2008). An experiment utilized transcranial magnetic stimulation (TMS) and motor evoked potentials (MEPs) and found the motion component somewhat preserved in metaphorical, but mostly lost in idiomatic expressions (Cacciari et al., 2011). These results are in line with the embodied abstraction model of the conceptual system (Binder & Desai, 2011) that suggests that unknown and rare expressions are processed by modality specific convergence zones, but familiar and frequent expressions are processed by supramodal convergence zones. But do these activations constitute a necessary component in the semantic analysis of novel language? An experiment measuring ERPs presented participants exclusively with novel two word expressions that ended on the same nouns, but belonged to three different categories: 1) physical 'painful moves', 2) abstract 'improvised moves', and

3) metaphorical 'rusty moves'. Only the physical condition elicited a concreteness effect relative to the abstract condition, the metaphorical condition did not. The results hint that perceptual processes might not be a necessary condition of semantic comprehension even in the case of novel metaphors, hence language might not be embodied in the strong sense, and abstract substitution has the potential to explanation the findings. (Forgács, Bardolph, DeLong, Amsel, & Kutas, in prep).

Mahon and Caramazza (2008) argue that sensorimotor activations do not prove embodiment anyway. They can have a disembodied explanation as well, assuming activation cascades along the interface between sensorimotor and conceptual systems. Such cascading activations are well known in psycholinguistics: the phonology of a word can have an effect on naming a preceding picture even if the word itself is not produced. Based on such a finding no body would conclude that phonological activations constitute word meaning. The authors theory of grounding by interaction offers an analogy to solve the puzzle *concepts : sensorimotor activation = syntax : words*. This means that syntactic structure is not defined by words, while it depends on them in the sense that with no words there is no syntax. Analogously concepts are not defined by sensorimotor activations but depend on them (Mahon & Caramazza, 2008).

In conclusion, first, it seems that brain areas activated by concrete concepts contain the areas activated by abstract concepts, perhaps indicating a neural basis for inverse containment. Second, metaphors might not involve concrete, embodied processing, but are understood abstractly, presumably by substituting the most relevant abstract sense of the vehicle of the metaphor. Finally, a literal paraphrase of a metaphorical expression might never be able to capture all the implicatures, and account for the cognitive effects evoked by loose language use.

4.5 *The lateralization of relevance*

An important question is which abstract feature the system is going to settle on if there are several possible candidates after filtering the concrete ones. The level of salience of the available abstract senses might be different from concept to concept: some could have one salient abstract sense, others a number of more or less equally weak and competing options. The availability of these possible senses partly depends on the metaphor vehicle's relation to other concepts it is most frequently used together with (i.e. its syntactics), and partly on the relevance of the intended meaning in the

given context. The former question should be possible to address by computational linguistic means, while the latter is going to be explored in the following. Such a perspective allows metaphors to be placed in the trinity of semiotics, linking semantics, syntactics, and pragmatics.

On a pragmatic account of language, Sperber and Wilson's (1995) Relevance Theory points out that lexicalized word meaning is always in an interaction with the cognitive environment and the present communicative goals. It postulates a continuum of broadening and narrowing meaning. Conversely meaning can be assigned so broadly that in a certain communicative context a whistle could be enough to convey the intended meaning. They view language as a dubious endeavor in the sense that signifiers and signifieds are not in a close correspondence: the meaning of words is somewhat underspecified, and pragmatics based inference plays a key role in meaning construction (Sperber & Wilson, 1998).

In their deflationary approach to metaphor they propose that it is not an independent linguistic category (Sperber & Wilson, 2008), and just as any other kind of figurative language metaphors fall near to the broad end of language use – while literal expressions (e.g., legal texts) strive to reach the narrow end. This is the reason, they argue, for a continuum of cases between metaphor, category extension, or hyperbole, all being cases of loose language use that utilize meaning broadening. The ad hoc concept account of metaphor by Carston (2010, 2012) suggests that metaphors require not only boarding of lexical concepts, but involve some narrowing as well. For example the utterance 'The water is boiling' can be intended to be understood literally (BOILING), the water being above boiling point; approximately (BOILING*), the water being hot enough for making a tea, but not necessarily literally boiling; hyperbolically (BOILING**), being too hot to take a bath in; or metaphorically (BOILING***), for example when 'a creek is boiling over rocks'. Note that in the last, metaphorical sense narrowing results in the complete lack of *heat*, a defining property of literal BOILING. Carston (2012) proposes that the various interpretations are reached essentially via the same inference: deriving contextual implications that meet a certain level of cognitive relevance. However, it is still open why broadening is accompanied by an extra narrowing for metaphors only, relative to other types of loose language use, what is the range of these procedures, and how their balance is reached.

Abstract substitution has the capacity to address these questions. Metaphor could be understood via a broadening, just as hyperbole or approximation, but while

these latter two keep concrete aspects as well, metaphors go through an extra narrowing when concrete properties are filtered. An important gain in the abstract substitution framework is that combining narrowing-broadening with the abstract-concrete dimension enables a closer description of processing, namely a procedure of substitution utilizing an abstract ad hoc concept. Further on, the process could be explained in a lateralized neural framework as well.

The finding that initially all possible meanings of ambiguous words are available during a brief period of time (Gergely & Pléh, 1994; Thuma & Pléh, 1995, 1999) suggests that a wide range of semantic properties is activated – presumably on a neural level as well. According to Jung-Beeman's (2005) lateralized language framework, the activations and the range of possible meanings are quickly and automatically narrowed in the LH, while broad activations are gradually built up in the RH. These broadened meanings are then maintained for later revision and ambiguity resolution (Chiarello, 1991). The conceptual locomotion on the narrow-broad continuum proposed by Relevance Theory could be conceived as the interplay between the broadening in the RH and narrowing in the LH. Such a neural interpretation of the theory has the advantage to specify the highly interactive cooperation of lateralized brain areas postulated by the BAIS model (Jung-Beeman, 2005). The idea is that the two cerebral hemispheres' broad and narrow semantic fields are not simply activated to overlap (or not), but narrowing and broadening are procedures or functions that are lateralized, and that are utilized in accordance with communicative goals to maximize relevance. Such a framework can account better for contradictory lateralization results, since it is not saliency, semantic distance, novelty, figurativeness or any kind of semantic property that determines hemispheric processing but the pragmatic requirements of the task.

From this perspective metaphor is a unique trope, a kind of loose language use, complete with an additional abstract narrowing. For literal language use narrowing would go in a concrete, and for metaphors (after a broadening) in an abstract direction. Other forms of loose language use keep concrete properties as well, thus they should require only broadening by the RH, no extra LH narrowing, and less semantic processing. This account can also explain why 'pragmatics' in general taxes the RH. Any kind of loose language use (approximation, hyperbole, category extension, etc.), and asks aiming at pragmatic processes in general usually requires the listener to broaden meaning and compute extra linguistic inferences, what creates a considerable

pragmatic task demand in experimental situations, relative to 'pragmatically not demanding' literal (and narrow) language use.

In conclusion, even though metaphors might not serve as the basis of the conceptual system as proposed by Lakoff and Johnson (1980b), perhaps they provide one of the best examples of the workings of the conceptual system, being in an intimate relationship with meaning narrowing and broadening along the abstract-concrete dimensions. Highly frequent senses of words (i.e. often used ad hoc concepts) might enhance the locomotion on the continuum by providing salient options for intended meaning, hence channeling comprehension. A single, highly probable use could make meaning more accessible, allowing for highly apt novel metaphors to be understood easily. At the same time, certain conventional metaphors with extensive mappings could have several possible active abstract senses, requiring disambiguation in certain contexts (e.g., a 'sly fox' referring either to *smart* or to *mean*). In short, in order to extract the meaning of a metaphor, first, just as with every kind of loose language use we need to broaden meaning, but then also to narrow it by filtering all concrete properties, and finally select the most relevant abstract sense in order to conceptually substitute the vehicle with it.

4.6 The use of metaphor

What is the reason for the extra work for metaphorical meaning? In Relevance Theoretical terms, what is the cognitive effect we get from such an effort? In general, the gain is that we do not need to say the abstract property itself, but can merely refer to it it with a different word – leaving the intended meaning for the audience to infer. This can bring mainly two, different effects that are the topic of Thesis point III.

First, strictly speaking, the speaker literally did not say what the hearer inferred. This allows to wrap, to cover up otherwise sensitive information. Even though sometimes a single whistle might be sufficient, other times we have to consider every single word carefully. A figurative inference might not be especially difficult: a metaphor, apt with regards to the specific communicational goals might not leave much doubt about the speaker's intention. Such potential double sidedness makes them excellent candidates for indirect speech that plays a key role in social bargains (Pinker et al., 2008). They provide safe means to effectively express, but sufficiently cover socially risky opinions, desires, or offers. Social bargains, deals regarding dominance, and a large number of interpersonal functions might be

mediated via the safe ambiguity if figurative language, and specifically metaphor.

The parallel availability of the literal and figurative interpretation can have a rather surprising effect, and it is often utilized to grab attention in puns, jokes or in advertisements. It also could have contributed to the success of the cognitive metaphor theory (Lakoff & Johnson, 1980a) that called attention to the literal reading of conventionalized metaphors. It has been hypothesized that the interpretation idiomatic expressions involve top-down pragmatic knowledge (Burgess & Chiarello, 1996). Cameron (2007) has reported for example that the metaphor LIFE IS A JOURNEY is sometimes used in conversations with the metaphorical meaning (fulfilling emotional goals) and the literal meaning (actually travelling) being simultaneously available. If a figurative meaning is apt enough to come to mind easily, but the literal meaning is also available contextually, the intended meaning might become negotiable.

The second cognitive effect metaphors can bring is to reveal connections and relations on an abstract level (not on a concrete one, like similes). When a highly abstract idea is described in terms of a concrete one, the choice of a specific vehicle can be elucidating. Metaphors are often utilized to expand knowledge and enhance comprehension in scientific contexts for example (Nuessel, 2006). Their open-ended nature makes them highly useful in knowledge transfer (Boyd, 1993). This aspect is going to be further explored in the next section.

Taken together, at the micro level of concepts, striving for relevance can explain how a hearer is able to arrive at an intended abstract sense of the vehicle. This level of interpretation is related to the relevance of the implicature of the metaphorical utterance. At the macro level of context, the explicatures of the metaphorical term, the choice of a specific vehicle also bears relevance. The vehicle's literal, narrow sense can be used (1) to cover up socially risky intended meanings, and (2) to illuminate new ideas. This section attempted to build up a comprehensive framework for the pragmatics of metaphors addressed by the paper related to Thesis point III.

5 The metaphors of cognitive science

Metaphors have been, and are, playing a central role in scientific language, from physics through philosophy to psychology. Many expressions might not seem metaphorical anymore (e.g., 'electric current' or 'sound waves'), but analogies

expressed by figures of speech oftentimes led and misled research. With time novel expressions become conventionalized, which could alter their processing steps as well. Over long periods of time metaphors become practically literalized (Gergen, 1990), as most of us take for example the term 'understand' to be literal, and do not attend to its original literal reading 'to stand under'. It worth to mention that most proposals on metaphor change assume a continuity between historical time and individual lifetime, but this is not evident, since different processes could lie in the background.

What certain is that there is a conventionalization and eventually a literalization of concepts originally coined metaphorically in novel scientific analogies. Since metaphors presumably fulfill crucial communicational roles, and serve as important transducers of covert or overt assumptions, they might talk about the attitudes of researchers as well. Thesis point IV is addressing this hypothesis, trying to interpret the word use of science in a metaphor framework. The two core issues are: (1) can key concepts of areas of study express preferences of (sometimes conflicting) world views metaphorically, and (2) can they be linked to a kind of 'mental perception', a neural preference or brain processing dominance of scientists?

5.1 Metaphors of the mind

Historically one of the first systematic attempts to link words (more specifically personality traits) to the brain was the dubious pseudo-scientific approach of phrenology (Pléh, 2009). During the past 150 years initially neurology, then neuropsychology, and recently cognitive neuroscience associated psychological functions (i.e. philosophical concepts) with certain brain areas. Following the cognitivist turn of the late 1950s, the representational theory of mind has emerged as the most viable model for mental functions. Since then various proposals have surfaced on the nature of the mind's contents, and on how information processing is implemented in the brain. What and how is represented by neural substrates can be interpreted as a kind of semiotic question – how are phenomena (objects) are represented (via signs) in the bran?

Peirce's (1975) classical trichotomy provides and exquisite framework to address this issue. He described three kinds of signs, based on their relational nature or motivation to represent an object (a stimulus pattern). Iconic signs physically resemble what they stand for, in a picture like manner, such as pictograms or (in part) Egyptian hieroglyphs, for example. Indexical signs imply or point to something they

correlate with, via some kind of sensory feature. A car's dashboard indicates the states of the engine (although it does not resemble it), and Chinese characters are partially indexical, just as for example the Latin letter 'o'. Symbolic signs are purely conventional and they represent an arbitrary rule for representation – Arabic numbers are symbolic. Language is thought to be symbolic in general, since it has no specific sensory motivation: Saussure proposed that meaning is arbitrary and is governed by convention (Pléh, 1995). At the same time, some researchers suggest an iconic, some an indexical, and some others a symbolic relationship between concepts and their instantiation in the brain and the mind.

Kosslyn's (1994) model delineates a perfect correspondence between the physical world (and physical objects) and their mental representations, thus an iconic relationship. Mental images have a depictive, picture-like format, where objects are represented by a pattern of points and their spatial relations. A key argument is that imagery seems to activate primary visual areas (Kosslyn, Thompson, Kim, & Alpert, 1995). The research agenda might be viewed as an attempt to empirically support the THOUGTH IS MENTAL IMAGERY metaphor. A similar iconic correspondence lies at the heart of the perceptual symbol system of Barsalou (1999, 2008), and his situated cognition model (Barsalou, 2003). An important divergence is that in Barsalou's proposal icons are established via a large number of encounters with actual exemplar objects and/or situations that are eventually averaged into condensed and summed representations. These are available for complex multimodal simulations that can serve as the basis even for certain symbolic functions (THOUGHT IS SIMULATION). Nevertheless, these representations are iconic in principle as they simulate the world in a more or less veridical manner. The theory proposes a secondary, practically indexical function for language, and that conceptual processing is carried out on simulations, with no linguistic representations involved (Barsalou, Santos, Simmon, & Wilson, 2008).

The proponents of embodiment (Lakoff & Johnson, 1999) advocate an indexical representation proper. Every concept points towards sensorimotor areas, but with several intermediate steps. During the course of comprehension image schemas are activated, that are cross-modal 'mental icons'. Not only literal, but also metaphorical senses of words activate sensorimotor areas via mappings. Summoning classical empiricist ideas and conceptual containment theories, every complex metaphor is thought to be constructed of primary metaphors (Grady, 1997). As a

result, the conceptual system is not only metaphorical in nature (Lakoff & Johnson, 1980b), but in principle it is instantiated on sensorimotor areas from concrete to abstract: "Language is physical. That's it." (Lakoff, 2012). Strangely enough, it has not been clarified where exactly in the brain, for example the often quoted physical warmth, closeness, or cross-modal containers are coded; another intriguing assumption is that physical sensations are easy to experience, but emotions with a considerable bodily basis need metaphors for conceptualization. Anyhow, the assumption is that words (via mappings) are indexing physical experience, which is the primary organizational principle of representations. THOUGHT IS EMBODIED, or more specifically THOUGHT IS SENSORIMOTORIC, as also Thelen (2000), Fauconnier and Turner (1998), among many others, claim.

Champions of classical Chomskyan cognitivism and a representational theory of mind propose purely symbolic relations in the brain (e.g., LOT by Fodor, 2008). Highly specialized modules translate perceptual information into the unified symbolic language of thought or mentalese that is actually language-like in nature (THOUGHT IS LANGUAGE). This approach has been dominating the first period of cognitive science and it still plays a defining role. Although alternative theories could not profoundly challenge it, evidently it is at odds with the mental imagery accounts of representation, and it has been challenged from a computational standpoint as well.

Rumelhart and McClelland (1986) in their model proposed that the brain does not require syntactic or other rule based manipulations in order to function computationally, but not even any kind of mental imagery based representations. Connectionism offers a complex network of simple, interconnected units, imitating a neural network (THOUGHT IS PARALLEL DISTRIBUTED PROCESSING) that has been shown to possess the capacity to account for otherwise hard to explain phenomena, such as the developmental pattern of learning regular and irregular past tense forms without no specified rule or any explanation proper. The model also suggest an alternative take on the mind, that, in essence it is not a symbol cruncher, and has not got much to do with signs other than the signals between units. As a consequence, instead of representations, networks possess inherent properties and mechanisms (i.e. constraints and attributes) with an explanatory value.

In the lack of decisive evidence the debate among the former three kinds of representations for the mind is undecided. Even though the recurrent observation of sensorimotor activations during language comprehension makes a weak version of

embodiment tenable, the theory has been challenged seriously (discussed in section *4.4. The relevance of abstractness*). Ignoring alternative explanations and counterevidence, and focusing on presumptions rather than on experimental results, some supporters of embodiment are not famous for their enthusiasm for debate. As to connectionism, limitations of postulating no representations (and the side effect of no mental life) have been central in the turn against behaviorism, and have been extensively and substantially criticized by Chomsky, Fodor, and many others. Despite the initial zeal these arguments have not been addressed thoroughly by connectionist models, and the mostly associationist approach does not seem to have the capacity to become a comprehensive model for the human mind.

Finally, the three main levels of interpretation of signs vary in the extent to which they take labels for brain areas literally: iconic is literal, indexical is perhaps more literal than figurative, while symbolic is metaphorical in essence. These layers also could be aligned along Sperber and Wilson's continuum of narrow and broad senses, symbolic being clos to the broad (and figurative), while iconic to the narrow (and literal) end. As a consequence it also tells about worldviews: some researchers conceptualize cognition from a physical experience (e.g., vision), and some from an abstract, language-like perspective. Thus approaches could be interpreted as researchers' preference on how much broadening they allow for, how literally they take representations, and how much abstraction they suppose between representations and their content. In this regard all perspectives have a unique and profound contribution to the scientific understanding of the human mind.

5.2 Brains mapped on the brain

What is the source of such various worldviews, and what is the machinery behind them? Let us take a closer look at the source domains of the scientific metaphors that were proposed to understand the mind. Crucially all of them can be related to the brain, either to a specific dedicated region, as in the case of language, or to a more general computational style, as parallel distributed processing. On this basis they can be considered to be different regions of the hypothetical brain of cognitive science. Each major approach can be viewed as an attempt to project one major function on the system as a whole in order to provide a unique explanation. Whereas it is easily conceivable that one of them will receive stronger empirical evidence and proves to be more plausible than the others, all of them are relevant for understanding

the mental architecture, as they all tell about the understanding of understanding. The proposal is that scientists could have a kind of Kantian *a priori* stance, a preferred individual perspective on the world: not simply goggles, but a set of projections from one preferred major domain to the rest of the brain, posing a personal neural architecture on the mind they are exploring.

At the same time, this interpretation does not seek more than to find the center of gravity of approaches that metaphorically model the brain, keeping in mind that they are based on broad and complex systems, and often strive to establish a balance of views. For example the operational modes of the left and right hemispheres' could manifest on various levels. On the one hand, several hemispheric differences have been observed as a minor (yet systematic) processing dominance, a potentially measurable weighting of functioning. On the other, the rapid development of neuroimaging has revealed that there is hardly ever a function that is not instantiated on widely distributed, typically bilateral systems.

The point is that it is possible to view the various approaches as units of a comprehensive system, or in other words, modules of the brain. Visual imagery has been directly linked to RH processing (Kosslyn, 1987), making the iconic approach projecting functions from occipital and RH regions to the brain as a whole. In contrast LOT (Fodor, 2008), symbolic syntactic computations (Pylyshyn, 1984, 2003), and followers of classical Chomskyan cognitivism's, are rendering the brain as a whole under the LH's linguistic capacities. Parallel distributed processing (Rumelhart & McClelland, 1986) could also be related to structural differences between the hemispheres. Denser grey matter for LH and denser white matter for RH, and the more pronounced branching of neurons in the RH are well documented (cf. Beeman, 1998). In this context, advocating the importance of the links and relations of the system over symbols, rules, and content hints at a RH orientation for connectionism. Similarly, implicit processes emphasized over explicit operations might be apprehended as a turn towards the non-verbal and more automatic functions of the RH – of course again metaphorically. The explicit and implicit distinction originates in Ryle's (1949) 'knowing what' versus 'knowing how', who attempted also to refute the Cartesian dualism of mind and body. He suggested that Descartes' "theatre of the mind" is merely talking about dispositions, and mental phenomenon is an illusion of this dualistic use of language. As a result the distinction is not tenable, and it can and should be reduced to the body, specifically to behavior and dispositions. Practically he

transforms the mind-body dualism into another one, where the two main centers of conceptual gravity remain present. Perhaps another solution to the mind-body problem would be to take it as a metaphor for two approaches of the brain: a language, philosophy, thinking oriented 'mental approach' by the LH, and a visuospatial, mental imagery oriented 'bodily approach' by the RH.

Hypothetically it might not only be that metaphors shape scientific conceptualization of the brain, but the structure of the brain also shapes metaphors of science. For example, Bruner and Feldman (1990) point out that, historically, metaphors of consciousness have been circulating around two great traditions. One is that consciousness develops from the outside in, and therefore "governed by rules of entry and principles of responsiveness" (pp. 233). The other is that it develops somehow from the inside out, governed by "acts of creation" (pp. 233). The authors also note that the common ground is consciousness being somehow inside, not outside. When Piaget (1965/1997) formulated his idea of consciousness he emphasized that psychic functioning is automatic, and we become aware of it only when it is blocked by an obstacle. It is centripetal, meaning that it originates from the 'outer effects' of functioning, before it moves on to the 'inner mechanisms'. Such an orientation aspect could be referencing to the anterior-posterior dimension of the brain, with an action and a perception weighted interpretation, respectively, of conscious experience. Reinterpreting recent neuroscientific findings Ned Block (2001; 2005a, 2005b) proposed a distinction between phenomenal and access consciousness. Such a dual definition allows for the integration of the two neural perspectives. Phenomenal consciousness refers to the subjective experience, the content, while access consciousness, refers to the part of the content that is available to a large number of brain systems and eventually to the "rational control of action" (Block, 2005a; pp. 47). Not all of aspects of phenomenal consciousness reach access consciousness, but the general direction is going from posterior and temporal perceptual regions towards frontal executive regions. The compelling part of the theory is that it differentiates between the two historic approaches, and integrates them in a neural framework. The riddle of the nature of consciousness might be at least partially a linguistic one (Block, 2005b), and competing views could reflect competing personal preferences, which, at the same time point out key aspects.

Advocates of a certain way of understanding most of the time could take sides as a result of their mental architecture, which is reflected in their manner of framing

phenomenon. Wittgenstein's observation is a perfect example here: "The limits of my language mean the limits of my world" (1918/1963, 5.6). For him thought is primarily language, and we cannot say what we cannot think. This thought is highly relevant in a lateralization sense as well: the personalized architecture of individual minds sets up boundaries for thought, and as a result, perhaps, boundaries for language. This phenomenon could create the traditions of misunderstanding in science. On the other hand it also reflects on the limits of thought and the verbal exploration of the world – a limit of language that could be a burden for the RH. The attempt to mark the boundaries of logical exploration might be even more strongly expressed in "Whereof one cannot speak, thereof one must be silent." (Wittgenstein, 1918/1963, 7)

Taken together, the general architecture of the brain could exercise constraints not only on how humans experience the world, but as a result, how they interpret it. Personal neural configurations might pose a personal barrier, but also a personal vantage point on how the mental world conceptualized. Conversely, the 'mental perception' of scientists could talk about the individual neural arrangement of their brain. Every large system of the brain allows for a possible take on cognition, emotions, insights, instincts or induction – and eventually science.

5.3 Unresolvable debates of cognition

The history of cognitive science (but perhaps even science in general) might be a history of borrowing modes of functioning from various brain areas for specific models. Sometimes the dominance of people and ideas of a certain neural function is transcended by the dominance of people and ideas of another function. A Kuhnian paradigm shift (Kuhn, 1962) is a complete transformation of institutions, worldviews, frameworks, and metaphors, on the one hand, but it might also be a return of a previously visited (neural) perspective on the world, on the other. Nevertheless, most of the time various perspectives exist parallel, and some debates seem impossible to settle.

One of the most famous one dates back to the birth of scientific psychology, to the rivalry between the 'imageless thoughts' (Ogden, 1911) of the Würzburg School and the structuralists of Leipzig (Pléh, 2009). Although in new cloth, it has flared up between Pylyshyn (1984, 2003), a proponent of THOUGHT IS LANGUAGE, and Kosslyn (1987, 1994), a proponent of THOUGHT IS MENTAL IMAGERY – despite the availability of highly sophisticated experimental methods. The strong version of embodiment

(Lakoff & Johnson, 1999) seems to join the very same debate. The THOUGHT IS SENSORIMOTORIC metaphor extends the source domain of vision with further sensory and motoric functions when challenging the Chomskyan approach. Introducing cross-modal image schemas and assigning metaphors a necessary mediating role pushed representations from icons to indices, but it did not go as far from the core ideas of 19th century psychology (or Giambattista Vico) as the loudest proponents often claim.

Following the footsteps of Woodworth (1915), these perspectives could be viewed not as incompatible or mutually exclusive, but as complementary ones – even in neural terms. They tell about the nature of human cognition, not only by the metaphors they propose, but more importantly, by the different qualities they offer on constructing the mind. More specifically, the mere possibility of their emergence, and the specific constellation might be just as informative as resolving disputes. Together they constitute the full spectrum of the approaches the human mind has produced so far, which opens up the possibility to combine their strengths. This option is getting closer as we understand more about the structure and function of the brain's systems. There are a number of frameworks that offer a comprehensive model of large domains for cognition. They could serve as the blueprint to integrate the diverse approaches of cognitive science, and eventually science in general, or perhaps even human epistemology of various arts.

