Metaphor in Good Shape

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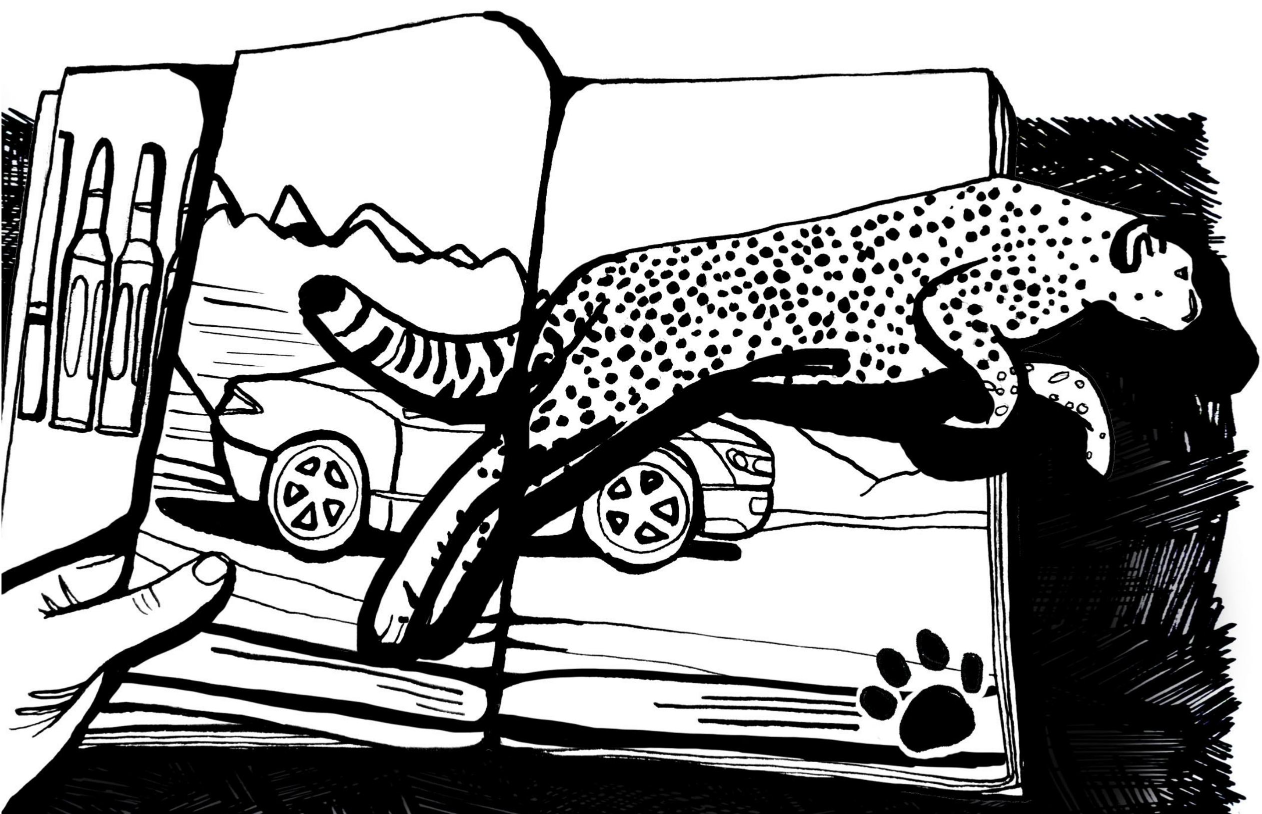

I was just a little girl when I watched the brilliant movie 'Forrest Gump' and heard Forrest say, "My momma always said, *life was like a box of chocolates*." Beyond the fact that the metaphor is about chocolate, for which I always have had a weakness, I love that it tries to explain something so puzzling and intangible as life in terms of a very recognizable experience, namely the moment when you pick a chocolate from a box, bite it and are surprised by the filling.

Just as Forrest's mom used a metaphoric relation to make the world a bit more comprehensible to her son, metaphors are generally used to explain abstract concepts in terms of concrete concepts or experiences (Gibbs, 1994; Katz, 1989; Lakoff & Johnson, 1980). So when we perceive a metaphor, we try to understand the so-called target concept (e.g., 'life') in terms of the so-called source concept (e.g., 'a box of chocolates'). That is, we try to find out why the concept of life may be similar to the experience of picking a chocolate from a box and eating it. In doing so, we look for characteristics of latter concept which can be mapped onto the former concept. It is the ease with which we undertake this process that astonishes and fascinates many researchers, and hence explains the great deal of research that has been dedicated to this topic.

The view on the nature of metaphor has been subject to a radical shift. While until the early eighties metaphor was considered a matter of language, from then on, the view emerged that metaphor is a matter of thought (Lakoff & Johnson, 1980; Ortony, 1979). Ever since its introduction, Lakoff's (1993) view of metaphor as a cross-domain mapping in the conceptual system has dominated the field of metaphor research and has led to a vast increase in the number of studies on how people process verbal metaphoric expressions. In addition, this view has led to the idea that language is not the only modality in which metaphoric relations can be expressed. Indeed, research has shown that metaphors are also present in gesture (e.g., Cienki & Müller, 2008) and in both static (e.g., Carroll, 1994, 2001; Forceville, 1996; Kaplan, 2005) and moving images (e.g., Carroll, 1996; Ortiz, 2011).

Yet unlike the research on verbal metaphors, research on visual metaphors until now has been dominated by a structural semiotic approach (Steen, 2007). Studies have focused on the identification and classification of visual metaphors, thereby describing and analyzing their ingredients (Carroll, 1994; El Refaie, 2003; Forceville, 1996; Forceville & Urios-Aparisi, 2009; Groupe Mu, 1992; Kaplan, 1992; Maes & Schilperoord, 2008; Ortiz, 2010; Phillips & McQuarrie, 2004; Schilperoord, In press; Schilperoord, Maes, & Ferdinandusse, 2009; Teng & Sun, 2002; Van Mulken, 2003). Far less attention, however, has been paid to the psychological aspects of visual metaphor. The present dissertation is a first attempt to fill this gap, by studying visual metaphor from a psycholinguistic perspective.

To justify the focus and explain the relevance of the present research, the remainder of this introduction presents a comparison between our knowledge on verbal metaphors and our (lack of) knowledge on visual metaphors. First, metaphor will be approached from a structural semiotic perspective, thereby addressing the possible linguistic and visual structures of metaphor. Second, metaphor will be discussed from a psychological perspective, leading up to the goal of this dissertation.

To evoke metaphorical relations, the target and source concept have to be expressed somehow. The most studied verbal expressions of metaphorical relations are the comparison statement – "*an X is like a Y*" – and the categorization statement – "*an X is a Y*" –, in which X and Y denote a reference to the target and source concept respectively. Crucially, in expressions of metaphorical relations, the target and source concepts originate from disparate conceptual domains (Aisenman, 1999; Bowdle & Gentner, 2005; Glucksberg, 2003; Jones & Estes, 2006). For example, "*My new motorcycle is like cheetah*". This as opposed to *literal* comparison and categorization statements, in which the target and source concepts originate from the same conceptual domain. For example, "A leopard is like a cheetah".

The presence of the word 'like' in metaphoric comparison statements, or so-called similes, encourages a cross-domain comparison to find out why the two concepts are alike. The set of found shared attributes is then used to create an ad hoc metaphoric category under which both concepts can be subsumed. Categorization statements, or so-called metaphors, on the other hand, invite to subsume the target under the category represented by the source, thus projecting particular attributes of the source onto the target.

When it comes to the visual expression of metaphor, several structural classifications have been proposed (e.g., Forceville, 1996; Maes & Schilperoord, 2008; Phillips & McQuarrie, 2004; Van Mulken, 2003). Phillips and McQuarrie's (2004) typology differentiates various ways in which a visual rhetorical figure can be constructed, metaphors being one of those. Their typology isolates three ways in which the two objects that comprise the visual metaphor can be presented perceptually. The target object can be visually replaced by, fused with, or juxtaposed to the source object. Consider Figures 1.1 to 1.3, respectively. Figure 1.1 shows an advertisement for a brand of iced tea. It expresses the metaphorical relation between a plant stem and a drinking straw. By replacing the drinking straw (which we usually encounter in a can of soda) with a plant stem, the interpretation is evoked that the can contains a liquid that is usually transported by plant stems, that is, a healthy and natural fluid. Figure 1.2 shows an advertisement for a particular car. The advertisement expresses the metaphorical relation by fusing two objects into one hybrid object. The car is merged with a red pepper to communicate the message that the car drives and accelerates as 'spicy' as a red pepper. Figure 1.3 shows an advertisement in which the target and source objects are juxtaposed. In this advertisement for a brand of sleeping bags, a sleeping bag is juxtaposed to three seals to highlight the fact that this type of sleeping bag will keep you warm, just like the thick skin of seals.

Research from a structural semiotic angle has provided knowledge about the different structures in which verbal and visual metaphors can be expressed. Clearly, differences between modalities are to be found at this structural level. Language and vision have their own units of expression and principles of assemblage. Compared to the verbal constructions of "*an X is like a Y*" and "*an X is a Y*," the visual structures distinguished by Phillips and

McQuarrie are far less conventional and clear-cut. For example, the distinction between juxtapositions and replacements can be rather blurry. Is in Figure 1.3, the sleeping bag juxtaposed to the seals, or does it replace a seal? These rather vague boundaries between visual structures pose a challenge in creating controlled items for experimental research. This may explain why experimental research on visual metaphors is rather scarce. The researchers that did face the challenge focused mainly on audience responses to the rhetorical figures, such as belief formation, attitude towards the advertisement or commercial, and perceived complexity (see McQuarrie & Mick, 1999; Van Enschot, Beckers, & Van Mulken, 2010; Van Enschot, Hoeken, & Van Mulken, 2008). Questions about whether and how differences in visual structures affect the processing and understanding of metaphoric relations are still unaddressed, among which the pivotal question how visual structures affect the type of features that ground cross-domain mappings. The features that can be projected from the source object onto the target object of Figure 1.1, for example, can consist of common *relational* structures (e.g., both entities can perform the same action or can be used to accomplish the same goal) and common *attributive* features (e.g., the entities are perceptually similar).

Figure 1.1. An advertisement for a brand of iced tea. (Replacement)

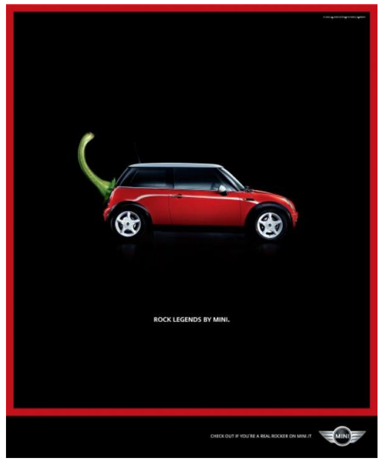

Figure 1.2. An advertisement for a car brand. (Fusion)

Figure 1.3. An advertisement for a brand of sleeping bags. (Juxtapostion)

In the field of verbal metaphor research, this issue of feature mapping has received wide attention (e.g., Gentner, 1988; Gentner & Clement, 1988; Gibbs, 1994). Verbal metaphors can be divided into three different categories: image, relational, and double metaphors. Image (or resemblance) metaphors operate on mental imagery, that is, on the mapping of perceptual features (Gibbs & Bogdonovich, 1999; Lakoff, 1987; Urena & Faber, 2010). For example, consider the metaphor "*My wife whose waist is an hourglass*" from André Breton's poem Free Union. We understand this metaphor by mapping the shape of an hourglass onto the waist of a woman. Relational metaphors, on the other hand, are interpreted by mapping relational structures only (Gentner, 1983, 1988; Gentner & Clement, 1988; see also Gentner & Kurtz, 2005). For example, in interpreting "*A cigarette is a time bomb*," we project the fact that a time bomb often goes unnoticed and does its damage after a period of time, onto the cigarette. Double metaphors can be interpreted both by mapping relational and attributive features from the source onto the target. An example of such a metaphor is "*A plant stem is a drinking straw*." In interpreting this metaphor we can think of relational commonalities, such as that both objects are used to transfer liquids from below to nourish a living thing, and common attributive features, such as that they are both long and cylindrical. Yet according to Gentner and Clement (1988), people prefer to map common relational structures, such as the former, rather than attributive commonalities, such as the latter.

If we were to express these three types of verbal metaphors visually, we would not have difficulty in creating a visual counterpart of an image metaphor. A hybrid picture of a woman and an hourglass or a juxtaposition of a woman and an hourglass would quite probably lead to the attributive mapping of the shape of the hourglass onto the, thus very slim, waist of the woman. Visual expressions of relational and double metaphors, however, would need to be processed in the same way as verbal metaphors, through the mapping of relational features from the source object onto the target object. Yet, consider Figures 1.1 to 1.3 again. Note that quite some perceptual features have been manipulated to make the objects look similar. This perceptual similarity might evoke attributive mappings, as attributes typically relate to perceptual characteristics of objects. But it might also be the case that the cognitive processes that occur in verbal metaphor processing apply to visual metaphors as well, as the Conceptual Metaphor Theory (Lakoff & Johnson, 1980) states that they are relatively independent of the input modality. As such, the same preference for relational mapping might occur in visual metaphor processing. The question is how the obvious perceptual manipulation affects this type of mapping. The fact that the drinking straw *can* be replaced by the plant stem, the pepper *can* be fused with the car, and the sleeping bag *can* be lined up with the seals might suggest that the objects have similar conceptual features as well. Under this view, perceptual similarity is employed to encourage relational mapping. This is the general hypothesis that will be put to the test in this dissertation.

Although the perceptual manipulation is rather evident in each of the presented visual templates (i.e., replacement, fusion, and juxtaposition), particularly the template of juxtaposition is assumed to rely heavily on these perceptual manipulations. Teng and Sun (2002; see also Ortiz, 2010) propose that interpreting the relation between juxtaposed objects is based on perceptual grouping (cf. Wertheimer's Gestalt Theory, 1923). Perceptual grouping is created by perceptually aligning the objects in terms of different object-constitutive factors, such as size and shape, and object-depictment factors, such as orientation and distance (for an overview, see Schilperoord et al., 2009). The sleeping bag and seals in Figure 1.3 for example, are lined up at equal distances from each other, with a similar spatial orientation, shape, size, and color. This perceptual grouping might work as the visual counterpart of the comparative term ‘like’ in the sense that it might encourage viewers to find out why the objects, stemming from different conceptual domains, are disposed as to belong the same perceptual group. As such, when there is perceptual grouping, this might stimulate to look for conceptual commonalities between the presented objects, as opposed to when perceptual grouping is absent. The aim of the present dissertation is to assess how perceptual grouping affects attribute and, more interestingly, relational mapping during visual metaphor processing.

Although perceptual grouping can be established through the manipulation of multiple perceptual factors, as can be seen in Figure 1.1 to 1.3, this dissertation's focus in on perceptual grouping as a result of one factor, the object-constitutive factor *shape*. The reason for the exclusive attention to this factor is that shape was found to be the most salient visual cue in object recognition (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976) and therefore is expected to play an important role in perceptual grouping. Throughout this dissertation, shape is defined as the outline of the picture of a particular object, rather than the inherent shape of the object. As such, the focus is on similarities between objects such as sleeping bags and seals in the way that they are depicted, rather than on what they look like in reality.

