On the role of perceptual features in metaphor comprehension

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In this chapter we present three studies that were conducted to investigate the role of perceptual features in metaphor comprehension. Results suggest that priming verbal metaphors with explicit perceptual images facilitates comprehension. Moreover, stimulating the source concept facilitates metaphor comprehension more effectively than stimulating the target concept. Finally, on analysing the semantic associations between the source, target, and metaphor features, we found that when both the source and the target are primed with their respective images, relatively more perceptual features of the source are related to the metaphor's features; as opposed to the no-priming condition when relatively more conceptual features of the source are related to the metaphor's features. Based on the results of these studies, a perception-based model of metaphor processing is proposed.

Keywords: imagery, priming, perception, metaphor

1. Introduction

The role of metaphor in human communication is well known. Metaphor is not just a linguistic phenomenon, but is a multimodal, conceptual one in which various cognitive processes such as perception and imagery interact together. Therefore, one of the central issues in metaphor research is to understand the role of these cognitive processes in metaphor in particular, and communication in general. In this study, we focus on the role of perception and imagery in metaphor understanding and in communication.

Many studies suggest that imagery plays a key role in understanding metaphors (Neisser 1976; Walsh 1990). But imagery is inherently subjective, and the only thing we can say for sure is whether the brain areas generally used for visual

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imagery are also used during metaphor processing (Schmidt *et al.* 2007; Shibata *et al.* 2007; Eviatar & Just 2006; Bottini *et al.* 1994). As there are wide variations in how an individual reader evokes imagery in response to a metaphor (Pylyshyn 2002), it is difficult to study it empirically. However, an alternative is to use perceptual stimuli, where specific visual images are provided to the participants. The features of these images can be controlled precisely, and we can study whether these images facilitate or hinder metaphor processing.

The three experiments presented in this chapter are designed to study the role of images in metaphor processing. In the next section we present the background and motivation for this research, starting with the idea that metaphor is not just a verbal phenomenon but is a conceptual process, which can occur in different modes of communication. In the next section we review the role of imagery in metaphor comprehension and discuss in what ways imagery is like perception. The three experiments to study the effect of image priming and image stimulation on metaphor processing are presented in Section 4. Finally, in Section 5, we discuss the implications of this study and outline a model for textual and visual metaphor processing.

2. Metaphor, imagery and perception

2.1 Metaphor as a conceptual process

Metaphor is defined as the experience of one thing in terms of another thing. Since Richards (1936) argued, "Thought is metaphoric and proceeds by comparison, and the metaphors of language derive there from", there have been many approaches to consider metaphor as a conceptual phenomenon (Ortony 1979; Lakoff & Johnson 1980). In particular, the Conceptual Metaphor Theory (CMT) of Lakoff and his colleagues argues that human cognition is organized in conceptual schemas, which are metaphoric in nature. These schemas are constantly enriched and modified by interaction with the world. Language draws on these cognitive schemas but is not identical to them. Moreover, verbal metaphors are surface manifestations of the metaphorical grounding of these schemas. To sum up, metaphor is "fundamentally conceptual, not linguistic in nature" (Lakoff 1993).

Considering metaphor as a predominantly conceptual phenomenon, and not merely a verbal one, has sparked many explorations of different aspects of metaphor processing and its relation with other cognitive processes such as perception, memory, and imagery. A number of attempts have also been made to examine the nature of non-verbal metaphors (Kennedy 1982; Forceville 1996; Carroll 1994), and they have found ample evidence that metaphors occur in various modes of communication like vision, gestures, etc. For example, synesthetic and physiognomic phenomena have been studied as forms of non-verbal metaphor (Werner & Kaplan 1963). Johnson & Malgady (1980) have suggested that the interpretation of some works of visual art (paintings) may parallel the interpretation of verbal metaphors, while Verbrugge & McCarrell (1977) reported some success in using musical passages as prompts for recall of metaphoric sentences. All this shows that the apprehension of figurative relations can also occur in non-linguistic media; one can even argue that the origins of many metaphors lie in perception and only later they are expressed through verbal forms.

2.2 Mental imagery and metaphors

Research on metaphor and imagery suggests that during metaphor comprehension perceptual experiences are evoked and the success of a metaphor partially depends on the vividness of the experience it produces in the reader's imagination. Neisser (1976) suggested that words are embedded in the perceptual schema associated with the [perceptual] situations in which they have been encountered. Further, words produce a quasi-perceptual experience (imagery) that shares certain implicit characteristics of the direct perception of the corresponding physical environment. In another study (Walsh 1990), it was found that noun-noun metaphors are easier to understand and are considered more apt when they evoke some appropriate imagery in the reader: "what we imagine is what we transfer" (Walsh 1990, 239). Gibbs & Bogdonovich (1999) presented three studies to show that concrete mental images are evoked during comprehension of poetic metaphors.

Indurkhya (2006) proposed a theoretical framework that distinguishes between 'analytic' and 'synthetic' metaphors. According to this view, in 'analytic metaphors' the interpretation of metaphor can be obtained by analysing the meaning constituents of the components of the metaphor. In 'synthetic metaphors' however, the interpretation of metaphor cannot be obtained by merely analysing the meaning constituents of the components of the metaphor. In this regard, they can be said to be non-compositional and the meaning is created by synthesis. As an example he mentions the poem 'Seascape' by Stephen Spender and argues that metaphors in the poem cannot be understood without a resonance between the perceptual experiences related to the concepts. Moreover, created meanings are subjective, and hence we see a wide variation among different subjects' interpretations (See also Nueckles & Janetzko 1997; Indurkhya 2007). The significance of these studies is that they show the importance of imagery and the role of perceptual processes in metaphor comprehension. However it must be noted that these studies focussed on verbal metaphors and not on visual or pictorial metaphors.