5.4 Systems of domains

One influential theory comes from developmental psychology. Susan Carey and Elizabeth Spelke (1994, 1996) propose that infants are born with four – or possibly five (Kinzler & Spelke, 2007) – core knowledge systems. These are prewired, innate modules that are, in essence, part of our evolutionary history, but require specific input to fully develop. A large bulk of experimental results supports the existence of the core systems. One is to represent physical objects and their mechanical properties, governed by a set of principles, such as cohesion, continuity, and contact. The second is to represent agents and their actions, and it seems to be specialized in detecting goal directed actions. The third is a basic numerical system, where core number representation has three central properties: it is imprecise, cross modal, and combinatorial, complete with operations such as addition and subtraction. The fourth core system is representing surface geometry, that is, the spatial relations of places, distances and angles. Recently, perhaps as a kind of response to the natural

pedagogy theory (Csibra & Gergely, 2009; Gergely & Csibra, 2006), a fifth core system also has been proposed (Kinzler & Spelke, 2007), which is to represent actual and potential social partners by identifying members of the infant's social group in order to guide interactions. The authors argue that there are things that are relatively easy to learn, because they fall under the domain of one of the core systems, while other things are difficult, because they do not. Interestingly, language is not considered to be a separate domain, but a feat that enables the system to work comprehensively. At birth the mind is neither a general problem solving device nor a Swiss army knife with hundreds of adaptations (Cosmides & Tooby, 1994), but optimized around these crucial core systems. In short, experience transforms and vastly extends knowledge within these general domains enabling the later mapping of various problems onto them. Presumably this is how scientists create new models, and achieve a better understanding of their field in various disciplines (Carey & Spelke, 1994).

Steven Mithen (1996) presented an elegant model of cognition based on archeological data. His metaphor for the mind is a cathedral: the originally small central chapel of general intelligence had been extended gradually by four side chapels of specialized systems. Technical intelligence enabled our ancestors to prepare chipped stone tools and the like. Natural history intelligence covers the capacity to learn about the natural habitats and the environment, the habits of prey animals and predators, to make inferences about the weather, and follow natural cycles. Eventually it allowed our ancestors to move on from the original ecological booth of our species, and navigate in a great variety of climatic conditions, floras and faunas. Social intelligence is a feat that allowed members of the homo lineage to stick together in ever-larger groups, finding the balance between the advantage of having collaborators and the challenge of having competitors nearby all the time. The fourth independent domain is thought to be linguistic intelligence that is not related to any of the former capabilities, but emerged on its own right.

The most compelling part of the theory is the eventual transformation of the cathedral's architecture. The four kinds of specialized intelligences have evolved as separate knowledge domains, accessed from the central, limited capacity general intelligence, but at some point of evolutionary history the walls between the various intelligences came down. This created a kind of fluid intelligence that is able to combine the four specialized and the original general intelligence in a creative and

highly productive manner. The combinations are metaphorical in nature, enabling not simply communication between domains, but a recombination of specialized feats. Mithen takes such metaphorical thinking (of cross domain mappings) to be the most important hallmark of the truly modern human mind. For example the combination of technical and natural history intelligence yielded specialized tools and weapons for hunting various game, or the overlap of technical and social intelligence led to the production of jewelry and other objects that mark social status. Interestingly, he dates this jump well after the emergence of Homo Sapiens Sapiens, to the cultural explosion around 40,000 years BC.

The former ontogenetic and the latter phylogenetic developmental approaches both emphasize the importance of mappings. While the core system approach proposes the mapping of problems on the domains, the cathedral of the mind propose cross-domain mappings. The mapping of 'mental perspectives' outlined above is a mixture of the two. It is a cross-domain mapping in the sense that a specific module or brain function is mapped on the brain as a whole; at the same time it is a mapping of the scientific problem of how the mind works on one of the large cognitive domains. However, neither of the former two approaches specify the specific neural systems that instantiate the domains and carry out mappings.

The Global Neuronal Workspace model (GNW – Changeux, 2008; Dehaene & Changeux, 2011; Dehaene, Kerszberg, & Changeux, 1998) offers a plausible mechanism for such large-scale cross-domain mappings between conglomerates of neuron networks. According to the GNW conscious access emerges as a result of recruitment of neurons with long-range axons across the cortex. A central workspace is at the heart of the system, which is connected to several modular processors. These latter have a parallel distributed network structure, and are encapsulated as a result of their local or maximum mid-range connections, highly specific to their main function. The processors are linked to the global workspace, which is characterized by pyramidal cells with long range horizontal connections distributed across the cortex in varying density. The five domains consist of: (1) perceptual systems, up till regions integrating multimodal stimuli, and extracting categorical and semantic kind of information; (2) motor systems that include pre-motor areas, and guide intentional action; (3) long term memory, allowing for the recall of vast amounts of information and past experience; (4) evaluation systems, tagging the contents of the workspace as positive or negative; and (5) attention networks, mobilizing mental resources

independent of environmental stimuli by switching the amplification or attenuation of signals from the processors.

When the activation of a processor passes a certain threshold (for example a visual stimuli is consciously perceived), it ignites large-scale frontal areas and gets connected to the GNW. The spreading activation mediated by long, horizontal axons enables the utilization of a great variety of inner conceptual and problem solving systems. The synchronized activation of wide spread regions allows for the resources of the processors to be productively employed in the workspace. The activation of these interconnected sub-domains is mediated by inner and outer factors, and it is able to sustain and govern itself, solving the homunculi paradox as well.

The model has strong parallels with the Global Workspace Theory (Baars, 1988, 1997), however it offers a much more detailed neuronal mechanism, and specifically identifies five modular subsystems serving the workspace in a flexible manner. One concern with this model however is that it underspecifies the systems within the five main processors. For example long-term memory contains and manages disproportionately large chunks of information, and perhaps even meta-information of other modules. Another concern is that it does not address the cooperation with specialized processors outside the workspace, such as language, which probably utilizes all systems, and even seems to be governed from specific brain centers. Nevertheless, the GNW offers a neat model for establishing neural mappings. Theoretically, if required by a specific task, specialized resources could be summoned to the workspace, including specific knowledge domains, such as syntactic and mathematical systems, configuration and relational structures, operations, previously acquired problem solving templates, complex patterns of analogies, etc. Practically any possible neural system that has a representational format, from visual imagery to formal logic could be linked to the workspace. Modules could be related to one another via similes, metaphors, and analogies, all resulting in slightly different implications. Similes transfer a few concrete and abstract features, metaphors abstract ones only, while analogies all features, systematically. Since the manipulation happens in the GNW's workspace, not in the peripheral processors (even though they could utilize their capacities), all mappings should go from symbolic to symbolic structures. One example of mappings between processors is the two approaches to consciousness, mapping either input or output systems on the attention system.

Epistemological schools, competing models of cognition, and various

perspectives of scientists probably do involve the transfer of neural activation patterns across knowledge domains, and map relational structures based on one brain system to another. However, the framework outlined in this section departs from the above accounts in a crucial aspect. It is not simply a specific system that is projected on the mind as a whole, but an entire system of systems, summing into kind of attitude, a personal phenomenal experience of the world as a whole. It tries to capture the subjective nature of relying on a specialized knowledge domain. Some might perceive cognition as a vast mechanic structure; others might see it as a huge orchestra of melodies; and again others as a giant assembly of visual patterns. Thus, it is not arranged around the five most salient neural systems, or around systems that are the most likely evolutionary adaptations of primates, but neural systems that create various experiences for various types of people. Although all of us have access to these systems, probably we all have an individual constellation, a weighting, and a single most preferred one, driving intuitions about the workings of the environment.

Finally, mappings offered by specific scientists probably do not work via quick structure transfer, but develop gradually, in a step-by-step manner. Scientific metaphors and analogies are a result of elaborated work, systematic interpretation, and piecemeal extension of mappings, carried out on representations of representations. Therefore, they are unlikely to be automatic (embodied) activations of sensorimotor neural networks. Further on, novel ideas and complex models are probably the results of projections across knowledge domains, which might not be metaphorical in a linguistic aspect only. As opposed to embodiment, where mappings are instantiated by the identical sensorimotor system, the GNW's perspective allows for metaphors to be conceived as mappings between any neural networks. These system-to-system mappings can account also for the high number of source domains mapped onto a single target domain of conventional conceptual mappings, and the high number of target domains a single source domain can structure. It would not be surprising if several known systems were necessary to describe an idea properly.

In conclusion, such a framework offers a way to synchronize various approaches humans utilize to understand cognition. Instead of looking for answers for century old debates, the attention of scientist could move on to the very source and the mere possibility of such debates, the brain itself, in order the gain more insight into the nature of the human way of thinking. Thanks to cognitive science this endeavor does not need to be reduced to a biological level, and hopefully, comprehensive

models are going to provide better templates for future cooperation between various disciplines. Perhaps one of the highest feats of humans involves metaphorical mappings of known and familiar approaches, personal perspectives, and thereby underlying brain systems to questions, such as the nature of the human mind itself.

6 Thesis points

6.1 Thesis point I

It is the left hemisphere that processes metaphorical noun noun compound words, specifically, the LIFG, if they are conventional, and the left temporal pole and left posterior superior temporal sulcus, if they are novel. The right hemisphere theory of metaphor is challenged by fMRI results. The graded salience hypothesis (Giora, 2003) is unable to account for hemispheric activations evoked by literal and metaphorical, conventional and novel expressions in the experiment. All novel noun noun compound words activated the LIFG, whereas all conventional noun noun compound words activated right temporoparietal areas. Results are interpreted in the light of combinatorial semantic processing (cf. Graves et al., 2010), the extended version of the coarse semantic coding theory (Jung-Beeman, 2005), and semantic 'meaning making' (Bruner, 1990).

The study related to the Thesis point:

Forgács, B., Bohrn, I., Baudewig, J., Hofmann, M. J., Pléh, Cs., & Jacobs, A. M. (2012). Neural correlates of combinatorial semantic processing of literal and figurative noun noun compound words. *Neuroimage, 63*(3)*, 1432-1442. DOI: 10.1016/j.neuroimage.2012.07.029

6.2 Thesis point II

According to the results of a divided visual field experiment the left hemisphere processes two-word adjective-noun expressions faster, be they metaphorical and/or novel, while conventional metaphorical and literal expressions are processed also more accurately by the left hemisphere. Semantic integration might be the primary computational challenge when comprehending novel expressions, and it seems to be carried out by the left hemisphere. Conventional metaphors take more time to process relative to conventional literal expressions, suggesting some kind of extra processing, perhaps due to the parallel activation of literal and figurative

meanings and and semantic selection. Novel metaphors are not processed slower than novel literal expressions, arguing against serial processing of figurativeness, but salience as well, which suggest a remarkably fast computation of a relevant metaphorical meaning. The results bring the graded salience hypothesis (Giora, 2003) into question.

The study related to the Thesis point:

Forgács, B., Lukács, Á., & Pléh, Cs. (2014). Lateralized processing of novel metaphors: disentangling figurativeness and novelty. *Neuropsychologia, 56*, 101-109. DOI: 10.1016/j.neuropsychologia.2014.01.003

6.3 Thesis point III

Pragmatics could play a key role in metaphor production and interpretation. Metaphors might be especially important in optimizing relevance by, on the one hand, making meaning more concrete via source domains, thus revealing and highlighting hidden relations; and on the other, creating a subtext where intentions and desires can be communicated covertly by indirect speech, concealing risky offers and enabling social bargains. These two pragmatic functions of metaphors are explored in a theoretical study in the light of Relevance Theory (Sperber & Wilson, 1995).

The study related to the Thesis point:

Forgács, B. (2009). Verbal metacommunication – Why a metaphorical mapping can be relevant? (In Hungarian) *Hungarian Psychological Review, 64*(3), 593-605. DOI: 10.1556/MPSzle.64.2009.3.8

6.4 Thesis point IV

Scientific metaphors, and more specifically, particular choices of conceptual source domains (to explain the mind for example) could tell about personal cognitive preferences and the underlying neural architecture of scientists. Scientific models, theories and schools might be talking about a preference for a specific neural stance, a kind of ease at understanding, driven by language or vision, etc. Epistemological traditions might not be viewed necessarily as competing, but as complementing each other. Major approaches to the mind in cognitive science could be interpreted as metaphorical mappings across knowledge domains, motivated by individual preferences in cognition. As they emphasize one neural system over another, it is possible to arrange them in a comprehensive framework of human epistemology on

the basis of neural domains of the brain.

The study related to the Thesis point:

Forgács, B. (2013). The right hemisphere of cognitive science. In Cs. Pléh, L. Gurova, and L. Ropolyi (Eds.), *New Perspectives on the History of Cognitive Science*. Budapest: Akadémiai Kiadó.

7 Studies

7.1 Study 1: Neural correlates of combinatorial semantic processing of literal and figurative noun noun compound words

Forgács, B., Bohrn, I., Baudewig, J., Hofmann, M. J., Pléh, Cs., & Jacobs, A. M. (2012). Neural correlates of combinatorial semantic processing of literal and figurative noun noun compound words. *Neuroimage, 63*(3)*, 1432-1442. DOI: 10.1016/j.neuroimage.2012.07.029
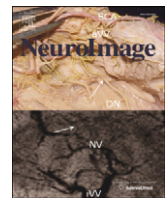
Neural correlates of combinatorial semantic processing of literal and figurative noun noun compound words

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ABSTRACT

The right hemisphere's role in language comprehension is supported by results from several neuropsychology and neuroimaging studies. Special interest surrounds right temporoparietal structures, which are thought to be involved in processing novel metaphorical expressions, primarily due to the coarse semantic coding of concepts. In this event related fMRI experiment we aimed at assessing the extent of semantic distance processing in the comprehension of figurative meaning to clarify the role of the right hemisphere. Four categories of German noun noun compound words were presented in a semantic decision task: a) conventional metaphors; b) novel metaphors; c) conventional literal, and; d) novel literal expressions, controlled for length, frequency, imageability, arousal, and emotional valence. Conventional literal and metaphorical compounds increased BOLD signal change in right temporoparietal regions, suggesting combinatorial semantic processing, in line with the coarse semantic coding theory, but at odds with the graded salience hypothesis. Both novel literal and novel metaphorical expressions increased activity in left inferior frontal areas, presumably as a result of phonetic, morphosyntactic, and semantic unification processes, challenging predictions regarding right hemispheric involvement in processing unusual meanings. Meanwhile, both conventional and novel metaphorical expressions induced BOLD signal change in left hemispherical regions, suggesting that even novel metaphor processing involves more than linking semantically distant concepts.

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Introduction

Although brain regions traditionally held responsible for language processing, like Broca's and Wernicke's areas, are located in the left hemisphere (LH), a growing number of studies are reporting evidence for linguistic functions localized in the right hemisphere (RH). The hemisphere historically often treated as the "mute" one apparently takes part in a number of linguistic functions, especially in the processing of meaning below the surface, as in indirect requests (Weylman et al., 1989), lexical ambiguity resolution (Faust and Chiarello, 1998), understanding jokes (Coulson and Williams, 2005; Coulson and Wu,

2005), irony (Eviatar and Just, 2006), and metaphors (Ahrens et al., 2007; Anaki et al., 1998; Arzouan et al., 2007; Bottini et al., 1994; Mashal et al., 2005, 2007; Pobric et al., 2008; Sotillo et al., 2005; Stringaris et al., 2006). The message level meaning seems to be an important factor in the interpretation of such linguistic materials, what is in line with the RH's sensitivity to contextual effects (Grindrod and Baum, 2003; Van Lancker Sidtis, 2006; Vigneau et al., 2011). Several studies have found evidence for a RH involvement also in the processing of short, out of context, two word expressions, such as novel metaphors (Anaki et al., 1998; Mashal et al., 2005, 2007; Pobric et al., 2008), or during the semantic combination of two nouns into a highly meaningful phrase (Graves et al., 2010).

The aim of the present study was to assess the impact of two often confounded factors on RH language processing, familiarity and figurativeness, while controlling for context, imageability, emotional valence, and arousal, thought to be posing higher processing demands on the RH. Specifically, the goal was to see whether there are neural processes associated with novel metaphor comprehension independently of processing semantic distance, namely could the selection and suppressions of certain semantic features play a separate role.

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Neural processing of metaphors

While there had been extensive previous work on metaphors (e.g., Miller, 1979; Ortony, 1979; Richards, 1936; Searle, 1979; Tversky, 1977), the cognitive metaphor theory by Lakoff and Johnson (1980a, 1980b; also Lakoff, 1987) brought the issue real popularity in the field. Breaking away from the classical view of metaphors regarded as poetic or rhetorical tools, basically ornaments of language (Aristotle, 335 BC/1952), and primarily violations (Grice, 1975), they pointed out that metaphors are widely used in everyday language, and proposed that even the conceptual system is metaphorical in nature (Lakoff and Johnson, 1980b). Abstract concepts are understood via the systematic mapping of more concrete concepts onto them, which are based on the experiential gestalts of bodily perceptions in the case of primary metaphors, or on the recombination of the latter in the case of complex metaphors (Grady, 1997). For instance, the metaphorical expression "I can see your point" is an example of the conceptual metaphor SEEING IS UNDERSTANDING, where a concrete experience, *seeing* is the source domain mapped onto the abstract target domain, *understanding* (Lakoff and Johnson, 1980a). During these mappings certain features of the source domain are selected and others are filtered, hence there is no complete correspondence between the two conceptual domains (Kövecses, 2005). Cognitive metaphor theory, though, has been criticized (e.g., Jackendoff and Aaron, 1991; McGlone, 2007; Murphy, 1996, 1997), and there are alternative theories, like the class inclusion theory (Glucksberg and Keysar, 1990), the structure mapping theory (Gentner, 1983), or the conceptual blending theory (Fauconnier and Turner, 1998).

The classical linguistic approach proposed a sequential processing for metaphors, requiring a re-analysis of the literally false meaning (Grice, 1975), but the parallel view suggests that literal meaning has no advantage, as figurative language (an indirect request or an idiom) does not take more time to comprehend in a supportive context (Gibbs, 1994). At the same time some ERP studies suggest that there is a gradual component to metaphor processing, conventional metaphors requiring a slightly higher effort than literal expressions, while novel metaphors posing even more demand on comprehension (Arzouan et al., 2007; Lai et al., 2009), perhaps because of the selection and filtering of specific conceptual features.

There seems to be a systematic division of labor between the two cerebral hemispheres regarding words and concepts (Beeman, 1998; Chiarello, 1991), but more broadly the LH is thought to expect and actively predict likely upcoming material, while the RH is assumed to integrate and assemble meaning directly from the ongoing information (Federmeier, 2007; Federmeier and Kutas, 1999; Federmeier et al., 2005). The RH theory of metaphor processing suggests a division for literal and figurative language. It evolved from studies with RH damaged patients (Winner and Gardner, 1977) and was strengthened by a landmark PET study with healthy individuals (Bottini et al., 1994). However, there are several studies that could not confirm a special role of the RH, and reported bilateral processing (Coulson and Van Petten, 2007; Schmidt and Seger, 2009), while still others found mainly LH involvement (Chen et al., 2008; Eviatar and Just, 2006; Lee and Dapretto, 2006; Rapp et al., 2004, 2007; Stringaris et al., 2007). Nevertheless, as Schmidt and Seger (2009) pointed out, studies that have reported RH activations for figurative language have been involving novel metaphorical expressions and unusual semantic relations (Ahrens et al., 2007; Arzouan et al., 2007; Bottini et al., 1994; Mashal et al., 2005, 2007; Pobric et al., 2008; Sotillo et al., 2005; Stringaris et al., 2006).

With frequent use novel metaphors lose their novelty, and as eventually they become conventionalized, fixed, and familiar expressions, there is no need to create the conceptual mappings, as proposed by the career of metaphor hypothesis (Bowdle and Gentner, 2005). When compared directly, such "dead" metaphors were found to be processed similarly to literal expressions, mainly by LH areas (Mashal et al., 2005, 2007; Pobric et al., 2008). This could account for parts of the diverse results found in previous studies. However, the re-activation of the mapping can trigger RH processing again, for example when the literal meaning of idioms is evoked (Mashal et al., 2008); for this reason the term "sleeping" metaphor seems to be a useful refinement (Müller, 2008).

Semantic distance

Most of the time RH involvement is not attributed to metaphorical meaning per se, but to the bridging of unusual semantic relations in novel expressions. The graded salience hypothesis (Giora, 1997, 1999, 2002, 2003) suggests that the figurative–literal distinction is not a good predictor of processing. Highly salient meanings, both literal and figurative (e.g. conventional metaphors) are always activated directly and processed first, regardless of context. Even contexts favoring less salient meanings (e.g. literal interpretation of conventional metaphors) do not inhibit the activation of salient meanings (Giora, 1999). If the context supports an alternative interpretation that is similarly salient, parallel processes are activated, whereas novel metaphors require a serial processing where the intended figurative meaning is derived following the more salient literal meaning (Giora, 1997).

The salience of meaning is determined by a number of factors, such as being coded in the mental lexicon, prominence due to conventionality, frequency, familiarity, and prototypicality (Giora, 2002). In terms of hemispheric processing the graded salience hypothesis predicts (Giora, 2003), regardless of figurativeness, a selective LH processing during the comprehension of salient meanings (e.g. even conventional metaphors), and a selective RH activation for non-salient meanings (e.g., novel metaphors).

Another important framework focuses more on the neural attributes of the hemispheres. The coarse semantic coding theory (Beeman, 1998; Beeman et al., 1994; Jung-Beeman, 2005) proposes that the LH is coding narrow semantic fields in a fine grained manner, including word representations, synonyms, the word's semantic features, and first-order associates. The RH is coding broad semantic fields coarsely, including distant meanings too, allowing for the semantic integration of otherwise non-overlapping concepts. When Beeman et al. (1994) presented subjects the prime words "foot", "cry", and "glass", none of which is closely associated with the target word "cut", the RH benefitted more from the sum of the priming effects than the LH. In a second experiment they showed that the RH benefits equally from direct and summation primes, while the LH only from direct primes.

According to Beeman's model, the critical factor that determines which hemisphere is more sensitive to a given semantic relation is closeness of association or in other words, semantic distance. For example, when two words are strongly associated and are category co-exemplars ("arm"–"leg") priming is equivalent in the two hemispheres, but when they are nonassociated category members ("arm"–"nose"), priming is observed only in the RH (Chiarello et al., 1990). Even though this is rather due to semantic feature overlap than association per se, the higher the number and the more central the shared features of the concepts are, the more strongly they are associated. This suggests that even though category members also share some features, only strongly associated ones share enough to prime the LH (Beeman, 1998).

On the one hand, these theories provide an elegant account for the LH processing of most conventional metaphors, where narrow semantic field processing and high salience go hand in hand, and figurative meaning is accessed directly. On the other hand, it is still not exactly clear what role the processing of large semantic distances play in the processing of figurative meaning in novel metaphors. The question whether low salience and/or coarse coding by itself can account for RH processing of novel metaphors has been scarcely addressed directly.

In a divided visual field experiment Schmidt et al. (2007) found RH effects for unfamiliar metaphorical and unfamiliar literal sentences

too, although there were no LH effects even for familiar literal sentences. It is possible that the RH processing dominance for unfamiliar conditions was not induced by semantic distance, but by context. In their fMRI study, also involving sentences, Schmidt and Seger (2009) found the right insula involved in the processing of unfamiliar vs. familiar metaphors, but the opposite contrast revealed right hemispheric regions also (inferior and middle frontal gyrus). In an experiment employing the same conditions as the present study, but using sentences, Diaz et al. (2011) found both the two novel and the two figurative conditions activating right inferior frontal gyrus (IFG). However, familiar and novel literal sentences, and familiar metaphors all evoked RH regions; novel metaphors did not differ from familiars or novel literals at all; and when contrasting the two literal conditions only LH regions showed up for novel ones. All in all, as the authors also point out, the complexity of stimulus construction could have played a role. In further neuroimaging studies semantic distance, context, and figurativeness all could have been similarly tangled with each other: Intriguingly there were no RH activations for novel metaphors embedded in sentences (Mashal and Faust, 2010; Mashal et al., 2009; Shibata et al., 2007). As sentences put a higher processing demand on the RH via pragmatics (Van Lancker, 1997; Van Lancker Sidtis, 2006), the RH effects could have been canceled in the analysis. As metaphorical contexts' numerous linguistic dimensions (Steen, 2004) can mask RH effects, isolated word pairs or compound words could help reduce the computational load on the RH.

Noun noun compound processing

Compound words belong to a special linguistic realm being combinations of nouns (or adjectives and nouns, not considered from now on): more complex than single words, governed by morphology, but simpler than propositions or sentences, governed by syntax. Their morphological complexity does not stem from pre- or suffixes, but from their constituents' internal hierarchical structure. In German (and in English) noun noun compound words (NNCs) are right headed, meaning that the second constituent, the *head* determines the semantic category and the morphosyntactic features of the whole compound, while its meaning is altered by the first noun, the *modifier* (Downing, 1977). This idea is by an eye tracking study showing strong second lexeme frequency effects (Juhász et al., 2003). Compounds can be endocentric/transparent (e.g., "snowball") where the meaning is constructed from the parts, or can be exocentric/opaque with no head (as in "humbug", which is not a kind of bug) where the meaning does not emerge as the result of a semantic combination (Spencer, 1991).

Compounds are processed slower when separated by a space, suggesting that they are represented as lexical units, at least to a certain extent, however both constituents can have some priming effect, even in opaque compounds (Libben et al., 2003), which are nevertheless processed more slowly than matched transparent ones (Ji, 2008).

Eye-tracking studies suggest that there are two separate processing steps both in German (Inhoff et al., 2000), and in English (Juhász et al., 2005): a decomposition and a reintegration stage. The second stage seems to be a semantic composition, determined by the relational structure of the constituents, like head FOR modifier (e.g., "cheese-knife"), or modifier HAS head (e.g. "coat-button"). This conceptually driven integration is true not only for novel compounds (Gagné and Spalding, 2004), but apparently for familiar ones too (Gagné and Spalding, 2009). According to a picture naming experiment, relations are represented independently of the parts, and relational priming might be similar to syntactic priming (Raffray et al., 2007).