Dissertation outline

This dissertation consists of four studies, which are presented in Chapter 2 to 5. The four chapters each present a study that has been published, has been accepted for publication, or has been submitted for publication in an international peer-reviewed journal. Being self-contained, each chapter has its own abstract, introduction, discussion, and reference list. As a result, definitions or introductions of certain theories may be repeated several times throughout this dissertation. Chapter 6 contains the general discussion and conclusion.

Each chapter provides insight into the role of shape in the process of seeking literal or figurative relations between objects or concepts. Chapter 2 presents a study on the role of shape in comparing objects. This study assesses whether shape affects the comparison of objects that are functionally similar (e.g., a guitar and a banjo) or different (e.g., a guitar and a spoon) and hence need to be compared in a within-domain or cross-domain fashion respectively. Through the use of three different experimental methods, the role of object shape is investigated in three distinct temporal phases of object comparison. The first two experiments explore the initial processes of object comparison by employing a similarity judgment and rating task, whereas the third experiment taps into the actual content of the correspondences found between the objects by means of a production task.

The study presented in Chapter 3 examines the step that follows object comparison: (ad hoc) categorization. This study tests whether shape has a fundamental role in semantic memory organization. Using the Proactive Interference paradigm, this study assesses whether we automatically use shape to store objects in our memory and whether shape information is encoded differently for objects from similar and dissimilar conceptual categories. As such, this study explores categorization in a within-domain and cross-domain fashion.

The study of Chapter 4 investigates whether shape affects the construction of metaphoric relations (i.e., correspondences) between pairs of depicted objects. Similar to the third experiment of the first study, this study aims at gaining more insight into the actual content of the metaphoric relations found between the pairs of objects. However, this study uses pairs of objects from highly dissimilar conceptual domains (e.g., vehicles and animals), which are therefore closer to the visual metaphors we encounter in advertisements.

The study presented in Chapter 5 takes a step aside from visual metaphors as it assesses the role of shape in mental representations of (verbal) similes. In this study, the findings of the previous studies will be projected onto verbal metaphors. Because of the comparative sentence structure of similes, they invite readers to compare two entities in order to find metaphorical relations between them. This study tests whether the identification of conceptual similarities between the entities comes with an assumption of shape similarity.

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Chapter 2

The role of shape in comparing objects

Abstract

Comparing objects is a process necessary to cognitive tasks involving categorization. Shape is considered one of the primary vehicles for object categorization. We hypothesize that similarity in shape facilitates finding conceptual correspondences between objects, both for objects stemming from the same and from different conceptual categories. In the latter case, the comparison process requires the construction of an *ad hoc* category, which is also required when interpreting visual metaphors. We used three experimental tasks to investigate the role of shape in comparing objects: a similarity judgment task, a similarity rating task, and a production task. The results of our experiments support the hypothesis that an essential component of visual metaphor processing—comparing objects stemming from disparate conceptual domains—is positively affected by similarity in the objects' shape.

This chapter is based on:

Van Weelden, L., Maes, A., Schilperoord, J., & Cozijn, R. (2011). The role of shape in comparing objects: How perceptual similarity may affect visual metaphor processing. *Metaphor and Symbol, 26*(4), 272-298.

Introduction

Comparing objects is a necessary process in many cognitive tasks that involve objects' similarity (Gentner & Kurtz, 2005; Keil, 1989; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Tversky, 1977). For example, we compare things when we look for identical objects, such as when we look for two one Euro coins in our wallet. Or, we compare things when we want to highlight similarities between two different objects. For example, when we ask a supermarket attendant to help us look for a vegetable for which we have forgotten its name, we could say, "It is more or less cauliflower, but then green." For these comparisons, both objects stem from the same category. Yet other comparisons involve objects that (at first sight) do not belong to the same category. Photo albums and pets, for instance, are seemingly unrelated things. However, they do possess similarity in that they are both things that you would take from a house that is on fire. The latter example shows that we are able to construct *ad hoc* categories (Barsalou, 1983).

Where all aforementioned comparisons use literal correspondences between objects, other comparisons are figurative or metaphorical in nature. For instance, we can talk about a relationship in terms of "*a long and bumpy road*." Here, we compare a relationship with a car trip, two things that belong to different categories. The process underlying this kind of metaphorical reasoning comes from people's tendency to conceptualize abstract concepts (e.g., a relationship) in terms of concepts that are relatively concrete (e.g., the characteristics of a car trip). Lakoff and Johnson (1980a, 1980b, 1999) propose that the cognitive mechanism for such conceptualizations is *conceptual metaphor*. They define conceptual metaphors as mappings across conceptual domains that structure our reasoning, experiences, and everyday language.

Grady (1997) proposes the distinction between resemblance and correlation-based metaphors. Where resemblance metaphors are based on shared characteristics of the source and target domains, correlation-based metaphors are composed of abstract target domains and experience-based source domains. The latter group of metaphors is made up of smaller metaphorical parts, called primary metaphors. According to Grady (1997), each primary metaphor has a minimal structure, which we acquire naturally, automatically and unconsciously by our immediate interaction with the physical world. A famous, and much discussed, example of a primary metaphor is "*MORE IS UP, LESS IS DOWN*," which states that people's conceptualization of a subjective judgment of quantity is directly connected to the physical experience of verticality. The relation between more-up and less-down comes from everyday experiences such as looking at a stack of dishes that need washing and seeing it shrink as one proceeds, or pouring wine in a glass and seeing the level rise. In everyday language, the metaphor is manifested in sentences like "*The price of cucumbers is very high*" or "*Inflation has risen.*" These expressions are therefore not mere ways of saying something about prices and inflation, but they actually reflect nonlinguistic mappings between the two domains.

If primary metaphors are conceptual in nature, rather than just a particular use of language, people should structure abstract concepts metaphorically also if they are not using language. There is an increasing body of evidence supporting this idea, specifically for the metaphors: "*SIMILARITY IS PROXIMITY*" (Boot & Pecher, 2010; Casasanto, 2008, 2009), "*CATEGORIES ARE CONTAINERS*" (Boot & Pecher, 2011), "*TIME IS SPACE*" (Boroditsky, 2000), and "*POWER IS VERTICALITY*" (Schubert, 2005). This research shows that primary metaphors do not only occur in language, but also in gestures and pictures. The present study focuses on the role of primary metaphors in the latter mode, to be more precise, in the search for relations between visual objects.

If it comes to the categorization of visual objects, shape is a very general and important aspect (Rosch et al., 1976). Shape is the most difficult of all characteristics of objects to express in language, as it holds both the visual representations of the parts of an object and the way in which those parts are placed in relation to each other. Hence, an object's shape can only truly be acknowledged when we actually see that object or a picture of it, and only then are we able to detect directly similarities and differences between shapes of objects.

Inseparable from the way an object looks is the possible use of the object, that is, its function. Gibson's (1977, 1979) Theory of Affordances postulates that objects are not only perceived in terms of object shapes and spatial relationships but also in terms of their affordances; an object's property that interacts with a property of someone using the object in such a way that an activity can be supported. Keil (1989) provides an interesting account of this correlation between shape and function. In his view, we use shape similarity, first, to identify an object and, second, to assign it to a category. In concordance with Lakoff and Johnson's (1980a, 1980b) Conceptual Metaphor Theory and Grady's (1997) Theory of Primary Metaphor, Keil postulates that these categories are more than lists of perceptual features. Based on experience, everyone creates organized sets of causal theories that distinguish kinds of objects according to whether they are natural or artifacts, alive or not, useful when building a house or not, can be used to bake a cake or not, and so on. It is the relationship between these causal theories and shape that forms the core of a category. In other words, if something is shaped in a particular way, it will probably be functionally similar to objects that are shaped similarly, and, for this reason, belong to the same conceptual category (Glenberg, 1997; Rosch et al., 1976; Zwaan, Stanfield, & Yaxley, 2002). In short, "shape is function."

Keil's view is supported by studies of Gentner (1978) and Landau, Smith, and Jones (1998) on the role of shape and function in object naming. In Gentner's (1978) study, participants were presented with two different novel objects with a particular function; a 'jiggy,' for which parts of the face could be moved, and a 'zimbo' that dispensed jellybeans. After the participants inspected the objects' function, they were presented with a hybrid object that had the form of the jiggy, but dispensed jellybeans like the zimbo. Subsequently, they were asked whether the object in front of them was a jiggy (based on perceptual similarity) or a zimbo (based on functional similarity). Gentner found a strong shape-bias in adults. In addition, Landau et al. (1998) found a similar shape-bias among adults in their experiment involving familiar objects. Participants were presented with object sets (e.g., a set of combs), containing the prototype object of the set and four same-shape and four same-function test objects. After the prototype of the set was introduced, each of the eight test objects was shown. The question that the participants had to answer was "Is this a comb?" The adults' response pattern suggested that if the test objects did not look like the prototype, it was not named as such, regardless of whether it had the same function. So, both studies show that shape and function are closely related, and, interestingly, that shape sometimes dominates function in a functional-comparison task.

Ortiz (2010) examined this relationship between shape and function in pictorial advertisements. Doing so, she used one of Grady's (1997) primary metaphors; "*THE NATURE OF AN ENTITY IS ITS SHAPE*." In her view, this metaphor expresses a nonlinguistic mapping between the shape of an object and its nature or, in other words, its purpose, and is therefore largely akin to the idea of "*SHAPE IS FUNCTION*." Ortiz showed that the metaphor is indeed visually manifested in advertisements. Consider for example Figure 2.1.

In this advertisement for a car brand, a lifebelt is juxtaposed to an airbag-equipped steering wheel to communicate the message that an airbag-equipped steering wheel has the ability to save someone's life in case of an accident, just like a lifebelt. According to the metaphor at hand, the fact that both objects are round might stimulate the metaphoric interpretation that they are similar in nature and, therefore, members of the same category. Consequently, if the objects do not have the same shape, the process of finding a metaphoric relation between them might be hampered, or at least not stimulated. Compare for example Figure 2.1 with Figure 2.2. The message of the advertisement presented in Figure 2.2 is also that an airbag-equipped steering wheel has the ability to save someone's life. However, as the shape of the steering wheel and the shape of the rescue can are different, it might be more challenging to find the metaphoric relation between the two objects. To further substantiate this suggestion, experimental evidence is needed. Therefore, the purpose of the present study is to find experimental evidence for the facilitating role of shape in comparing functions of objects.

Figure 2.1. An advertisement for a car brand.

Figure 2.2. An advertisement for a car brand (adjusted).

If shape indeed informs us about an object's function, then similarity in shape might facilitate finding correspondences between objects, and hence to find a joint conceptual category. In the present study, three experiments were conducted in which we manipulated both object shape and the presence or absence of a common conceptual category. The study's purpose is to test the hypothesis that similarity in shape between objects facilitates finding conceptual categories to which both objects can be assigned.

Description of experiments

We now briefly describe the background, purpose and setup of the experiments. In each of our three experiments, we ask participants to compare object pairs. In order to investigate the role of shape in different phases of comparing objects, we gradually extend the time frame of the object presentation and the time frame of the participants' response over the three experiments, see Table 2.1.

Table 2.1. Experiment specifications

	Experiment 1	*Experiment 2*	*Experiment 3*
Object pair presentation	Sequential	Simultaneous	Simultaneous
Presentation duration	50 ms	2 s	20 s
Max. response time	Max. 2 s	Max. 5 s	Max. 20 s
Response	Binary	Scale	Speech
Measures	Reaction times Type of response	Similarity ratings	Correspondences Speech onset times

Experiment 1 is a reaction time experiment that aims to investigate the role of shape similarity in the initial phase of the identification/recognition stage. Participants are asked to compare the functions of two objects by answering the question "Can you use these two objects for the same purpose?" This way, we urge the participants to focus on the functional correspondences of the objects, without deliberately making them aware of any perceptual resemblances. The two objects are presented sequentially and the first object is presented for a duration of 50 ms only. Participants are asked to give a “yes” or a “no” response. In our analysis, we focus on reaction times and type of response.

In Experiment 2, we investigate the role of shape by using a similarity rating task. Participants are asked to functionally compare simultaneously presented pairs of objects by answering the question “To what extent can you use the two objects for the same purpose?” The object pairs are presented for 2 seconds. Rather than giving a binary response, participants rate functional similarity on a scale from 1 (not at all) to 9 (completely). This requires a more fine-grained evaluation of the objects’ similarity. We analyze the similarity ratings.

In Experiment 3, we ask participants for an explicit evaluation of the objects’ similarity. The experiment is based on Gineste, Indurkhya, and Scart’s (2000) study on emergent features – features that are not associated with the source or the target of the metaphor – in metaphor processing. In their production task, participants were asked to produce concepts or properties related to a metaphor they had just read (for example, “*a kiss is a fruit*”). Since the present experiment does not contain object pairs that are metaphorically related, we focus on participants producing correspondences between two objects. Within a time frame of 20 seconds, participants are asked to describe target objects in such a way that another participant would be able to pick the object from a set of 9 objects. Yet the only way in which they are allowed to talk about the target object is in relation to another object. Therefore, participants are forced to produce correspondences between the objects. We test whether shape similarity affects the number of correspondences found between two objects, the type of these correspondences, and the speech onset times.

In each experiment, the same item sets are used. Each of these sets contains five objects that are presented to participants in pairs. Each pair consists of one identical target object and one match object, see Figure 2.3.

guitar-banjo	drum-banjo	spoon-banjo	sunglasses-banjo
C+P+	C+P-	C-P+	C-P-

Figure 2.3. Example picture set with four picture pairs: conceptually and perceptually similar (C+P+), conceptually similar and perceptually dissimilar (C+P-), conceptually dissimilar and perceptually similar (C-P+), conceptually and perceptually dissimilar (C-P-).

Half of the pairs show objects that look similar (e.g., a guitar and a banjo, a spoon and a banjo), whereas the other half of the pairs show objects that look distinctively different (a drum and a banjo, sunglasses and a banjo). We shall refer to these pairs as P+ (perceptually similar) and P- (perceptually dissimilar), respectively. In addition, half of the pairs show objects that can be used for the same purpose – for which there is a common category available (a guitar and a banjo, a drum and a banjo), whereas the other half shows pairs of objects that cannot be used for the same purpose – for which no such category is available (a spoon and a banjo, sunglasses and a banjo). We shall refer to these pairs as C+ (conceptually similar), and C- (conceptually dissimilar), respectively.

Note that for the experimental task that the participants had to perform in each of the three experiments, the perceptual similarity variable in principle represents an irrelevant object attribute. A pair of musical instruments shows objects that can be used for the same purpose, regardless of their outer appearance. So, if similarity in shape affects participants' task performance, it will show up as a 'Stroop' effect (Stroop, 1935): Although the tasks explicitly draw attention to functional characteristics, similarity in shape is expected to affect task performance. Therefore, we expect performance to improve if a pair shows objects that are both conceptually and perceptually similar (C+P+), and if objects are dissimilar in both respects (C-P-). On the other hand, performance is expected to deteriorate if a pair shows objects that conceptually and perceptually differ (C+P-, C-P+).