2.3 Imagery and perception

In imagery research there has been an on-going debate between the view that images are picture-like and pseudo-perceptual, and the opposing view that images are just another kind of propositional or symbolic representation (Pylyshyn 2002; Kosslyn, Thompson & Ganis 2006). Given this debate, it is important to ask, "What is the status of imagery?" and "Is imagery perception-like?" In order to understand the imagistic component, we refer to the sensorimotor account (O'Regan & Noë 2001; Thomas 2002; Thomas 2009), according to which a component of the meaning representation incorporates sensorimotor contingencies – that is, information about various ways in which the object can be acted upon, and how its perceptual properties change in response to those actions – and various cognitive processes may refer to this representation as needed.

Given several studies to show that perception and imagery use the same underlying brain mechanism (Griffith & Zaidi 2000; Zaidi & Griffith 2002; Kosslyn & Thompson 2003; Dehaene 2009), we may assume that both perception and imagery have a similar effect on higher cognitive processes such as metaphor comprehension. Imagery is subjective, and it is difficult to manipulate perceptual features of imagined concepts or to directly determine their effect on metaphor comprehension. On the other hand, perceptual features of conceret images can be manipulated, and their effect on metaphor comprehension can be ascertained.

2.4 Text vs image priming and semantic processing

During cognitive processes involving language, such as metaphor comprehension, perceptual features of the concept are evoked through text, but this evocation is highly subjective. On the other hand, when an image is shown to a participant, perceptual features of the image are objectively given. Though it has been noted that text and images are processed differently (Clark & Paivio 1991; Paivio 1986), there is evidence to suggest that they interact and influence each other in tasks that require semantic processing, and perhaps this is why we see facilitative effects when text is primed with pictures. Text and images can represent the same information differently. Text is described as 'descriptive' and pictures are described as 'depictive' representations (Schnotz 2002). The distinction between descriptions and depictions can be applied not only to external representations such as texts and pictures, but also to internal mental representations, which are constructed during text and picture comprehension. Current approaches in text comprehension research assume that in understanding text the reader constructs multiple mental representations. These include a surface representation of the text, which happens at the perceptual level, a propositional representation and later a mental model of what the text is about at the conceptual level (See Graesser *et al.* 1997). In picture comprehension, the viewer also constructs multiple mental representations, which include a surface structure representation (perceptual) and then a mental model.

The important point to note here is that in an image, surface structure representation corresponds to the perceptual (visual) image of the picture in the participant's mind. So, when the text is primed with the corresponding image, it evokes the picture comprehension process as well, and their combined effect somehow results in faster semantic processing. Such cross-modal priming effects have been observed for a variety of tasks that require semantic processing, such as naming, categorization, and lexical decision (Bajo 1988; Durso & Johnson 1980; Zwaan *et al.* 2004). However, to our knowledge, no such study is available for metaphor comprehension. Therefore, we chose to study the effect of perceptual features on metaphor comprehension in three different experiments using the priming paradigm.

3. Experiments

Considering that: (1) imagery facilitates metaphor comprehension, (2) imagery and perception use the same underlying brain mechanism, and therefore can be considered to be the same (or similar) process and (3) image priming fecilitates text comprehension; we hypothesize that image priming will facilitate verbal metaphor comprehension too. We also hypothesize that by image priming, effect of perceptual features on metaphor comprehension can be ascertained, which is difficult to measure in the case of imagery evoked by words. We expect to see a facilitative effect if one or both of the source and the target concepts of a verbal metaphor are primed with perceptual features (via images).

Therefore, to investigate the role of concrete visual stimuli in metaphor comprehension we conducted three experiments. To be more specific, if a textual metaphor is stimulated with the visual image of the source concept, visual image of the target concept, or visual images of both the source and the target concepts, what is the effect on metaphor comprehension? When imagery is evoked through words, it is highly subjective because it comes from the previous experiences of the cognitive agent. There is no way of controlling the previous experiences of the agent, or to measure any characteristic of the imagined experience. Therefore, it is difficult to probe the imagery process experimentally. However, an alternative is provided by visual metaphors, where at least one concept is depicted as an image. Images are presented concretely; their perceptual features like shape, texture, orientation, etc. are given objectively, and can be manipulated or measured in stimuli and their effect on the metaphorical process can be ascertained. For example, if 'umbrella' is presented as text, then one can imagine an umbrella that is red or black, has a different shape, is small or large etc. and we cannot measure any of these attributes. However, if an umbrella is presented as an image, then its colour, shape, size, etc. can be experimentally controlled.

There are two possible effects of image stimulation on the process of metaphor comprehension. If the image is presented first, it may evoke certain perceptual features, and we can measure how these evoked features facilitate or hinder metaphor comprehension. On the other hand, if the text is presented first, the participants may start to imagine the object referred to by the text, but the perceptual features of these imagined objects are likely to vary widely across the participants. Now if an image is presented after a short interval, then an interference effect is possible because the concrete features of the presented image may clash with the imagined features. For example, if the stimulus is the word 'umbrella', the participant may start to imagine a big wide umbrella. But when the image of a folding umbrella is presented shortly after, its features would conflict with the features of the imagined object. So it would be interesting to see how this conflict influences the participants' response. We can measure the effect of perceptual features in metaphor comprehension in both these situations by analysing the response time, generated list of features, etc.