The above results are best accounted for by the structured storage theory of compounds (Bien et al., 2005), which suggests that compounds are decomposed and reassembled along the stored structural position of the constituents: The structural position is part of the representation, allowing a differentiation between "doghouse" and "housedog". The

theory thereby lies somewhere in-between nondecompositional and fully decompositional views, the former proposing a complete list of compounds in the mental lexicon, while the latter taking the position that all of them are decomposed and reassembled at every instance.

Event-related potential (ERP) studies also support a semantic integration account. The N400 component, a response often associated with semantic processing (Hillyard and Kutas, 1983; Kutas and Federmeier, 2000), has been found sensitive to the lexical-semantic integration, and the late anterior negativity (LAN) suggests morphosyntactic decomposition (Chiarelli et al., 2007; Koester et al., 2004).

In an fMRI experiment the production of Dutch NNCs has been primed via the presentation of the picture of the first constituent (the modifier). This morphological process activated BA 47 in left inferior frontal gyrus (LIFG) independently of phonological and semantic processes (Koester and Schiller, 2011).

Taken together these results support the idea of a hierarchical representation of the internal structure of NNCs, suggesting that morphosyntactic and semantic features are integrated primarily at a conceptual level.

Combinatorial semantic processing

In some special cases it is possible to dissociate the almost always overlapping dimensions: the salience of an expression, referring mainly to familiarity, frequency, etc., and the coarseness of coding, referring mainly to associatedness and semantic feature overlap.

In an experiment aimed directly at the processing of noun noun phrases the constituents were not unfamiliar, and were co-occurring, but they were not closely associated either. Stronger activations were found in angular gyrus (AG), adjacent supramarginal gyrus (SMG), and middle temporal gyrus (MTG), but unexpectedly in the RH for highly meaningful phrases (e.g., "lake house") as compared to their less meaningful reversals (e.g., "house lake"). The latter in turn evoked a stronger activation of the left inferior frontal junction (IFJ) and LIFG (Graves et al., 2010). According to the authors the phrases required coarse semantic coding (Beeman et al., 1994) that allowed more space for the constructive combinatorial semantic processing of compatible concepts, even though they were not novel.

Conventional German NNCs' are also unique linguistic constructs: Two lemmas are joined together to form a compound with a salient meaning, however the second constituents (the heads) are neither closely associated, nor do they share several semantic features with the first constituents (the modifiers). Unlike highly familiar, conventional adjective–noun word pairs that are strongly associated and highly co-occur, NNC constituents do not go together often. They most likely appear together in specific NNC combinations, but NNCs even have a relatively low frequency in general (as compared to non-compound words, which is actually a methodological concern for compound research, see Juhász and Rayner, 2003).

As even conventional NNCs are processed via a semantic decomposition and reintegration of not strongly associated elements, they could require coarse semantic coding (despite their salient meaning). Their constituents are definitely compatible, and so their processing is expected to resemble the RH combinatorial semantic processing of highly meaningful noun noun phrases observed by Graves et al. (2010).

However, according to the graded salience hypothesis (Giora, 2003) it is salience that determines hemispheric processing, both metaphorical and literal novel NNCs, regardless of figurativeness should increase BOLD signal change in RH regions more than conventional metaphorical and literal expressions. At the same time the latter two should increase BOLD signal change in LH regions that are thought to process salient meanings.

Taking both theories into consideration novel and conventional NNCs should not be processed identically. Novel NNCs also should require coarse coding, but most probably on a much more thorough level than conventional NNCs. Nevertheless, based on previous findings

novel metaphors are expected to evoke a stronger BOLD signal change in the RH. Contrasting them to novel literal expressions could shed light on metaphor processing independent of semantic distance processing.

Conventional and novel NNCs allow a gradual testing of the interaction between semantic relatedness and figurativeness. Novel and conventional compounds, regardless of figurativeness, should require a very similar level of semantic combination, and could be indistinguishable in terms of behavioral measures. Meanwhile, as metaphors require the selection and suppression of certain features of one of the constituents, metaphorical NNCs could pose an overall higher computational demand on the system than literal NNCs, above the semantic combination they both require. For this reason a gradually increasing processing demand was predicted for our four categories of NNCs: because of their salient meaning *conventional literal* NNCs should pose the lowest computational demand, followed by *conventional metaphorical* NNCs, with an extra meaning selection step. *Novel literal* NNCs should be even more demanding, because of the non-salient nature of the unfamiliar combination of the nouns, whereas *novel metaphorical* NNCs should put the highest computational load on the system being non-salient, and because of the required meaning selection procedure.

Methods

Participants

Forty healthy adult volunteers (20 females, mean age: 24.2 years, range: 19–30) participated in the study for cash or course credit. All were native speakers of German, right handed, as determined by the Edinburgh Handedness Inventory (Oldfield, 1971), $M = 89.7$, $SD = 12.5$, had normal or corrected to normal vision, and had no history of neurological or psychiatric disorders. Approval of the ethics committee of the Freie Universität, Berlin, and informed consent of participants were obtained.

Stimuli

The stimuli consisted of 200 German noun noun compound words (NNCs), divided equally among four conditions: conventional metaphors (CM) e.g. "Stuhlbein" ("chair-leg"), novel metaphors (NM) e.g. "Plastikschwur" ("plastic-oath"), conventional literal (CL) e.g. "Alarmsignal" ("alarm-signal"), and novel literal expressions (NL) e.g. "Stahlhemd" ("steel-shirt"). The criterion for metaphors was that they should make no sense when read strictly literally, whereas novel literal expressions should have literally possible, but unusual meaning. NNCs also allow for the simplest possible (single word) presentation for metaphorical expressions.

For each condition 100 items were produced by three German native speaker research assistants at the Freie Universität, Berlin. NNCs were controlled for length (number of letters); the sum of the frequencies of the constituents' lemma form, and the sum of their lemma frequency class (e.g., the German word "*der*" ("*the*") has got about $2^{(\text{frequency class})}$ the number of occurrences than the selected word), based on University of Leipzig's Wortschatz Lexikon: http://wortschatz.uni-leipzig.de/; and factors of the Berlin Affective Word List/BAWL (Võ et al., 2006): emotional valence, arousal, and imageability. For compounds not listed in the BAWL (e.g., novel ones) ratings were obtained in line with the original procedure from 19 volunteer university students, who received course credit, and did not participate in the fMRI experiment. In the next step, three linguist experts ranked the words for being plausible examples of their category or not, and selected the 50 best representatives.[1] Since the most important goal was to keep

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[1] An attempt to have doctoral students of linguistics categorize the words according to Lakoffian theoretical concerns failed, as the results were few in number and strongly inconsistent.

Table 1
Mean (SD) values of linguistic factors of the compounds.

	Conventional metaphor	Conventional literal	Novel metaphor	Novel literal
Nr. of letters	10.78	10.52	11.16	10.82
	(1.67)	(1.64)	(1.67)	(1.45)
Lemma frequency sum	39081	86190	42181	27827
	(52202)	(150649)	(62895)	(35758)
Lemma frequency class sum	21.02	19.44	23.36	23.98
	(5.28)	(5.16)	(3.02)	(3.41)
Valence (between −3 and +3)	−0.379	0.122	−0.559	−0.213
	(1.176)	(0.881)	(1.151)	(0.780)
Arousal (1 = none)	3.268	2.968	3.325	3.095
	(0.619)	(0.656)	(0.636)	(0.459)
Imageability (1 = none)	4.835	5.356	3.075	4.579
	(1.232)	(1.189)	(0.866)	(0.832)
Meaningfulness (1 = highest)	2.434	1.813	4.395	4.122
	(0.581)	(0.314)	(0.646)	(0.716)
Literalness (1 = highest)	3.863	2.174	3.917	2.582
	(0.742)	(0.244)	(0.417)	(0.416)

the key qualitative differences between conditions, while using the best examples, it was not possible to match all the above factors completely across all conditions (e.g., novel compounds naturally being less imageable or meaningful than conventional compounds). Still, differences were reduced as much as possible, and factors were controlled for during the final data analysis. An additional 26 volunteer university students, who also did not participate in the fMRI experiment, rated the compound words also for how meaningful and how literal they are on a 7 point Likert scale. The values of all the factors are presented in Table 1.

Although novelty and unfamiliarity refer to large semantic distances by definition, it is possible that some unfamiliar items are in fact existing but outdated expressions, or some novel items are not truly distant semantically (e.g. according to co-occurrence measures). Based on the above concerns, semantic relatedness for the novel NNCs (NM and NL) was controlled by excluding all compounds for which the constituent lemmas were significantly co-occurring in the Wortschatz corpus of 43 million German sentences (Quasthoff et al., 2006), and conventional compounds had to occur in the corpus of contemporary German. A recent computational and behavioral analysis has provided evidence that this measure of semantic distance accounts well for semantic relations between words (Hofmann et al., 2011). Familiar NNCs (CM and CL), being already existing words, all have a frequency value of their own, and a salient meaning — despite the fact that they are neither sharing many semantic features, nor are they closely associated. Although a portion of them was found significantly co-occurring, none of the second constituents was a significant right neighbor of the first constituents.

Experimental procedure

After reading the instructions and completing a 20 item practice task, participants were scanned in 5 imaging runs, each consisting of 40 trials. In each trial a compound word was presented centrally for 2000 ms on a black background, using white, 16 pt Arial capital letters, followed by a fixation cross jittered between 4000 and 8000 ms. Participants were instructed to read the items silently, and to indicate via button press as fast and as accurately as possible whether the word appearing on the screen seemed familiar or unfamiliar to them. Participants were required to respond with their right thumb using an MR-compatible button box.

fMRI data acquisition

Neuroimaging data was collected by a 3 T Siemens Tim Trio MRI scanner fitted with a 12-channel head coil (Siemens Erlangen, Germany), at the laboratory of the Dahlem Institute for Neuroimaging of Emotion

(D.I.N.E.), Freie Universität, Berlin. Initially, a high-resolution 3D T1-weighted dataset was acquired from each subject (176 sagittal sections, $1 \times 1 \times 1$ mm³). During every run 200 whole-brain functional T2*-weighted echo planar images (EPI) were taken with the parameters as follows: $3.0 \times 3.0 \times 3.0$ mm voxels, TR 2 s, TE 30 ms, flip angle 90°, matrix size 64×64, FOV 192 mm, slice thickness 3 mm, no gap, 37 slices.

Data analysis

The behavioral data were analyzed using SPSS 13 (IBM SPSS Statistics). To analyze the recorded fMRI data BrainVoyager QX 2.2 (Brain Innovation, Maastricht, The Netherlands) was used. The data were motion and slice-scan time corrected (cubic spline interpolation). Intra-session image alignment to correct for motion across runs was performed using the first image of the first functional run as the reference image. Following linear trend removal, data was filtered temporally in 3D with a high pass Fourier filter of 2 cycles in time course to remove low frequency drifts. Preprocessed data were spatially smoothed using an 8 mm full-width-half maximum Gaussian kernel to reduce noise. Statistical analyses were performed in Talairach space (Talairach and Tournoux, 1988) (Table 2). The T1 images were first rotated into the AC–PC plane, transformed into Talairach space, and then used to register the functional data to the subjects' 3D images. Anatomical regions were identified by manual inspection using the Talairach atlas and the Talairach demon (http://www.talairach.org).

The statistical analyses were carried out using a voxel-wise General Linear Model (GLM) at the single-participant-level first, based on design matrices built from the four conditions (CM, CL, NM, NL). BOLD responses were separately modeled using a boxcar function, which was convolved with a theoretical two gamma hemodynamic response function (Friston et al., 1998) for each experimental condition, and the model was independently fitted to the signal of each voxel. Subsequently these parameter fits were evaluated in the second level analysis applying the Random Effects Model. To examine the effects of familiarity and metaphoricity direct contrasts of the conditions were calculated, using a threshold of $p < .00001$ and a cluster size > 4. This cluster threshold was determined by running an AlphaSim analysis with NeuroElf v0.9c (http://neuroelf.net/) to correspond to an FWE-correction of $p < .05$.

To detect brain areas responding to the degree of valence, arousal, imageability and meaningfulness parametric analyses were carried out. The former linguistic factors were separately modeled as parametric regressors. Additionally, as measurement of the BOLD response beta-values were extracted from the LIFG for each single word and correlation coefficients were calculated from these values with meaningfulness in order to visualize the results of the afore mentioned parametric modulation analysis. Emotional valence, arousal, and imageability were included as covariates in one, and the sum of the logarithm of the constituent's word frequency and reaction times (as an extra control for difficulty) in another analysis. These regressors were generated in the following way: the previously modeled BOLD responses (evoked by the four main conditions) were modulated by multiplying them with normalized values (from −1 to +1) of individual reaction times (and other variables) for each single word. Hereby the response to each condition was split into 2 parts: the condition itself and the parametric modulation of the specific effect. Then General Linear Models were calculated including these additional regressors to create an extended model.

Results

Behavioral results

During the outlier procedure 4.7% of all the recorded data were removed. Reaction time and error rate data were submitted for both

Table 2
Talairach coordinates of BOLD signal change peaks.

Contrast	x	y	z	k	Max	Diameter
(CM + CL) > (NM + NL)						
Precuneus	0	−58	31	1572	10.491110	d = 1.0 mm
	0	−58	31	L	10.491110	d = 1.0 mm
	0	−34	33	L	9.673079	d = 1.0 mm
	−3	−64	50	L	6.259244	
L inferior temporal gyrus	−56	−14	−11	237	10.207053	d = 1.0 mm
Medial frontal gyrus	−11	51	2	1794	10.024557	
	−11	51	2	L	10.024557	
	7	34	2	L	9.460264	d = 1.0 mm
	0	64	12	L	9.067936	d = 3.6 mm
	0	6	4	L	6.866185	d = 4.0 mm
	−19	65	21	L	6.201931	d = 1.0 mm
	0	56	40	L	5.525948	d = 4.1 mm
R SMG	50	−47	35	1805	9.406252	d = 3.7 mm
	50	−47	35	L	9.406252	d = 3.7 mm
R MTG	59	−20	−6	L	8.942244	
R angular gyrus	45	−67	29	L	8.801411	d = 2.4 mm
R posterior STS	61	−55	1	L	7.559316	
	55	−35	−4	L	7.452419	
	61	−31	16	L	6.512668	d = 2.2 mm
	64	−44	12	L	6.374903	d = 1.0 mm
R SFG	25	24	46	282	9.344021	
L angular gyrus	−47	−64	33	542	8.982792	d = 1.4 mm
L SFG	−40	26	45	92	6.594738	
	−40	26	45	L	6.594738	
	−34	15	46	L	6.459573	d = 2.0 mm
	−22	31	40	14	6.228384	d = 1.0 mm
R STG	50	4	−13	37	6.188431	
	−29	31	22	6	5.756945	d = 5.0 mm
(CM + CL) < (NM + NL)						
LIFG	−43	−2	28	921	10.096503	d = 1.0 mm
	−43	−2	28	L	10.096503	d = 1.0 mm
	−46	22	21	L	9.711818	d = 1.4 mm
L insular cortex	−34	21	8	L	8.039451	
	−50	−8	43	L	7.628479	
Pre-SMA	−8	−1	53	265	9.481983	d = 2.8 mm
	−8	−1	53	L	9.481983	d = 2.8 mm
	11	22	38	L	7.877074	
R insular cortex	30	20	10	139	8.968314	d = 1.0 mm
L fusiform gyrus	−43	−55	−6	77	7.122552	d = 5.8 mm
	−43	−55	−6	L	7.122552	d = 5.8 mm
	−39	−40	−8	L	6.071026	d = 4.0 mm
(CM + NM) > (CL + NL)						
LIFG and LIFJ	−46	19	14	609	8.258172	d = 1.0 mm
	−46	19	14	L	8.258172	d = 1.0 mm
	−50	6	24	L	7.126366	d = 2.2 mm
L temporal pole (aSTS)	−49	3	−6	L	6.776460	d = 1.0 mm
	−50	14	−1	L	6.755461	d = 2.2 mm
L posterior STS	−53	−41	8	46	6.565135	
L amygdala	−21	−11	1	8	5.759394	
L anterior STS	−54	−10	1	5	5.671626	d = 2.0 mm
CM > CL						
LIFG and LIFJ	−46	25	11	731	12.040571	d = 2.4 mm
	−46	25	11	L	12.040571	d = 2.4 mm
	−42	7	29	L	10.068727	d = 3.0 mm
Pre-SMA	−8	10	48	16	6.507284	
L posterior STS	−53	−36	8	12	5.919095	d = 3.2 mm
L hippocampus	−33	−11	−14	4	5.458577	d = 2.2 mm
NM > NL						
L temporal pole (aSTS)	−52	3	−3	85	7.105155	d = 1.7 mm
L posterior STS	−55	−41	10	11	5.746142	d = 1.0 mm
NM < NL						
L parahippocampal gyrus	−27	−36	−8	9	5.709272	d = 1.4 mm

a subject (F_1) and an item (F_2) based one-way ANOVA analysis, and post-hoc tests were performed to determine the differences between categories (Fig. 1).

Subject based analysis revealed significant main effect of the categories for error rates, $F_1(3,156) = 17.598$, $p < .001$. Levene's test for the
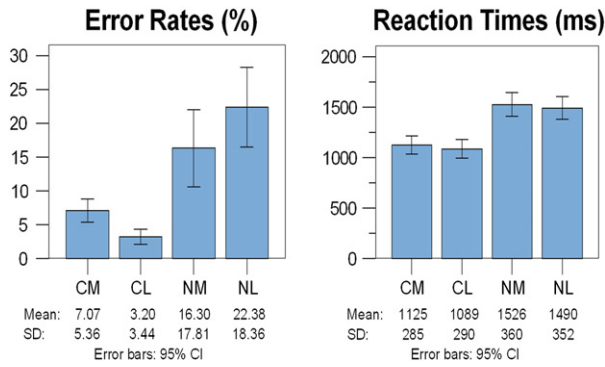
Fig. 1. Mean error rates and reaction times according to the F_1 analysis.

Results were calculated for the uncorrected data set also, but the differences between categories remained exactly the same.

Neuroimaging results

Familiarity

To examine familiarity effects, the two conditions with salient meaning (CM and CL), were joined and contrasted against the two novel conditions with non-salient meaning (NM and NL): (CM + CL) > (NM + NL). Conventional compounds significantly increased the BOLD signal in right MTG (BA 21), right SMG (BA 40), bilateral AG (BA 39), right superior frontal gyrus (SFG: BA 8), left inferior temporal gyrus (ITG: BA 20) and in broad bilateral midline structures, as the ventromedial prefrontal cortex (VMPFC: BA 10, 12), the dorsal anterior cingulate cortex (dACC: BA 32), and subgenual cingulate area (BA 25), the posterior cingulate cortex (PCC: BA 23, 31), and the precuneus (BA 7). Novel NNCs increased BOLD responses in left IFJ (ventral BA 6) and LIFG (BA 44, 45), left fusiform gyrus (BA 37), bilateral insula, and pre-SMA (BA 6), as illustrated in Fig. 2.

Emotional valence, arousal, and imageability included in the analysis as covariates did not change the findings. The sum of the logarithm of the constituent's word frequency, and reaction times (to control for difficulty) also have been included as covariates in a separate analysis, and were found not to affect our main results either. As these factors cannot explain our findings we included an image and coordinates of activation peaks for this extended model in the Supplementary material. Results of parametric analyses and corresponding coordinates also can be observed in the Supplementary material.

Figurativeness

Brain areas associated with metaphor processing were found active by contrasting the two metaphorical against the two literal conditions (CM + NM) > (CL + NL). BOLD responses increased in LIFG (BA 44, 45), left IFJ (ventral BA 6), left temporal pole (BA 38), left posterior STS (BA 22), and left amygdala. As the LIFG was found involved

homogeneity of variances proved significant, $L(3,156) = 24.902$, $p<.001$, hence Tamhane post hoc test was performed, revealing significant differences between all but the NM and NL categories. Reaction time differences were calculated only for accurate responses, and were also significantly different between categories, $F_1(3,156) = 20.865$, $p<.001$. Tukey post hoc test showed differences between all categories, except for the CM–CL and the NM–NL comparisons.

Item based F_2 analysis provided similar results. Word category had a significant main effect on error rates $F2(3,196) = 28.909$, $p<.001$. As Levene's test proved to be significant, $L(3,196) = 8.522$, $p<.001$, the homogeneity of variances was not assumed; Tamhane post hoc test revealed significant differences between all categories except for CM and CL, and for NM and NL. Item based analysis of reaction times also showed a significant main effect of categories $F_2(3,196) = 119.466$, $p<.001$, and as the variances were not homogenous ($L(3,196) = 3.083$, $p<.028$), Tamhane post hoc test was applied, showing differences for all comparisons, but CM–CL and NM–NL.

Fig. 2. BOLD signal change for contrasting conventional NNCs (warm colors) against novel NNCs (cold colors): (CM + CL) > (NM + NL). Conventional metaphorical and literal NNCs increased BOLD signal change in right temporoparietal areas, suggesting combinatorial semantic processing, in line with the coarse semantic coding theory, as their constituents are not closely associated. Novel metaphors and novel literal expressions induced BOLD signal increase in LIFG, presumably as a result of meaning making: unifying phonetic, morphosyntactic, and semantic features of novel words, via fine grained semantic coding.
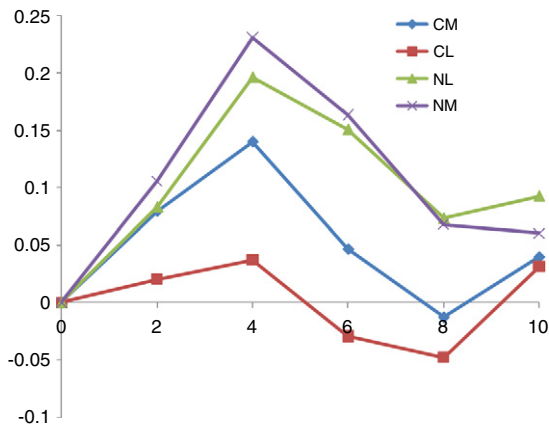
Fig. 3. BOLD responses in the LIFG in the (CM + NM) > (CL + NL) contrast. X-axis: percent BOLD signal change, Y-axis: time (s). The gradual BOLD signal increase of the four conditions suggests a gradual semantic processing demand for conventional literal expressions being the least complex, followed by conventional metaphors, requiring the selection and suppression of certain semantic features to construct figurative meaning; then came novel literal NNCs, where a new meaning has to be constructed from the two constituents, and finally by novel metaphors, where the novel figurative meaning has to be established via the selection and suppression of certain semantic features.

in several different contrasts, dynamics of the BOLD response in this region can be observed in Fig. 3.

To disentangle the effect of metaphoricity from the effect of familiarity, conventional and novel metaphors were separately contrasted against the corresponding literal condition with comparable salience. Conventional metaphors (CM > CL) increased the BOLD signal in left IFJ (ventral BA 6), LIFG (BA 44, 45), and pre-SMA (medial BA 6), and left posterior STS (BA 22). Novel metaphors (NM > NL) activated left temporal pole (BA 38) and left posterior STS (BA 22); this latter contrast revealed that NLs increased activation in left parahippocampal gyrus. The above results are shown in Fig. 4.

Discussion

The present experiment examined figurative language processing with special emphasis on semantic relatedness in an effort to separate these factors. Since all four categories of NNCs require some, albeit different kinds of semantic combination the question was: how does the computational load change as these factors interact, and specifically how much does semantic distance processing contribute to the processing of novel metaphors?

Familiarity

According to the graded salience hypothesis (Giora, 2003), non-salient (not coded, not co-occurring, not conventional, and not familiar) novel items seemed to be better candidates for activating the RH, while salient (coded, familiar, conventional, etc.) items were expected to more likely activate the LH. However, just the opposite pattern was observed: Despite being salient, conventional items (CM and CL) elicited higher BOLD signal increase in right temporoparietal regions, specifically in the SMG. Although the AG was activated bilaterally, the signal increase was lateralized to the right side in the SFG and MTG too. Nevertheless, these results can be interpreted according to Beeman's (1998) coarse semantic coding theory, as there was no close semantic relation even between the constituent words of familiar NNCs. They also fit well with the results of Graves et al. (2010) who also found right SMG activation. They attributed this to combinatorial semantic processing of the highly meaningful noun noun phrases, where the constituents are weakly associated with no overlapping semantic fields. Nonetheless, the right temporoparietal cortex also plays an important role in recognition memory (Cabeza et al., 2008): it is thus possible that memory processes modulated the familiarity effect in both studies.