In particular, for Experiment 1, we expect shorter reaction times for the C+P+ pairs as compared to the C+P- pairs, and shorter reaction times for the C-P- pairs as compared to the C-P+ pairs. Additionally, we expect more incorrect responses for the C-P+ pairs as compared to the C-P- pairs. Similarly, with regard to Experiment 2, we expect lower similarity ratings for the C+P- pairs as compared to the C+P+ pairs, and higher similarity ratings for the C-P+ pairs as compared to the C-P- pairs. Finally, with regard to the production task in Experiment 3, we expect shorter speech onset times for C+P+ pairs than for the C+P- pairs, and shorter speech onset times for C-P+ pairs than for the C-P-. As the task allows participants to make use of perceptual correspondences as well, we expect more correspondences for the C+P+ and C-P+ pairs as compared to the C+P- and C-P- pairs, respectively.

Experiment 1

Method

Participants

Twenty-one Tilburg University undergraduates (14 women and 7 men) participated for course credit. The mean age was 25 years, ranging from 21 to 37. All participants were naive with respect to the purpose of the experiment and had normal or corrected-to-normal vision. Furthermore, none of the participants had participated in the materials pretests.

Materials

The pictures were black and white line-drawings depicting utensils. The line-drawings were simple illustrations and each drawing was placed in an area of 200 x 200 pixels. We created 20 item sets, each consisting of 5 pictures, see Figure 2.3. The item sets were pretested by three tests. Below, each test is described. As a result, the final experimental material consisted of 12 sets, see Appendix 2.1.

Picture-naming test. To ensure that the pictures could be recognized and named, a picture-naming test was conducted. Eighteen Tilburg University undergraduates (12 women and 6 men) participated for course credit. The mean age was 21 years, ranging from 18 to 25.

Participants were told that they were going to take part in a picture-naming test involving the short presentation of pictures, and that their task was to press a button as soon as they recognized the object in the picture and then to name the object out loud. E-Prime software[1] was used to present each picture for a duration of 50 ms. The presentation of the pictures was randomized. All responses were recorded with a microphone and later transcribed.

The percentages of incorrect responses (i.e., a false recognition of the depicted object) and non-responses (e.g., "I don't know") were summed, yielding an error rate for each picture. The pictures with an error rate higher than 20% were eliminated together with the set of which they were part of. This resulted in the removal of 5 sets of picture pairs.

Sentence-completion test. After the picture-naming test, the same participants took part in a sentence-completion test. The goal of this test was to confirm that the pictures of the conceptually similar pairs are indeed judged as belonging to the same conceptual category.

Participants were told that they were going to see all pictures of the picture-naming test once again. For every picture they were asked to complete the sentence "This object is meant to…." The task was illustrated with an example picture of an accordion. For this picture, the sentence was completed with "make music with." The experiment was carried out using WWStim.[2] The presentation of the pictures was randomized.

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[1] See http://www.pstnet.com/eprime.cfm

[2] See http://www.let.uu.nl/~Theo.Veenker/personal/projects/wwstim/doc/en/

Pictures of the 15 sets that resulted from the first pretest were analyzed. For each picture, participants' responses were clustered (i.e., combining synonyms or very similar responses in one category). For example, based on the responses, practically all musical instruments were clustered into the category "making music," whereas the responses for an object like a glove were clustered into several categories, such as "protecting," "keeping warm," and "keeping clean." Subsequently, for each picture, the number of clusters and the corresponding percentages were used to determine the conceptual similarity of the picture pairs. The criterion for accepting a picture pair as conceptually similar was that it had at least one overlapping cluster. Picture pairs that failed this criterion were considered to be conceptually dissimilar. The analysis revealed that all C+ picture pairs satisfied the criterion. Two pictures of the C- picture pairs had to be replaced, because their conceptual categories overlapped with the conceptual category of the target picture to which they belonged.

Shape context matching test. The similarity in object shape was tested by using a Shape Context Matching program that computes shape similarity (Belongie, Malik, & Puzicha, 2002). The method uses the contours of drawn shapes to measure their similarity. The procedure randomly selects a relatively small number of sample points from the contours of two shapes and calculates the shape context. The procedure results in a matrix of shape context points that can be compared to the matrix of another shape. Subsequently, each point of the target shape is matched to a point of the other shape. The similarity between the two shapes is defined in terms of distance. The 'shape distance' is calculated for each point, and finally averaged, which results in a total shape distance between the two shapes. The smaller the shape distance for a pair of objects, the higher their perceptual similarity. The shape distance between the pictures is shown in Figure 2.4. The closer the objects are placed to each other, the higher their perceptual similarity. For example, the distance between the banjo and the guitar is much smaller than the distance between the banjo and the drum.

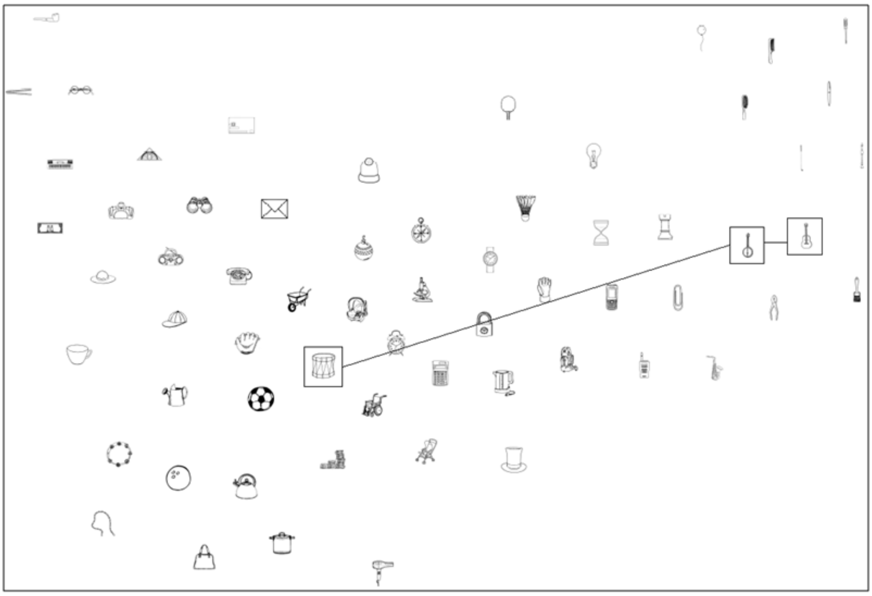

Figure 2.4. Visual shape distances between pictures.

Based on this procedure, we were able to compare the shape distances of the four picture pairs of each set. The criterion to maintain a set was that the shape distances for both the C+P+ and the C-P+ picture pairs were than the shape distances for the C+P- and the C-P- picture pairs. The analysis resulted in the removal of an additional three sets of picture pairs. Consequently, the final experimental materials consisted of 12 sets of pictures. Each set contained four picture pair combinations, which resulted in 48 experimental trials. We added 24 filler trials, which resulted in a total of 72 trials.

Design

The factors Perceptual similarity and Conceptual similarity were implemented as within subject factors yielding four conditions: C+P+, C+P-, C-P+, and C-P-.

Procedure

Participants were told that they were going to take part in a reaction-time experiment involving the comparison of pictures and that their task was to judge as fast as possible whether the two presented pictures could be used for the same purpose. The participants were instructed to base their judgment on what they believed most people would think. The procedure was practiced with pictures of two pairs of objects printed on paper. First, the experimenter showed the participant the picture of a gun, asked to name it and to indicate what it is used for. This was repeated for the picture of a slingshot. Subsequently, the participant was asked whether he or she thought that the two objects could be used for the same purpose (i.e., shooting). In case of an incorrect answer, the participant was corrected. The procedure was then repeated with the picture pair of an umbrella and a slingshot.

Each experimental trial (of one picture pair) consisted of the sequence shown in Figure 2.5.

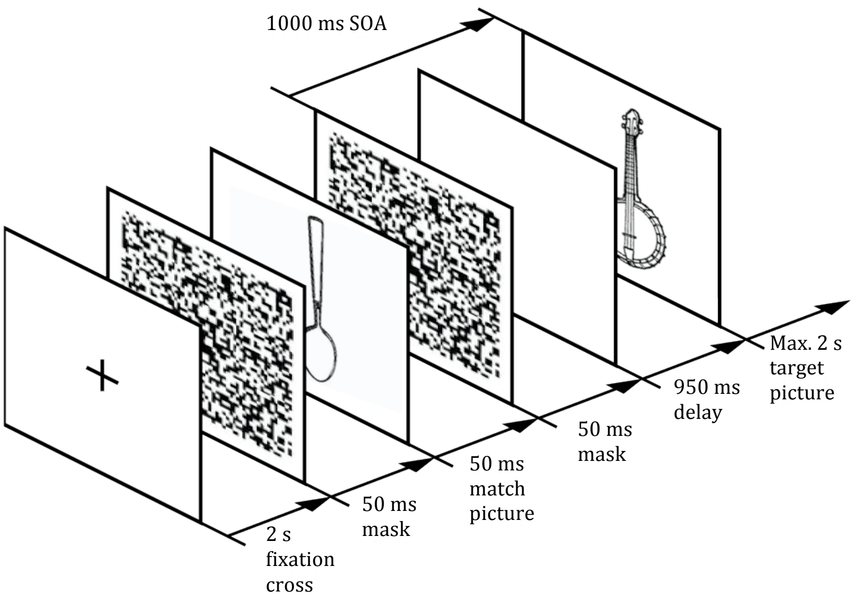

Figure 2.5. Stimulus trial; order and duration of the fixation cross, mask(s), match picture, and target picture.

First, the participants had to press a response key to start a stimulus trial. When the key was pressed, a fixation cross appeared for 2 seconds. Subsequently, a visual noise mask appeared for 50 ms, which consisted of random black and white pixels within a 300 x 300 square. Immediately following the mask, the match picture (e.g., the spoon) was presented for a duration of 50 ms. After the match picture, another mask was presented to erase the icon of the picture. This procedure prevents the fading icon of the match picture to be still perceptually available to the participant at the time the target is presented (Di Lollo, 1980). The mask was followed by a delay – a blank screen – of 950 ms, which resulted in a stimulus onset asynchrony (SOA) of 1,000 ms. After the delay, the target picture (e.g., the banjo) was presented and the participants had to judge as fast as possible whether the two objects could be used for the same purpose. They produced their response by pressing a key on a button panel. The "yes" response key was always located on the dominant hand side of the participants. Immediately after their judgment, feedback indicated whether the answer was correct, incorrect, or given too late, that is, after more than 2 seconds. Right after the feedback, the next trial started with a fixation cross on the screen. The procedure was practiced with 10 practice trials.

Results

The analyses focused on the reaction times for the correct responses ("yes" for the C+ pairs and "no" for the C- pairs) and the number of "yes" responses (correct for the C+ pairs and incorrect for the C- pairs). First, all reaction times were screened for outliers. Reaction times that deviated more than two standard deviations from the overall mean were excluded from the analyses. This resulted in the omission of 4.8% of the data. The analyses were done using an Analysis of Variance, with Perceptual similarity (P) and Conceptual similarity (C) as within-subjects factors.

Reaction Time Analysis

For the C+ pairs, the analyses were performed on the correct "yes" responses and for the C- pairs, on the correct "no" responses. Mean reaction times for each picture pair are shown in Figure 2.6.

For the C+ pairs, the analysis revealed a main effect of Perceptual similarity, $F(1, 20) = 8.49$, $p < .01$, $\eta^2_p = .30$. This indicates that the participants were faster in producing a correct "yes" response for the P+ pairs (614 ms) than for the P- pairs (666 ms).

For the C- pairs, there was a main effect of Perceptual similarity as well, $F(1, 20) = 85.42$, $p < .001$, $\eta^2_p = .81$. It took participants more time to produce a correct "no" answer for the P+ pairs (747 ms) than for the P- pairs (629 ms).

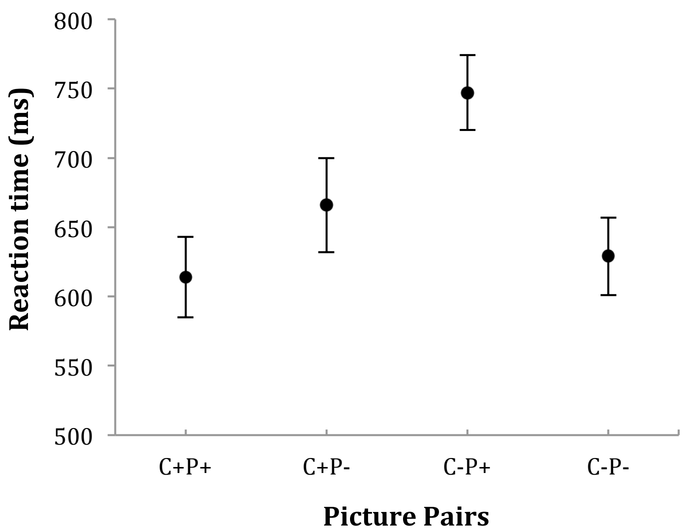

Figure 2.6. Mean reaction times (ms) of the correct responses for the four different picture pairs ("yes" for the C+ pairs and "no" for the C- pairs). Bars represent standard errors.

Response Analysis

The analysis was performed on the "yes" responses. The percentages of the "yes" responses are presented in Figure 2.7.

There was a main effect of Perceptual similarity, $F(1, 20) = 30.69$, $p < .001$, $\eta^2_p = .61$. There were more "yes" responses for the P+ pairs (55%) than for the P- pairs (39%). The analysis of Conceptual similarity revealed a main effect as well, $F(1, 20) = 777.64$, $p < .001$, $\eta^2_p = .97$. C+ pairs (82%) resulted in more "yes" responses than C- pairs (11%). There was no interaction between the two factors, $F(1, 20) = 2.03$, $p = .17$. As can be seen in Figure 2.7, for both the C+ and C- pairs, perceptual similarity led to more correct "yes" responses.

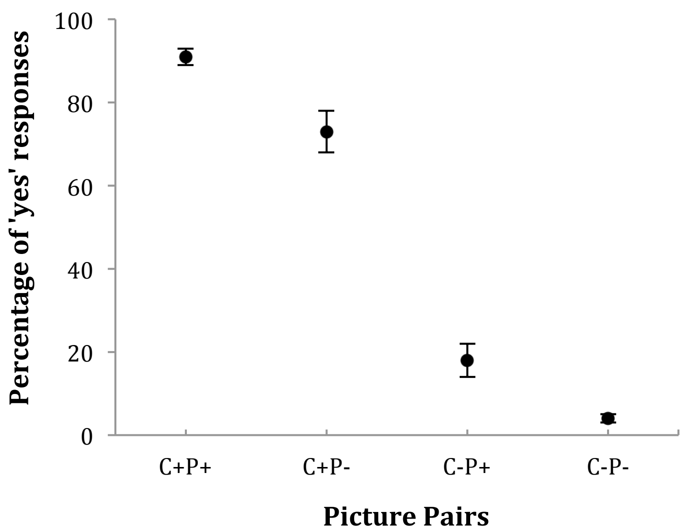

Figure 2.7. Percentages of "yes" responses (%) for the four different picture pairs (correct response for the C+ pairs and incorrect response for the C- pairs). Bars represent standard errors.