One more issue related to the priming of images is the role of perceptual features. Several studies (following the comparison theory of metaphors) have shown that features of the source or the target may lend themselves as metaphor features. However, studies following the interaction theory of metaphor suggest that at least some of the metaphor features are *emergent* (they are not related to either the target or the source). In this study our objective is to study how this facilitation or interference of perceptual features affects the overall metaphor comprehension and, in particular, the emergent features. For example, are the metaphor features more strongly related to the source features, or to the target features? This can be measured using semantic association between the source, target and metaphor features.

The first two experiments were conducted to study this effect of stimulated perceptual features on metaphorical comprehension. In each experiment, images of the source concept, the target concept or both the concepts were presented to the participants together with the text. In the first experiment these images were shown before the presentation of the textual stimuli, and in the second experiment they were shown after the presentation of the textual stimuli. In the third study, we measured the relationship between the perceptual features of the stimulated concepts and the metaphorical features by analysing the semantic association between these features using Latent Semantic Analysis (LSA) (Landauer & Dumais 1996).

3.1 Experimental method and setup

Our objective is to determine how perceptual features influence metaphor comprehension and how features of the source and the target associate with metaphor features. For measuring comprehension, various parameters have been used in the past research: such as memory recall, recognition, and feature counting (Franklin & De Hart 1981; Bock & Brewer 1980). For our study, we used the following measures: (1) Response time to decide the meaningfulness of metaphor, (some researchers prefer to call it processing time but in our research we would call it response time as the majority of literature suggests) (Van Weelden *et al.* 2011; Paivio 1986), (2) aptness rating, and (3) number of features generated for the metaphor.

The stimuli for all our studies were textual metaphors in X is Y format, where X is the target concept and Y is the source concept. This methodology is commonly used for empirical study of verbal metaphors (Keneddy & Chiappe 1999; Chiappe *et al.* 2003; Chiappe & Keneddy 2000). Study 1 used a cross-modal priming paradigm in which the participants were primed with images corresponding to the source concept, the target concept or both the source and the target concepts before presenting the textual stimuli. Study 2 was similar to Study 1 except that images corresponding to the concepts were presented 200 milliseconds after presenting the textual stimuli. In Study 3, we used similar stimuli. First, pairs of concepts were shown, and then those concepts were shown individually to generate features. This methodology is similar to the one used by Gineste *et al.* (2000) in a verbal metaphor study.

In the literature, *aptness* of metaphor is used in different ways. For example, in some experimental studies, aptness is considered to be the extent to which a comparison captures salient features of the topic in question (Katz 1989, 1992; Malgady & Johnson 1976; Tourangeau & Sternberg 1981, 1982; Trick & Katz 1986). However, this characterization is based on the comparison theory of metaphor. In the interaction theory of metaphor, on the other hand, there can be *emergent* features, which affect the aptness of metaphor (see, for instance, Gineste *et al.* 2000). In our study, aptness was determined by asking the participants: "How much did you like the metaphor?" This method of rating aptness has been used in several other experimental studies as well (e.g. Kennedy & Chiappe 1999).

Images corresponding to the concepts were presented only for 100 milliseconds. This duration is sufficient to process perceptual information from images but not enough to integrate this information into object recognition (Bullier 2001; Thorpe *et al.* 1996). This ensures that the participant processes only the perceptual information such as shape, texture and orientation, but not the semantic information associated with the images. Moreover, images were converted into black and white to remove the color parameter in order to reduce their cultural association.

3.2 Study 1: Priming condition

Participants
Twenty-eight undergraduate students (thirteen females and fifteen males), fluent English speakers and with the average age of 21 years participated in this study.

Stimuli material and priming conditions
The stimuli consisted of 80 textual sentences in 'X is Y' format, where X and Y were concrete nouns. X is considered to be the target and Y the source. Participants were presented with all the sentences in four conditions: so 20 sentences for each condition. Condition 1 with no priming (TT), served as control; Condition 2, where only the target concept was primed with its image for 100 milliseconds (IT); Condition 3, with only the source concept primed with its image for 100 milliseconds (TI); and Condition 4, where both the target and the source concepts were primed with their respective images for 100 milliseconds simultaneously (II). This is shown in Figure 1, which illustrates the priming conditions: 'T' corresponds to text and 'I' corresponds to image. The first element is the target and the second element is the source. So TT means no priming, TI means that source of the metaphor was primed, IT means the target of the metaphor was primed and II means both the source and the target were primed.

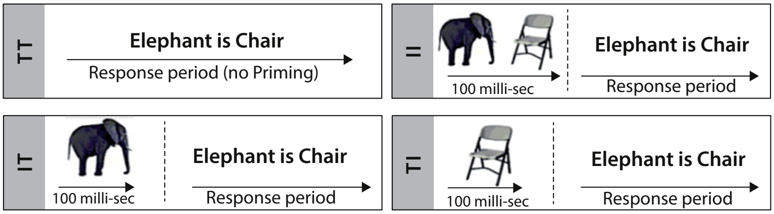

Figure 1. Priming conditions ('T' corresponds to text and 'I' corresponds to image)

Procedure and task
Participants were given a training session before the actual experiment. The training set included two metaphors in all four conditions. It was done to familiarize participants with the experimental procedure. Data from the training session was not included in the analysis. Actual experimental stimuli included 80 metaphors in four conditions (20 each). Participants were primed randomly with images of only the source, or only the target, or both the source and the target for 100 milliseconds before the metaphors appeared on the screen. They were asked to decide if the metaphor 'X is Y' was meaningful to them in any context. If it was not meaningful, they were asked to proceed to the next stimulus by pressing 1 on the keyboard. If

the metaphor was meaningful, then they were asked to rate its aptness ("How much you liked it?") on a 1–7 scale by pressing the corresponding numeric key. Once they gave their aptness rating, a blank screen with a + sign appeared and they were asked to give up to five features of the metaphor. The participants gave this response orally, which was recorded and later transcribed for analysis (Figure 2).