Temporal areas are traditionally associated with the mental lexicon and are thought to store information about objects and their attributes, while right SFG seems to play an important role in goal-directed
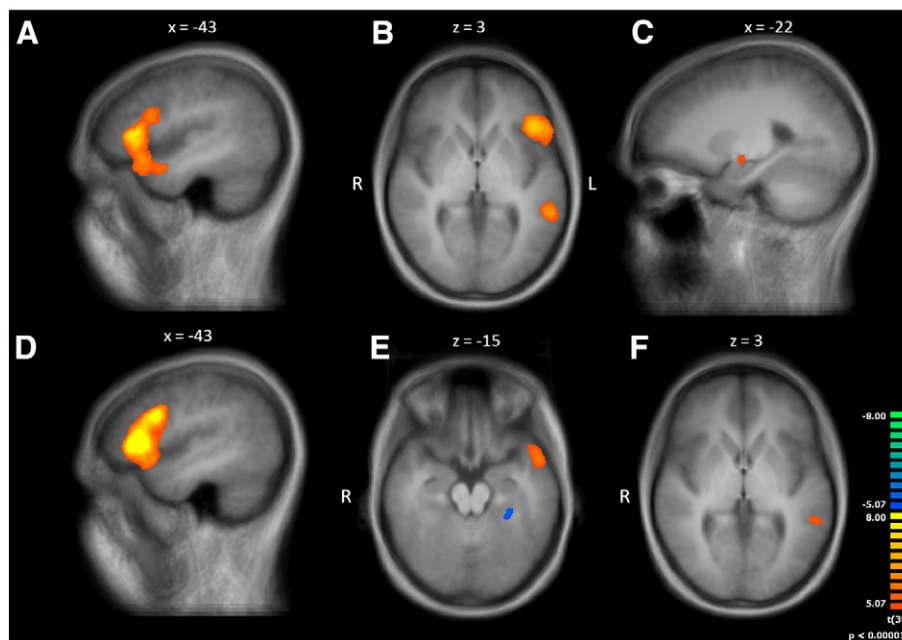
Fig. 4. BOLD signal increase for metaphorical NNCs. A, B, C: (CM + NM) > (CL + NL); metaphors activated LIFG, left IFJ, left temporal pole, left posterior superior temporal sulcus. Activations elicited by metaphors are constituted almost entirely of regions that showed an increased BOLD signal either for the CMs in the CM > CL, or for the NMs in the NM > NL contrast, suggesting that these conditions could have played decisive role in activating corresponding regions in the general figurative contrast. D: (CM > CL); conventional metaphors (compared to matched conventional literal expressions) activated LIFG and left IFJ, suggesting semantic selection and unification procedures, and left posterior superior temporal sulcus as a result of stronger semantic activation. E, F: (NM > NL); novel metaphors (relative to matched novel literal NNCs) increased BOLD responses in left temporal pole, perhaps as a result of higher demands on semantic integration, and in left posterior superior temporal sulcus also, again for stronger semantic activation. According to radiological convention the left side of the brain is on the right side of the figure.

semantic retrieval, especially when a large set of responses is possible (Binder et al., 2009). Together with the above mentioned regions and the broadly activated medial structures such as the VMPFC, the dACC, the PCC, and the central region of the precuneus, these areas are all part of a large semantic network identified by a comprehensive meta-analysis of the semantic system by Binder et al. (2009). The medial activations completely overlap with the default state network, which could reflect the ease of processing, but most probably they took part in comprehension too, as this network is thought to be a virtually inwardly oriented conceptual system, being responsible for semantic processing (Binder et al., 2009). As even conventional NNCs have complex relational structure, RH activations might be reflecting more than a mere linking, but a non-syntactic semantic combination of the two elements. Apparently coarse semantic coding does not necessarily pose a higher processing demand and can be effortless, reflected in short reaction times and default state network activations.

Novel NNCs (NM and NL) elicited strong activations in LH prefrontal areas, which seems to be at odds with the graded salience hypothesis, and at first glance even with the coarse semantic coding theory, since the lemmas did not share narrow semantic fields. However, when it came to the semantic composition of non-associated, non-salient, and not even significantly co-occurring lemmas into truly novel NNCs, processing requirements might change. Beeman (1998) suggests that hemispheric activation primarily depends on semantic feature overlap. The system could have required a more focused, fine grained conceptual analysis, and narrower semantic feature selection to establish the meaning, as it is forced to come up with a single solution during retrieval, and competing candidate concepts need to be filtered during the selection of an appropriate one. Longer reaction times could also reflect a higher processing demand and hence a more thorough analysis of novel items.

Left inferior frontal areas were found responsible for both linguistic and non-linguistic processes. According to a meta-analysis (Owen et al., 2005) the IFG plays an important role in working memory and attention, while the IFJ was found to be involved in cognitive control and task switching by another meta-analysis (Derrfuss et al., 2005). However, the LIFG is associated with the processing of morphological complexity in general (Bozic et al., 2007; Marslen-Wilson and Tyler, 2007), morphosyntactic compounding (Koester and Schiller, 2011), but even with the processing of difficult unfamiliar metaphors as compared to easy unfamiliar metaphors (Schmidt and Seger, 2009). In fact different subregions may actually play different roles: In their meta-analysis Liakakis et al. (2011) found left BA 44 involved in working memory, whereas left BA 45 and BA 46 associated with semantic, and phonological processing. This latter area, the anterior portion of the IFG, is identical to the cluster identified by an earlier meta-analysis, found to be activated by semantic processing (Bookheimer, 2002). These results partly serve as the basis of Hagoort's (2005) neurobiological language model, the Memory, Unification, Control (MUC) framework, where the LIFG is responsible for the Unification gradient: the interactive and concurrent integration of phonology, syntax, and semantics into a complex whole. Importantly working memory is an integral part of the system, as the neural requirements of the unification include keeping the lexical building blocks activated.

Jung-Beeman's (2005) Bilateral Activation, Integration, and Selection (BAIS) framework assigns a slightly different role to the LIFG. As bilateral language areas are interacting in line with task demands, fine grained coding taking place in LH, and coarse coding in RH areas, this model suggests that the LIFG is responsible for the meaning Selection component within narrow semantic fields.

Although these theories propose somewhat different procedures to the LIFG, presenting novel NNCs could easily impose higher processing demands on this region, as the main challenge is the precise selection and/or complex unification of the phonetic, syntactic, and semantic features of the parts into novel units.

The left fusiform gyrus showed a negative correlation with association values in the study of Graves et al. (2010), hence the activation found in the present experiment fits well with the processing of novel NNCs, with no significant co-occurrence. The anterior insula was found activated for novel metaphors previously (Ahrens et al., 2007; Mashal et al., 2007), but it could be a marker of the selective ventral attention system (Eckert et al., 2009). Pre-SMA also expressed higher BOLD signals, an area taking part in working memory tasks, such as sequence learning (Owen et al., 2005), hence this neural response could reflect the sequential ordering aspect of processing novel NNCs.

This complex pattern of phonetic, morpho-syntactic, and semantic unification, meaning selection, processing and sequencing of non-associated lemmas, cognitive control, and working memory load could reflect a more demanding (and more compelling) meaning-making procedure (cf. Bruner, 1990), where meaning is actively constructed, rather than passively comprehended. Such a productive effort would not be unusual for poetic, non-everyday language that does not necessarily always give in easily to understanding, and requires interpretation.

Figurativeness

The activations elicited by metaphorical (CM + NM) vs. literal (CL + NL) NNCs are constituted almost entirely of regions that showed an increased BOLD signal either for the CMs in the CM > CL, or for the NMs in the NM > NL contrast. This suggests that activations showing up in the combined figurative contrast could have been mainly the sum of the activations of the two otherwise not overlapping metaphorical conditions (except for left anterior STS).

Contrasting CMs and CLs (that are indistinguishable by reaction times) revealed a BOLD signal increase in LIFG and left IFJ for the CMs, probably as a result of their higher complexity. LIFG was found activated also by Diaz et al. (2011) for an identical contrast. Metaphors require the listener to select non-concrete features of the figurative constituent words — a "chair-leg" is not a leg in the literal, physical sense. Hence they could have imposed higher computational demand on meaning selection processes, and required a more thorough unification procedure. In general these results are in line with conventional metaphors evoking stronger LH activations in fMRI studies, and posing a slightly higher effort relative to literal expressions in ERP experiments (Arzouan et al., 2007; Lai et al., 2009).

The contrast between the behaviorally also indistinguishable NM and NL categories showed activations for NMs in the left posterior STS (BA 22), probably as a result of the higher conceptual complexity of figurative language, and in the left anterior STS, an area suggested to be responsible for verbal as compared to perceptual knowledge by Binder et al. (2009). The region included the temporal pole, also found activated by Schmidt and Seger (2009) for figurative language in general, and by Ahrens et al. (2007) for novel (anomalous) metaphors. According to the MUC model (Hagoort, 2005) temporal regions play a role in memory retrieval, while according to the BAIS model (Jung-Beeman, 2005) they are responsible for two separate functions: posterior STS is where semantic information is supposed to be activated (required by both metaphorical conditions), while anterior STS and temporal pole are held responsible for semantic integration. Based on the observed pattern of activations of brain regions associated with semantic functions, our results suggest that novel metaphorical expressions required higher conceptual processing than similarly novel, unfamiliar, but literal NNCs. This is most probably not due to coarse coding, but to the fine grained activation of an appropriate, not dominant, and not literal sense of one of the constituents, and the following, more complex integration of the two parts into a novel figurative meaning. Up to this date, to our knowledge, this is the first study reporting LH activations for novel metaphorical stimulus material out of context. Previous studies might have found RH activations mainly because of semantic distance processing, but since in

the present experiment semantic relatedness was carefully controlled for, it was possible to parse it out from the neural processing correlates of novel metaphorical expressions.

Posterior STS (BA 22) and LIFG, regions found expressing BOLD signal increase in the metaphorical vs. literal contrast, are located at the overlap of areas activated by both internal-conceptual, and external-perceptual information (Binder et al., 2009), suggesting that the integration of both knowledge domains is important for metaphor comprehension. Metaphorical items apparently required a thorough processing, involving stronger neural markers for activating, selecting and integrating semantic information.

Finally, a gradually increasing processing demand was proposed for the four conditions, and has been confirmed according to the LIFG activation patterns (Fig. 3). Familiar CLs induced the least BOLD signal change, followed by CMs, requiring the selection and filtering of certain semantic features in order to construct the figurative meaning; reflected also in behavioral results, NLs posed even higher processing demand, as a result of integrating semantically distant concepts, and finally NMs evoked the highest BOLD signal change, requiring both bridging semantic distance, and establishing metaphorical meaning.

Conclusions

The present study examined the neural correlates of processing familiar and unfamiliar, literal and figurative NNCs. On the one hand, at odds with the graded salience hypothesis (Giora, 2003), but in line with the coarse semantic coding theory (Beeman, 1998), distantly related familiar NNCs activated right temporoparietal regions (e.g., SMG) probably reflecting combinatorial semantic processing (Graves et al., 2010). On the other hand, unfamiliar conditions increased BOLD signal change in LH regions, such as the LIFG, which could be accounted for by the coarse semantic coding theory, since novel items could have required fine grained conceptual analysis, and narrow semantic feature selection (Jung-Beeman, 2005) for the unification of phonological, (morpho-)syntactic and semantic information (Hagoort, 2005), presumably due to meaning-making (Bruner, 1990). The comprehension of figurative language was successfully separated from semantic distance processing, and LH regions were found activated even for novel metaphorical expressions, suggesting a fine grained conceptual analysis during the selection and suppression of certain conceptual features in order to establish figurative meaning.

Acknowledgments

Appendix A

Conventional metaphorical	Conventional literal	Novel metaphorical	Novel literal
ANGSTHASE	ALARMSIGNAL	ALPENMATTEN	AUTOFILM
ARMLEUCHTER	ALTARBILD	ÄRGERBERG	BLECHGLOCKE
ARMUTSZEUGNIS	BAUFIRMA	BEWERBERPEST	DACHFEUCHTE
ARSCHKRIECHER	BETTRUHE	BLUMENBLICK	DAUMENVERBAND
AUGAPFEL	BLEISTIFT	BUMERANGLAUNE	EINSATZANTRAG
BÄRENHUNGER	BOXSACK	DANKEBBE	ERZTROMPETE
BAUMKRONE	BRIEFMARKE	DUFTGESANG	EULENFALLE
BEIFALLSSTURM	BÜRGERAMT	EREIGNISPULS	FASANMÖRDER
BÖRSENHAI	EHEPARTNER	ESSIGHUMOR	FELLINSEKT
DONNERBALKEN	FENSTERGRIFF	FANTASIEPAPST	FILZKANNE
DRAHTESEL	GASHEIZUNG	FETTGÜRTEL	FLÖTENKISTE
ERFOLGSREZEPT	GEBETSSTUNDE	FLAMMENSCHRIFT	FLUCHTLUKE

Appendix A (continued)

Conventional metaphorical	Conventional literal	Novel metaphorical	Novel literal
FLUGHAFEN	GERICHTSSAAL	FLUMMIVERSTAND	FUGENCREME
FLUSSLAUF	GESCHÄFTSMANN	GEIERBERUF	FUNDREGAL
FRAUENHELD	GITTERSTAB	GELDDURST	GALGENLEITER
GEBÄRMASCHINE	HILFSARBEITER	GLAUBENSSÄER	GÄNSEPFEIFE
GEDANKENGANG	HUNDELEINE	HAUSDIKTATUR	GEWITTERSPUR
GEHIRNWÄSCHE	IMBISSSTAND	HENNENHYSTERIE	GLASAFFE
GEWISSENSBISSE	KAFFEESAHNE	IDEENHAGEL	GLITZERTELEFON
GNADENBROT	KIRCHTURM	IGELFROST	GURKENTÜTE
HAARWURZEL	KLEIDERHAKEN	KAKTUSBART	HIRTENTROMMEL
HANDSCHUH	KREDITKARTE	KATERBREMSE	HOLZFLASCHE
HEIZKÖRPER	KÜCHENMESSER	KIRSCHWANGE	KARTONFLIEGE
HERZKAMMER	LASTWAGEN	LEIDWOGE	KEKSVERSTECK
JAMMERLAPPEN	LEBENSFREUDE	LISTENTEUFEL	KEROSINDOSE
KABELSALAT	LEHRJAHR	LÜGENBRATEN	KÖRNERKUCHEN
KADERSCHMIEDE	MARINESOLDAT	MATRATZENRUHM	KRANSCHRAUBEN
KINDERGARTEN	MIETZINS	MEINUNGSKÄFIG	KRÄUTERHEFE
KUMMERKASTEN	MOTTOPARTY	MENSAKOMA	KUNSTSCHWAN
LUFTBRÜCKE	NATURSCHUTZ	MUSIKSUPPE	LABORTABLETTE
LUNGENFLÜGEL	OFENROHR	MUTTROPFEN	LEHRERORDNER
LUSTMOLCH	PFIRSICHKERN	MÜCKENKUSS	LIPPENFALTEN
MEERBUSEN	PFLEGEVATER	NASENSCHAUER	LÖWENNETZ
MONDGESICHT	POLIZEIBEAMTE	NEIDFIEBER	MODELLGELENK
MOTORHAUBE	POSTFACH	ORDNUNGSBIENE	MÖNCHSJACKE
NOTNAGEL	RASIERAPPARAT	PARADIESMORAL	PAPIERSÄGE
ORANGENHAUT	REGENSCHIRM	PHRASENVULKAN	PARKTONNE
PANZERFAUST	REISEPASS	PLASTIKSCHWUR	RASENKREUZ
PECHVOGEL	SCHLACHTFELD	SCHMUTZMAGNET	SANDTISCH
RABENELTERN	SEGELBOOT	SEELENFARBEN	SCHILFGEHEGE
RAMPENSAU	STEUERZAHLER	SPRACHKANONE	SILBERSAITE
SCHÜRZENJÄGER	STIERKAMPF	STADTNARBE	SOFALADEN
SKANDALNUDEL	STREIKFÜHRER	STAUBKOST	STAHLHEMD
SPIELHÖLLE	STROHBALLEN	TASCHENBAUCH	STEINLACK
STUHLBEIN	TAUFBECKEN	TRAUMACHIRURG	TABLETTFOLIE
TALSOHLE	TAXIFAHRER	WALFIGUR	TANZHOSE
WASSERSPIEGEL	WEINKELLER	WANDKOSTÜM	TIGERPYJAMA
WESPENTAILLE	WETTERBERICHT	WEISHEITSSEE	TRAKTORBUCH
WOLKENKRATZER	WOCHENENDE	WISSENSPIRAT	ZIEGELMASSE
WÜSTENSCHIFF	ZIMMERPFLANZE	WORTHAUFEN	ZUFALLTASTE

Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.neuroimage.2012.07.029.

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7.2 Study 2: Lateralized processing of novel metaphors: disentangling figurativeness and novelty

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Lateralized processing of novel metaphors: Disentangling figurativeness and novelty

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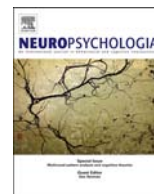
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A B S T R A C T

One of the intriguing and sometimes controversial findings in figurative language research is a right-hemisphere processing advantage for novel metaphors. The current divided visual field study introduced novel literal expressions as a control condition to assess processing novelty independent of figurativeness. Participants evaluated word pairs belonging to one of the five categories: (1) conventional metaphorical, (2) conventional literal, (3) novel metaphorical, (4) novel literal, and (5) unrelated expressions in a semantic decision task. We presented expressions without sentence context and controlled for additional factors including emotional valence, arousal, and imageability that could potentially influence hemispheric processing. We also utilized an eye-tracker to ensure lateralized presentation. We did not find the previously reported right-hemispherical processing advantage for novel metaphors. Processing was faster in the left hemisphere for all types of word pairs, and accuracy was also higher in the right visual field - left hemisphere. Novel metaphors were processed just as fast as novel literal expressions, suggesting that the primary challenge during the comprehension of novel expressions is not a serial processing of salience, but perhaps a more left hemisphere weighted semantic integration. Our results cast doubt on the right-hemisphere theory of metaphors, and raise the possibility that other uncontrolled variables were responsible for previous results. The lateralization of processing of two word expressions seems to be more contingent on the specific task at hand than their figurativeness or saliency.

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1. Introduction

In recent decades, experimental work on the neural processing of figurative language has been expanding rapidly. One of the main reasons for the broad interest is the finding that certain patient populations, including people diagnosed with right-hemisphere lesions, schizophrenia, Asperger's syndrome, and Alzheimer's disease, appear to have problems interpreting figures of speech, and specifically metaphors, while they retain mostly intact general language skills (Thoma & Daum, 2006). This observation has lead to the idea that regions beyond classical, left hemisphere (LH) language areas are computing the figurative meaning of metaphors and idioms. To date it remains uncertain if they need a special kind of "extra-linguistic" processing, and if the right hemisphere (RH) is necessarily involved in their comprehension, as has been postulated by the RH theory of metaphor (e.g., Coulson & Van Petten, 2007).

Another core question is the serial or parallel availability of figurative meaning. According to the direct access view by

Gibbs (1994), metaphors are comprehended easily in a supportive context, since the literal and figurative meanings are available in parallel. The category assertion view (Glucksberg, 2003; Glucksberg & Keysar, 1990) also suggests that the figurative meaning of metaphors (or at least nominal ones, such as "My lawyer is a shark") is readily accessible as a result of the dual reference of the figuratively used term ("shark") to a literal subordinate category (*marine creature*), and a metaphorical ad hoc superordinate category (*predatory creature*). Bowdle and Gentner (2005), in their career of metaphor hypothesis, propose that only conventional metaphors have such a dual reference, and novel metaphors are processed serially, as a kind of comparison, like similes, following a failed categorization attempt. Nevertheless, beside the question of lateralization, the temporal course of metaphor comprehension is not entirely clear either. The available empirical evidence is inconclusive as to whether metaphors are understood as quickly as literal expressions due to parallel processing, or if they are comprehended slower as a result of serial processing of their figurative meaning.

Thus the two key questions that remain unanswered are (1) what computational steps metaphors require and how these are reflected in the timing of processing, and (2) whether the RH of the brain is necessarily involved in their comprehension. In the following section we are going to review previous findings on the

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individual hemispheres' contribution to the understanding of metaphors, which are often contradictory.

1.1. Metaphors and the right hemisphere

The RH had been regarded as the "mute" hemisphere for decades (e.g., Sperry, 1985). However, accumulating evidence suggests that it plays an important role in language comprehension, and it has been associated with a large variety of linguistic functions (Van Lancker Sidtis, 2006). The most notable of these are related to communicational pragmatics (Pléh, 2000; Van Lancker, 1997), such as comprehending jokes (Bihrle, Brownell, & Gardner, 1986; Brownell, Michel, Powelson, & Gardner, 1983; Coulson & Williams, 2005; Coulson & Wu, 2005; Marinkovic et al., 2011; Shammi & Stuss, 1999), sarcastic statements (Kaplan, Brownell, Jacobs, & Gardner, 1990), irony (Eviatar & Just, 2006), and indirect requests (Brownell & Stringfellow, 1999; Foldi, 1987; Stemmer, Giroux, & Joanette, 1994; Weylman, Brownell, Roman, & Gardner, 1989).

Metaphorical expressions were among the first linguistic materials whose processing was linked to the RH. In an early experiment performed on individuals with brain injury, Winner and Gardner (1977) found that patients with right hemisphere damage (RHD) preferred the literal depiction of figurative expressions relative to patients with left hemisphere damage (LHD). These findings were replicated in further picture naming experiments (Kempler, Van Lancker, Merchman, & Bates, 1999; Rinaldi, Marangolo, & Baldassari, 2004; the latter also controlled for the patients' visuospatial deficits). Another study found that RHD patients also experienced difficulties with metaphors in purely language-based tasks (Brownell, Simpson, Bihrle, Potter, & Gardner, 1990). A landmark PET study with healthy individuals by Bottini and colleagues (1994) presented novel metaphors to avoid the automatic processing associated with fixed expressions. They found activation in the right middle temporal gyrus, right prefrontal regions, and right precuneus. Subsequent studies also found RH involvement in metaphor comprehension using neuroimaging techniques (Ahrens et al., 2007; Diaz, Barrett, & Hogstrom, 2011; Mashal, Faust, & Hendler, 2005; Mashal, Faust, Hendler, & Jung-Beeman, 2007; Schmidt & Seger, 2009; Stringaris et al. 2006; Yang, Edens, Simpson, & Krawczyk, 2009), event-related potentials (ERPs) with source localization (Arzouan, Goldstein, & Faust, 2007; Sotillo et al., 2005), TMS (Pobric, Mashal, Faust, & Lavidor, 2008), and the divided visual field (DVF) paradigm (Anaki, Faust, & Kravetz, 1998; Faust, Ben-Artzi, & Harel, 2008; Faust & Mashal, 2007; Mashal & Faust, 2008; Schmidt, DeBuse, & Seger, 2007).

Other groups have found no evidence for the RH's involvement in understanding metaphors (Chen, Widick, & Chatterjee, 2008; Coulson & Van Petten, 2007; Eviatar & Just, 2006; Kacinik & Chiarello, 2007; Lee & Dapretto, 2006; Rapp, Leube, Erb, Grodd, & Kircher, 2004, 2007; Stringaris, Medford, Giampietro, Brammer, & David, 2007). One possible explanation for these contradictory findings is that novelty was not systematically controlled in these experiments (Schmidt & Seger, 2009). In support of this hypothesis a recent meta-analysis of fMRI studies on figurative language (Bohrn, Altamann, & Jacobs, 2012) showed that metaphors evoked LH activations, and only novel metaphors – relative to conventional ones – activated RH areas.

1.2. Lateralized language processing models

The most relevant models attribute the RH's involvement in language comprehension to slightly different, but closely related linguistic factors. The RH's participation is generally not attributed to figurativeness per se, but to its sensitivity to novel and unusual meanings (Beeman, 1998; Chiarello, 1991, 2003; Giora, 2003; St. George, Kutas, Martinez, & Sereno, 1999). The graded salience

hypothesis (Giora, 1997, 1999, 2003) proposes that, regardless of figurativeness, salient meanings are processed by the LH, while non-salient meanings are processed by the RH. According to this view, the LH processes conventional metaphors, since they have a salient meaning, even if it is figurative. Novel metaphors, on the other hand, have no salient meaning and are processed by the RH in a slower, serial manner. Only after their salient literal meaning has been rejected can the non-salient, figurative meaning be selected (Giora, 1997, 1999; Giora & Fein, 1999). Saliency is determined by the meaning being coded in the mental lexicon, its prominence, conventionality, frequency, familiarity, and prototypicality. An interesting implication of the theory is that even conventional idiomatic expressions may evoke RH activations when they are interpreted in a non-salient, literal sense. Indeed, this prediction was born out in an fMRI study (Mashal, Faust, Hendler, & Jung-Beeman, 2008).

The coarse semantic coding theory (Beeman, 1998; Beeman et al., 1994) is a language processing model that emphasizes the neural differences of hemispheric organization. The asymmetry in the micro-circuitry of the two hemispheres creates narrow semantic fields in the LH, which code concepts in a fine-grained manner, and broad semantic fields in the RH, which code concepts in a coarse manner. Since elements of conventional expressions are strongly associated, the LH's narrow semantic fields code them. The comprehension of novel expressions requires the activation of a wide range of meanings, because their constituents are weakly associated, therefore the broad (and hence overlapping) semantic fields of the RH code them. In other words, the lateralization of processing depends on the semantic-feature overlap between constituents. Two factors have been posited to contribute to semantic feature overlap: (1) category membership and (2) strength of association. The RH has been argued to process category members that are not associated (arm-nose), while the LH to exhibit a processing advantage for category members that are also associated (arm-leg) (Chiarello, 1991). As a consequence, the degree of lateralization during processing expressions that do not involve category membership and have no overlapping semantic features (e.g. adjective–noun expressions in the present study) shall be determined by the strength of association.

The Bilateral Activation, Integration, and Selection (BAIS) framework (Jung-Beeman, 2005) is an extended version of the coarse semantic coding theory, which is more flexible in terms of lateralization of language processing. Jung-Beeman proposes that three finely tuned semantic systems work together in a highly interactive manner: the posterior middle and superior temporal gyri activate, the inferior frontal gyrus selects, and the anterior middle and superior temporal gyri integrate semantic information, bilaterally. The fine coding systems of the LH settle on rapid and focused solutions via close links, while the coarse systems of the RH maintain broader interpretations via distant semantic links, in accordance with specific task demands. As a result, any given semantic task might partially place demands on the LH and on the RH – for example, it is possible that activation spreads in a coarse manner, but selection or integration requires fine coding.

Taken together, these models of lateralized language processing do not consider the figurativeness of expressions to be a relevant factor. At the same time empirical studies often fail to point out that the RH processing is not specific to metaphors. The formulation of the conclusion that novel metaphors require RH processing lends itself to the interpretation that the cause is not solely novelty, but also figurativeness. Because of these contradictions the issue needs more clarification.