Discussion

The goal of Experiment 1 was to find empirical evidence for the role of shape in comparing functions of objects. We measured reaction times and responses to the question whether two objects could be used for the same purpose. Based on the prediction that if two objects are similar in shape, they are perceived as being similar in nature and, hence, should belong to a joint category (Keil, 1989; Ortiz, 2010), we expected shape similarity to facilitate task performance when pairs are conceptually similar. Our results confirmed this expectation: Shorter reaction times and more correct "yes" responses were found when the objects were perceptually similar. Regarding the conceptually dissimilar pairs, similarity in shape was expected to impede task performance. Furthermore, we expected more incorrect "yes" responses as a result of similar shapes. Our results confirmed both expectations: Longer reaction times and more incorrect "yes" responses were found when the objects were perceptually similar. So, shape seems to play a prominent role in comparing functions of objects.

Experiment 2

The prolonged reaction times and increased incorrect responses for the C-P+ pairs in Experiment 1 suggest that participants experienced a moment of uncertainty. This suggestion seems to hold for the C+P- pairs as well. If so, we can expect this behavior to reoccur in a judgment task with a more gradual character, this time in terms of more moderate judgments. Therefore, in Experiment 2, we used a similarity rating task to assess the role of shape when comparing functions of objects.

Method

Participants

Forty-five Tilburg University undergraduates (28 women and 17 men) participated for course credit. The mean age was 22 years, ranging from 18 to 27. All participants were naive with respect to the purpose of the experiment and had normal or corrected-to-normal vision. None of the participants had participated in the materials pretests or Experiment 1.

Materials

We used the same 12 picture sets as in Experiment 1. The source picture (i.e., the match picture in Experiment 1) and target picture were presented at a distance of 10 pixels on each side of the vertical midline of the screen.

Design

Similar to Experiment 1, the factors Perceptual similarity and Conceptual similarity were implemented as within subject factors yielding four conditions: C+P+, C+P-, C-P+, and C-P-.

Procedure

Participants were told that they were going to take part in a similarity rating experiment involving pairs of utensils and that their task was to rate the picture pairs' functional similarity on a scale from 1 (not at all functionally similar) to 9 (completely functionally similar). They were instructed to base their judgment on their first impression.

Each experimental trial consisted of the following sequence. First, a fixation cross appeared for 1 second. Subsequently, the two pictures of a picture pair were simultaneously presented for a duration of 2 seconds. Then, the question "To what extent can you use the two objects for the same purpose?" and the 9-point scale appeared on the screen. The participants had to press one of 9 numeric buttons on a QWERTY keyboard within 5 seconds. If their judgment was produced too late, a feedback screen appeared for 2 seconds. Subsequently, the next trial started with a fixation cross on the screen. The procedure was practiced with four trials.

Results

The analysis focused on the similarity ratings, using an Analysis of Variance, with Perceptual similarity (P) and Conceptual similarity (C) as within-subjects factors. The mean similarity ratings are presented in Figure 2.8.

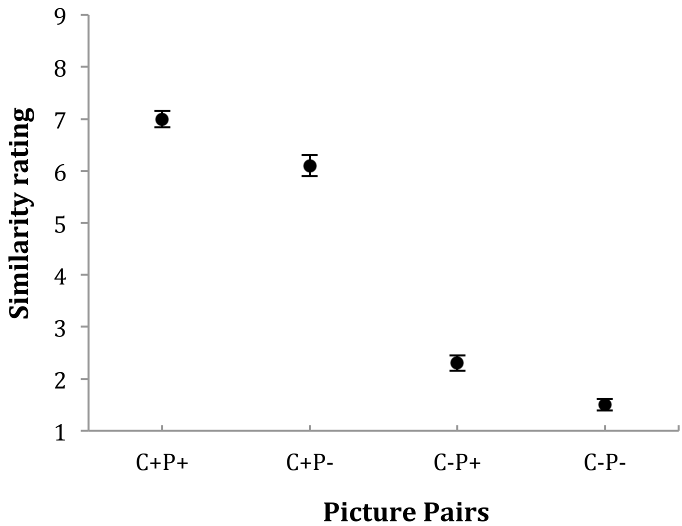

Figure 2.8. Mean similarity ratings for the four different picture pairs. Bars represent standard errors.

The analysis of Perceptual similarity revealed a main effect, $F(1, 44) = 27.73$, $p < .001$, $\eta^2_p = .39$. Similarity judgments were higher for P+ pairs (4.6) than for P- pairs (3.8). There was a main effect of Conceptual similarity as well, $F(1, 44) = 987.71$, $p < .001$, $\eta^2_p = .96$. C+ pairs (6.5) were judged to be functionally more similar than C- pairs (1.9). There was no interaction between the two factors, $F < 1$.

Thus, for the C+ pairs, perceptual similarity resulted in higher similarity judgments as compared to pairs that were perceptually dissimilar. For the C- pairs, a similar pattern was observed. Perceptual similarity led to higher similarity judgments in comparison to perceptually dissimilar pairs.

Discussion

In Experiment 2, we measured similarity ratings that participants gave based on the question to what extent two objects could be used for the same purpose. If the function of an object indeed is represented by its shape, the results of Experiment 2 should corroborate with the findings of Experiment

1. Our results confirmed this expectation: The general pattern for the similarity ratings was comparable to the one found for the “yes” responses in Experiment 1. That is, higher similarity ratings were found as a result of similarity in shape, both for the conceptually similar and dissimilar picture pairs.

Discussion Experiments 1 and 2

We now take a closer look at the results of both Experiment 1 and 2. Both experiments were based on the following consideration: If participants are instructed to decide whether two objects can be used to serve the same function, they are asked to engage in a process of functional comparison. If, in addition, the outer appearance of objects would somehow affect the process of functional comparison, this would manifest itself in their behavior, both in the response itself (binary or scale) and in the time it would take them to produce the response. Together with the objects as shown, the experimental instruction is likely to activate their knowledge of the proper function of the objects, that is, their 'nature', for example, to make music with, to cook with, to comb hair, and so on.

The results obtained by the two experiments showed that if the shape of objects provided information in correspondence with the objects’ functional compatibility (i.e., objects had similar functions and similar shapes, or different functions and different shapes), then more correct responses were produced and similarity judgments were more towards the extremes of the 9 point scale. In addition, the process itself speeded up. If on the other hand, the two types of knowledge were contrasting (i.e., objects had similar functions but different shapes, or different functions but similar shapes), more incorrect responses were produced, similarity judgments were more moderate, and the comparing process slowed down.

In sum, for functionally similar objects, the cognitive processes of comparing and categorizing seem to benefit from additional similarity in shape. On the other hand, in case of functionally different objects, similarity in shape seems to impede the before mentioned processes. The latter seems to be the result of the participants getting confused by the fact that the objects' shape does not match with their functional (dis)similarity.

Experiment 3

Comparing functions of objects involves the search for properties that the compared concepts have in common. Whether the objects are judged to be member of the same functional category depends on the number of shared and non-shared properties (Barsalou, 1983; Tversky, 1977). The tasks of Experiment 1 and 2 did not allow for any inferences about the role of shape in this particular process. Therefore, in Experiment 3, we addressed the questions how viewers extract information from representations of objects and what kind of comparisons they make between objects that do or do not share perceptual features. Using a production task, we aimed at getting insight into the mental operations that viewers undertake when comparing objects. By asking the participants to describe an object in terms of another object, we implicitly asked them to look for correspondences between the objects. We explored whether shape similarity affects the number of (perceptual and conceptual) correspondences found between two objects, as well as the time it takes to find them.

Method

Participants

Ten Tilburg University undergraduates (4 women and 6 men) participated for course credit. The mean age was 20 years, ranging from 18 to 24. All participants were naive with respect to the purpose of the experiment. None of the participants had participated in the materials pretests, Experiment 1, or Experiment 2.

Materials

We used the same 12 picture sets as in Experiment 1 and 2.

Design

Similar to Experiment 1 and 2, the factors Perceptual similarity and Conceptual similarity were implemented as within subject factors yielding four conditions: C+P+, C+P-, C-P+, and C-P-.

Procedure

Participants were told that they were going to take part in an experiment in which they had to describe objects and that their descriptions would be recorded. We instructed them to describe an object in such a way that, in a (presumed) follow-up experiment, another participant would be able to correctly identify the object from a set of 9 objects. While doing so, the participants were restricted in that they were only allowed to talk about the target object in terms of a source object. Furthermore, they were only allowed to mention correspondences between the objects, not differences. We further exemplified the procedure by giving an example of a source object (a gun) and a 'to be described object' (a cigarette). We also showed the participants a screenshot with 9 possible objects of which the other participant had to choose from.

Each experimental trial consisted of the following sequence. First, the source object was presented on the left hand side of a computer screen for a duration of 3 seconds. Then, accompanied by a beep, the 'to be described object' appeared on the right hand side of the screen. The picture pair was presented for a duration of 20 seconds. The end of this presentation was again marked by a beep. The next trial started by the participant pressing the spacebar. The procedure was practiced with six practice trials.

Results

The analyses focused on the speech onset times, the number of correspondences that were mentioned, and the type of these correspondences. The analyses were done using an Analysis of Variance. Perceptual similarity (P) and Conceptual similarity (C) were again implemented as within-subjects factors.

Speech Onset Time

We refer to the speech onset time as the time period that elapsed between the presentation of the second picture (the 'to be described object') and the start of speech sounds produced by the participant. The speech onset times were screened for outliers. Speech onset times that exceeded the 20 second time span for mentioning correspondences were excluded from the analysis (1.2%). Subsequently, the speech onset times that deviated more than two standard deviations from the overall mean were excluded from the analysis as well (4.6%). This resulted in the total omission of 5.8% of the data. The mean speech onset times are presented in Figure 2.9.

The analysis showed a main effect of Perceptual similarity, $F(1, 9) = 25.29$, $p < .01$, $\eta^2_p = .74$. Speech onset times were shorter for P+ pairs (1.8 s) as compared to P- pairs (2.5 s). The factor Conceptual similarity revealed a main effect as well, $F(1, 9) = 23.25$, $p < .01$, $\eta^2_p = .72$. Speech onset times

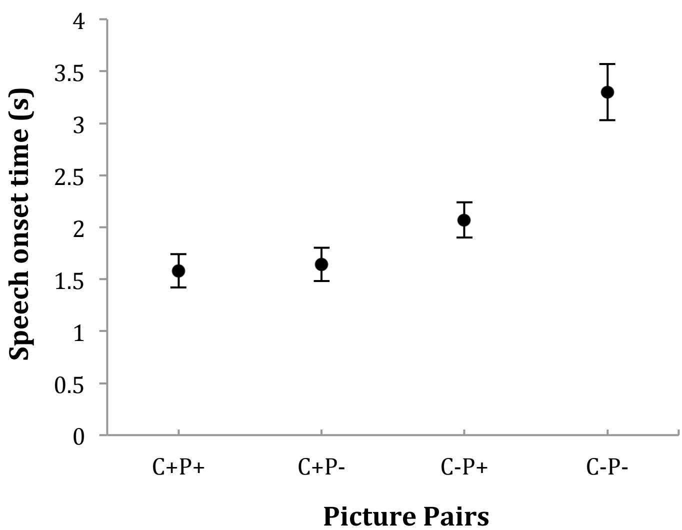

Figure 2.9. Mean speech onset times (s) for the four different picture pairs. Bars represent standard errors.

were shorter for C+ pairs (1.6 s) as compared to C- pairs (2.7 s). We also found a significant interaction between Conceptual and Perceptual similarity, $F(1, 9) = 20.15$, $p < .05$, $\eta^2_p = .69$.

Looking at Figure 2.9, we see that for both the C+ and the C- pairs, the speech onset times were shorter for the P+ pairs than for the P- pairs. However, the difference between the C- pairs seems much more prominent than the difference between the C+ pairs. Post hoc analysis showed indeed an effect of Perceptual similarity for the C- pairs, $F(1, 9) = 30.22$, $p < .001$, $\eta^2_p = .77$. For the C+ pairs, such an effect was absent, $F < 1$.

Correspondences

The audio files were transcribed into written protocols. For each item, we segmented the protocols into clauses ($n = 1225$). Then, we classified the clauses into two categories; *correspondence* (a clause describing a similarity between the objects; 98%) or *difference* (a clause describing a difference between the objects; 2%). The analyses focused on the correspondence category. We measured the number of correspondences per item and the type of these correspondences. The means per item for these factors are presented in Figure 2.10.

There was a main effect of Perceptual similarity, $F(1, 9) = 484.90$, $p < .001$, $\eta^2_p = .98$. Participants produced more correspondences for P+ pairs (2.99) than for P- pairs (2.01). The analysis of Conceptual similarity revealed a main effect as well, $F(1, 9) = 37.97$, $p < .001$, $\eta^2_p = .81$. Participants mentioned more correspondences for C+ pairs (2.95) than for C- pairs (2.05). There was also an interaction between the two factors, $F(1, 9) = 8.75$, $p < .05$, $\eta^2_p = .49$.

Thus, for the C+ pairs, perceptual similarity resulted in the production of more correspondences per pair as compared to perceptually dissimilarity. For the C- pairs, perceptual similarity also resulted in the production of more correspondences when compared to perceptually dissimilar pairs.

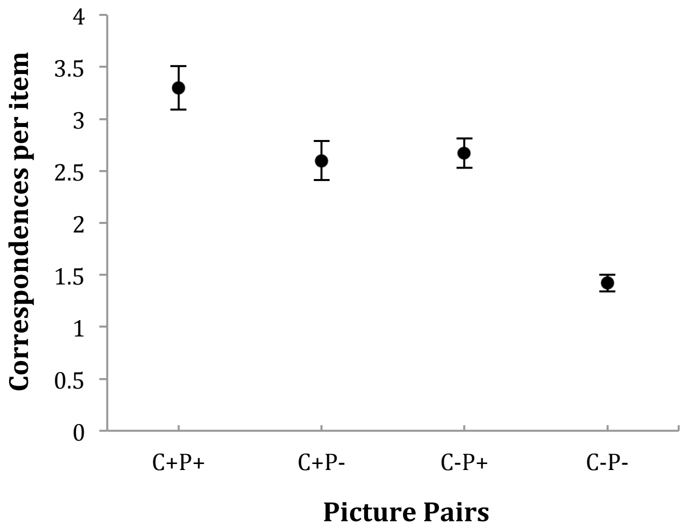

Figure 2.10. Mean number of correspondences per item for the four different picture pairs. Bars represent standard errors.

For the analysis of the *type* of these correspondences, we coded each correspondence as 'perceptual' or 'conceptual'. A correspondence was coded as 'perceptual' if it described a similarity in shape or in part-whole structure that could be extracted from the pictures, such as "both objects are round." All other correspondences could not be derived from the visual presentation of the objects and were therefore coded as 'conceptual', such as "both objects are used to play sports with."