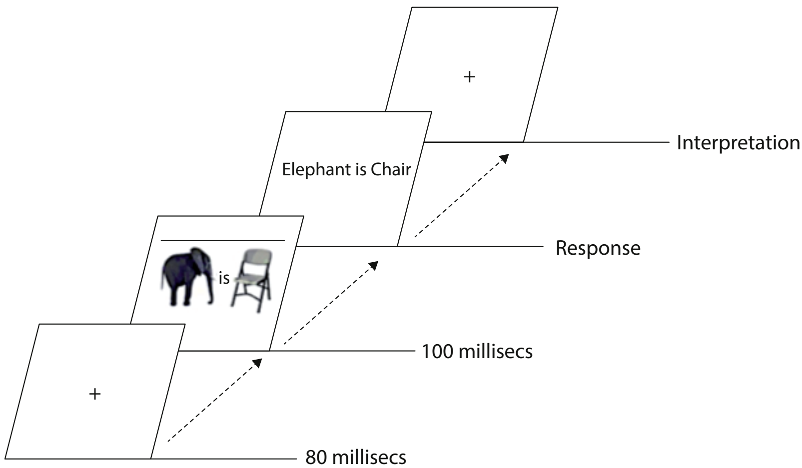

Figure 2. Procedure followed in Experiment 1

Results

An analysis of the response times to comprehend metaphors showed that primed metaphors (II, IT and TI) were comprehended faster than non-primed metaphors (TT). (Mean response time for II = 5.90 seconds, for TI = 6.94 seconds, for IT = 6.59 seconds and for TT = 8.30 seconds). We did a t test to determine the statistical significance. The rest of T test showed that differences between TT and II [$t\ (1,18) = 8.22$, $p < .01$], TT and IT [$t\ (1,18) = 5.2627$, $p < .05$], TT and TI [$t\ (1,18) = 9.37$, $p < .01$] were significant. Differences between IT and TI and II were not significant (Figure 3).

We found no significant difference in the aptness ratings among the four conditions. Therefore, in another analysis, we divided the ratings of TT (ranging from 1–7) into high and low ratings. We expected to find the effect of image priming on those metaphors that got high aptness ratings. For this, all ratings above the median (4.00) were considered high and all ratings below the median were considered low. Then high-aptness metaphors of TT condition were compared with II, IT and TI conditions. We found that the aptness ratings for those metaphors in II ($M = 5.43$), TI ($M = 5.29$) and IT ($M = 5.25$) conditions were significantly higher than TT ($M = 4.61$) condition. The T test showed that the difference between TT and II [t (1,18) = 7.22, $p < .01$], TT and TI [t (1,18) = 6.24, $p < .02$] and TT and IT [t (1,18) = 4.68, $p < .05$] were statistically significant. In the low-aptness group this difference was not significant (Figure 4).

Results of this study show that priming of perceptual features (a concrete image) of the target, the source, or both, before the presentation of verbal metaphors significantly reduces the comprehension time. Moreover, it also shows that priming had a significant effect on aptness if the metaphor was liked. If the metaphor was not liked then the priming had no effect. This suggests that priming facilitates metaphor comprehension.

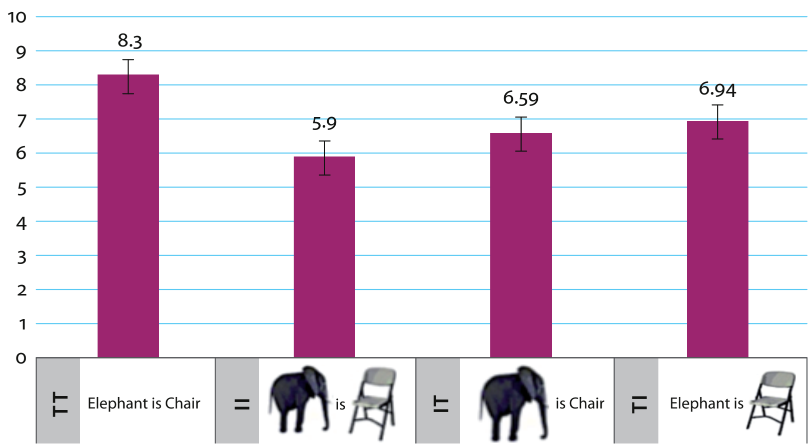

Figure 3. Mean response time to comprehend the metaphor

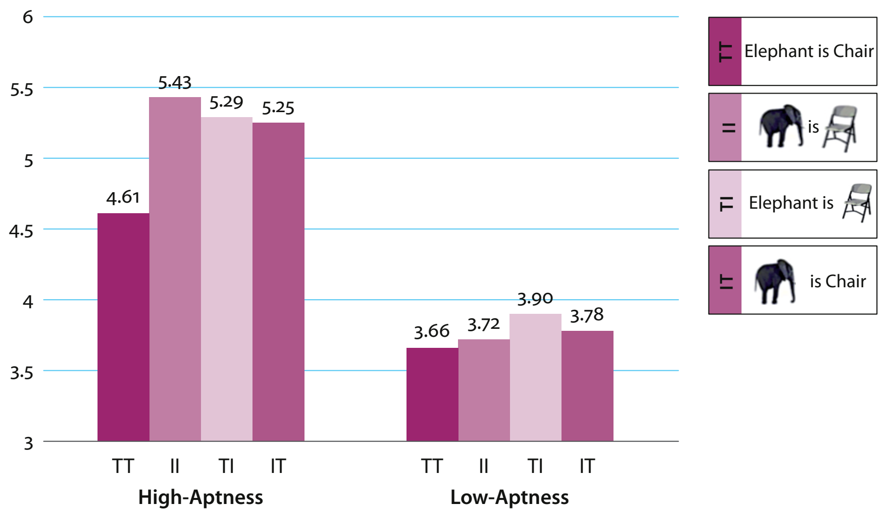

Figure 4. Aptness ratings under different conditions

3.3 Study 2: Image stimulation condition

Experiment 2 was similar to Experiment 1 except that images were presented 200 milliseconds after presenting the textual stimuli. The objective was to test how the perceptual features of the presented image interact with the evoked imagery (if any), and its effect on the metaphorical comprehension.