1.3. Novelty and figurative language

Most metaphor researchers did not study figurativeness independent of novelty, even though a number of groups compared novel metaphors with conventional ones. This is only a partial

solution, because such a design potentially confounds novelty and figurativeness. A right-hemisphere advantage could either be due to novelty, or figurativeness, or both. Another way to shed light on processes specific to metaphors is to keep the level of novelty constant, and compare novel metaphors with novel literal expressions.

A number of studies compared novel metaphorical and novel literal sentences, but the question of lateralization has not been settled. In their ERP study, Coulson and Van Petten (2007) found that the generators of a late positivity in the 600–1200 ms time window, evoked by novel sentences with similarly low probability sentence final words, are not identical for novel metaphorical and novel literal sentences. Therefore, novel metaphors might require unique computations. In a DVF experiment Schmidt et al. (2007) found RH advantage for unfamiliar metaphorical and unfamiliar literal sentences, but they failed to obtain any clear LH effects for familiar literal sentences, nor did they find any interaction between conditions and hemispheric presentation. When participants were familiarized with novel metaphors, activation decreased in bilateral and LH regions (Cardillo, Watson, Schmidt, Kranjec, & Chatterjee, 2012), suggesting that novelty processing does not necessarily depend upon the RH. In an experiment with patients with brain injury, interpreting familiar idiomatic expressions posed difficulties for RHD patients, while novel literal expressions were problematic for LHD patients (Van Lancker & Kempler, 1987). Diaz et al. (2011) asked healthy individuals to evaluate figurative and literal sentences, both familiar and novel, using fMRI, but found contradictory results. Group comparisons showed RH activations for all novel sentences, and for all figurative sentences. On the other hand, novel literal expressions, relative to familiar literals, elicited BOLD signal change only in the LH, and novel metaphors did not differ either from novel literals or from familiar metaphors. Neither of these results is in line with the predictions the graded salience hypothesis (Giora, 2003), or the original version of the coarse semantic coding theory (Beeman, 1998). And the above two experiments hint that it might be the LH that processes novel literal expressions. Forgács et al. (2012) tested the very same four conditions as Diaz et al. (2011), using noun–noun compound words without context. Novel words, in general, relative to conventional words, induced a stronger BOLD signal change in left inferior frontal gyrus (LIFG), perhaps reflecting both the selection of the appropriate meaning in a fine-coded manner and the semantic unification (Hagoort, 2005) of the two constituents. Novel metaphors, relative to novel literal expressions, evoked left anterior and posterior middle temporal activations. These areas, according to the BAIS model (Jung-Beeman, 2005), are responsible for fine-grained semantic integration and activation, respectively. The results suggest that the brain allocates its resources flexibly in a way that is finely tuned to the task at hand, and that RH areas might not be necessary for computing either figurativeness, or novelty.

1.4. Computational demands on the RH

One possible explanation for the contradictory findings with figurative and novel language is that the RH is sensitive to a number of linguistic variables, such as context (Ferstl, Neumann, Bogler, & von Cramon, 2008; St. George et al., 1999; Vigneau et al., 2011; Xu, Kemeny, Park, Frattali, & Braun, 2005). Contextual effects could have masked RH effects in fMRI studies. When metaphors are embedded in sentences, activations could cancel out each other across conditions. In one fMRI study context congruity exerted a stronger effect on the RH than figurativeness (Diaz & Hogstrom, 2011). Another possibility is that sentential processing places demands on the LH to an extent that overrides RH effects for novel items in sentences (cf. Mashal, Faust, Hendler, and

Jung-Beeman 2009). One straightforward way to control for contextual and sentential effects is to present metaphors in isolation. Further on, emotions (Ferstl, Rinck, & Von Cramon, 2005) and visual imagery (Just, Newman, Keller, McEleny & Carpenter, 2004) are dimensions that are also potentially driving up the processing load on the RH, hence are necessary to control.

1.5. The rationale for the study

Motivated by contradictory findings in the literature, we designed the current study (1) to replicate a DVF experiment involving two word expressions by Faust and Mashal (2007); and (2) to extend it with a novel literal condition to directly control for the effect of processing novelty. More specifically, our goal was to test the predictions of the graded salience hypothesis (Giora, 2003), and determine whether the RH has a processing advantage in the comprehension of novel expressions irrespective of their figurativeness. In order to reduce potential hemispheric computational confounds, we presented word pairs in isolation, without sentential context, and controlled for a number of linguistic factors (emotional valence, arousal, and imageability) that could influence processing.

Comparing metaphorical and literal expressions matched according to novelty also offers a good opportunity to explore whether there are processes specific to metaphor comprehension. Particularly we could test whether the figurative meaning of novel metaphors is available only after a serial procedure, either as a result of a failed categorization, or the rejection of a salient literal meaning.

Our hypotheses were: (1) novel expressions, both metaphorical and literal, will be processed faster and more accurately when presented to the left visual field (LVF)–RH than to the right visual field (RVF)–LH, while conventional expressions, both metaphorical and literal, will be processed faster and more accurately when presented to the RVF–LH than to the LVF–RH. (2) There will be no processing differences in terms of response accuracy and reaction times between conventional metaphorical and literal expressions. However, novel metaphors will be processed slower than novel literal expressions – either because in the case of novel metaphors the salient literal meaning has to be rejected before arriving at the non-salient figurative meaning (Giora, 1997, 1999; Giora & Fein, 1999), or because of a lack of a failed categorization attempt, specific to novel metaphors (Bowdle & Gentner, 2005).

2. Methods

2.1. Participants

Thirty-seven undergraduate university students (18 female), aged 18–27 ($M = 20.29$, $SD = 1.97$), participated in the study for course credit. All participants were native speakers of Hungarian, had normal or corrected to normal vision, had no history of neurological or psychiatric disorders, and were right handed with a handedness quotient above or equal to 50 ($M = 76.53$, $SD = 14.19$) according to the Edinburgh Handedness Inventory (Oldfield, 1971). Ten additional participants were excluded because their handedness quotient was below 50, and another eight because of inaccurate eye-tracker calibration for more than 50% of the trials.

2.2. Stimuli

Stimuli consisted of 288 Hungarian adjective–noun word pairs. There were four experimental conditions, each with 36 word pairs. Conventional Metaphors (CM) (e.g., "warm heart"), Conventional Literal (CL) (e.g., "full stomach"), Novel Metaphors (NM) (e.g., "stinky deal"), and Novel Literal (NL) expressions (e.g., "boiled coke"). 144 semantically unrelated word pairs (e.g., "dilled zero") served as fillers for the semantic decision task. We present examples in Table 1. Word length was controlled for with number of characters, and frequency for each target word was determined based on frequency counts in the Hungarian Webcorpus (http://mokk.bme.hu/en/resources/webcorpus/) by MOKK (Halácsy et al., 2004;

Table 1
Examples of the stimuli from the four experimental conditions and the filler condition (translated from Hungarian).

Conventional Metaphor	Conventional Literal	Novel Metaphor	Novel Literal	Unrelated
brilliant idea	famous painter	soft irony	adult ant	corrupt pump
blind love	deep water	silky sunset	canned radish	cooked mass
light meal	wilted flower	worn idea	funny donor	ticklish roller
warm heart	full stomach	sparkling party	kitschy bus	dilled zero
dark secret	straight line	smoky song	cycling chorus	angular dew
crude joke	narrow hips	stinky deal	elegant pimp	alert edge
sharp mind	frizzy hair	dusty poem	muddy train	drunk armor
bitter cold	knitted sweater	cruel building	boiled coke	thermal acacia

Kornai, Halácsy, Nagy, Trón, & Varga, 2006). Conventional word pairs were commonplace, fixed expressions, and part of everyday language. Novel word pairs were constructed from words that did not form a conventional or familiar expression, were not associated, but that were semantically compatible. In order to assign word pairs to categories in an objective manner, we entered pairs in a Google search. We included in the novel conditions only combinations that had zero word bigram frequencies; and in the conventional conditions we included only those that were frequent (at least 1000 hits). According to a Shapiro–Wilk test the distribution was not normal either for CMs, $W(36)=.6$, $p < .001$, or for CLs, $W(36)=.9$, $p < .01$, but according to a Mann–Whitney test there was no statistical difference between the two conditions, $U=785.5$, $p > .12$, $r=.18$; CM:$Mdn=5255$; CL:$Mdn=10,070$.

When selecting word pairs we controlled for a number of semantic factors that included meaningfulness, literalness, emotional valence, arousal, and imageability. First, 23 university students, who did not participate in the DVF experiment, rated the word pairs on a 7-point Likert scale for meaningfulness ("Please rate the word pairs according to how meaningful they seem to you." 1: "Completely" and 7: "Not at all"). Then participants engaged in a second task in which they rated the same words for literalness ("Please rate the word pairs according to how literally you interpreted them during your previous meaningfulness rating." 1: "Completely" and 7: "Not at all"). In a separate norming-study 30 university students (who also did not participate in the subsequent DVF experiment) rated the words according to the procedures of the Berlin Affective Word List, or BAWL (Võ, Jacobs, and Conrad 2006), on a 7-point Likert scale for emotional valence ("Please rate the word pairs according to their emotional valence." −3: "Highly negative", +3: "Highly positive"); arousal ("Please rate the word pairs according to how emotionally arousing they are." 1: "Not at all", 7: "Completely"); and imageability ("Please rate the word pairs according to how easily they evoke a mental image." 1: "Not at all", 7: "Completely").

We performed a one-way ANOVA on the norming data with word category as the differentiating factor. Experimental conditions did not differ in terms of target word frequency, $F(3, 140)=1.7$, $p=.17$, and length, $F(3, 140)=.6$, $p=.6$. As expected, literalness was significantly different across categories, $F(3, 140)=374.6$, $p < .001$, and Tamhane's post-hoc test revealed that except for conventional and novel metaphors all categories were significantly different ($p < .001$). It was not possible to make the experimental categories completely homogenous with regard to imageability, $F(3, 140)=49.3$, $p < .001$ (all categories being different according to Tamhane's post-hoc test, $p < .04$), and arousal, $F(3, 140)=2.8$, $p=.04$ (only CLs and NMs being different according to Tamhane's post-hoc test, $p < .04$), but we found no difference in valence, $F(3, 140)=1.9$, $p=.13$. We conducted a second one-way ANOVA, with unrelated word pairs also included, in order to test meaningfulness ratings. As expected, the effect was significant, $F(4, 283)=683.3$, $p < .001$. Tamhane's post-hoc test revealed that the meaningfulness of all categories were significantly different from each other ($p < .001$). Results of the norming are shown in Table 2. We included meaningfulness and all BAWL factors in the final statistical analysis as covariates.

2.3. Experimental procedure

After reading the instructions and completing 16 practice items (eight examples of the unrelated and two of each meaningful conditions, not included in the stimuli), participants viewed 288 word pairs. The first words of the expressions (the adjectives) that served as primes were presented centrally, while the second, target words (the nouns) appeared randomly either in the LVF or in the RVF. There were two stimulus sets, so that each target word was presented to both LVF–RH and RVF–LH across participants. Central fixation during the lateralized presentation was assured by an infrared eye-tracking system (IView X RED, SMI, Germany). If the subjects moved their gaze away from the central fixation-cross and towards the target, the word disappeared, and the trial ended. We presented stimuli, recorded responses, and controlled the eye-tracker with the Presentation 14.8 software (www.neurobs.com). Participants placed their head on a chinrest, at a viewing distance of 60 cm from the screen. All words appeared in white Arial letters (font size: 22) on a black background. After a fixation cross ("+") appeared centrally for 3000 ms, prime words appeared centrally for 400 ms. Following a central fixation-

cross for 400 ms (SOA=800 ms), target words appeared for 180 ms, either to the left or to the right of the re-appearing central fixation-cross. Once the participant responded, the next trial began. We presented target words 1.6° to the left or to the right of the central fixation cross, since there is no strong evidence in favor of the bilateral representation of the fovea in the cortex, suggesting that it is split in humans (Brysbaert, 2004; Lavidor, Ellis, Shillcock, Bland, 2001; Lavidor & Walsh, 2004). According to participants' subjective account, words appeared in their visual periphery. Participants performed two blocks of trials, with a break in between. The eye-tracker's calibration was automatically checked at every 20 trials, and was re-established when necessary. We told participants to decide, as fast and accurately as possible, whether or not the two words constituted a meaningful combination. We instructed them to keep their right index finger above the right-arrow-key of the keyboard and to push it to indicate "yes", and to keep their left index finger above the left-arrow-key and push it to indicate "no".

3. Results

We excluded trials if eye-tracker calibration failed or if the target word appeared for less than 180 ms, indicating eye-movement (19.22%). We performed both subject (F1) and item (F2) based analyses on response accuracy and on the median of reaction times for correct responses. Meaningfully unrelated word pairs were not included in the analyses since they served as fillers.

For the F1 subject analysis we conducted a $2 \times 2 \times 2$ (Visual Field $\times$ Figurativeness $\times$ Novelty) repeated measures analysis of variance (ANOVA). We found all main effects to be significant for response accuracy: visual field, $F_1(1, 36)=25$, $p < .001$, $\eta_p^2=.41$, figurativeness, $F_1(1, 36)=55.3$, $p < .001$, $\eta_p^2=.61$, and novelty, $F_1(1, 36)=422.7$, $p < .001$, $\eta_p^2=.92$. There was a significant three-way interaction between visual field, figurativeness, and novelty, $F_1(1, 36)=6.3$, $p=.02$, $\eta_p^2=.15$, a two-way interaction between novelty and figurativeness, $F_1(1, 36)=4.2$, $p=.049$, $\eta_p^2=.1$, and novelty and visual field, $F_1(1, 36)=4.5$, $p=.04$, $\eta_p^2=.11$. To break down the three-way interaction responses to conventional and novel conditions were entered into a 2×2 (Visual Field $\times$ Figurativeness) ANOVA separately, which yielded a significant interaction between the two within-subject variables for the conventional items, $F_1(1, 36)=5.4$, $p=.03$, $\eta_p^2=.13$, but not for the novel items, $F_1(1, 36)=1.9$, $p=.18$, observed power=.27. It was not possible to explain the interaction, since we found the one-way (visual field) ANOVA significant for CMs, $F_1(1, 36)=26.2$, $p < .001$, $\eta_p^2=.42$, and for CLs, $F_1(1, 36)=20.3$, $p < .001$, $\eta_p^2=.36$, both being processed more accurately in the RVF–LH. However, the effect sizes suggest that this former difference in accuracy was greater for CMs than for CLs. In the two-way ANOVAs there was a significant main effect of visual field for conventional items, $F_1(1, 36)=38.5$, $p < .001$, $\eta_p^2=.52$, and also for novel items, $F_1(1, 36)=4.4$, $p=.04$, $\eta_p^2=.11$. Based on the effect sizes, the difference in accuracy in the RVF–LH was greater for conventional items than for novel items. The main effect of figurativeness was significant again for both conventional, $F_1(1, 36)=24.2$, $p < .001$, $\eta_p^2=.40$, and novel expressions, $F_1(1, 36)=35$, $p < .001$, $\eta_p^2=.49$, where the effect sizes suggest that the higher accuracy of NLs relative to NMs was a greater difference than the higher accuracy of CLs relative to CMs. These latter main effects of the 2×2 ANOVAs were equivalent with a brake

Table 2
Mean (SD) values of psycholinguistic properties of the four experimental conditions and the filler condition.

	Conventional Metaphor	Conventional Literal	Novel Metaphor	Novel Literal	Unrelated
Frequency of target word	22378	8402	22246	10290	4332
	(35420)	(12895)	(49636)	(30552)	(11605)
Length of target word	5.31	4.94	5	5.19	5.31
	(1.79)	(1.09)	(1.07)	(1.04)	(1.01)
Meaningfulness (1=highest)	1.54	1.25	3.4	2.59	5.39
	(.35)	(.15)	(.85)	(.67)	(.53)
Literalness (1=highest)	4.73	1.95	4.52	2.41	3.96
	(.51)	(.21)	(.53)	(.44)	(.45)
Valence (−3 to+3)	.03	.14	−.45	−.16	−.22
	(1.26)	(1.32)	(1.04)	(.84)	(.7)
Arousal (1=none)	3.95	3.57	4.29	3.99	4.04
	(1.2)	(1.21)	(.94)	(.76)	(.66)
Imageability (1=none)	4.31	5.56	3.77	4.78	3.26
	(.78)	(.58)	(.6)	(.61)	(.58)

down the two-way interactions of the three-way ANOVA (Novelty × Figurativeness and Novelty × Visual Field), however, because both subtests were significant in both cases, neither was possible to explain.

The median values of reaction times (F1) were entered also in a $2 \times 2 \times 2$ (Visual Field × Figurativeness × Novelty) ANOVA, and all main effects proved significant: visual field, $F_1(1, 36)=12.1$, $p=.001$, $\eta_p^2=.25$, figurativeness, $F_1(1, 36)=11.8$, $p=.002$, $\eta_p^2=.25$, and novelty, $F_1(1, 36)=117.5$, $p<.001$, $\eta_p^2=.77$. The three-way interaction was not significant, $F_1(1, 36)=1.1$, $p=.29$, observed power=.18, but there was a significant two-way interaction between figurativeness and novelty, $F_1(1, 36)=17.7$, $p<.001$, $\eta_p^2=.33$. In order to break down the interaction, the data was collapsed across visual fields. Conventional and novel conditions were entered separately into a single level ANOVA with figurativeness being the only within-subject variable. CLs were processed significantly faster compared to CMs, $F_1(1, 36)=47.5$, $p<.001$, $\eta_p^2=.57$, but there was no difference between NLs and NMs, $F_1(1, 36)=.2$, $p=.66$, observed power=.07.

The F2 item analysis consisted of a two-level (visual field) repeated measures ANCOVA, with figurativeness and novelty as between-subject variables, and valence, arousal, imageability and meaningfulness as covariates. For response accuracy only the three-way interaction between visual field, figurativeness, and novelty, $F_2(1, 136)=4.9$, $p=.03$, $\eta_p^2=.04$, and the main effect of novelty, $F_2(1, 136)=13$, $p<.001$, $\eta_p^2=.09$, were significant. Meaningfulness was the only covariate that had a significant effect, $F_2(1, 136)=29.3$, $p<.001$, $\eta_p^2=.18$. When it was not included in the analysis, effects remained the same, except that the interaction between visual field and imageability became significant, $F_2(1, 137)=4.1$, $p=.04$, $\eta_p^2=.03$. When imageability was removed, the three-way interaction and the main effect of novelty remained, but also the between-subject effect of figurativeness proved significant, $F_2(1, 138)=15.7$, $p<.001$, $\eta_p^2=.1$. This suggests that the main effect of figurativeness in the F1 accuracy analysis could be due to the higher meaningfulness and imageability of literal expressions. To break down the three-way interaction, conventional and novel items were introduced separately to an ANCOVA identical to the one above except that only figurativeness was included as a between-subject variable. For conventional expressions there was no interaction between visual field and figurativeness, $F_2(1, 66)=.2$, $p=.66$, observed power=.07. Visual field had a significant main effect, $F_2(1, 66)=4.6$, $p=.04$, $\eta_p^2=.07$, and it was in interaction with meaningfulness, $F_2(1, 66)=8.9$, $p=.004$, $\eta_p^2=.12$, which latter also had a significant covariate effect, $F_2(1, 66)=19.6$, $p<.001$, $\eta_p^2=.23$. When we removed meaningfulness from the analysis, only figurativeness had a significant effect, $F_2(1, 67)=7.7$, $p=.01$, $\eta_p^2=.1$ (and visual field not). This suggests that the higher

accuracy in the F1 analysis for conventional expressions in the RVF–LH relative to LVF–RH is reliable, even though modulated by meaningfulness, while the higher accuracy of CLs relative to CMs could be due to the higher meaningfulness of CLs. In the case of novel expressions, only meaningfulness had a significant effect, $F_2(1, 66)=13$, $p=.001$, $\eta_p^2=.17$, and when it was omitted, imageability marginally covaried with visual field, $F_2(1, 67)=3.8$, $p=.054$, $\eta_p^2=.05$. When both of the latter covariates were omitted, the effect of figurativeness become significant, $F_2(1, 68)=7.5$, $p=.01$, $\eta_p^2=.1$, suggesting that the more accurate processing of NLs compared to NMs in the F1 analysis, could be due to their higher meaningfulness and imageability.

Finally, median reaction times for the F2 analysis were included in an ANCOVA whose design was identical to the one above. There was no significant three-way interaction between visual field, figurativeness, and novelty, $F_2(1, 136)=1.9$, $p=.18$, observed power=.27. We found a significant main effect for novelty, $F_2(1, 136)=28.2$, $p<.001$, $\eta_p^2=.17$, but neither figurativeness, nor visual field was significant. Arousal was in interaction with visual field, $F_2(1, 136)=5.6$, $p=.02$, $\eta_p^2=.04$, and imageability marginally covaried, $F_2(1, 136)=3.9$, $p=.050$, $\eta_p^2=.03$. Emotionally more arousing word pairs were processed slower only in the LVF–RH. When arousal was not included in the model, the effect of visual field was still not significant, while the main effect of novelty and a trend for imageability remained, $F_2(1, 137)=3.8$, $p=.052$, $\eta_p^2=.03$. When only imageability was omitted, the main effect of visual field turned out to be significant, $F_2(1, 137)=4.5$, $p=.04$, $\eta_p^2=.03$, and figurativeness as well, $F_2(1, 137)=7.2$, $p=.01$, $\eta_p^2=.05$, otherwise all effects remained the same. Only in the RVF–LH were more imageable expressions processed faster, and was figurativeness in an interaction with novelty. These results suggest that in the F1 analysis the main effect of faster responses in the RVF–LH could be due to imageability and modulated by arousal, and the main effect of faster responses to literal expressions could be due to imageability. In a separate analysis, bigram frequency was also included in the relevant comparisons, but the pattern of results did not change. No other statistical tests were significant (all values of $F < 3.8$, and $p > .058$).

In summary, our analyses revealed no RH processing advantage for novel items, either for metaphorical or literal. Both novel and conventional expressions were processed more accurately in the RVF–LH than in the LVF–RH (where meaningfulness contributed to the latter advantage), and all word pairs were processed faster in the RVF–LH (which was influenced by imageability, and in interaction with arousal). Irrespective of lateralization, CLs were processed more accurately than CMs, but it could be due to meaningfulness; NLs were processed more accurately than NMs, but meaningfulness and imageability could have contributed to
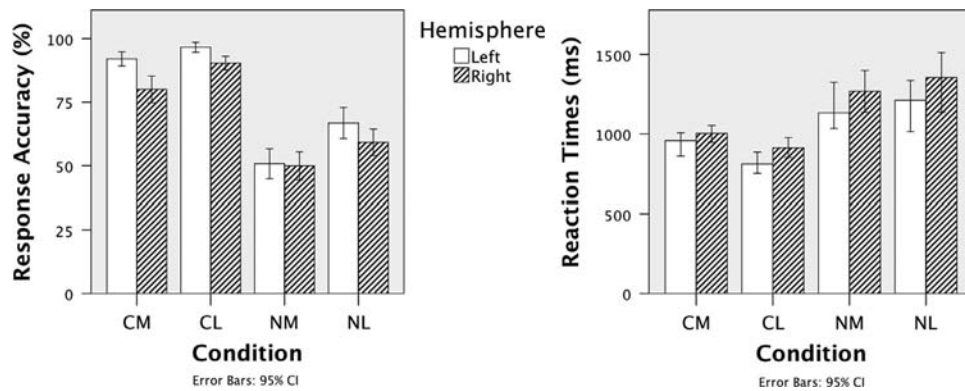
Fig. 1. Response accuracy (%), and median reaction times (ms) according to the F1 analysis. CM: conventional metaphor, CL: conventional literal, NM: novel metaphor, NL: novel literal expressions. All conventional and novel literal word pairs were processed more accurately, and all word pairs faster in the RVF–LH. NMs were processed just as fast as NLs, while CMs were processed slower than CLs.

this effect. CL word pairs were processed faster than CMs, but NMs did not need more processing time than NLs. We present the results of the F1 analyses in Fig. 1.

4. Discussion

The goal of the present study was to clarify the RH′s role in the comprehension of novel expressions, especially novel metaphors. In order to separate the effects of figurativeness and novelty, we introduced an experimental condition in which we presented novel literal word pairs. In contrast to most DVF experiments on figurative language (except when ERPs are recorded), we ensured lateralized presentation by using an eye-tracker. Additionally, we controlled for a number of factors that could activate the RH and act as confounds. We presented stimuli without context, and in the statistical analysis we included emotional valence, arousal, imageability, and meaningfulness as covariates.

4.1. Novel expressions

The LVF–RH processing advantage for two word novel metaphorical expressions was not evident in our results, either in response accuracy or reaction times, which we attribute to our careful control for potential confounds. Thus, our findings do not support the RH theory of metaphor processing. This observation is in line with earlier studies that did not identify RH processes during NM comprehension (Faust & Weisper, 2000; Mashal & Faust, 2010; Mashal et al., 2009; Shibata, Abe, Terao, & Miyamoto, 2007), although these research groups presented metaphors in sentences that could have affected their results. We presented novel metaphors without context, similarly to experimenters who used word pairs only (e.g., Anaki et al., 1998; Faust & Mashal, 2007; Mashal & Faust, 2008; Mashal et al., 2005, 2007; Pobric et al., 2008). The latter studies reported RH involvement that contradicts our findings. A possible resolution lies in the fact that we controlled for potential confounds such as imageability, emotional valence, and arousal. It is possible that novel metaphors, especially those taken from poetry (e.g., Faust & Mashal, 2007), differed from literal expressions in ways beyond those related to metaphoric value or novelty. Poetic effects often evoke pragmatic processes that are known to require RH resources (e.g., Pléh, 2000; Van Lancker, 1997). Our controlling for the aforementioned factors could explain why we did not replicate the previously reported LVF–RH processing advantage.