For the conceptual correspondences, the analysis showed a main effect of Perceptual similarity, $F(1, 9) = 7.02$, $p < .05$, $\eta^2_p = .44$. This indicates that participants produced more conceptual correspondences for the P+ pairs (1.92) than for the P- pairs (1.75). We found a main effect of Conceptual similarity as well, $F(1, 9) = 19.28$, $p < .01$, $\eta^2_p = .68$. This shows that pairs than for the C- pairs (1.45). The analysis showed a trend of an interaction between the two factors, $F(1, 9) = 3.01$, $p = .10$. Looking at Figure 2.11, we see that there seems to be an effect of Perceptual similarity for the C- pairs,

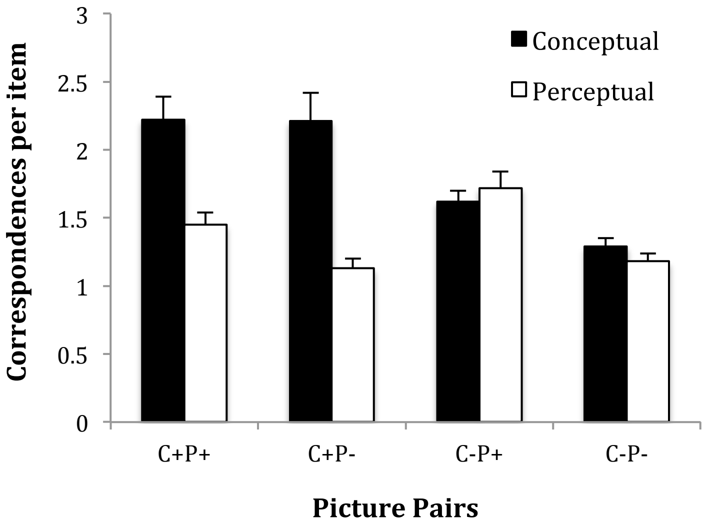

Figure 2.11. Mean number of conceptual and perceptual correspondences per item for the four different picture pairs. Bars represent standard errors.

whereas such an effect seems to be absent for the C+ pairs. Post hoc analysis showed indeed an effect of Perceptual similarity for the C- pairs, $F(1, 9) = 16.02$, $p < .01$, $\eta^2_p = .64$, whereas for the C+ pairs such an effect was absent, $F < 1$. So, for the C+ pairs, Perceptual similarity resulted in more conceptual correspondences, whereas this was not the case for the C- pairs.

For the perceptual correspondences, there was a main effect of Perceptual similarity, $F(1, 9) = 22.47$, $p < .01$, $\eta^2_p = .71$. Participants produced more perceptual correspondences for the P+ pairs (1.59) as compared to P- pairs (1.16). There was no main effect of Conceptual similarity, $F(1, 9) = 2.71$, $p = .13$. There was no interaction between the two factors, $F(1, 9) = 2.18$, $p = .17$.

Discussion

In Experiment 3, we wanted to explore the role of shape in the search for and production of correspondences between objects. The analysis of the number of correspondences showed that both conceptually similar and dissimilar pairs benefited from similarity in shape; more correspondences were produced. Similarity in shape had an effect on the type of the mentioned correspondences as well. That is, more perceptual correspondences were produced. More interestingly, shape similarity also resulted in more conceptual correspondences, yet only in case of conceptual dissimilarity. This shows that similarity in shape facilitates finding conceptual similarities indeed. The absence of this result in case of conceptual similarity suggests that perceptual similarity only stimulates finding a conceptual link if this link is not already present. In line with this suggestion, the analysis of the speech onset times showed reduced speech onset times as a result of shape similarity in case of conceptual dissimilarity. Again, such a result was absent in case of conceptual similarity. Hence, the effect of shape similarity is more prominent if there is no common category present.

General discussion

The goal of the experiments was to find experimental evidence for the role of shape in different phases of comparing objects. We hypothesized that similarity in shape between objects facilitates finding conceptual categories to which both objects can be assigned.

In Experiment 1 and 2, we directed participants' attention to functional characteristics of pairs of objects by asking them whether two objects could be used for the same purpose. The results of Experiments 1 and 2 supported our hypothesis. Similarity in shape facilitates and improves task performance in case there is a readymade category to which the objects can be assigned, confirming the idea that similarity in shape serves as the basic level of categorization (Rosch et al., 1976). Yet, if this common category is absent, perceptual similarity impedes processing, that is, reaction times increase, more errors are made, and similarity judgments are more moderate.

We suggest that the latter results are the outcome of the process of creating an ad hoc category. To overcome the fact that the objects do not belong to a common category, people are inclined to establish a new category (Barsalou, 1983, 1991). In the present experiments, the objects of the conceptually dissimilar pairs are also unrelated, that is, there is no common category available. Therefore, participants may have started creating a category; a process that we argue to be encouraged in case the objects showed perceptual similarity. Compared to the process of finding common categories, creating a category is a time-consuming process, which accounts for the increased reaction times and, eventually, an increase of affirmative responses in Experiment 1. In the same vein, ad hoc category construction might explain the more moderate functional similarity judgments that were obtained in Experiment 2. Perceptual similarity may have stimulated participants to look for a new category, resulting in similarity ratings moving away from the extreme "not at all functionally similar."

Creating an ad hoc category starts with the search for the properties that the compared objects have in common (Barsalou, 1983; Tversky, 1977). The category results from computing the number of shared and non-shared properties. Therefore, in Experiment 3, we addressed the role of perceptual similarity in the process of finding correspondences (i.e., shared properties) between two objects. We found that the production of correspondences increased as a result of perceptual similarity, both when there was and when there was no ready-made category available. But, more interestingly, we also found that perceptual similarity positively affected the number of *conceptual* correspondences that was produced for objects stemming from different conceptual categories. Thus, establishing a conceptual ad hoc category seems to benefit from similarity in shape.

Furthermore, in Experiment 3, we found higher speech onset times in case of the absence of a common category as compared to when such category was present. The latter finding can be related to a finding of Flor and Hadar (2005). In their study, they employed an experimental paradigm for eliciting the spontaneous production of metaphoric expressions. Participants were presented with a series of word pairs, which consisted of the target and source words from various metaphorical expressions. The relation between each pair of words was either literal (i.e., common category was available) or metaphorical (i.e., no common category available). The participant's task was to state as quickly as possible what the relation between the target and the source concept was. Flor and Hadar's main finding was that responses for metaphoric expressions involved longer speech onset times than responses for literal expressions. As such, the prolonged speech onset times found in the present study might be the result of looking for a metaphoric relation as well. For example, a participant produced "things that wealthy people use" for the picture pair of a hat and a chess tower.

Interestingly, Experiment 3 also showed a decrease of the speech onset times as a result of perceptual similarity for the conceptually dissimilar pairs, whereas no such effect was found for conceptually similar objects. Similarly, perceptual similarity resulted in an increased production of *conceptual* correspondences, whereas such an effect was absent for conceptually similar objects. All in all, the effect of similarity in shape seems to be more prominent for objects that have distinct functions and for which no ready-made common category is available.

To sum up, we suggest that the results of our experiments lend support to the idea that an essential processing component of visual metaphor processing – comparing objects stemming from disparate conceptual domains (Bowdle & Gentner, 2005; Gibbs, 2006; Gibbs & Steen, 1999; Lakoff & Johnson, 1980a; Steen, 2007) – is affected by shape. In the remainder of this discussion section we shall elaborate further on the implications of similarity in shape for visual metaphor processing.

In Experiments 2 and 3, the objects were presented to participants side by side. This visual structure actually mimics one of the three basic templates that are considered apt for the visual expression of metaphoricity – so called juxtapositions (see Forceville 1996, Phillips & McQuarrie, 2004, Schilperoord, Maes, & Ferdinandusse, 2009). In fact, juxtapositions are very often used in advertisements. An example of juxtaposed objects in an advertisement is shown in Figure 2.12 (see also the example discussed in Chapter 1).

Figure 2.12. An advertisement for a brand of men's underwear, "Comfortably packed, Simply ingenious."

Although the verbal elements "comfortably packed, simply ingenious" provide important cues, the advertisement shows quite an unusual set of items in that they belong to different common categories, that is, packaging and clothing. In the absence of some relevant common category, the viewer has to find out why the disparate objects are nevertheless shown side by side. So, the viewer has to compute the correspondences between egg boxes and underpants which may, in the end, lead to the category of "things that protect fragile goods." Since egg boxes are regarded as being very efficient if it comes to protecting fragile goods, this object acts as the source domain of the visual metaphor, whereas the topic of the advertisement is its target domain.

This process of comparing objects and computing a category actually presents a real life equivalent of the question we asked our participants for the presented pairs of experimental items: Can you use these two objects for the same purpose? For the pair of objects presented in the ad, the answer to the question if taken literally, is "no." But once an ad hoc category is constructed, the response is "yes," because you can use them both to protect fragile goods. In other words, many ads present viewers with the kind of task our participants had to perform for the conceptually dissimilar pairs in our experiments, that is, functionally compare two seemingly unrelated objects that can nonetheless be related in some specialized context. Clearly, the two types of performances differ. Whereas in processing visual metaphors the construction of categories is instrumental to understanding the ad's communicative purpose, in our experiments the construction of such categories is primarily a product of the task given to participants. However, this difference should not blind us for obvious similarities: comparing objects and computing functional similarity.

From these considerations it follows that especially the results obtained for the conceptually dissimilar pairs in our experiments are relevant with regard to visual metaphor processing. If the advertisement in Figure 2.12 constitutes a real life counterpart of our conceptually and perceptually dissimilar (C-P-) object pairs, Figure 2.13 is a likewise example of our conceptually dissimilar yet perceptually similar (C-P+) pairs. Again, there is no common category available – atomic bombs belong to the category of weapons of mass destruction and guitars to the category of musical instruments – and, therefore, in order to understand the ad's message viewers have to construct a category of "energetic things." The ad's design uses visual depictment strategies, such as varying the viewing distance and placing an object upside down, in order to highlight perceptual similarities. In this respect, it is an example of symmetric object alignment, which is a design pattern that "perceptually aligns different types of objects in an attempt to facilitate a metaphoric or associative conceptual link between them" (Schilperoord et al., 2009, p.155) and "invites viewers to connect the depicted objects according to some salient functional attribute or property" (p. 169).

Ortiz (2010) has demonstrated that the processing relevance of the design pattern identified by Schilperoord et al. (2009) can be accounted for in terms of Grady's (1997) Theory of Primary Metaphor, among which the primary metaphor "*THE NATURE OF AN ENTITY IS ITS SHAPE*." Hence, by creating perceptual similarities between otherwise remotely related objects,

Figure 2.13. An advertisement for a guitar brand.

designers may stimulate viewers to metaphorically process the objects (i.e., construct an ad hoc category on the basis of similarity comparison) due to the tendency of viewers to connect an object's outer appearance to its conceptual aspects. Our results clearly support this view. The results of Experiment 3, for example, show that people produce an increased number of conceptual similarities for objects stemming from different common categories if the objects look similar. To conclude, if a visual message has the purpose of establishing metaphorical relations between presented objects, similarity in shape actually contributes to that purpose.

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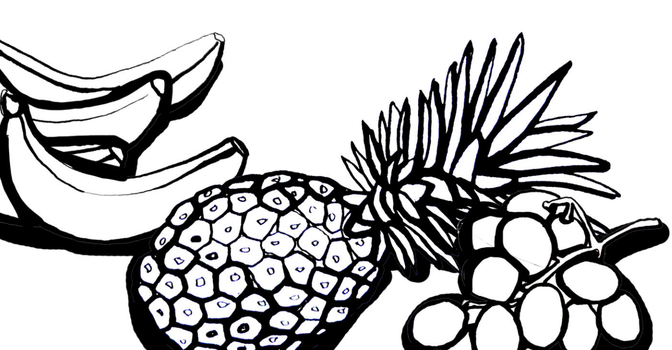
Appendix 2.1

Set	Target	C+P+	C+P-	C-P+	C-P-
1	 banjo	 guitar	 drum	 spoon	 sunglasses
2	 bowling ball	 football	 shuttle	 Christmas ball	 brush
3	 hockey stick	 golf club	 table tennis bat	 fish hook	 cup
4	 hat	 winter hat	 cap	 chess tower	 saxophone
5	 comb	 hairbrush	 hairdryer	 toothbrush	 baseball glove

Set	Target	C+P+	C+P-	C-P+	C-P-
6	 clarinet	 flute	 tambourine	 pen	 paperclip
7	 ruler	 carpenter's rule	 set square	 keyboard	 skipping rope
8	 knife	 saw	 scissors	pencil	 hat
9	 credit card	 banknote	 coins	 envelope	 balloon
10	 walkie talkie	 cell phone	 telephone	 calculator	 shovel

Set	Target	C+P+	C+P-	C-P+	C-P-
11	 wheelchair	 stroller	 baby's car seat	 wheel-barrow	 light bulb
12	 alarm clock	 watch	 hourglass	 compass	 screwdriver

Chapter 3
The role of shape in semantic memory organization of objects



Abstract

Visual information contributes fundamentally to the process of object categorization. The present study investigated whether the degree of activation of visual information in this process is dependent on the situational relevance of this information. We used the Proactive Interference (PI) paradigm. In two experiments, we manipulated the information by which objects could be retrieved from memory: by both semantic and shape information or by shape information only. The pattern of PI-release showed that if objects could be stored and retrieved both by semantic and shape information, then shape information was overruled by semantic information. If, however, semantic information could not be (satisfactorily) used to store and retrieve objects, then objects were stored in memory in terms of their shape. We present implications for visual metaphor processing.

This chapter is based on:

Van Weelden, L., Schilperoord, J., Swerts, M., & Pecher, D. (Submitted). The role of shape in semantic memory organization of objects: An experimental study using PI-release.

Introduction

If we observe a cat-like creature in the zoo, even if it is a type that we have never seen before, we may classify that animal as belonging to the same category as lions, tigers and pumas. Presumably, the reason for doing this is that the observed animal shares some observable properties with those of the other cat-like animals that we remember having seen before. Object categorization is hence a fundamental process in constructing and using our memory, as it helps to organize our knowledge and relate (novel) objects to other objects in order to assign meaning to them.

This process of object categorization is driven by mental representation. When we encounter an object, we create a mental representation based on sensory and semantic information. In order to categorize the object, the mental representation is compared to a mental prototype that represents category members (Rosch & Mervis, 1975) or to other category exemplars in memory (Nosofsky, 1986). The representations are compared on both sensory and semantic information, however the relative weighting of these two types of information varies across concepts and semantic categories (Humphreys & Forde, 2001; Warrington & McCarthy, 1987). For example, the shape of an animal or the color of a fruit might be more important to assign the object to the correct category than the shape or color of a kettle. In the present study, we investigate the role of sensory features in the categorization of visual objects. We focus on the visual sensory feature *shape* and investigate whether the relative weighting of shape and semantic information affects the organization of semantic memory.

Barsalou (1999) proposed that sensory information plays a critical role in cognition. According to his Perceptual Symbols Theory, perception, action, and cognition share processing mechanisms. He views mental representation as a process of sensory-motor simulation. Central in his theory are perceptual symbols by which a mental representation is defined. A mental representation is constructed of a combination of several perceptual symbols for different components of the concept. This perceptual symbol formation process does not only concern the concept's visual features (e.g., its color, shape, and orientation), but operates as well on other sensory modalities such as audition, haptics, olfaction, and gustation. As such, perceptual symbols are learned through actual experiences with concepts. Modality-specific sensory-motor systems capture such experiences and hierarchical association areas integrate experiences from different modalities. Hence, these association networks represent knowledge of the concept that can be recruited for cognitive processing via the process of simulation (i.e., mental representation).