Participants
Twenty-eight undergraduate students (twelve females and sixteen males), fluent English speakers and with the average age of 21 years, participated in the experiment.

Stimulus material and image stimulation conditions
The same material and the same four conditions (TT, II, TI and IT) as in Experiment 1 were used for this experiment, with the only difference being that the image stimulation followed the textual presentation (Figure 5).

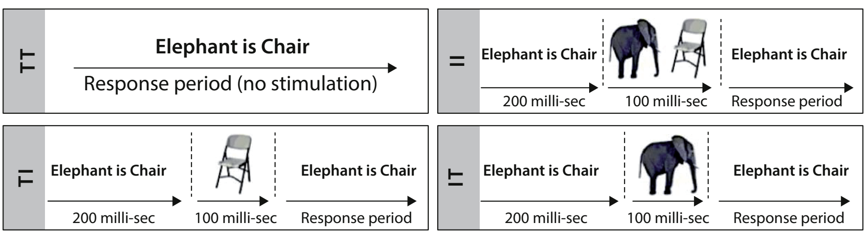

Figure 5. Stimuli used in Experiment 2

Procedure and task
Instructions were similar to Experiment 1 and the participants had to perform the same task but the order of stimuli presentation was slightly different: the textual stimuli was presented for 200 milliseconds, followed by the image of the source (TI), or the target (IT), or both (II) or none (TT) for 100 milliseconds (Figure 6).

Results
We found that in the image stimulation conditions, the response time to comprehend a metaphor was faster (mean response time for II = 6.05 seconds, for TI = 5.75 seconds, for IT = 6.65 seconds and for TT = 8.50 seconds). The T test showed that the differences between TT and II [$t(1,18) = 9.17$, $p < .01$], TT and IT [$t(1,18) = 5.54$, $p < .05$], TT and TI [$t(1,18) = 8.76$, $p < .01$] were significant. The differences between IT and TI and II were not significant (Figure 7).

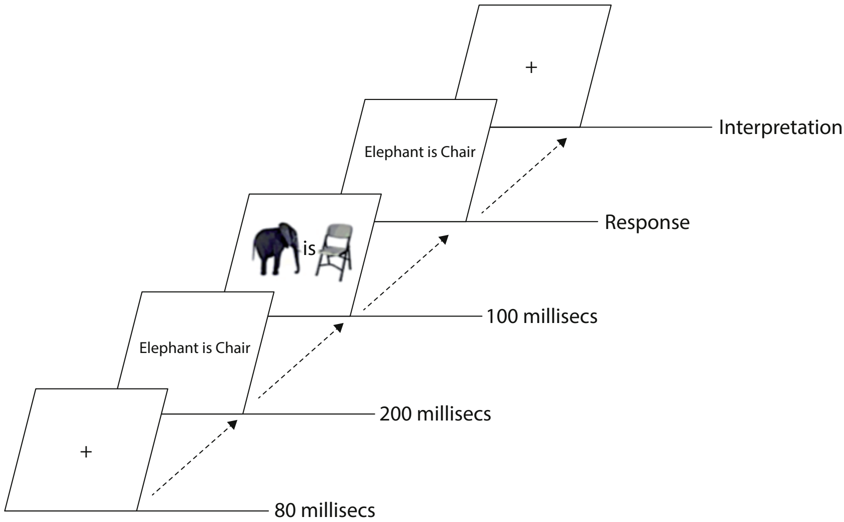

Figure 6. Procedure followed in Experiment 2

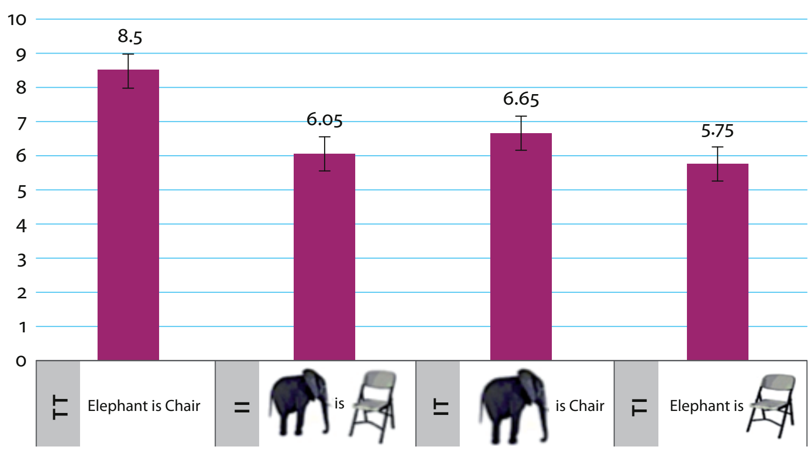

Figure 7. Mean response time to comprehend a metaphor

We did not find any significant difference in the aptness ratings across the four conditions. So in a follow-up analysis similar to Experiment 1, we divided the ratings of TT (ranging from 1–7) into high and low ratings. We expected to see the effect of image suggestion on those metaphors that got high-aptness ratings. For this, all ratings above the median (2.98) were considered high and all ratings below the median were considered low. Then high-aptness metaphors of TT condition were compared with II, IT and TI conditions. We found that the aptness ratings for those metaphors in II (M = 4.80), TI (M = 4.64) conditions were significantly higher than TT (M = 3.88) condition. The difference between TT and IT (M = 4.32) was not significant. The differences between TT and II [$F(1,18) = 8.58$, $p < .009$], and between TT and TI [$F(1,18) = 6.49$, $p < .02$] were statistically significant. In the low-aptness group this difference was not significant (Figure 8).