The finding that novel literals were processed more accurately, and that all novel word pairs were processed faster in the RVF–LH was not predicted by the graded salience hypothesis (Giora, 2003)

or by the first version of the coarse semantic coding theory (Beeman, 1998); however, the BAIS framework (Jung-Beeman, 2005) can provide an explanation. According to this model there are two kinds of semantic activations, integrations, and selections: a finely coded one, and a coarsely coded one. The various sub-processes of language comprehension can tax either of the two hemispheres depending on the specific task. Selecting a relevant meaning, or integrating the word pairs into novel meaningful expressions could have required fine coding, even though they were not related semantically. Forgács et al. (2012) found that literal and metaphorical novel noun–noun compound words activated the LIFG. The inhibition of irrelevant, and the selection of appropriate senses seem to be LH weighted tasks, especially when conditions encourage strategic and post-access processing (Chiarello, 1988, 1991; Chiarello, Senehi, & Nuding, 1987). Alternatively, semantic integration of lexical items might be primarily a LH procedure (while contextual integration still could be carried out by the RH). Importantly, the paradigmatic summation priming task in the experiment of Beeman et al. (1994) did not require the integration of words into novel units. In that experiment subjects read three prime words ("foot", "cry", "glass"), each distantly related to the target word ("cut") that had to be named following lateralized presentation. Furthermore, priming studies show that RH activations could be explained solely by spreading activation, but the LH dominance in semantic processing is not merely the result of automatic activation or focused lexical access (Chiarello et al., 1987). When one′s task is to arrive at coherence, rather than predictive inferences, the LH clearly shows a priming advantage (Beeman, Bowden, & Gernsbacher, 2000).

The comparable reaction times for NMs and NLs indicate that contrary to predictions of the graded salience hypothesis, there was no serial processing of salience. If the salient (i.e. literal) meaning of a NM had been processed first, and the non-salient figurative meaning inferred only afterwards (Giora, 1997, 1999, 2003), NMs should have taken longer to process than NLs. Even though the graded salience hypothesis proposes that unlike conventional expressions, novel expressions have no salient meaning, it is not clear why NLs required as much processing time as NMs. Does any kind of salient (literal) meaning have to be dropped in order to reach another, non-salient (but again literal) meaning? Thus, a saliency based explanation seems unsupported by our results. A more plausible explanation is that the meaning of novel expressions is not computed serially, but instead it is directly accessible once a semantic analysis has taken place. After the possible meanings of the constituents are activated, the most plausible candidates are selected, and then integrated. The processing of potential meanings seems to be carried out directly both

for literal and metaphorical expressions. Blasko & Connine (1993) provided evidence that figurative meaning could be quickly available for apt NMs.

Similarly, the career of metaphor hypothesis (Bowdle & Gentner, 2005), as much as it can be generalized from nominal metaphors, proposes that NMs are processed serially. They should be comprehended as a comparison only after a failed categorization attempt (that is evoked by their grammatical concordance with literal comparisons). Since NLs do not require this extra step, NMs are expected to take longer to process. This was not apparent in our experiment, thus the theory is not supported by our results. Glucksberg (2003) proposes in his category assertion view that even novel (nominal) metaphors are comprehended via a categorization. Metaphorical terms are understood because they have a dual reference to a literal subordinate, and to a figurative ad hoc superordinate category, both of which are available. Whether or not this is the case, our results do not contradict his theory. During the processing course of novel expressions probably several potential meanings are activated and a figurative or a literal meaning is equally accessible, within a comparable time.

4.2. Conventional expressions

In line with the graded salience hypothesis (Giora, 2003) all conventional items were processed faster and more accurately in the RVF–LH than in the LVF–RH (although accuracy was modulated by meaningfulness, the RVF–LH advantage was consistent). Fixed expressions may be stored as lexical units, and it could be easier for the LH to retrieve and evaluate them.

Irrespective of lateralized processing, we found that CMs were processed slower and less accurately than CLs (the slower reaction times to metaphors appeared to be influenced by their lower imageability, and the lower accuracy by their lower meaningfulness). This is an important result, since the graded salience hypothesis (Giora, 2003) predicts no processing difference between conventional items in terms of figurativeness. Since we did not find evidence for serial processing of NMs, the processing delay is unlikely to indicate serial processing of CMs either. However, compared to CLs, CMs have not one, but two possible meanings, a literal and a figurative, both of which could be readily available. This dual activation is predicted by both the parallel access view (Gibbs, 1994) and the graded salience hypothesis (Giora, 2003). Contrary to novel expressions, the figurative and literal meanings are not just directly accessible, but both of them are accessed – and both of them are accessed faster than the meaning of any kind of novel expression. The activation of two possible meanings could explain the overall slower processing time, since one of them has to be selected. Semantic selection is probably taking place primarily in the LH (Burgess & Simpson, 1988), imposing extra processing load on that hemisphere. Forgács et al. (2012) found that conventional metaphors (relative to conventional literal expressions) activated the LIFG; the BAIS framework (Jung-Beeman, 2005) suggests that this area is responsible for fine-coded selection. Based on our results Gibbs' (1994) parallel access view could be extended to CMs not presented in a supportive context. The modulating effect of the closely related imageability and meaningfulness is an issue that should be explored in future studies, even though it might be an inherent feature of metaphorical language. Most metaphors refer to abstract concepts, which are more difficult to experience with the senses, thus are less imageable – and as a consequence less meaningful. Across all categories of word pairs the latter two factors correlated strongly: $r(288) = -.77$, $p < .001$.

4.3. Conclusions

In the present divided visual field study we employed an eye-tracker to ensure hemifield presentation of adjective-noun word pairs, without sentential context, to study the lateralized processing of novel metaphors. With our experiment we attempted to both replicate that of Faust and Mashal (2007) and, at the same time, extend it by an additional condition of novel literal expressions. With the new condition we controlled for processing novelty, and with including in the statistical analysis a number of potentially confounding variables (such as emotional valence, arousal, imageability, and meaningfulness) we were able to control for their influence on RH processing.

With this design, we found that all categories of word pairs were processed faster in the RVF–LH, and accuracy was also higher in the RVF–LH. Our results contradict studies in which researchers argued for a LVF–RH processing advantage for novel metaphors, and raise the possibility that other uncontrolled variables were responsible for previous results. Reaction times data indicated that the degree of lateralization of processing is influenced by how arousing the expressions are – even though only CLs and NMs were significantly different. Controlling for emotional factors, such as arousal, might be crucial for future studies examining hemispheric differences in figurative language comprehension. Responses to novel word pairs were faster in the RVF–LH, and were slower than those for conventional expressions, which together suggest that primarily a left hemisphere weighted semantic integration is responsible for their processing costs. The lack of reaction time differences between novel metaphors and novel literal expressions call into question the theories that posit a serial processing, either of salience (Giora, 1997, 1999), or as a consequence of a failed categorization attempt (Bowdle & Gentner, 2005). Both conventional categories of word pairs were processed faster and more accurately in the RVF–LH, while conventional metaphors were processed slower than conventional literal expressions, perhaps as a result of a parallel access to their literal and figurative senses. The results highlight the task sensitivity of the division of labor for language comprehension between the two cerebral hemispheres, and indicate that the role of the RH might not be as specific to metaphors, or even to non-salient language, as it has been proposed. Previous studies could have reported pragmatic effects stemming from the experimental situation and task. Further empirical studies are required to elucidate the language specific processes of the RH.

Acknowledgments

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7.3 Study 3: Verbal metacommunication – Why a metaphorical mapping can be relevant?

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Szemle

VERBÁLIS METAKOMMUNIKÁCIÓ – MITŐL RELEVÁNS EGY METAFORIKUS LEKÉPEZÉS?

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Az egymásnak látszólag ellentmondó kognitív metaforaelmélet és a relevanciaelmélet nemcsak kiegészíthetik egymást, de találkozási pontjaik érdekes elemzési lehetőségeket nyújtanak. Egy szigorúbb és egy lazább elemzési példán keresztül tekintem át azokat a területeket, ahol az elméleteknek tartalmi összefüggése lehet. Egyrészt a fogalmi metaforák az absztrakt fogalmak megértését konkrét forrástartományok bevonása révén segítik, amivel hozzájárulhatnak az optimális relevancia létrehozásához. Ez túlmutat a relevanciaelmélet által nekik szánt szerepen, amely szerint csupán a laza nyelvhasználat költői eszközei lennének. Lehetséges, hogy a fogalmi leképezések nem elhanyagolható szerepet játszanak kognitív környezetünkben. A második elemzésben a metaforák metakommunikatív értékére próbálok rámutatni, ami a relevanciaelmélet kiegészítését eredményezheti. Az indirekt beszéd virágnyelve egy olyan metaforikus réteget jelenthet a nyelvben, amelynek a szemantika szintjén is metakommunikációs értéke lehet.

Kulcsszavak: *kognitív metaforaelmélet, relevanciaelmélet, metakommunikáció, pragmatika, konkrét, absztrakt*

BEVEZETŐ

A metafora, ez a különleges nyelvi eszköz, nagyjából 150 évvel ezelőtt keltette föl a nyelvészek érdeklődését, ám a modern nyelvészet hozzávetőleg harminc éve kezdett el intenzívebben foglalkozni vele. Ugyanakkor a kognitív nyelvészetet meghatározó *relevanciaelmélet* (SPERBER, WILSON, 1995) egészen eltérő álláspontot fogalmaz meg a metaforákkal kapcsolatban, mint a *kognitív metaforaelmélet* (LAKOFF, JOHNSON, 1980a), amely a metaforákat a fogalmi gondolkodás középpontjába helyezi.

A két elmélet között feszülő ellentétek a legtöbb nyelvész számára feloldhatatlannak tűnnek, de TENDAHL és GIBBS (2008) cikkükben amellett érvelnek, hogy a két felfogásra úgy is tekinthetünk, mint amelyek kiegészítik egymást. Noha az elméletek a metaforákat alapvetően eltérően ítélik meg, számos ponton nem mondanak ellent egymásnak, és több kérdést illetően az egyik ott kezdi az érvelést, ahol a másik abbahagyja. A legfontosabb részek áttekintését követően (és azok alapján) megpróbálok olyan további kapcsolódási felületeket keresni a metaforák és a relevanciaelmélet között, amelyek a kognitív metaforaelmélettel is összhangban vannak.

A relevanciaelmélet szerint mindig az adott kognitív környezet határozza meg, hogy a jelek pontosan mire is utalnak (például akkor, amikor a szökni próbáló rabok, anélkül, hogy meg tudták volna beszélni előre, tudják, hogy mit kell tenniük a mögöttük sétáló őrrel, ha a megfelelő pillanatban az egyikőjük füttyent; SPERBER, WILSON, 1995). Azonban ahhoz, hogy az adott helyzetnek megfelelő jelentésréteget nyilvánvalóvá tegyük, konkrétnak kell lennünk – éppen annyira, hogy megértessük magunkat hallgatóságunkkal.

A kognitív metaforaelmélet szerint a metaforák úgy szervezik gondolkodásunkat, hogy az elvont fogalmakat konkrétabb fogalmak rávetítésével értjük meg, ezért *a metaforák segítségével tulajdonképpen hatékonyan nyílttá és nyilvánvalóvá tehetjük mondanivalónk lényegét*. A hétköznapi beszédben gyakran előfordul, hogy egy gondolatot egy másikkal helyettesítünk, vagyis áttételesen fejezzük ki magunkat (például azt, hogy „bevásárolok", kifejezhetjük úgy, hogy „leugrom a boltba"). A metaforák is hasonlóan működnek, de a leképezések rendszere hatékony támpontokat biztosíthat a releváns vonatkozások megfejtésében: ezzel a nyelvi eszközzel „lóugrásban" haladhatunk a beszélgetések releváns információi felé (hiszen valójában senki sem „ugrik" a boltba).

A metaforák továbbá nagyban megkönnyíthetik az absztrakt fogalmak használatát, mert nélkülük lehetséges, hogy nem tudnánk megfelelően kötni a szavakat, illetve elvont jelentésüket az adott kontextushoz, így sokkal nehezebb lenne megtalálni a pillanatnyi relevanciájukat. Ez a kérdés a mentális és a nyilvános lexikon közti átfedés kérdésköréhez kapcsolódik, hiszen például a szinonimák azonos vagy legalábbis nagyon hasonló fogalmakra utalnak, miközben a több jelentéssel bíró szavak eltérő fogalmakhoz kapcsolódnak, és így nem valószínű, hogy egy az egyhez lenne a megfeleltetés a fogalmak és a szavak között (SPERBER, WILSON, 1998).

A metaforaelmélet egy másik úton is hozzájárulhat a beszélgetések relevanciájához. A lényeges mozzanatokra rámutató (osztenzív) jegyeket a metakommunikáció is hordozza (például a hangsúlyozásban), ám a metaforák révén a metakommunikáció *nyelvi réteg*ét érhetjük tetten, mivel az elsődleges metaforák (GRADY, 1997) fiziológiai és gyermekkori élményekre utaló forrástartományai, amelyek rejtetten átszövik a beszédet, folyamatosan közvetítenek egyfajta mélyebb, szenzomotoros jelentésrétegről is. A metaforák metakommunikációs háttérjelentése tudattalanul (is) folyamatosan tudósít a beszélő számára a releváns mozzanatokról. Lényegét tekintve ez az értelmezés közel áll FÓNAGY Iván (1974) kettős kódolás koncepciójához, mely szerint a beszéd önkényes kódrendszerét egy archaikus, természetes kód egészíti ki, amely a jelek és a jelenségek közötti „szimptoma-

tikus" vagy „szimbolikus" kapcsolatokat is hordozza. Az elsődleges metaforák esetében a természetes kódot a szenzomotoros élmények hordozzák.

Ide kapcsolódik a *kétértelmű beszéd* (PINKER, 2007), amely gyakran metaforák segítségével jön létre: a metaforák virágnyelve egy olyan nyelvi réteget biztosít, ahol a kétértelműség hátterén egyértelműen ki lehet fejezni a releváns információkat (például a vágyakat) anélkül, hogy el kéne hagyni a semlegesség biztonságos terepét. A metaforákkal osztenzív jegyek nyílt kommunikációjára van lehetőség, miközben forma szerint nem hangzik el semmi különös. Ilyen kifejezés például a „mélyebben megismerkedtek egymással".

A KOGNITÍV METAFORAELMÉLET ÉS A RELEVANCIA

LAKOFF és JOHNSON (1980b) kognitív metaforaelméletének lényege, hogy a metaforák nem csak észrevétlenül hatják át mindennapi beszédünket, hanem fogalmi rendszerünk is metaforikus szerveződésű. A *fogalmi metaforák* egy konkrétabb forrástartomány elemeit szisztematikus leképezések rendszerében vetítik rá az általában elvontabb céltartományra. A fogalmi metaforák (például AZ ELMÉLE-TEK – ÉPÜLETEK) olyan *metaforikus nyelvi kifejezésekben* nyilvánulnak meg, mint a „szilárd alapokon nyugszik az érvelés" (KÖVECSES, 2005). Amint eltávolodunk a konkrét fizikai tapasztalatoktól, és absztrakciókról vagy érzelmekről kezdünk beszélni, metaforikus nyelvi terepre érkezünk (LAKOFF, 1992). Az egyébként „üres", absztrakt fogalmakat metaforák segítségével fogjuk fel: ezeket általában elvontságuk miatt nehéz szó szerint kommunikálni, sőt, bizonyos helyzetekben talán egyáltalán nem is lehet. Például elég nehéz akár csak beszélni is elméletekről, ha nem szeretnénk használni AZ ELMÉLETEK – ÉPÜLETEK fogalmi metaforát.

A metaforákat többféleképpen szokták csoportosítani. GRADY (1997) felosztása szerint az *elsődleges metaforák* úgy jönnek létre, hogy bizonyos szenzomotoros élmények nem szenzomotoros élményekkel kapcsolódnak össze (például A DÜH – EGY FORRÓ FOLYADÉK). Ezek kombinációiból állnak össze a *komplex metaforák*, amelyek motivációs háttere már nem nyilvánvaló (például A CÉGEK – NÖVÉ-NYEK), de ha elsődleges metaforákra bonthatjuk őket, akkor könnyen megállapítható. A különböző tudásterületek *tapasztalati gestalt*ok sémáiban kapcsolódnak össze (LAKOFF, JOHNSON, 1980a), tehát egységes megtapasztalásuk miatt jönnek létre az összeköttetések a távolabbi fogalmak között.

Az *elsődleges metaforák integrált elmélete* szerint (LAKOFF, JOHNSON, 1999) elképzelhető, hogy nemcsak hasonló élmények, hanem azonos agyterületek aktiválódnak, amikor szenzomotoros élmények vetülnek absztrakt fogalmakra. Az elsődleges metaforák két terület *párhuzamos neurális aktiváció*ja révén jönnek létre, amit kísérletek is igazolni látszanak (ROHRER, 2005).

Relevanciaelmélet és metafora

A relevanciaelmélet (SPERBER, WILSON, 1995) lényege, hogy az emberi kommunikáció a relevancia maximalizálására törekszik. A relevancia kommunikatív elve az, hogy minden kijelentés figyelmet von magára, ami saját relevanciáját előlegezi meg a hallgató számára. A relevanciaelmélet szakít a jelelmélet klasszikus és újabb formáival is: a Grice-féle közös tudás helyett a kognitív környezetre helyezi a hangsúlyt, amelyben a beszélő rámutató (osztenzív) viselkedésével nyílttá (manifesztté) teszi kommunikációs szándékát, hogy ezzel tájékoztassa hallgatóságát kijelentése tartalmáról (vagyis saját mentális állapotáról). Ebben a helyzetben két vezérlőelv működik: a *kognitív hatás* maximalizálása és a *kognitív erőfeszítés* minimalizálása, amelyeket erősen meghatároz a kognitív környezet. Kognitív hatást új információ, vagyis egy korábbi feltételezés megerősítése vagy egy meglévő feltételezés cáfolata révén érhetünk el. Minél nagyobb a hatás és minél kisebb az erőfeszítés, annál relevánsabb a kijelentés.

A beszédben ez két lépésben valósul meg: először az adott kijelentés logikai formájának kidolgozása történik meg (morfológia, szemantika, szintaxis), ami egy nem propozicionális vázat hoz létre. A propozícióhoz már szükség van a relevanciára: az adott kognitív környezetben elhangzó kijelentés alapján egyrészt *explikatúrák*at dolgozunk ki (mik következnek az adott kijelentésből – például abból, hogy „hideg van itt", az következhet, hogy nyitva van az ablak) másrészt *implikatúrák*at hozunk létre (vagyis miket foglal magában a kijelentés – például azt, hogy be kéne csukni az ablakot). Ezek a *jelentés* tulajdonképpeni hordozói. A két lépés a gyakorlatban valós időben, párhuzamosan megy végbe, elvárások és hipotézisek alapján (TENDAHL, GIBBS, 2008).

A relevanciaelmélet szerint a metaforák egyáltalán nem foglalnak el különleges helyet sem a hétköznapi beszédben, sem a gondolkodásban. A metafora mindöszsze egyike a „költői hatáskeltés" eszközeinek, melyek révén olyan *laza nyelvhasználat*ra nyílik mód (a beszélő nem szigorúan az „igazságot" mondja), amely optimalizálja a kijelentések relevanciáját. A laza nyelvhasználat gyenge implikatúrákkal jár, amely utóbbi azt fejezi ki, hogy a hallgató nem lehet egészen biztos abban, hogy mire is utalt a beszélő. Ez aztán több kognitív erőfeszítéshez vezet, ami viszont cserébe nagyobb kognitív hatással jár, és így jön létre a költői hatás – a relevancia optimalizálása mellett.

A laza nyelvhasználat pontosabb meghatározásához szükség van a leíró („descriptive") és a magyarázó („interpretive") reprezentációk megkülönböztetésére. Minden reprezentáció, amely állít valamit, vagy *1.* leírja az (akár hipotetikus) állapotokat, vagy *2.* egy másik állítást magyaráz. A kapcsolat egy állítás és a beszélő fejében lévő gondolat között minden esetben pusztán magyarázó jellegű. Tehát a hallgató mindig valamilyen magyarázó feltételezést dolgoz ki a beszélő információközlési szándékáról. Továbbá maga a kijelentés sem teljesen azonos a beszélő gondolataival; gyakran nem is lehetséges szó szerinti kifejezést találni egy-egy öszszetett gondolatunkhoz, ezért beszélünk lazán. A relevanciaelmélet szerint a kettő teljes egyezése és a kettő egészen kicsi átfedése egy kontinuumot alkot. A metafora is valahol ezen helyezkedik el, és ezért nincs lényegi különbség a metaforikus és

a nem metaforikus kijelentések feldolgozása között: a hallgatók sosem veszik úgy, hogy teljesen szó szerint érti a beszélő azt, amit mond. Az optimális relevancia érdekében lazán beszélünk, és ezért a hallgatók sem várnak szó szerinti kijelentéseket, sőt a metaforikus kijelentések gyakran relevánsabbak, mint a szó szerintiek (TENDAHL, GIBBS, 2008). Ezek szerint, noha nem metaforikus az a kijelentés, hogy „a terem üres", általában mégsem szó szerint értelmezzük, mert bútorok is lehetnek benne, és a mozitól az iskoláig sok mindenre utalhat.

A metaforák laza használatát CARSTON (2002) pontosította, *ad hoc fogalmakra* vonatkozó elméletében, amely szerint ezeket online hozzuk létre, a lexikai fogalmak lazításával (enciklopédiai és lexikai részeik visszatartásával denotációjuk növelése, például „Géza egy zsiráf"), illetve szűkítésével (megszorító információk hozzáadásával denotációjuk csökkentése, például „Géza rugalmatlan"). Ezáltal jön létre a metaforák explikatúrája. Például a „Robi egy buldózer" kifejezésben a „buldózer" fogalmat addig lehet tágítani, hogy ember is lehet belőle. Tulajdonképpen csak a szigorúan szó szerinti kifejezések nem alkalmazzák a fogalmak szűkítését vagy tágítását.

A metaforákról alkotott elméletek keresztmetszete

A kognitív metafora- és a relevanciaelmélet radikálisan eltérő szemléletmódja ellenére TENDAHL és GIBBS (2008) szerint a két szemlélet megfér egymás mellett sőt, ki is egészítik egymást. A különbségek abból fakadhatnak, hogy a kognitív metaforaelmélet kutatói általában a nyelvbe már beépült metaforákra, implicitté vált forrástartományaikra és egyfajta fogalmi-reprezentációs szintre koncentrálnak, míg a relevanciaelmélet kapcsán általában a hasonlóságon alapuló, újszerű metaforákkal foglalkoznak (például ezért nem kapunk magyarázatot tőlük arra, hogy miért használunk bizonyos bejáratott, konvencionális metaforákat). Tehát a „fogalmak és kifejezések" és a „kommunikáció és kontextus" értelmezési szintek olykor jelentős, de inkább csak látszólagos ellentéteket hozhatnak létre.

Fontos kérdés, hogy a metaforának mi a kontextuális hatása – pontosan hogyan is járulnak hozzá az optimális relevancia eléréséhez. Általánosságban a beszélgetésekben felbukkanó metaforák a relevancia elővételezését segítik, ezzel teszik gördülékenyebbé a kommunikációt: „A fogalmi metaforák készletét, amit metaforikus kijelentések értelmezése során hívunk elő, a kognitív környezet meghatározó részének tekinthetjük, amely erősen manifesztté válik, ha bizonyos kulcsszavak előhívják" (TENDAHL, GIBBS, 2008, 1840).

SPERBER és WILSON (1998) a relevanciaelmélet kapcsán a fogalmi rendszerről is kifejtik álláspontjukat, amely szerint szóprototípusok helyett mindig csak ad hoc jelentéseket konstruálunk, amiket a rendelkezésre álló szavak segítségével próbálunk kifejezni. Ezért viszonylag laza a megfeleltetés a mentális és köznyelvi lexikon között, és ezért van sokkal több fogalmunk, mint szavunk. Sok személyes fogalmat ismerhetünk (lehetnek olyan érzeteink, amelyekre többször ráismerünk, mondjuk egy bizonyos fájdalom), még sincs mindre külön szavunk. Ez az elgondolás értékes információkkal szolgál az újszerű metaforák megalkotásáról, de

ellentmond a konvencionális fogalmi metaforák puszta létének, ahol a fogalmi leképezések már rögzültek a nyelvben. Az újszerű metaforák esetében egy bizonyos fogalmat, gyakran hasonlósági alapon, egy másikkal helyettesítünk, de rajtunk múlik az, hogy pontosan mivel. Például azt, hogy „jól megy az üzlet", mondhatjuk úgy is, hogy „virágzik a kereskedelem", de kereshetünk más kifejezést is.

Tehát egy elvont fogalmat a helyzetnek megfelelően több konkrét fogalommal is kifejezhetünk. A konvencionális metaforák esetében ezek az eleinte ad hoc kifejezések már rögzültek, így egy kisebb gondolatmenetet is magukban foglalhatnak (például a „leugrom a boltba" azt fejezi ki, hogy csak nagyon rövid időre, és csak a boltba megyek). Ez utóbbi az implikatúrával van kapcsolatban, és inkább a pragmatikáról szól, miközben az, hogy a „leugrom" szó több értelmet kaphat, inkább a fogalmakról szól, ami ezt a vonatkozást az explikatúrához kapcsolja.

Összefoglalva: a metaforák tulajdonképpen kis rövidítésekként működnek a nyelvben: egy-egy szó kerül kisebb gondolatmenetek helyére, kiemelve a helyzetben leginkább releváns vonatkozását. A denotáció szűkítése és lazítása révén az implikatúrák mellett explikatúrák is megjelennek, és a laza nyelvhasználat révén – amennyiben a hallgató megértette a metaforát – optimalizálódik a relevancia, mert nagyon pontos és aktuális jelentést kaphat az adott állítás, egy viszonylag rövid kifejezés révén.