Evidence supporting the PS theory is provided by work that shows that visual sensory information is indeed activated during language comprehension (e.g., Borghi, Glenberg, & Kaschak, 2004; Huettig & Hartsuiker, 2008; Huettig & McQueen, 2007; Kaschak et al., 2005; Pecher, Van Dantzig, Zwaan, & Zeelenberg, 2009; Pecher, Zeelenberg, & Barsalou, 2003; Pecher, Zeelenberg, & Raaijmakers, 1998; Solomon & Barsalou, 2001; Stanfield & Zwaan, 2001; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; Zwaan, Stanfield, & Yaxley, 2002). For example, Huettig and Hartsuiker (2008) showed that naming a category exemplar (e.g., musical instrument – saxophone) elicited eye movements to a picture of a semantically unrelated object that was similar in shape (e.g., ladle). This activation of visual sensory information is context related. Zwaan, Stanfield, and Yaxley (2002) showed, for example, that context can affect the particular shape of the object that is represented. In their experiment, participants were presented with sentences like “The ranger saw the eagle in the sky” or “The ranger saw the eagle in its nest,” which were followed by a line drawing of the object described in the sentence, in this case an eagle with outstretched wings or an eagle with folded wings. Participants recognized the picture faster if the implied shape of the object in the sentence matched the shape of the object in the picture.

While language has been shown to elicit perceptual representations, there is also work that shows that the opposite occurs as well, that is, that semantic information is activated during visual object perception. Boucart and Humphreys (1997) suggest that as a result of the strong interplay between sensory and semantic information, people cannot even attend selectively to the global shape of an object without automatically processing its semantic properties. Caramazza, Hillis, Rapp, and Romani (1990) try to explain this interaction with their Organized Unitary Content Hypothesis (OUCH). Their theory is based on the idea that, contrary to a word for a particular concept, the object itself tends not to have an arbitrary relationship to its meaning. Some visual sensory features are directly related to the semantic properties of the object that specify its function (cf. Gibson's Theory of Affordances; 1977, 1979). These features are therefore perceptually salient. For example, visual features of a "fork" are the handle, the tines, the silver color, and the smooth texture. Yet the tines of the fork are perceptually salient as they directly relate to the fork's function "used for spearing food". So, the closer the perceptual feature is related to the object's function, the more salient that feature becomes. As such, shape is very frequently a salient perceptual feature. Note that, along the same line as Barsalou's (1999) PS theory, these perceptually salient features only become salient through actual experiences with the object.

Accordingly, visual sensory information contributes fundamentally to the process of object identification and categorization. In the present study, we propose that the *degree* of activation of visual information in the process of object categorization might depend on the *situational relevance* of this information (Chaigneau, Barsalou, & Samani, 2009; Pecher et al., 1998). We define this situational relevance as the result of the visual and semantic relations between the objects. For example, we might predict that when we have to look for an overarching category for a number of presented objects, visual features, such as shape, might play a bigger role if objects belong to different semantic categories as compared to when they stem from the same semantic category. Therefore, in the present study, we investigate whether shape information is encoded differently in our semantic memory for objects from similar and dissimilar semantic categories.

One way to investigate how visual information is encoded, and hence whether the objects are organized in semantic memory by means of their shape, is by looking at the process of retrieval of this particular information. The encoding and retrieval of the encoded information are interdependent; a retrieval cue will be effective if and only if the information in the cue was generated at encoding (Blaxton, 1989; Morris, Bransford, & Franks, 1977; Tulving & Thomson, 1973). Hence, by examining whether the shape of objects is used as a retrieval cue when trying to retrieve objects from memory, we can determine whether shape information was encoded in the semantic memory.

To do so, we use the Proactive Interference (PI) paradigm (Wickens, 1970). Proactive interference occurs when previously encountered information interferes with the memorial access of more recently encountered information. The standard procedure to test this interference is to present a triad of items from the same semantic category and, subsequently, have the participant perform a 25-s rehearsal-preventing task, such as a backward counting task. Then, participants recall the triad. This procedure is repeated for four trials. The idea is that because the items are members of the same semantic category, the meaning of the items is being encoded and so is the meaning of the non-presented category under which they subsume. The PI paradigm results in decreasing performance on the recall task as more triads from the same semantic category are presented. Because participants use the same category cue to recall the items, increasing interference arises. If, however, the semantic category shifts on the fourth (i.e., the critical) trial, the category cue will change as well. Therefore, the discriminability and accessibility of the items will increase, resulting in an increased performance on the recall task. This mechanism is called *release from interference*.

In previous studies, the PI paradigm has been used to investigate a variety of category memberships. For example, Dempster (1985) used the paradigm to investigate whether we encode the overarching topic of sentences during sentence processing. Gunter, Clifford, and Berry (1980) studied the memory for TV news items, which they found to become worse if there was no change in the visual format of the news items. Katz and Law (2010) used the PI paradigm to study whether conceptual metaphors are automatically activated during the processing of instantiations of conceptual metaphors (e.g., whether "*LIFE IS A JOURNEY*" is activated when we read "*Her future depends on what path she chooses to take*").

Classic PI studies focused on the magnitude of the semantic distance between exemplars from different semantic categories (i.e., shift from fruits to vegetables as compared to shifts from fruits to professions), phonemic categories (i.e., shift from words with "air" sound to "eye" sound), and sensory features (i.e., shift from "round" words to "white" words) (Wickens, Dalezman, & Eggemeier, 1976; Zinober, Cermak, Cermak, & Dickerson, 1975). The main conclusion drawn from these studies is that the degree of release from interference is inversely related to the number of common characteristics. That is, a shift between categories with a high overlap in characteristics (i.e., from fruits to vegetables) obtains a lower release from interference as compared to a shift between categories with no overlapping characteristics (i.e., from fruits to professions).

Moreover, Marques' (2000) study showed release from interference as a result of a shift from nonliving to living things. Interestingly, Marques tested this living/nonliving distinction for both words and pictures of the objects. The visual stimuli yielded the same types of interference effects as verbal stimuli. Accordingly, this study shows that the PI paradigm can also be used to investigate which retrieval cues people use to recall *visual* objects from their memory and, hence, which information was encoded when the visual objects were processed.

On top of the living/nonliving distinction, Marques' study also focused on the release from interference as a result of a shift in *visual features* within the category of living things, such as number of legs (from two legged to four legged animals) and size (from small to big animals). Prior to the experiments, participants were informed about the different stimuli that they could encounter (e.g., that the triads would be composed of objects that had four legs or fewer than four legs, or were bigger or smaller than a human being). For both words and pictures, Marques did not find release from interference as a result of the shift in number of legs. For the verbal condition, the shift might have been subtle, as the number of legs might not be a prominent feature in the mental representation of the concepts. For the visual condition, however, the manipulation of the number of legs was actually visual. Yet as a lot of other visual features changed along with the number of legs, the latter change might have been concealed. For the shift in size, Marques' results only showed release from interference in the verbal condition. The reason why this effect was limited to this condition might be that the manipulation was conceptual rather than perceptual. The manipulation concerned a shift from small to big animals, yet, in relation to the size of a human being. The size of the animals was not manipulated visually in terms of increased size with respect to the screen they were presented on. This way, the manipulation might have been too subtle to evoke the establishment of new category and thereby release from interference. Moreover, another possible explanation could be that the explicit cue about the visual feature change might have inhibited the effects. On a more general level, Marques' study shows that in investigating how visual features are stored in memory, the PI paradigm is highly perceptive to the precise manipulation of visual features and the instructions provided at the beginning of the task.

In an attempt to control for this, the present study employs the PI paradigm (1) with the visual manipulation of the most prominent sensory feature of objects, their shape and (2) without explicit cues regarding the type of shifts. We refer to shape as the outline of the picture of a particular object, rather than its inherent shape. We predict that if depictions of objects are encoded in such a way as to include information about the shape of the objects, then objects with a particular shape should form a different category than objects with another shape. Therefore, interference should build up as objects with similar shapes are presented on successive trials, and a release from interference should occur with a shift of shape. Yet the relative weighting of shape information might differ as a result of the situational relevance of this information. In two experiments, we manipulate the semantic and shape similarity between the objects and, thereby, the situational relevance of shape. In Experiment 1, we combine a shift of shape with a semantic shift (i.e., from fruits to flowers). For this type of shift, we expect that a semantic category cue will be sufficient to recall the objects from the critical trial. So, for this situation, the role of shape might be inferior. We expect that shape plays a more prominent role when there is no distinguishing semantic category cue available. In Experiment 2, we will only manipulate a shift of shape, keeping the semantic category (i.e., fruits) similar throughout the experiment. As the preceding objects belong to the same semantic category, a semantic category cue might not be sufficient to retrieve the objects of the critical trial. For this situation, we expect shape to be a distinguishing factor and to be used as a retrieval cue.

Experiment 1

This first experiment evaluated the role of shape in the PI-release situation with both a shape and semantic categorical shift. The semantic shift comprised a shift between two natural categories, fruits and flowers. We used this type of shift because living things are primarily differentiated on the basis of perceptual features (Humphreys & Forde, 2001; Warrington & McCarthy, 1987). That is, most types of natural objects have a high perceptual overlap, and therefore small perceptual differences are highly informative. Hence, it can be expected that visual information will have a relatively high weighting as compared to other types of information in the representation of living things.

Both the participants in the Shift and No-Shift condition of the present experiment received three fruits triads followed by a flower triad, shown in Appendix 3.1. In the No-Shift condition, the shape of the fruits and flowers did not change throughout the experiment. The objects either were round in shape (App. 3.1.1) or were shaped irregularly (App. 3.1.3). In the Shift condition, however, the shape of the objects changed on the critical trial. The critical trial established a shift from irregularly shaped objects to round shaped objects (App. 3.1.2) or vice versa (App. 3.1.4).

For both the Shift and No-Shift condition, we predicted release from interference to occur as the change from fruits to flowers reduces or eliminates interference. However, there may be gradual differences in the amount of release, both as a result of the shape shift itself and the type of shape shift. We expected the release to be most prominent for the Shift condition as there is an additional shift of shape. Considering the type of shape shift, we predicted the release to be stronger when triads changed from round shaped objects to irregularly shaped objects than the other way around. That is, if pictures of objects are encoded in such a way as to include information about the shape of the objects, then the buildup of interference is stronger for round objects, which might result in a stronger release effect.

For the No-Shift condition, we predicted the release from interference to be hampered when the triads of the four trials consist of round objects. Although there was a semantic change from fruits to flowers, the objects remained perceptually similar. As a result, the previously seen objects may continue to interfere with the objects presented on the critical trail. When the triads of the four trials consist of irregularly shaped objects, however, this interference effect may be more moderate as the objects are not perceptually similar. The semantic shift would then be sufficient to eliminate such interference effects.

Method

Participants

Eighty Tilburg University undergraduates (57 women and 23 men) participated for course credit. The mean age was 21 years, ranging from 18 to 34. All participants were naive with respect to the purpose of the experiment and had normal or corrected-to-normal vision.

Materials

The stimulus pictures consisted of 18 pictures of fruits (9 round shapes and 9 irregular shapes) and 6 pictures of flowers (3 round shape and 3 irregular shapes), shown in Appendix 3.1. The pictures were arranged in triads (6 for fruits and 2 for flowers). In arranging these triads, we controlled for various factors. For the fruits triads, we controlled for typicality. In a typicality pretest, ten participants (who did not participate in the future PI experiment) were asked to sort the pictures of the objects from most typical member of the category 'fruits' to the least typical member of this category. Based on this taxonomy, every fruits triad was assigned a low, medium, and high typical member of the category. In addition, every fruits and flowers triad consisted of three differently colored objects. We kept the visual complexity similar across triads in terms of mean JPEG file sizes (Chikhman et al., 2012; Donderi, 2006).

With these triads, four different sets were created. For two sets, the first three triads consisted of nine pictures showing round objects. For one of these, the triad for the final trial also consisted of round objects, and for the other set it consisted of irregular objects. For the two other sets, the first three triads consisted of nine pictures showing irregularly shaped objects. For one of these, the triad for the final trial also consisted of irregular objects, and for the other set it consisted of round objects. Thus, in two of the sets the shape of the objects changed between trials 3 and 4 and in the other two sets the shape remained the same (all round or all irregular). In addition, one practice set was created that consisted of twelve pictures of animals. For this set, there was no semantic or shape shift between trials 3 and 4.

Design

The experiment had a 2 x 2 x 4 design, with Condition (levels: Shift and No-Shift) and Triad Shape (levels: Round shape and Irregular shape) as between-subjects factors and Trial (levels: 1, 2, 3, and 4) as within-subjects factor. In the Shift condition, the shape of the pictures changed from round to irregular or vice versa.

Procedure

The participants were informed that the purpose of the experiment was to test their ability on both backward counting and their memory of triads of objects. During each trial, participants first saw a fixation cross in the center of the screen for 2 s. Subsequently, the objects of one triad were presented one-by-one for 2 s each (with no inter-stimulus interval). Participants were instructed to identify the objects silently, to remember them, and also to remember the order of the objects. They were told that they had to recall the objects in the right order afterwards. A three-digit number was then presented in the middle of the screen for 25 s during which the participant had to count backwards by threes out loud. Participants were instructed to count backwards as fast as possible while still being accurate. After 25 s the question "Which three objects did you see?" appeared, signaling the beginning of the 12 s recall period. Participants typed the names of the three objects. After 12 s the question was replaced with "Time's up" to indicate the end of the recall period. Participants pressed a button to continue to the next trial. The next trial started again with the fixation cross.

Participants trained on both the counting backward and memory task with a four trial training block. E-Prime software was used to control the presentation durations of the fixation crosses and pictures, to randomize the first three triads, and to collect the responses. The entire procedure took approximately 15 minutes.

Results and discussion

For each participant, the mean recall score was computed for each trial. Following the procedure of Wickens, Dalezman, & Eggemeier (1976), one point was given for each object recalled correctly and one extra point was assigned when the three objects were recalled in the correct order. So, for each trial, there was a maximum of 4 points. The mean scores per Condition and Trial are presented in Figure 3.1.

PI-buildup and PI-release effects were analyzed independently. The PI-buildup analysis was performed on the first three trials. The PI-release analyses were performed on (1) the third and fourth trial and (2) on the fourth trial separately. For all three analyses an ANOVA was conducted with Condition (levels: Shift and No-Shift) and Triad Shape (levels: Round shape and Irregular shape) as between-subjects factors. For the PI-buildup analysis the latter factor concerned the Shape of the first three triads, whereas for the PI-release analyses this regarded the Shape of the fourth triad. The PI-buildup analysis also involved the within-subjects factor Trial (levels: 1, 2, and 3).

For PI-release, the analysis on the third and fourth trial revealed a main effect of Trial, $F(1, 152) = 31.19$, $p < .001$, $\eta^2_p = .17$. The mean recall score was higher on the fourth trial (M=3.55, SD=.95) than on the third trial (M=2.53, SD=1.31). Participants recalled more items after the semantic shift.