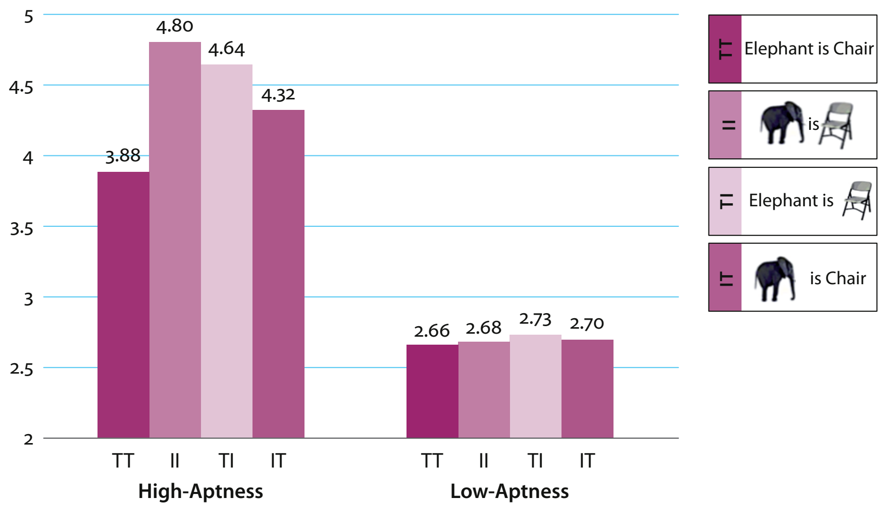

Figure 8. Aptness ratings under different conditions.

Similar to Study 1, we found facilitative effect of images in comprehension and aptness of metaphor. Even though images were presented after 200 ms of verbal metaphor presentation (which was enough time to evoke imagery), images facilitated metaphor comprehension instead of interfering.

3.4 Study 3: Semantic association between source/target features and metaphor features

The last two studies showed that image suggestion facilitates metaphorical comprehension, as primed metaphors (prior and during verbal metaphor presentation) are comprehended faster. The aim of the third study was to discern if there was any difference between how strongly perceptual and conceptual features of the source and the target are semantically associated with the metaphor features. We consider metaphor features to be those features that are generated in interpreting a metaphor, and source/target features to be those features that are generated for the source/target concepts individually (see Gineste *et al.*, 2000). For determining the strength of semantic associations, we used the technique of Latent Semantic

Analysis (LSA), which has been developed for extracting and representing the contextual meaning of words from statistical computations based on a large corpus of text (Landauer & Dumais 1996).

Participants
Twenty-two undergraduate students (sixteen males and six females), fluent English speakers and with the average age of 21 years, participated in the experiment.

Stimulus material
The same material as in Experiment 1 was used for this study. Four conditions (TT, II, TI and IT) in this experiment were the same as in Experiment 1.

Procedure and task
The study was conducted in two stages. In the first stage, participants were shown 20 sentences in 'X is Y' format, and were primed with the images of the concepts in the four conditions (TT, II, IT and TI) as in Experiment 1. We made sure that all participants received non-repeated stimuli in all conditions. The participants were asked to interpret each stimulus metaphorically, if possible. If they did not find it metaphorical, they could proceed to the next sentence by pressing 1 on the keyboard, and the second stage did not follow. But if they found the sentence metaphorical, they proceeded to the second stage by pressing 2 on keyboard, when they were shown individual concepts either as text or as an image. Participants were asked to list up to five features of the concept being shown. They provided their response orally, and it was later transcribed. This procedure for the image-image (II) condition is shown in Figure 9.

Scoring
After the two-stage study we compiled the generated features into three categories: (1) metaphor features, (2) source features, and (3) target features (see Gineste *et al.* 2000). For example, if "Earth is an Apple" was given as a stimulus in the first stage, then the features obtained for it were considered to be metaphor features. Features generated for 'Earth' or 'Apple' individually were considered as the target features and the source features, respectively.

A feature can also be categorized as a conceptual feature or a perceptual feature (Nolan 1994; Van Weelden *et al.* 2011; Schilperoord *et al.* 2009). For example, 'red' and 'round' are perceptual features, and 'beautiful' and 'strong' are conceptual features. We asked five participants to categorize each of the source/target features into conceptual-perceptual category. Based on the inter-subjective agreement we calculated the semantic association between the metaphor features and the source/target features using LSA. An example is given below in Table 1. Higher values in