KONKRÉTSÁGRA TÖREKVÉS

A fentiek alapján elképzelhető, hogy a kognitív metaforaelmélet szorosabban is összekapcsolható a relevanciaelmélettel, mert a fogalmi leképezések működését magyarázó elmélet fontos célt szolgál a nyelvben: *a mondanivaló konkretizálás*át. A fogalmi metaforák absztrakt céltartományaikat konkrét forrástartományok révén képezik le, így gyakorlatilag konkrét mozzanatokkal helyettesítik be a mondanivaló absztrakt, nehezen értelmezhető részét. A relevancia érdekében a hallgató a helyzetnek megfelelően, konkrétan igyekszik értelmezni a mondottakat, ezért a beszélő is konkrétan próbálja kifejezni magát – tehát igyekszik leszűkíteni az explikatúrákat. Tulajdonképpen ehhez kellenek a metaforák, ezért alkalmazzuk őket, így válik átláthatóvá a mondanivaló (A MEGÉRTÉS – LÁTÁS).

Ráadásul bizonyos fogalmakról rendkívül nehéz másként gondolkodni, mint metaforák segítségével: mit tudunk mondani az elméletekről, ha megpróbáljuk kikerülni AZ ELMÉLETEK – ÉPÜLETEK fogalmi metaforát? Ez ma már fogalmi rendszerünk része, értelmezésünk nehézkes nélküle, de amikor még újszerű metafora volt, valójában a konkretizálást segítette. Ez a szerepe persze ma is nyilvánvaló, hiszen a hétköznapi beszédben sem úgy működik, hogy az elméleteknek az „épület jellege" lenne lényeges, hanem „megalapozottsága" vagy „felépítése". *A relevancia adja meg, hogy mit képezünk le a forrástartományból, és hogy a céltartomány mely részére képezzük le azt.* Éppen ezért a konvencionális metaforákat csak a kontextus adekvát helyein használhatjuk, máshol nem. A metaforák konkrét forrástartományai, illetve képi nyelve gyorsítja a kommunikációt, ezért könnyű elképzelni őket – és éppen ezért válnak idővel konvencionális szókapcsolatokká, vagy akár szó-

lásmondásokká. Az elvont mondatokba behelyettesített konkrét fogalmak a céltartomány relevanciáját adják meg, illetve emelik ki.

A metaforikus leképezések nem pusztán a kontextuális feltételezésekhez történő hozzáférést módosítják (és ezáltal az erőfeszítést, ami a metafora interpretációjának feldolgozásához szükséges), hanem a leképezések felelősek a *kapcsolat*ért a pszichológiai (elvont) és fizikai (konkrét) jelentésréteg között (TENDAHL, GIBBS, 2008).

Az állítások önmagukban teljesen absztraktak lehetnek (ezért lehet olyan sok vita például a szent szövegek értelmezése körül, lásd SPERBER, WILSON, 1998), de az adott kognitív környezet, illetve a konkrét példák, hasonlatok (és persze metaforák) az optimális relevancia szintjére szűkítik le az explikatúrákat. Egy metaforikus kifejezés egyaránt lehet az explikatúra vagy az implikatúra része, ezt a kontextus dönti el, illetve az, hogy inkább a kognitív erőfeszítésen vagy a kognitív hatáson van a hangsúly az adott állításnál – mi visz közelebb az azt megelőző állítás relevanciájához.

Mivel a metaforákban szereplő kifejezéseknek van egy nem metaforikus értelme is, kérdés, hogyan tudja kiválasztani a hallgató a relevanciának megfelelő jelentést online. A hagyományos megközelítések szerint, a szóval együtt asszociációs hálója is azonnal aktiválódik, tehát a metaforák is egyből kézre állnak. Ennek ellentmondani látszik, hogy bizonyos szavaknak – asszociációk nélkül is – akár 100 vonatkozása is lehet, és így nehéz megmagyarázni a feldolgozás gyorsaságát. TENDAHL és GIBBS (2008) szerint még azt sem zárhatjuk ki, hogy semmilyen hálózat sem aktiválódik. Eszerint a „látom" szó esetében nem számítana, hogy konkrétan látok valamit, vagy elvontan. Ennek nem mond ellent ROHRER (2005) kutatása, amely szerint a leképezések valóban működnek neurális szinten is. A GONDOLATOK (KÉZZEL MEGFOGHATÓ) TÁRGYAK metaforát (például „nehéz megragadni a lényeget") EEG-vel és ʃMRI-vel is vizsgálta, és azt találták, hogy a kezekkel kapcsolatos metaforikus és a szó szerinti mondatok olvasása közben egyaránt sok olyan szenzomotoros terület aktiválódott, amely a kéz taktilis ingerlése során szokott. Tehát a különböző értelemben használt szavak esetében ugyanaz a reprezentáció aktiválódhatott.

GIBBS (1994) szerint a metaforákat online dolgozzuk fel, így a metaforikus kifejezések megértése során egyből a fogalmi metaforára asszociálunk, és valószínűleg nem kell lépésenként leképeznünk a metaforikus kifejezést ahhoz, hogy megértsük. Ezt POBRIC, MASHAL és munkatársai (2008) vizsgálata is megerősítheti, amely szerint a jobb oldali Wernicke homológ agyterület transzkraniális mágneses zavarása jelentősen lelassítja az újszerű metaforák feldolgozását, miközben a konvencionális metaforák feldolgozását ez nem befolyásolja, ami arra utal, hogy ez utóbbiak már beépültek kifejezéseink közé. Vagyis ez a terület a *metaforikus értelmezés*ben játszhat szerepet: egyfajta „metaforakapcsolóként" más dimenzióba helyezi az adott szót és így nincs feltétlenül szükség arra, hogy létrehozzuk a teljes leképezést egy-egy kiemelkedő vonatkozás megértése érdekében. Tehát nem kell egy minden jellemzőre kiterjedő megfeleltetési rendszert létrehoznunk ahhoz, hogy megértsük az újszerű metaforákat, lehet, hogy elég csak az adott metaforikus kifejezés által kiemelt, leglényegesebb jellegzetességet rávetítenünk a céltartományra.

TENDAHL és GIBBS (2008) javaslata a kétértelműség feloldására a következő: a kognitív metaforaelmélet a fogalmi terek megalkotásáért, a relevanciaelmélet pedig a megfelelő jelentés kiválasztásáért felelős. Tehát a kétértelmű szavak szándékolt jelentése lehetséges, hogy közvetlenül hozzáférhető, ha a megfelelő kognitív környezetben találkozunk vele. Az adott szó olyan fogalmi térre is mutathat, ahol több értelmezési lehetőség található, és ha a kapcsolódás a szó és a kifejezni kívánt fogalom között nincs szigorúan meghatározva, akkor egy metafora vezethet el a szó megfelelő értelmezéséhez.

Mit nyújthat a kognitív metaforaelmélet a relevanciaelméletnek?

A fentiek alapján, egy értelmezési vagy gondolatkísérletként, megfordíthatjuk a relevanciaelmélet azon állítását, hogy a metaforák csak a laza nyelvhasználat egyik esetét képviselik (és önálló elméletre sincs szükség az értelmezésükhöz), és tekinthetjük úgy a laza nyelvhasználatot, mint a *metaforikus gondolkodás* terepét. Bizonyos értelemben a jel-jelentés megfeleltetés is metaforikus: a jeleknek lehet egy közvetlen jelentése, de a relevanciaelmélet szerint valójában mindig lokálisan, a kognitív környezetben születik meg a tartalmuk, tehát gyakran valami másra utalnak, mint elsődleges lexikai jelentésük – az adott helyzetnek megfelelően annál konkrétabbak. Így lehetséges, hogy a metaforikus és metonimikus fordulatok és a metaforikus értelmezés rendkívül gyakori. Természetesen ez szélsőséges álláspont lenne, és a „metaforikus" az „elvont" szóval hasonló értelemben jelennek meg. De a relevanciaelmélet keretei között, a fogalmi szinten működő ad hoc jelentésmegfeleltetésnek egy ilyen értelmezése is elképzelhető. Ennél azonban valószínűbb, hogy a két elmélet inkább kiegészíti egymást, és a jel--jelentés megfeleltetések egy fokozatos átmenetben távolodnak egymástól: bizonyos jelek jelentése minden körülmény között egyértelmű (például a tulajdonnevek), a tárgyak nevei már rugalmasabban használhatóak, és a kontinuum másik vége felé találnánk az igéket, és még távolabb azokat az elvont fogalmakat, amelyek a legrugalmasabban kaphatnak különböző jelentéseket. Mivel a kognitív környezet fogalma igen tág, valószínűleg szükség van egyfajta szimbólumlehorgonyzásra (HERNÁD, 1996), hogy valamilyen jelentéshez *képest* lehessen értelmezni a kijelentéseket, hogy ne mindig helyzetről helyzetre kelljen kitalálni a szavakat illetve a jeleket (még akkor se, ha a relevanciaelmélet ezt lehetővé teszi, például a füttyentő rabok esetében).

A kognitív metaforaelmélet ezzel a fogalomlehorgonyzással járulhat hozzá a relevanciaelmélethez, ami túlmutat a kognitív környezet mindig aktuális világán, de nem teszi szükségessé a jelelmélet „közös tudás" gondolatmenetét. Ez a szint az alapmetaforák forrástartománya, a fiziológiai/szenzomotoros szint, amely egyszerre univerzális és szubjektív is. Ha a jelek akár egy viszonylag szűk köre egyértelműen és közvetlenül van kötve a környezet bizonyos tulajdonságaihoz (például színnevek), akkor a hozzájuk kapcsolódó jeleknek vagy ezek kombinációinak (például színekkel kifejezett érzelmeknél: „sárga az irigységtől", „vörös a dühtől") referenciája már lazulhat. Ezáltal a legtöbb szót könnyedén lehet laza beszéd-

móddal használni a relevanciaoptimalizálás érdekében, és mégis megmarad egy olyan fogalmi réteg, amely a jelek használatát viszonylag lehatárolja, vagy legalábbis lehetőséget biztosít a bizonytalanságok feloldására.

Kontextusfüggetlenség és környezetfüggőség

Elképzelhető, hogy a jelek lehorgonyzása csak a beszéd elsajátítása során ilyen közvetlen, és később könnyen állhatnak a jelek szinte bármilyen fogalom helyett. Azonban éppen a beszédtanulás időszaka az, amikor az osztenzív kommunikáció meghatározóvá válik a csecsemők számára. GERGELY és CSIBRA (2006) természetes pedagógiai elmélete az osztenzív-referenciális kommunikációs jegyeket emeli ki a pedagógiai tanulás-hozzáállás kiváltásában, ami a kultúra- és minden bizonnyal a nyelvtanulás alapja is. Ezt a folyamatot nagyobb nehézségek nélkül össze lehet kapcsolni a relevanciaelmélettel: kora gyermekkorban a kulturális és nyelvi relevanciát az osztenzív jelek adják meg, többek között a dajkabeszéd révén.

A nyelvet még nem ismerő kisgyerekek és gondozójuk kognitív környezetében a szóhasználat annál könnyebben ér célt, minél kevésbé laza. Eleinte mindenképpen nagyon laza lesz a jelentésmegfeleltetés, a pontos elsajátításhoz ezt először szűkíteni kell, és csak a biztos használat teszi lehetővé az ismételt laza használatot később. Feltehetően ennek következménye, hogy a gyerekek könnyebben tanulják meg a főneveket, mint az igéket, és az absztrakt fogalmak még később jelennek meg (HARLEY, 2001). Idekapcsolódik TENDAHL és GIBBS (2008) érdekes felvetése, hogy bizonyos metaforák előbb működhetnek, mint maguk az absztrakt fogalmak. Például A TUDÁS – LÁTÁS fogalmi metafora lehet, hogy korábban használható a gyerekek számára, mint önmagában a „tudás" fogalma. Tehát elképzelhető, hogy az absztrakt fogalmakat metaforákon keresztül tanuljuk meg – és ezért áll elő az a helyzet, hogy később sem tudunk igazán másként gondolkodni róluk.

A jelek kombinálásának, majd metaforákon alapuló újrakombinálásának képességéről idevág, hogy a metaforák megértéshez már az elsőszintű mentális állapotreprezentációk elegendőek, miközben az iróniához legalább másodszintű metareprezentációk (reprezentációk reprezentációi) szükségesek (GYŐRI, 2006). Ez arra utal, hogy a metaforák használatához nincs feltétlenül szükségünk magas szintű tudatelméleti funkciókra, és lehetséges, hogy a relevanciaelmélet jóslatával szemben – mely szerint a gyenge implikatúrájú metaforák megértéséhez már szükségünk lenne metareprezentációkra – elegendő csak a fogalmi tartományok közötti kapcsolatokat megtanulnunk, ahogy azt a kognitív metaforaelmélet jósolja (TENDAHL, GIBBS, 2008).

A metaforák és jel–jelentés megfeleltetés kérdése szempontjából fontos LAKOFF és JOHNSON (1980a) metaforákkal kapcsolatos alapvető gondolata, mely szerint a metafora először is gondolat és cselekvés, csak azután nyelv. Tehát amint kontextusfüggetlen a (rá)mutatás, mindjárt egy metaforikus vonatkozást kap. Persze az ilyen kontextusfüggetlenség már jórészt nyelvi jellegű, éppen ingerfüggetlen, illetve behelyettesíthető jellege miatt. Lényeges azonban, hogy a gesztikuláció fel-

tehetően meghatározó volt a homonidák korai nyelvében, hiszen a beszédközpont a jobb kezet mozgató agyterületre nőtt rá (HÁMORI, 2005).

A konkrét jel–jelentés viszony magával az emberi nyelvvel tűnhetett el, hiszen amint ingerfüggetlenné válhattak a jelek, gyökeresen megváltozott jelentésük minősége is. A nyelvi jelek önkényesek, a jelentés mindenképpen közvetetten kapcsolódik. Ugyanakkor szükséges egyfajta meta-reprezentáció arról, hogy mi mit jelent (legalábbis a nyelvtanulás idején), hiszen másként lehetetlen kontextus-függetlenül használni a jeleket, és a szavak nem tudnának valami (időben és térben) távolira utalni.

A tértől és időtől, tehát a kontextustól független idegrendszer reprezentációi egy ehhez hasonló fogalomrendszert tesznek lehetővé. A metaforikus többletjelentés abból fakadhat, hogy a valamennyire eleve elvont jelentés további területekre is átvihető, és ott is felhasználható. Azonban a metaforák valódi előnye az, hogy a szenzomotoros forrástartományok révén állandó kapcsolatot biztosítanak egy olyan viszonylag konkrét fogalmi szinttel, ami testi és kisgyerekkori élményeken (vagyis tapasztalati gestaltok képi sémáin) nyugszik. Így lehetőségünk van valami korábbi, ismert dologra utalni. Ez egy nagyon hatékony nyelvi ugrást tenne lehetővé a kognitív környezet releváns vonatkozásainak manifesztté tételére. Mindehhez elég, ha a képi sémák csak időlegesen, online módon emelkednek ki a folyamatos elme, test és külvilág interakciókból (TENDAHL, GIBBS, 2008).

VERBÁLIS METAKOMMUNIKÁCIÓ

A metaforaelmélet másik hozománya a relevanciaelmélet számára a nyelv *metaforikus értelmezésé*ben rejlik. A pszichoanalízis szimbolikus értelmezését tekinthetjük egyfajta kiterjesztett metaforikus szövegértelmezésnek, amit az elszólásokra, a viselkedésre, az álmokra és végső soron magára a patológiára is kiterjeszt. Felfoghatjuk úgy, hogy mindezekben a jelenségekben a tudattalan indulatok működésének metaforáit látta Freud. A pszichoszexuális fejlődés gyermekkori élményei és a libidó fiziológiai megnyilvánulásai tapasztalati gestaltoknak tekinthetőek, amelyek olyan metaforákat motiválnak, ahol a tudattalan működés mint forrástartomány a viselkedés különböző céltartományira vetül rá. Például a trauma szimbolikus (metaforikus) kifejeződése (kivetülése) lehet a hisztéria. A tudattalan indulati működésről folyamatosan tájékoztatnak minket például az elszólások, tehát a metakommunikáció révén a tapasztalati gestaltok forrástartományai különféle céltartományokban nyilvánulnak meg.

Tulajdonképpen a hétköznapi beszélgetéseket folyamatosan aláfesti a beszélők indulati élete, tudattalanja: a szöveg maga is rendelkezik egy olyan réteggel, amit metaforikusan értelmezhetünk, ahol a tudattalan motiválja a (gyakran rejtett) metaforákat. Ez a nyelvi réteg azért kaphat jelentőséget, mert az osztenzív kommunikációs jegyeket a felnőttek is alkalmazzák, de a leggyakrabban tudattalanul. A metakommunikáció önmagában is sok osztenzív jegyet hordoz, ami a figyelem irányítását szolgálja (például hangsúlyozás, szünetek, hanghordozás), és ez a kommunikációs réteg az emocionális állapotok közvetítése révén, noha mindkét fél

számára általában tudattalanul is, de jól jelzi a szándékokat. Ezáltal válik nélkülözhetetlenné a kommunikáció releváns értelmezése szempontjából. Ez a mélyebb nyelvi szint a beszédtől függetlenül, zavartalanul működik akkor is, ha nagyon direkt módon verbalizáljuk, illetve tudatosítjuk. Saját és beszélgetőtársunk érzelmi-indulati állapota, a kognitív környezet részeként mindenképpen hatással van a kijelentések értelmezésre. Tulajdonképpen a manifesztté tett tartalom háttereként, referenciapontjaként működik. Mivel kevéssé vagyunk képesek irányítani, inkább hiszünk a metakommunikációnak, mint az elhangzott állításoknak, ezért ez az érzelmi szint folyamatos, de közvetett osztenzív jelzéseinek tekinthetjük. Például ha felmerül, hogy a beszélő nem az igazat mondja, hiába igyekszik átcsoportosítani az osztenzív jegyeket, metakommunikációja könnyen elárulhatja azok valódi helyét. Ez lenne a FÓNAGY (1974) által természetes vagy archaikus kódnak nevezett rétege a nyelvnek.

A hétköznapi beszédhelyzetekben, amikor egyik fél sem igyekszik szándékosan elrejteni (metakommunikációs) szándékait, a rejtett osztenzív jegyek jelezhetik a beszéd metaforikus rétegét, vagyis azt, hogy mely fordulatok rendelkeznek valódi *metaforikus jelentés*sel, a konkrét metaforikus kifejezés pedig megmutathatja, hogy mi is az indulati tartalma az adott kijelentésnek. Így közvetít a beszélő szándékairól, beemelve azt a kognitív környezetbe.

A metaforák tudatos használata: az indirekt beszéd

Lehetséges, hogy ezt a második nyelvi réteget használja ki az indirekt beszéd is (PINKER, 2007). Az indirekt beszéd lehetőséget biztosít a nyíltan nem vállalható vágyak és szándékok jelzésére, illetve a róluk folyó alkudozásra. Az indirekt kérések nagy előnye, hogy teret engednek nyílt megtagadásuknak is. Pinker szerint a beszéd az üzenetek közlésén túl a beszélgető partnerek között lévő viszony típusáról (a dominanciáról, az összetartásról és a kölcsönösségről) folyó alkuk helyszíne is. Ezt tekinthetjük a kommunikáció indulati rétegének.

Tehát az indirekt beszéd révén az (egyébként a metakommunikáció során megkötött) alkuk biztonságos újratárgyalására van lehetőség: tudatos alakításuk közben látszólag nem válik manifesztté a beszélgetés valódi tárgya a közös kognitív környezetben. Ezek a beszélgetések azért lehetnek indirektek, mert a valódi tartalom elemei egy fedő tartalom elemeinek vannak (metaforikusan) megfeleltetve. Látszólag „másról" van szó, és csak akkor válik manifesztté a valódi tartalom, ha mindkét fél beleegyezik ebbe – ebből fakad az indirekt beszéd biztonságossága. A kapcsolati alkuk nagyon gyakran valamilyen metaforikus virágnyelven zajlanak, amelynél alig számít, hogy mi a metafora céltartománya, mert a valódi párbeszéd a forrástartományról szól.

A relevanciaelmélet az indirekt beszédet valószínűleg a laza nyelvhasználat kategóriájába sorolná, ahol a gyenge implikatúrák több kognitív erőfeszítést igényelnek, de cserébe nagyobb kognitív hatással járnak: a társas viszonyok újratárgyalásával. Ha ezt kiegészítjük a kognitív metaforaelmélettel, akkor részletesebb elemzésre nyílik lehetőség, ami arra világíthat rá, hogy a két elmélet nem csak

kiegészítheti egymást, de közös alkalmazásuk mélyebb elemzést és értékelést tesz lehetővé. Noha tartalmi mondanivalójuk nem változott, kétségtelen, hogy az elméletek tágabb értelmezésére volt szükség a fenti gondolatmenethez. Mégis, ezáltal a fogalmi gondolkodás szintjéről inkább a metaforák pragmatikája felé tolódhatott el az elemzés.

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VERBAL METACOMMUNICATION –
WHY A METAPHORICAL MAPPING CAN BE RELEVANT?

FORGÁCS, BÁLINT

In my study I would like to show that in spite that they are seemingly contradictory, the cognitive metaphor theory and the relevance theory cannot only be complementary, but might even provide interesting possibilities of analysis. Through a stricter and a looser example I am going to look for the points that can be valuable for each theory. First, conceptual metaphors help understanding abstract concepts by the mapping of concrete source domains, which perhaps helps creating optimal relevance in conversations. This goes beyond the role relevance theory offers for metaphors, that they are simply the poetic tools of loose language use. Perhaps conceptual metaphorical mappings play an important role in our cognitive environment. Second, I would like to show the metacommunicative value of metaphors, which might expand relevant theory. The ambiguous language of indirect speech might reflect such a metaphorical layer of language that has a metacommunicative value on a semantic level.

Key words: *cognitive metaphor theory, relevance theory, pragmatics, metacommunication, concrete, abstract*

7.4 Study 4: The right hemisphere of cognitive science

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THE RIGHT HEMISPHERE OF COGNITIVE SCIENCE
Bálint Forgács

Introduction[1]

The aim of the present study is to establish a theoretical connection between the brain, or more precisely the scientific concepts describing it, and the everyday and scientific expressions referring to the mental world. These expressions often circulate around dichotomies common in Western philosophy and thinking, like emotional–rational, mind–heart, or body–soul. Their connotations are deeply embedded in everyday language; however, they are often hard to notice. Still, they profoundly influence the perception, understanding, and interpretation of mental functions. The main question is the following: could the structure of such concepts originate from human cognition, and from the architecture of the nervous system?

Independently of the philosophical question whether the concepts addressing mental phenomena are somewhere "outside" in the world – as proposed by reductionism, e.g., Ryle (1949) – or produced somehow "inside" the mind – according to Berkeley's solipsism – it is possible that these dichotomies are a "by-product" of our mental system. For example, the left and right hemispheres employ different sets of processes, such as propositional versus appositional (Bogen 1969), to address the diverse task demands of the environment. Such a neural division of labor might provide essentially different perspectives on the world which are well known to all of us, but most individuals do not master both of them equally well.

Broadly speaking, most concepts describing the three spatial dimensions of the nervous system seem to be bound to the traditional philosophical dichotomies: emotion and reason (for right and left hemispheres), cognition and motivation (for the cortex and the limbic system), and action and perception (for anterior and posterior regions). This could be a confusing linguistic factor when theorizing about neuroscience and during the conceptualization and operationalization of experiments. At the same time, realizing this bias could enable new levels of analysis via the metaphorical reinterpretation and recombination of the tags and labels on the brain. For example, the description of the anterior and posterior regions as being responsible for creating the balance of consciousness between the motor and sensory areas (in extreme cases, between involuntary actions versus hallucinatory experiences, e.g., Fischer 1986) could be combined with the emotional–rational dimension of the two hemispheres. Such a perspective would enable brain researchers to pose questions from novel theoretical grounds.

Concepts concerning the mental world have been brought into the scientific discussion from the everyday language of folk psychology: for example, from philosophy, phenomenol-

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ogy and the social sciences in the case of describing the two hemispheres (TenHouten 1985). They are constantly linked to the neural substrates of the brain via experimentation – again, often described by a "common sense" language of everyday concepts. As a result, even purely scientific descriptions and explanations might reflect personal preferences of scientists stemming from subjective cognitive and neural dispositions. In specific cases, this might mean an "individual hemisphericity" as proposed by Bogen, DeZure, TenHouten, and Marsh (1972). For example, taking representations as perceptual symbols (Barsalou 1999) could talk about a right-leaning, whereas taking representations language-like (Fodor 1975, 2008) about a left-leaning, manner of understanding. In a clinical context, the same process could motivate the idea that the core of human functioning is either emotional (as in psychoanalysis or humanistic psychology), or rational (as in behaviorism or cognitive therapy). Putting notions of different kinds in the focus of explanations might hinder scientific discussion in the absence of a common ground.

This problem is especially intriguing when the mind (of researchers) turns towards the (research of the) mind itself. Some mental capacities lend themselves to quantitative scientific analyses, such as perception, memory, or attention. However, others prove very difficult, or almost impossible to describe and account for scientifically, such as the creation and appreciation of fine art, or engaging in productive inductive reasoning. What makes such "soft", or qualitatively complex, mental phenomena so complicated to explore: our language – and philosophy – or our neuroscience? One possibility is that such "fuzzy phenomena" arise from the very architecture of the human mind and brain. Logical, deliberate, sequential and scientific reasoning is only a subset among many other intuitive, spontaneous, and parallel systems. Some of the most fascinating feats of the mind (such as musicality) might fall outside of our rational understanding because the subsystems instantiating them are organized according to entirely different principles than reasoning.