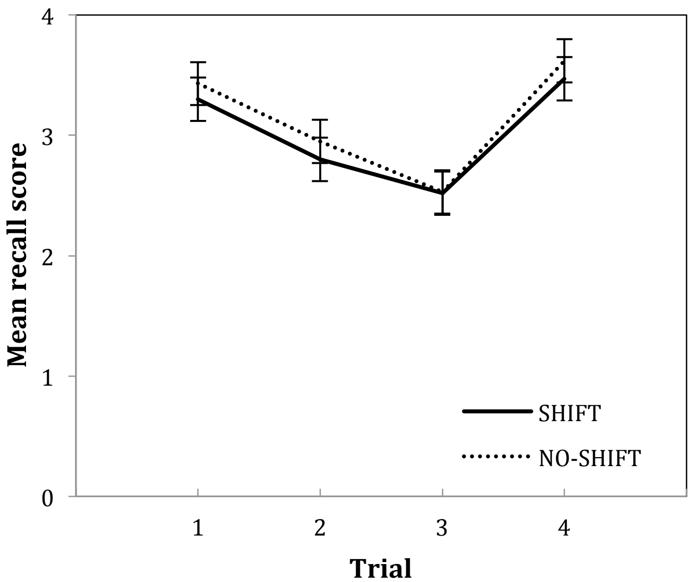


Figure 3.1. Mean recall scores on each trial for the Shift and No-Shift condition in Experiment 1. Bars represent standard errors.

There was no effect of Condition, $F < 1$, or Triad Shape, $F < 1$, and there were no two- or three-way interactions between the factors, $F < 1$. The analysis on the fourth trial alone revealed neither a main effect of Condition, $F < 1$, and Triad Shape, $F < 1$, nor an interaction between the two, $F(1, 76) = 1.98$, $p = .16$. Thus, the semantic shift did result in release from interference, but there were no (gradual) differences in release as a result of the shift in shape on the fourth trial.

For PI-buildup, the analysis showed a main effect of Trial, $F(2, 228) = 9.31$, $p < .001$, $\eta^2_p = .08$. Participants recalled fewer items as the number of trials increased. Post hoc analyses showed that the decrease from trial 1 to trial 2 was significant, $p < .05$. The decrease from trial 2 to trial 3 did not reach significance, $p = .22$. There was no effect of Condition, $F < 1$, nor an effect of Triad Shape, $F < 1$. The analysis did not reveal any two- or three-way interactions between the factors.

These results show that shape information was overruled by semantic information. Only semantic information was used as retrieval cue, as indicated by the build-up of interference during the first three trials and the release from interference when the semantic category changed. The change in shape did not affect performance.

We expected that the role of shape becomes more prominent if a semantic retrieval cue is not sufficient to recall the objects of the critical trial. This possibility was explored in Experiment 2.

Experiment 2

This second experiment evaluated the role of shape in the PI-release situation without a semantic categorical shift. Participants in both the Shift and No-Shift condition received four fruits triads, shown in Appendix 3.2. Identical to Experiment 1, the shape of the fruits was similar throughout the four trials in the No-Shift condition, in the sense that the objects either had a round shape (App. 3.2.1) or were shaped irregularly (App. 3.2.3). In the Shift condition, the shape of the objects changed on the critical trial. The change concerned a shift from irregularly shaped objects to round shaped objects (App. 3.2.2) or vice versa (App. 3.2.4).

For the Shift condition, we predicted release from interference to occur as a result of the shape shift. Again, we expected the release to be more prominent when triads changed from round shaped objects to irregularly shaped objects than when they shifted in the opposite direction. For the No-Shift condition, we predicted that the buildup of interference would continue throughout the four trials. The decrease in performance was expected to be the strongest for the round shaped objects as compared to the irregularly shaped objects.

Method

Participants

Eighty Tilburg University undergraduates (57 women and 23 men) participated for course credit. The mean age was 22 years, ranging from 18 to 33. All participants were naive with respect to the purpose of the experiment and had normal or corrected-to-normal vision. None of the participants had participated in Experiment 1.

Materials

The triads of the first three trials were the same as in Experiment 1. The experimental materials for these triads consisted of consisted of 18 pictures of fruits (9 round shapes and 9 irregular shapes). For the present experiment, the triads of the fourth trial consisted of 6 pictures of fruits (3 round shapes and 3 irregular shapes), shown in Appendix 3.2. In arranging these triads, we controlled again for typicality, color, and visual complexity. With these triads, four different sets were created in the same way as in Experiment 1. The practice set was identical to the one of Experiment 1.

Design

The experiment had a 2 x 2 x 4 design, with Condition (levels: Shift and No-Shift) and Triad Shape (levels: Round shape and Irregular shape) as between-subjects factors and Trial (levels: 1, 2, 3, and 4) as within-subjects factor.

Procedure

The procedure was the same as in Experiment 1 with respect to the instructions, the triad presentation, and the training session.

Results and discussion

For each participant, the mean recall score was computed for each trial. As in Experiment 1, there was a maximum of 4 points per trial. The mean scores per Condition and Trial are presented in Figure 3.2.

PI-buildup and PI-release effects were analyzed independently in the same manner as Experiment 1. For PI-release, the analysis on the third and fourth trial revealed a trend of an effect of Condition, $F(1, 152) = 2.76$, $p = .09$. The analysis also showed a trend of an interaction between Condition and Trial, $F(1, 152) = 2.89$, $p = .09$. There was no main effect of Triad Shape, $F < 1$, or Trial, $F < 1$, nor any other two- or three-way interactions. The

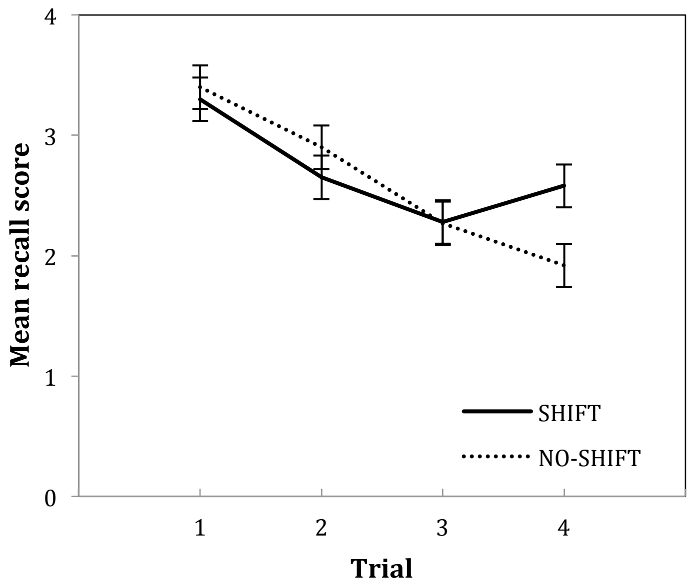


Figure 3.2. Mean recall scores on each trial for the Shift and No-Shift condition in Experiment 2. Bars represent standard errors.

mean recall score was higher for the Shift condition (M=2.58, SD=1.30) than for the No-Shift condition (M=1.92, SD=1.05). Participants recalled more items after the shape shift. There was no main effect of Triad Shape, $F < 1$, nor an interaction between Condition and Triad Shape, $F(1, 76) = 2.21$, $p = .14$. So, the shape shift resulted in release from interference, causing an increase of the recall scores on the fourth trial.

For PI-buildup, the analysis showed a main effect of Trial, $F(2, 228) = 18.40$, $p < .001$, $\eta^2_p = .14$. Post hoc analyses showed that both the decrease from trial 1 to trial 2, $p < .01$, and from trial 2 to trial 3, $p < .001$, was significant. There was no effect of Condition, $F < 1$, nor an effect of Triad Shape, $F < 1$. The analysis did not reveal any two- or three-way interactions between the factors.

These results show that if semantic information is insufficient to recall the objects of the critical trial, shape comes into play. The fact that shape is used as a retrieval cue to recall objects from memory suggests that the objects are assigned to a subordinate shape category within the semantic category of 'fruits'.

General discussion

The purpose of the present study was to investigate the role of shape in semantic memory organization of visual objects. We predicted that if depictions of objects are encoded in such a way as to include information about the shape of the objects, then objects with a particular shape should form a different category than objects with another shape. We also predicted that the degree of activation of shape information might depend on the situational relevance of this information. Therefore, in two experiments, we investigated semantic memory organization in two different situations using the PI paradigm. We created these different situations by manipulating the objects' shape and semantic nature. The results of the present study suggest that semantic memory organization of objects is indeed dependent on the interaction between semantic and shape information.

Experiment 1 showed that if objects can be categorized both on semantic and shape information, then shape information is overruled by semantic information. Namely, as indicated by the release from interference as a result of the semantic category change, semantic information was used as retrieval cue, which was not affected by the shift in shape. Hence, it seems that object categorization is largely driven by semantic features, as those features received higher activation than perceptual features.

Experiment 2 showed however that shape does play an important role in object categorization, that is, if semantic information is not a distinguishing factor and therefore does not receive high activation. In this experiment a situation was created in which the semantic information remained unchanged, whereas the shape of the objects did change. The release from interference as a result of the shift in shape showed that object shape was indeed used as retrieval cue. So, in this situation, objects are categorized based on their shape.

To summarize the results of Experiment 1 and 2, object categorization is driven by semantic information to a large extent, yet if semantic information cannot be (satisfactorily) used to store and retrieve objects, then shape comes into play.

This finding might give us more insight in the role of shape in processing visual metaphors. As visual metaphors involve the presentation of two (or more) objects from different semantic categories, semantic information cannot be used in a straightforward way to store the objects in memory. To interpret a visual metaphor, the objects need to be compared to each other in order to find conceptual correspondences between them. Based on these correspondences, an *ad hoc* category can be created under which the metaphorically related objects can be subsumed (Barsalou, 1983, 1991). Designers of visual metaphors very often perceptually align the objects in terms of different depictment factors, such as orientation, distance, size, and shape (for an overview, see Schilperoord, Maes, & Ferdinandusse, 2009). The goal of this perceptual grouping is to evoke the idea that the presented objects are somehow similar (i.e., belong to the same group, cf. Wertheimer's Gestalt Theory, 1923), although they stem from different semantic categories. For example, see Figure 3.3, an advertisement for a brand of cereals, in which a bowl of cereals is presented alongside eight other objects. The objects stem from different semantic categories (sports attributes, nutritional supplements, symbols, and food), however the fact that they are perceptually aligned in terms of distance, size and shape evokes the interpretation that they belong to the same group. In interpreting this ad, this might make it easier to assign the objects, including the bowl of cereals, to the group of healthy products.

In Chapter 2, we showed that perceptual grouping in terms of shape facilitates finding both perceptual and conceptual correspondences between functionally different objects. As a result, we proposed that shape similarity between objects might activate shared semantic knowledge by which an ad hoc category can be created under which both objects can be subsumed. So, the idea is that as semantic information is not sufficient to categorize the objects, information about the shape of the objects is used to categorize

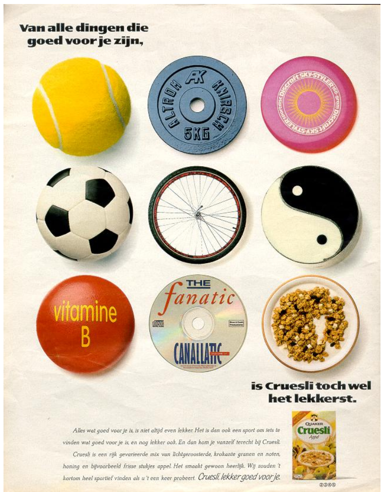


Figure 3.3. An advertisement for cereals,
"Of all things that are good for you, Cruesli is surely the tastiest."

them. As a result, it might be easier to find additional semantic overlap between the objects as well.

A PI-release situation in which semantic information is not sufficient to categorize the objects can be created in two ways: by using objects from entirely different semantic categories (such as in Figure 3.3) or by using objects from one semantic category (such as in Experiment 2). In both situations, a shift in shape is a distinguishing factor and therefore helpful to store (and retrieve) the objects. The results of Experiment 2 of the present study show that if semantic information is not sufficient to store and retrieve the objects due to interference, information about the objects' shape is encoded and used to store the objects in semantic memory. This shows that shape similarity indeed might play a role in the establishment of an ad hoc category.

Yet to further investigate this, it would be interesting to assess the role of shape in the PI-release situation in which every object stems from a different semantic category. As such, we could investigate the role of shape in the establishment of a higher-level category, rather than a subordinate category (i.e., the category of round shaped fruits within the category of fruits). Interference buildup when the shape of the objects remains the same and release from interference when the shape of the objects changes on the critical trial would show that the objects in advertisements such as in Figure 3.3 are indeed categorized based on their shape. As compared to Experiment 2, the release from interference caused by the shape shift might be more prominent in this situation, because the objects can then only be categorized in terms of their shape. The retrieval cue in the shift condition would change from [ø + ø] to [ø + round] or vice versa. This change might have a bigger impact on the memory organization as compared to when there is an overarching semantic category present.

Another interesting alley for future research would be to investigate the inclusiveness of shape categories. According to Rosch et al. (1976), every category is related to other categories by means of inclusion. In the taxonomy of categories, basic categories are at the most inclusive level and any category below this basic level will be a subordinate category. For example, the category of vertebrates includes the categories of mammals, birds, fish, reptiles, and amphibians. As such, this vertebrate's category has a higher level of inclusiveness than the category of mammals. If it comes to shapes, some shapes might be more basic than others, consider for example circles, squares, and triangles as opposed to ellipses, kites, and hexagons (see 'the graphic lexicon' by Cohn, 2012). Basic shape categories might therefore be higher-level categories in the taxonomy of shapes. It would be interesting to investigate this using the PI paradigm. We could set up an experiment in which objects change from, what we assume, one basic shape to another basic shape (such as, from circles to squares) or from a basic shape to a subordinate shape (such as, from circles to ellipses). As the level of inclusiveness would be similar for the former shift of shapes, release from interference should be present in both directions of the shift. For the latter, however, release from interference should only be present in one direction of the shift. As the shift from ellipses to circles would comply a shift from a subordinate to a basic shape, circles are expected not to be included in the established category of ellipsis, which should result in release from interference. The other way around, however, as a shift from circles to ellipses would comply a shift from a basic, highly inclusive, shape to a subordinate shape, ellipses are expected to be included in the established category of circles, thereby continuing buildup of interference.