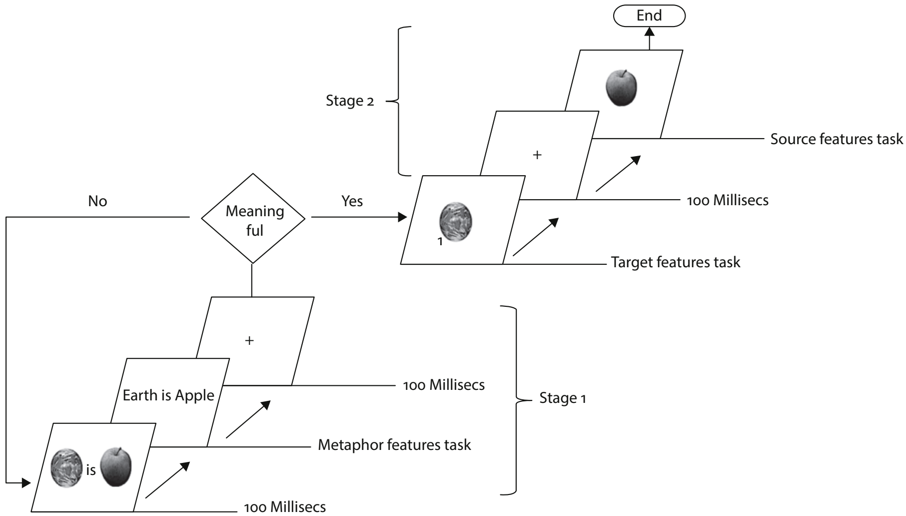

Figure 9. Procedure for Study 3 for the image-image condition

the table show stronger semantic associations between concepts. For example 'war' (an emergent feature) has a strong semantic association with 'red' (a perceptual feature of the source concept in one of the metaphors). Similarly 'healthy environment' (an emergent feature) has a relatively weaker semantic association with 'red' (a perceptual feature of the source concept in one of the metaphors).

Table 1. Semantic associations between source/target and metaphor features

Metaphor features						
			Sinful people	**Lots of pollution**	**War**	**Healthy environment**
Source features 	Perceptual	Red	0.25	0.21	0.36	0.12
		Round	0.33	0.3	0.08	0.06
	Conceptual	Fruit	0.19	0.1	0.04	0.17
		Adam	0.2	0.19	0.12	0.07
		Vitamins	0.07	0.04	0.01	0.17
		Keeps the doctor away	0.32	0.42	0.02	0.26
Target features 	Perceptual	Blue	0.29	0.1	0.15	0.13
		Round	0.33	0.3	0.08	0.06
	Conceptual	Third planet	0.17	0.16	0.08	0.14
		Environment	0.07	0.47	0.12	0.37
		Greenery	0.04	0.36	0.01	0.06

Analysis and results
A total of 932 features (245 metaphor features, 318 source features and 369 target features) were generated, from which the sets of unique features for the source (12 features), the target (16 features) and the metaphor (34 features) were identified along with their frequency for each metaphor. For example, for a given source/target concept, if 'red' was given as a feature by nine participants, 'round' by four participants and 'healthy' by three participants, then the total number of generated features for this concept would be sixteen, and the total number of unique features would be three ('red', 'round', 'healthy'). These unique features of the source, the target and metaphor were used to find the semantic association between features using LSA for each of the four experimental conditions. A weak semantic association between the metaphor feature and source and target concepts would indicate that metaphor feature is an emergent feature. On the other hand, a strong semantic association would indicate that the metaphor feature is associated with the target or the source.

Figure 10 shows the results: average semantic associations between the (perceptual and conceptual) source/target features and the metaphor features in all four experimental conditions. From the graphs we can see that when both the source and the target were primed with images (II condition), perceptual features of the source were more closely related to the metaphor features (mean association = 0.28), as opposed to the conceptual features of the source (mean association 0.18). On the other hand, under the no priming TT condition, it is the conceptual features of the source that were more closely related to the metaphor features (mean association = 0.24), as opposed to its perceptual features (mean

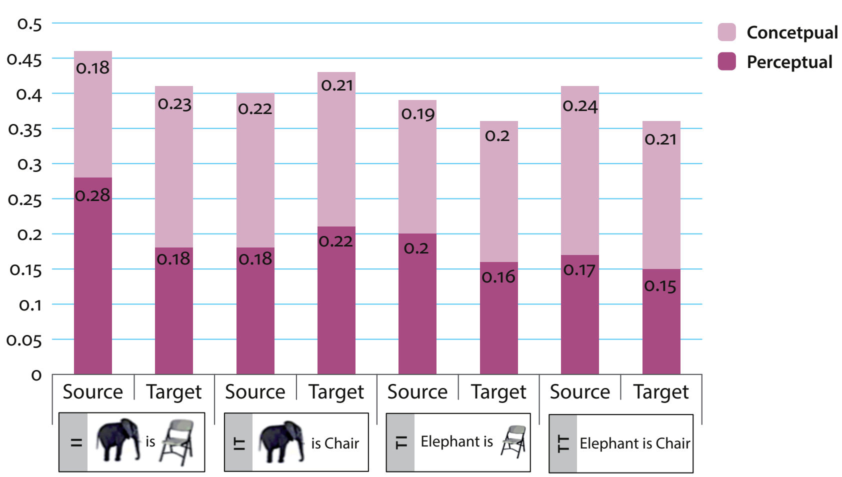

Figure 10. Average semantic association between source/target and metaphor features

association = 0.17). For target features, there was no such effect of image priming, and in both conditions, conceptual features (compared to the perceptual features) of the target were somewhat more strongly related to the metaphor features.

Perhaps surprisingly, however, when only one of the source and the target was primed with an image, we found no significant effect (compared to the control condition of no priming) on the semantic association between the metaphor features and the perceptual and conceptual features of the source and target.