Metaphors and the brain

In an attempt to address the above issue, the first step could be taking a close look at the relations and the linguistic structure of notions of both scientific and folk psychology. The next step could be to try to assess how they are related to the notions describing the brain. Then it would be possible to systematically map the connections of these distinct theoretical levels. The cognitive conceptual metaphor theory (Lakoff and Johnson 1980a) provides a plausible framework for the investigation of the possible links between mental concepts and phenomenal experiences, which could open the way to tracing the responsible neural systems.

Metaphors and the conceptual system

The conceptual metaphor theory of Lakoff and Johnson (1980a, b) proposes that metaphors are not ornaments of language but the building blocks of the human conceptual system. We understand abstract concepts by systematically mapping concrete concepts onto them. The easily comprehendible source domain (e.g., JOURNEY) is mapped onto the abstract target

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domain (e.g., LIFE). This works on a conceptual level (LIFE IS A JOURNEY) and can be caught in metaphorical expressions like *we had a bumpy year*.

According to Lakoff and Johnson (1980b), only those concepts are not metaphorical that are derived directly from our experiences – concepts of orientation (up–down, in–out), ontological concepts (materials), and structured experiences (eating, moving). The seemingly distant domains of metaphors are connected in specific experiential Gestalts, which are "multidimensional structured whole[s] arising naturally within experience" (Lakoff and Johnson 1980b: 202). The basis of the mappings, for example, in the expression *he is a hothead* is motivated by HEAT and ANGER appearing in the same situation. Its motivation can be closeness in time or space, for example, although cultural aspects can also play an important role. Hence, it is impossible to foretell the metaphors of a certain language, but one might tell which mappings are unlikely. These are the ones that are really counterintuitive to our very human experience, like anger being cold (Kövecses 2002, 2005).

Grady (1997) divides metaphors into two groups: complex metaphors and primary metaphors. Complex metaphors are constructed from primary metaphors. In the case of primary metaphors, sensorimotor and non-sensorimotor experiences get connected in a systematic way (in the expression *warm smile*, physical warmth and happiness are joint). On the basis of this idea, Lakoff and Johnson (1999) created the integrated theory of primary metaphors, according to which these mappings do not simply recall similar experiences, but they are suggested to activate the very same neural circuitry. Some fMRI and EEG data seem to support this prediction. When subjects read metaphorical sentences involving the hands (e.g., *[it is] hard to grab this idea*), many areas responsible for the motor control of the hands are activated (e.g., Rohrer 2005). These results promise that primary metaphors with an experiential basis might one day be traced back to certain neural areas, and that in fact we understand a great variety of knowledge domains by the activation of a relatively few neurocognitive resources (although this is a hotly debated question, cf. Mahon and Caramazza, 2008).

Concepts of neuroscience

Many notions utilized by neuroscientists to describe the brain also possess some experiential background (although mostly indirectly). Several of these are not simply mental concepts: some refer directly to experiences, like the labels of sensorimotor areas, and others to rather abstract concepts like "decision making". These notions are currently grounded to specific neural systems and areas via experimentation. Therefore, notions referring to experiential phenomena, as well as some abstract ones are possible to link to specific brain areas – at least in a specific experimental situation. Nevertheless, these words carry their connotations and broader meanings with them, and they have a place in the conceptual space of psychological notions.

As a result of the neuroscientific explosion of the past decades several such psychological notions have been "located" in the human brain. These words became citizens of two worlds: the networks of concepts and the networks of the brain. Several possibilities follow from this. First, it is possible that the description of the brain somehow follows the structure of notions referring to the mental world – this would be a solipsistic stance. Second, it is possible that there is simply no real relationship between notions referring to mental phenomena and

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the structure of the labels for the brain – a reductionist stance. Third, the correspondence is somewhere in-between, and these layers influence each other, but they are not related in a systematic way.

Mental metaphors

What kind of metaphors hide behind psychological expressions? Is there a systematic relationship? Actually, there seems to be some kind of "phenomenal" orientation according to light and temperature, alluding to the experiential grounds of the mental world. Here are some examples:

PRECISE THOUGHTS ARE BRIGHT – IMPRECISE THOUGHTS ARE DARK
What a bright mind!
His talk was very dull.

PRECISE THOUGHTS ARE COLD – IMPRECISE THOUGHTS ARE HOT
Cold calculation was the plan.
He has been a hothead with that decision.

POSITIVE EMOTIONS ARE BRIGHT – NEGATIVE EMOTIONS ARE DARK
We had a brilliant time in the evening.
Dark intentions seized him.

POSITIVE EMOTIONS ARE HOT – NEGATIVE EMOTIONS ARE COLD
His revenge was cold as ice.
She had warm feelings towards him.

Such concepts, which are based on mappings of primary metaphors, could combine, as subtle metaphorical building blocks, into the complex structures of abstract concepts. For example, irrationality is traditionally linked to emotions, while reasoning often seems to be logical, and mathematical proofs seem to be objective, while attitudes or feelings are often considered subjective. The more abstract concepts provide a kind of cognitive orientation in the mental space of folk psychology. In this huge network of associations, expressions bring along a number of connotations across contexts. Mappings could ground highly abstract, complex mental concepts like empathy or intuition to low-level perceptual sensations or phenomenal orientations. All this could add up to an Idealized Conceptual Model (Lakoff 1987) of the mind in Western culture and philosophy.

According to this analysis, psychological concepts that serve as tools for scientists to describe the human brain might be a part of a mental space that refers to experiential grounds (both phenomenal and cognitive), which in turn is a product of the brain itself. The aim of this study is to take a look at the metaphorical space of mental concepts with respect to neural architecture. Are there connections between the "phenomenal", the "cognitive", and the "conceptual" aspects of words referring to mental life? Do these correspond to the descriptions of the neural regions of the brain?

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Hypotheses

1) Psychological concepts can be arranged in a mental space representing the three spatial dimensions of the nervous system: the left and right hemispheres, the cortical and limbic systems, and the anterior–posterior regions.
2) University students majoring in psychology arrange these words differently compared to students who do not major in psychology as a result of their elaborated knowledge.

Methods

Participants

Altogether 83 graduate (MA) level university students completed the test, 48 of whom were majoring in psychology, and 35 students who were not.

Test

In the framework of a pilot study, a questionnaire was created. Participants had to assess psychological concepts in a forced choice task, according to three spatial dimensions of the brain. The questionnaire constituted of 105 words, each of which had to be assessed according to dichotomies of everyday, folk psychological expressions referring to the three neural axes of the nervous system: thinking vs. emotion for the left and right hemispheres, consciousness vs. instinct for the cortex and the limbic system, and action vs. perception for the anterior and posterior regions. For every word, participants had to decide for each three axes whether it fits one or the other dimension – there were no "neither" or "both" options. The 105 test words were a collection of the following:

    1) Expressions of folk psychology *(heart, mind)*.
    2) Expressions of scientific psychology *(cognition, reflex)*.
    3) Expressions of sensorimotor orientation *(warm–cold, inner–outer)*.
    4) Expressions having some cognitive orientation *(subjective–objective, personal–social)*.

    The latter contained rather more general expressions as the sensorimotor orientation, although from a more philosophical domain.

Results

The data was analyzed with the SPSS 17.0 software. A series of Pearson's chi-square tests were used to compare the two groups. Where the two groups did not differ, a second chi-square test (with 50% expected frequencies) was calculated on the whole sample, but when the first test showed a significant difference, the second test was run on the two groups separately.

    The two groups categorized the majority of the words identically. There were only 11 cases (out of the 315) where only one of the groups was able to categorize a word according to one of the dimensions, but the other group was not. Two more words (*bright* and *quality*) were located
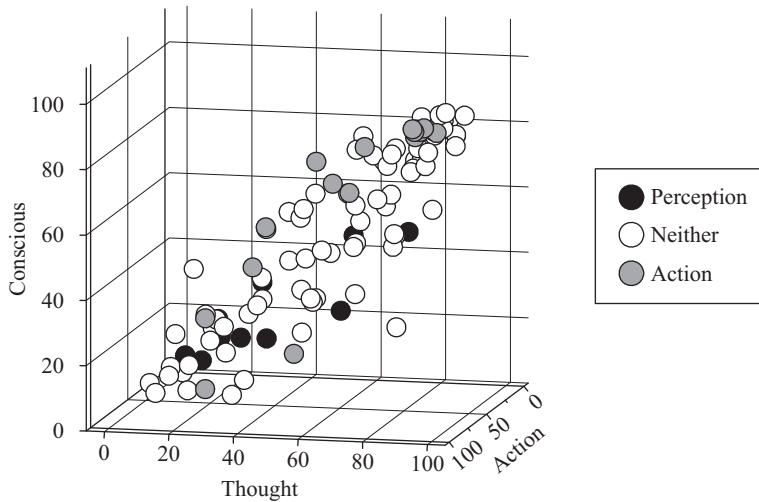
Figure 1. The 105 psychological expressions in a conceptual space, corresponding to the three spatial dimensions of the brain. Each point represents a word.

on the opposite side of the action–perception axis for the two groups. Altogether this was an approximately 4% difference. Almost all words were categorized either as conscious–thought–action or instinct–emotion–perception, suggesting a pervasive linguistic dichotomy. Only the word *association* was categorized as instinct and thought. Only the following words were categorized as action, but not as emotion, or instinct: *reflex, social, creativity,* and *mystical*.

As the difference between the two groups was marginal, the next step was to aggregate the data, in order to calculate an average value for each word on all three dimensions. On this restructured data set a factor analysis was run that revealed that the three linguistic dimensions actually fit onto a single component, this being responsible for 75% of the variance in the sample. Figure 1 shows a hypothetical three-dimensional mental space corresponding to the three linguistic dimensions of brain. Every point represents a word, by taking its average value on the three axes as coordinates. The single component runs diagonally from the emotion–instinct–perception corner to the thought–conscious–action corner.

Finally, a hierarchical cluster analysis was performed using the word's average values on the three axes. Two large clusters emerged. One of them crowded around the word *mental,* while the other around the word *hypnosis*. The former constituted of two smaller clusters labeled as "scientific" and "wisdom", while the latter as "emotion" and "arousal". The structure of the two large and a number of smaller clusters are presented in Table 1. Taken together, neither of the hypotheses were confirmed.

Discussion

The results of the present study do not provide strong evidence, even though there are some interesting findings. First, the fact that university students majoring in psychology did not differ significantly from the other group of students indicates that the concepts used in the study

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Table 1. Results of a hierarchical cluster analysis: Dendogram using average linkage

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C A S E        0    5   10  25          C A S E        0    5   10  25
Label          +------+-----+----+       Label          +------+-----+----+

heart        -+                          reason       -+     | |     |    |
feeling      -+                          intellectual -+     | |     |    |
soul         -+-+                        nous         -+     | |     |    |
deep         -+ |                        consciousness -+    | |     |    |
warm         -+ |                        attention    -+     | |     |    |
mystical     -+ +-----+                  mind         -+    +-+     |    |
inner        -+ |     |                  head         -+     |       |    |
intuition    -+-+     |                  sense        -+     |       |    |
unconscious  -+ |     |                  cognitive    -+-+   |       |    |
sensual      -+ |     |                  conceptual   -+ |   |       |    |
sentiment    -+ |     |                  quantity     -+ |   |       |    |
emotion      -+ |    +--+                intelligible -+ |   |       |    |
visceral     -+-+    | |                 quality      -+ |   |       |    |
empathy      -+      | |                 high         -+ |   |       |    |
wet          -+      | |                 bright       -+-+   |       |    |
subjective   -+-+    | |                 dry          -+ |   |       |    |
reception    -+ |    | |                 wit          -+ |   |       |    |
passive      -+-+-----+ |                mental       -+ +---+       +----+
below        -+ |       |                abstract     -+ |           |
hazy         -+ |       |                plausible    -+ |           |
hypnosis     -+ |        +-------+       awareness    -+ |           |
dark         -+-+        |       |       analog       -+ |           |
sensation    -+          |       |       above        -+-+           |
instinct     -+          |       |       inductive    -+ |           |
desire       -+---+      |       |       thought      ---+           |
unintended   -+   |      |       |       superficial  -+             |
artistic     -+  +-+     |       |       cold         -+             |
affective    -+  | |     |       |       outer        -+-----+       |
ambiguous    -+  | |     |       |       clean        -+     |       |
arousal      -+---+ +----+       |       positive     -+     |       |
homeostasis  -+     |            |       metaphoric   -+     |       |
reflex       ---+---+            |       apperception -+    +----+  |
spontaneous  ---+   |            |       perception   -+    |    | |
body         ---+   |            |       threshold    -+---+ |    | |
motivation   ---+---+            |       symbolic     -+   | |    | |
social       ---+               |        low          -+   | |    | |
action       -+                 |        visual       -+  +-+    | |
                                |        shallow      -+   |     | |
active       -+                 |        slow         -+-+ |     | |
will         -+-------+         |        wisdom       -+ +-+    +--+
direct       -+       |         |        memory       ---+ |      |
intended     -+       |         |        experience   -----+      |
planned      -+       |         |        negative     -+---+      |
evaluation   -+-+     |         |        imagination  -+   |      |
verbal       -+ |     |         |        determined   -+   |      |
rational     -+ |     |         |        individual   -+   |      |
logical      -+ +---+ |         |        conditioning -+---+---+ |
mathematical -+ |   | |         |        fast         -+   |   | |
scientific   -+ |   | +-----+   |        association  -----+  +--+
concrete     -+ |   | |     |   |        behavior     -+-+     |
objective    -+-+   | |     |   |        motion       -+ +---+ |
cleverness   -+     | |     |   |        free         ---+   +-+
deductive    -+     | |     |   |        creativity   -------+
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(even the more scientific ones) are deeply embedded in everyday thinking. This philosophical and folk psychological background certainly has some influence on the conceptualization and operationalization of scientific research, and on the interpretation of results. Words expressing psychological phenomena bring along their net of connotations, and these might shape the understanding of mental life and the human brain, since researchers most of the time have to choose from concepts with a history that is not neutral.

Another interesting finding was that the dichotomies corresponding to the dimensions of the brain do not differentiate sufficiently among the psychological expressions examined in the study – according to the factor analysis, their majority actually fits on one axis. This could be important for brain researchers since it sheds light on the conceptual ambiguity of words used to describe very different levels of processes in the nervous system. Perhaps the philosophical mind–body problem appears here: although it was often difficult for individuals to make a decision regarding one word or another, the fact that notions were eventually arranged according to one dimension suggests that a Cartesian dualism is deeply embedded in scientific and folk psychology. This could be true even for scientists or philosophers who actually deny being Cartesian. Another problematic aspect is the categorization that a hidden assumption creates. For example, psychological notions, which most people would consider "emotional", eventually should be linked to the "mind", and not the "body". There may be a number of lurking paradoxical consequences of language use in natural sciences exploring the human brain.

The cluster analysis revealed an interesting structure among concepts: they grouped together more or less in accordance with the predictions of the conceptual metaphor theory. For example, in the emotion cluster, words of perceptual orientation *(deep, warm, inner, dark),* and cognitive orientation *(subjective, spontaneous, active)* were located near to folk psychological expressions *(heart, soul, body),* and scientific expressions (*empathy, unconscious,* and the main label of the cluster, *hypnosis*). These four levels were in similar correspondence also on the other large, the mental, cluster as can be observed in Table 1.

The reason for choosing these categorizing concepts was that they were everyday expressions with a meaning that can be easily taken for granted by researchers as well. Thus, they seemed to be good candidates to bridge the gap between scientific and everyday language regarding the mental world. Nevertheless, it is possible that the test was not constructed accurately, and only one axis emerged because the test did not differentiate enough between the three dimensions. Another possibility is that the description of the brain does follow the structure of notions referring to the mental world. It is precisely the way language is used, both in folk and scientific psychology, that distorts the perception of the nervous system and does not allow for a sophisticated differentiation between the three spatial dimensions of the brain. Is it the right hemisphere that deals with emotions, or the limbic system? What is the role of the limbic system in the left hemisphere? The constraints of language might be important to be taken into consideration when studying the neural systems of the brain.

Scientific metaphors in psychology

On the basis of this arrangement of the psychological concepts, and when expanding the analysis to the mental world's conceptual space, it is possible to interpret the words describing

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Behaviorism
(conditioning, behavior, etc.)

Humanistic psychology
(holistic, self-actualization, etc.)

Cognitive psychology
(thinking, computations, etc.)

Psychoanalysis
(unconscious, instincts, etc.)

Gestalt psychology
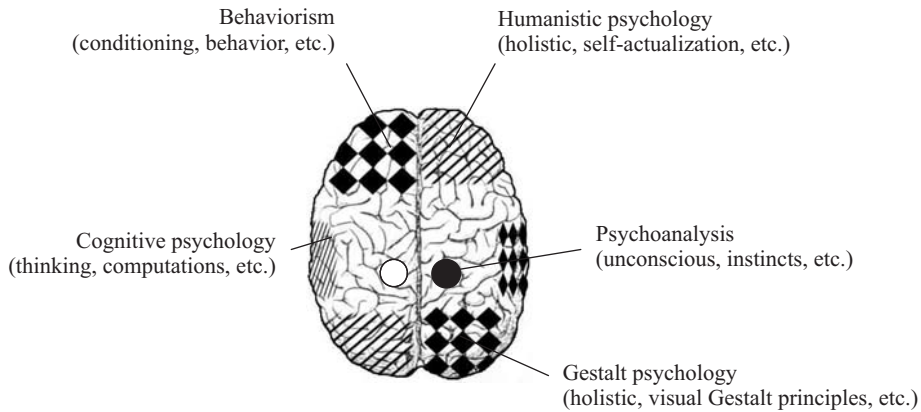(holistic, visual Gestalt principles, etc.)

Figure 2. The different approaches within psychology, arranged according to their key metaphors
in a hypothetical brain

the nervous system in a metaphorical map. The key concepts of various theories and approaches in psychology (Pléh 2010), some of which are associated with certain brain regions in one way or another, might talk about the neural dimension being central in the specific theory at hand. For example, the key concepts of psychoanalysis (e.g., libido, unconscious, instincts) could be viewed as metaphors mapped onto a broad variety of human functions representing limbic level functions. In other words, psychoanalysis might project limbic level functions on the whole brain. This analysis could be broadened to include further schools, approaches, or simply theories in psychology.

Gestalt psychology proposed a holistic view, its name directly referring to the "shape as a whole", or the "form as a unit"; the defining Gestalt principles (similarity, continuation, closures, etc.) all come from the visual domain. Combining these two main characteristics would put Gestalt psychology somewhere in the right (holistic) occipital (visual) regions. Behaviorism, emphasizing stimulus–response-based classical and operant conditioning as the main processes of human functioning could be linked to frontal areas, which are responsible for learning, attention, inhibition, and control. The denial of consciousness (and even mental phenomena) links this perspective also to subcortical regions, and more specifically to regulatory systems. Humanistic psychology, or the "third force" emphasizing self-actualization and creativity could be linked to the right hemisphere, where the representation of the self seems to be more elaborated. The case of cognitive psychology is going to be addressed in the next section. As a result, approaches within psychology can be arranged in the brain based on their key metaphors (Figure 2).

The search for new paths in cognitive science

Looking at cognitive science from this perspective, an interesting picture emerges. Key ideas of early cognitive science, such as generative grammar, the formalization of mental functions, Turing machine-like serial operations on symbols, and allowing for conscious thought
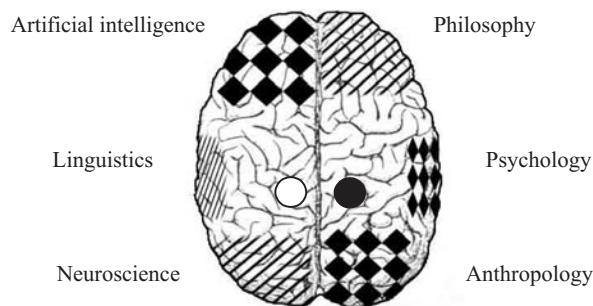
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Figure 3. Cognitive science, as a common approach within disciplines, covers a broad variety of epistemic capacities of the brain

might all talk about a left-hemispherical, language-based, and sequential approach, dealing with primarily cortical processes. Chomsky's (1957) groundbreaking ideas came from the linguistic domain, and syntax was (metaphorically) mapped onto the brain as computations, more specifically as the *Language of Thought* (Fodor 1975, 2008). The brain was considered to be a special computer, where even emotions are "calculated".

It is important to note that cognitive science defined itself as an interdisciplinary approach right from its outset, and as a result has bridged various disciplines like psychology, linguistics, anthropology, philosophy, neuroscience, and artificial intelligence (Pléh 2010). This has provided a broad epistemic capacity that promised to cover all major epistemic approaches (towards the mind) that the brain seems to produce (Figure 3).

At the same time, a number of the "soft functions" of the mind remained elusive, not just because it is extremely challenging to write a viable computational protocol for them. Another reason could have been the initial linguistic, and rule-based approach coming from the left hemisphere, and it might not be possible to map procedures of one hemisphere on the whole brain.

Intriguingly, from the 1970s cognitive science went through a gradual shift, perhaps driven by the need to take the missing aspects into consideration. As the first era lived up its theoretical resources, new currents appeared, still, primarily within the established domain. Connectionism (and pragmatism in general) offered models that were not based on rules or computations in the classical sense, but on information processing carried out by the structure itself (Rumelhart and McClelland 1986). This could reflect a shift towards the right hemisphere, having relatively more white matter, and being generally more interconnected than the left hemisphere (for a review, see Beeman 1998). The architecture (the "body") or the procedure was proposed to be prior to knowledge, or rules. Using terms that are describing memory systems, this was also a move from the declarative to the procedural, a distinction stemming from Ryle's (1949) knowing what vs. knowing how. Similarly, as opposed to explicit rules or functions, implicit processes became an independent research area, exploring verbally and/or consciously inaccessible (not left-hemispherical) functions.

Trends surfacing in cognitive linguistics during the 1980s addressed right-hemispherical language capacities such as pragmatics (Pléh 2000) – one outstanding example is relevance theory (Sperber and Wilson 1995). Embodiment (Lakoff and Johnson 1999) put the body (represented stronger in the right hemisphere) in the center of cognition. The idea that sen-
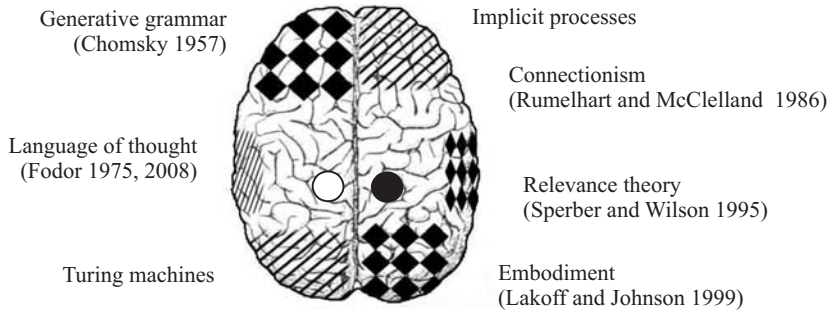
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Figure 4. Approaches of cognitive science, arranged metaphorically in a hypothetical brain

sorimotor areas are responsible for semantic processing not only challenged the Cartesian mind–body distinction, but also practically reduced the "mind" to the "body" (with the latter having stronger neural representations in the right hemisphere), advocating a neo-empiricist agenda. Figure 4 shows a brief summary of the various threads within cognitive science that seem to be open enough to integrate new approaches corresponding only loosely to some original ideas.

Epistemology and the brain

The main message of the present work is that every paradigm or approach might have a model of the mental world which is motivated by the neural preferences of scientists. Every attempt to give a complete account of the broad and diverse phenomena produced by the human brain is a result of specific personal dispositions in perceiving, understanding, and interpreting cognition. Metaphorically speaking, by projecting a subset of neural functions on the brain as a whole, every approach creates "brains" that are skewed to one region or another, as a result of overrepresenting it compared to the rest. For example, Chomskyan generativists could be conceived as having a metaphorical brain of a set of large left-hemispherical language areas, and a microscopic right hemisphere. Researchers and their approaches might be identified according to their way of reasoning: what kind of work methods, and more specifically, neural processes do they prefer when they frame problems and solutions?

When a certain approach is clearly articulated by a scientist, followers with similar neural dispositions join the new track, and schools are formed. The trends in the second phase of cognitive science are inspiring because they attempt to introduce research topics that can be associated with the "other side", the right hemisphere. This has opened up ways to explore aspects of the mind that are especially difficult to describe logically, formally, or verbally. However, importantly, waves in science do not follow one another in a linear fashion: approaches often exist and develop parallel. The brain might not be a computer as we know computers today, but this is still a strong model with testable predictions. Even though embodied cognition claimed a revolutionary approach, it has rather added a new perspective than put aside thousands of years of philosophy of the mind. Chomsky's or Fodor's legacy and contributions are not washed away by newcomers but are placed in a broader perspective – in a more complete metaphorical brain. Recent tendencies also emphasize one specific

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neural perspective over another, thus they also have a – novel and innovative – skew to their epistemology. Only the combination of the various approaches can provide a comprehensive picture of human cognition.

In this respect, scientific research itself serves as a diagnostic tool to gain insight into the workings of the brain. The Idealized Cognitive Model of the mind in Western culture provides a basic framework that is not neutral in the first place. It serves as a background behind the figure, the models and metaphors that scientists propose according to their preferred working methods and "mental perception". The interaction between these figure(s) and the background is what makes cognitive science a unique endeavor: this is the point where understanding turns towards understanding; the mind becomes the subject as well as the object of research. However, only the novel metaphors of the mind, which are yet to come, can tell us which part of the brain is going to have the privilege to lead (again) science and research during the next period of time.

The present pilot study has attempted to bring attention to the intricate relationship between psychological concepts and brain research. On the one hand, it tried to shed some light on the strong heritage of language referring to human cognition, which is deeply rooted in folk psychology, and perhaps influences neuroscience, as well. On the other hand, it tried to highlight how the personal perspectives of scientists could be expressed in their works and in the threads of science in general. Hopefully, it can contribute to the study of the mind by reflecting on the language of cognitive science.

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