4. General discussion and conclusions

The aim of our study was to explore the role of perceptual features in metaphorical comprehension and our results suggest that perceptual stimulation of concepts facilitates the metaphorical interpretation process. Specifically, there were three major outcomes of our experiments:

1. Image stimulation facilitates metaphorical interpretation. We found that the response time to comprehend a metaphor decreases significantly if perceptual information of concepts is provided. This is in agreement with the previous studies related to semantic processing in naming and categorization (Carr *et al.* 1982; Sperber *et al.* 1979; Vanderwart 1984).
2. We did not find any significant effect of perceptual stimulation on aptness ratings. However in Experiments 1 and 2, we found that for higher aptness metaphors, image priming or stimulation of the source, the target, or both, increases the aptness value. On the other hand, for lower aptness metaphors this priming and stimulation does not have any significant effect.
3. Compared to the conceptual features, perceptual features of the source are more closely related to the metaphor features when both the source and the target concepts are primed by images. In contrast, when there is no priming, the conceptual features (as opposed to the perceptual features) of the source are more closely related to the metaphor features. There is no such effect on the target features.

As for the question posed in the introduction, namely whether priming by visual images facilitates or hinders metaphor comprehension, our experimental results show that priming facilitates comprehension. It seems that concrete perceptual features such as shape, texture, and orientation of the source and/or the target concepts help the reader in creating associations between them, which in turn helps in generating a metaphorical interpretation.

We found that individuals take less time to comprehend a verbal metaphor if one or both of its concepts are primed with the corresponding images. Also, the perceptual features of these primed images are semantically more associated with the metaphor features. A possible explanation for this can be the difference between the text and the image processing. Initially, when an individual reads a piece of text, he or she processes its surface features at the perceptual level, creates a propositional representation and then an internal mental model at the conceptual level. On the other hand, in viewing an image, he or she processes the surface features of the image and then creates a mental model and then a propositional representation at the conceptual level. So when a metaphor is primed, the surface features of the image produce a similar visual image of the picture in the individual's mind (without creating a propositional model and these features are registered and used in metaphor comprehension) whereas in non-primed metaphors, surface structure of text is processed initially at perceptual level and then a propositional model is created, which in turn produces a mental representation of concept represented in text (which is comparatively a longer process).

We propose a model for metaphor processing which is based on the current theories of perception (O'Regan & Noe 2001; Treisman & Gelade 1980; Zimbardo & Gerrig 2002) and integrated model of text and image processing (Schnotz & Bannert 1999; Schnotz 2002).

The cornerstones of this model are a distinction between the conceptual and the perceptual spaces, and positing top-down and bottom-up mechanisms that allow features in these two spaces to stimulate each other. In top-down processes, conceptual features in the conceptual space stimulate perceptual features in the perceptual space; and in bottom-up processes, perceptual features in the perceptual space stimulate conceptual features in the conceptual space. In our earlier model (Indurkhya 2006), we had hypothesized that in certain metaphors, top-down processes stimulate perceptual features of the source and the target, more familiarly known as imagery, which interact together and in turn activate conceptual features (through bottom-up processes), which are identified as metaphor features. Moreover, those metaphor features that are not evoked by the source or the target alone are seen as emergent features.

A graphical schematic of our proposed model is shown in Figure 11. According to this model, when the image of the source or the target is presented directly, it stimulates perceptual features faster, thereby speeding up the generation of metaphor features, as indicated by our experiments.

We have not yet incorporated the asymmetry of metaphors in this model. Though it is generally accepted that metaphors are asymmetric in that 'X is Y' is not the same as 'Y is X' (Connor & Kogan 1980; Malgady & Johnson, 1980; and Verbrugge, 1980), there are different accounts of how this asymmetry is manifested. For example, the feature-transfer model of Ortony (1979) favours a source-to-target transfer, whereas Barnden (2001) has discussed a target-to-source transfer model.

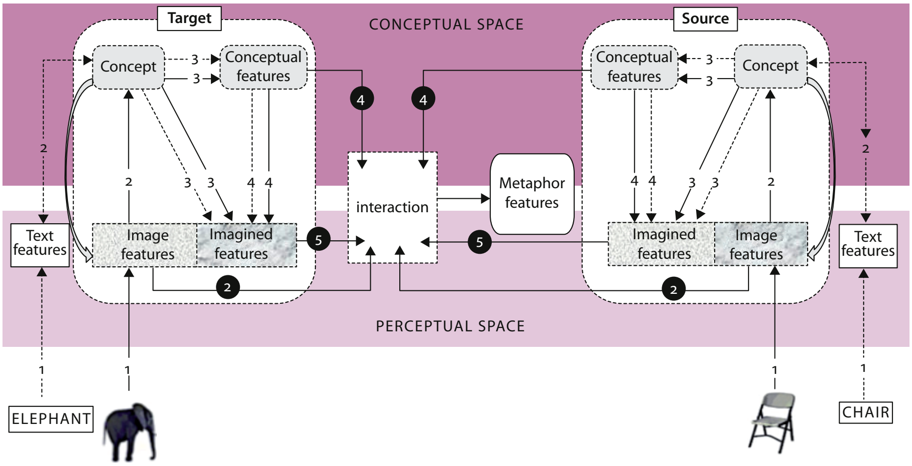

Figure 11. A model for visual and textual metaphor processing

Our experiments strengthen the results of Paivio & Clark (1986), who found that the source concept imagery is more effective in understanding a metaphor than the target concept imagery. Though in our Study 1 (priming condition), we found no significant difference between TI and IT conditions, in Study 2 (stimulation condition), stimulation by the source image led to a slightly faster response time than stimulation by the target image. Moreover, we found in Study 3 that when both the source and the target are stimulated with images, the perceptual features of the source are more closely related to the metaphor features compared to the perceptual features of the target. This suggests that though both the source and the target images facilitate perceptual feature interaction, it is the perceptual features of the source that end up being more strongly associated with the metaphor features. However, these findings are very preliminary, and we do not have an adequate explanation for the role of the target image in this interaction. All this requires further experimentation where we swap the source and the target, and study the effect of image priming and stimulation on the directionality of a metaphor.

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