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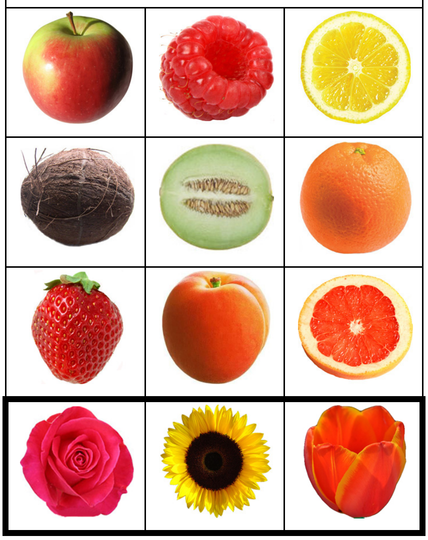
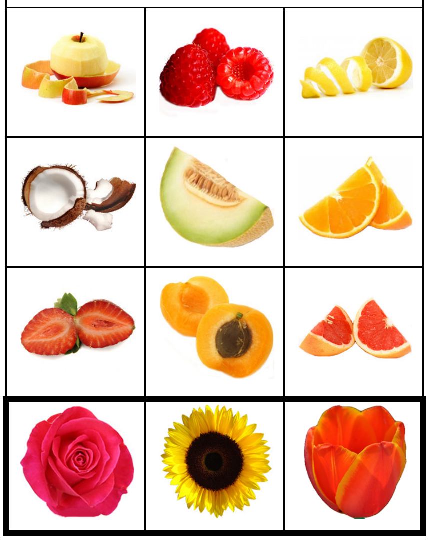
Appendix 3.1

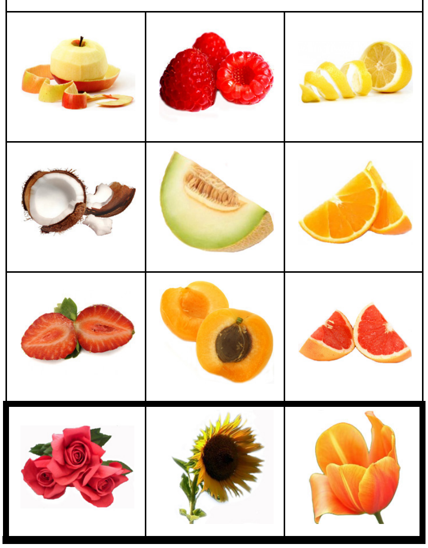
1: No-Shift condition (Round)



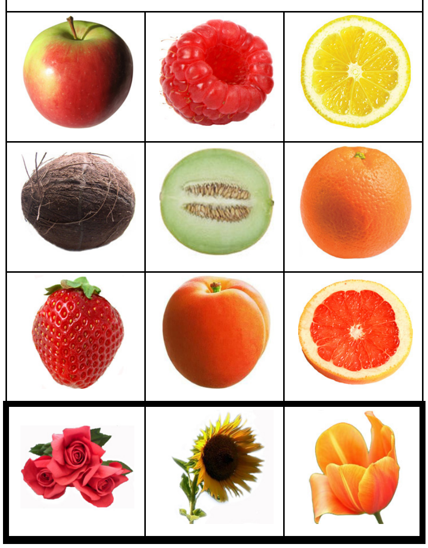
2: Shift condition (Irregular – Round)



3: No-Shift condition (Irregular)

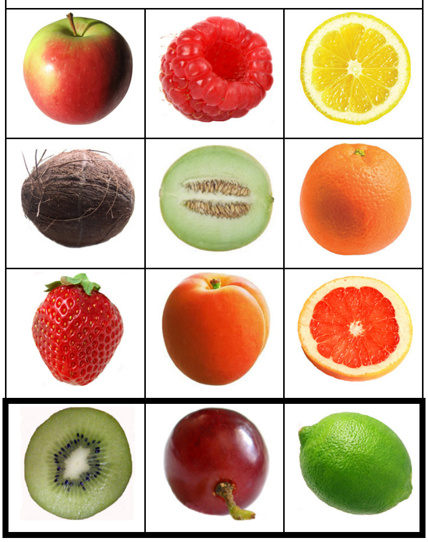


4: Shift condition (Round – Irregular)

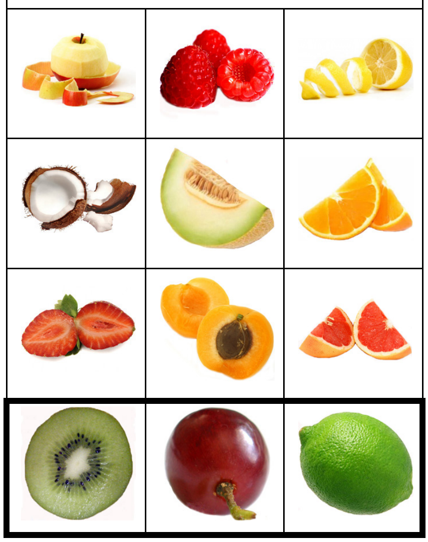


Appendix 3.2

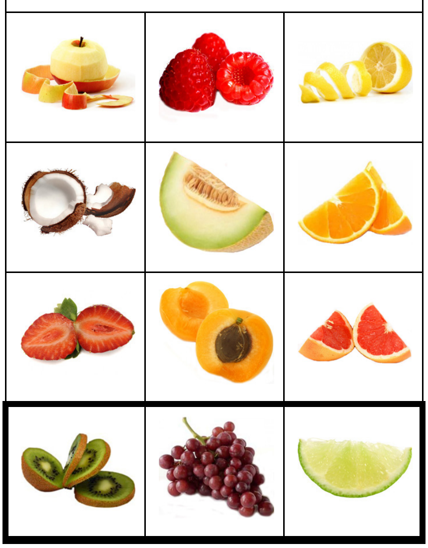
1: No-Shift condition (Round)



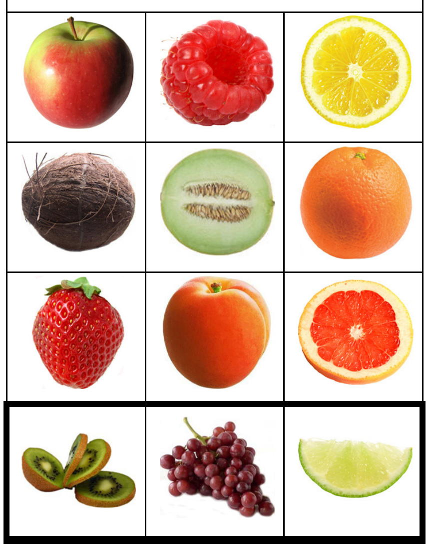
2: Shift condition (Irregular – Round)



3: No-Shift condition (Irregular)

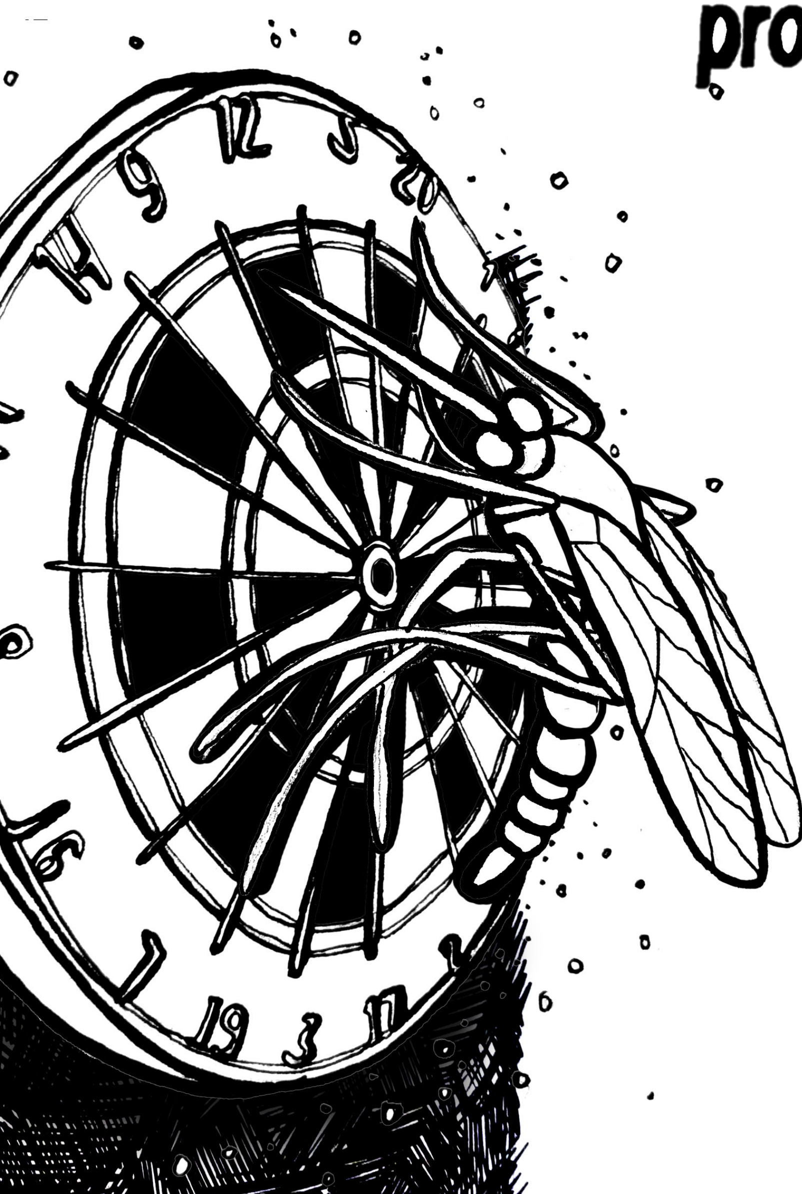


4: Shift condition (Round – Irregular)



Chapter 4

The role of shape in visual metaphor processing



Abstract

In order to interpret novel metaphoric relations, we have to construct *ad hoc* categories under which the metaphorically related concepts can be subsumed. Shape is considered to be one of the primary vehicles of object categorization. Accordingly, shape might play a prominent role in interpreting visual metaphors (i.e., two metaphorically related objects depicted in one visual array). This study explores the role of object shape in visual metaphor interpretation of 10- to 12-year-olds. The experiment shows that participants can produce more correspondences between similarly shaped objects as compared to dissimilarly shaped objects and that they need less thinking time to do so. These findings suggest that similarity in shape facilitates the process of interpreting visual metaphors.

This chapter is based on:

Van Weelden, L., Maes, A., Schilperoord, J., & Swerts, M. (2012). How object shape affects visual metaphor processing. *Experimental Psychology, 59*(6), 364-371.

Introduction

Interpreting a metaphor involves the process of understanding a (target) concept in terms of a (source) concept from a different conceptual domain (e.g., Bowdle & Gentner, 2005; Gibbs, 2006; Gibbs & Steen, 1999; Glucksberg, 2003; Lakoff & Johnson, 1980; Steen, 2007). In contrast to conventional metaphors in which the source concept refers to an already associated metaphoric category, novel metaphors involve source concepts that are not (yet) associated with such a category (Bowdle & Gentner, 2005). Novel metaphors need therefore to be processed by comparison in order to establish that category. For example, in "*my new motorcycle is like a cheetah*," a motorcycle has to be interpreted in terms of a cheetah. The absence of a common category under which the two metaphorically related concepts can be subsumed invites people to engage in a process of constructing a category that covers both cheetahs and motorcycles. In order to do so, motorcycles need to be compared to cheetahs.

This process of creating a novel metaphoric relation is comparable to creating an *ad hoc* category. That is, in order to reduce the complexity of the world they live in, people tend to categorize their environment into classes by which nonidentical objects can be treated as equivalent (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Common categories like "chairs," "fruit," and "vehicles" are deeply rooted in our memory as they are activated very often. However, in many daily tasks people appear to make use of other, instantaneously created categories. These categories are referred to as ad hoc categories (Barsalou, 1983, 1991). Creating an ad hoc category (e.g., for motorcycles and cheetahs) is characterized by a similarity comparison process.

In case of linguistic metaphors, such a comparison process will, first and foremost, employ the conceptual characteristics of the concepts. Gentner and Clement (1988) found that people prefer conceptually rich interpretations of metaphors (i.e., both entities can be used to accomplish the same function) over interpretations based on commonalities in their outer appearance (i.e., both entities look similar). Thus, when interpreting the metaphor "*my new motorcycle is like a cheetah*," people prefer to establish conceptual relations, such as the fact that both motorcycles and cheetahs have the ability to accelerate from 0 to 100 km/h in only a couple of seconds, over perceptual commonalities, such as the fact that both have a slender shape.

Now imagine that instead of verbally, the same metaphor is expressed visually, for example, by showing an image of a motorcycle and an image of a cheetah side by side in one visual array. We typically observe this arrangement in advertisements where the product (e.g., a motorcycle) is visually juxtaposed to another object to highlight the product's unique selling point. The mere fact that the objects are depicted visually may draw the interpreters' attention more strongly to the objects' perceptual attributes like their shape, size, and spatial orientation. Such attributes are now actually present in the pictures of the objects, rather than being part of the representation of the concept evoked by the lexical elements "motorcycle" and "cheetah." Therefore, if it comes to *visual* metaphor processing, it stands to reason to assume that perceptual features play a much more prominent role in establishing ad hoc categories. Yet we know little about how perceptual features are involved in the perception and interpretation of visual metaphors. In the present study, we investigate how the perceptual feature *shape* affects creating ad hoc categories in processing visual metaphors.

Various theoretical accounts have suggested that in the process of object perception, shape comes into play at the stage of perceptual organization (Biederman, 1987; Humphreys & Forde, 2001). In this stage, an internal representation of the object is formed including estimates of the object's likely size, shape, movement, distance, and orientation. In the subsequent stage, meaning is assigned to the perceptual representation and the object is identified. Humphreys and Forde (2001) provide a detailed account of this process. Their so-called Hierarchical Interactive Theory (HIT) describes how perceptual and semantic (i.e., conceptual) information influence object identification. The theory posits three types of stored knowledge of objects: (1) structural descriptions, (2) semantic knowledge, and (3) name representations. When we see an object like a cheetah, its visual features activate a *structural description* that captures information about the cheetah's outer appearance but does not include conceptual information such as the cheetah's behavior or its association with other objects. At the same time, structural descriptions of objects that are similar in shape are also activated. Thus, several visual features are activated, features that are unique to the cheetah, but also features that belong to similarly shaped objects. Structural descriptions spread activation to stored *semantic knowledge* of the object. According to the model, competition arises between semantic knowledge of the cheetah and semantic knowledge of similarly shaped objects. The main tenet of HIT is that activated semantic knowledge feeds back to structural descriptions. Due to higher activation of semantic knowledge of the cheetah, the activation of the correct structural description is reinforced, and suppresses activation levels of competing structural descriptions. So, first, visual information provides access to nonvisual semantic information, and second, this semantic information reinforces visual information in object identification.

Although features of more than one object come into play when identifying an object in isolation, HIT does not consider multiple object exposure. However, what would be a possible prediction of HIT for the process of finding relations between two objects? Let us consider the "motorcycle-cheetah" example again. In the absence of an immediate common category, the viewer may feel inclined to find out why the disparate objects are nevertheless shown side by side. In doing so, the viewer has to compute correspondences between motorcycles and cheetahs which may, in the end, lead to the category of, for example, "dangerous things that have the ability to run/ride at very high speed."

In case of similarly shaped depictions of a cheetah and a motorcycle, HIT predicts considerable overlap between the structural descriptions of the two objects (see Figure 4.1, left). The overlapping visual features will activate semantic knowledge that is relevant both to cheetahs and motorcycles. In turn, this might facilitate finding correspondences based on semantic knowledge. In addition, finding perceptual correspondences might be stimulated as well, as the feedback from the semantic level to the

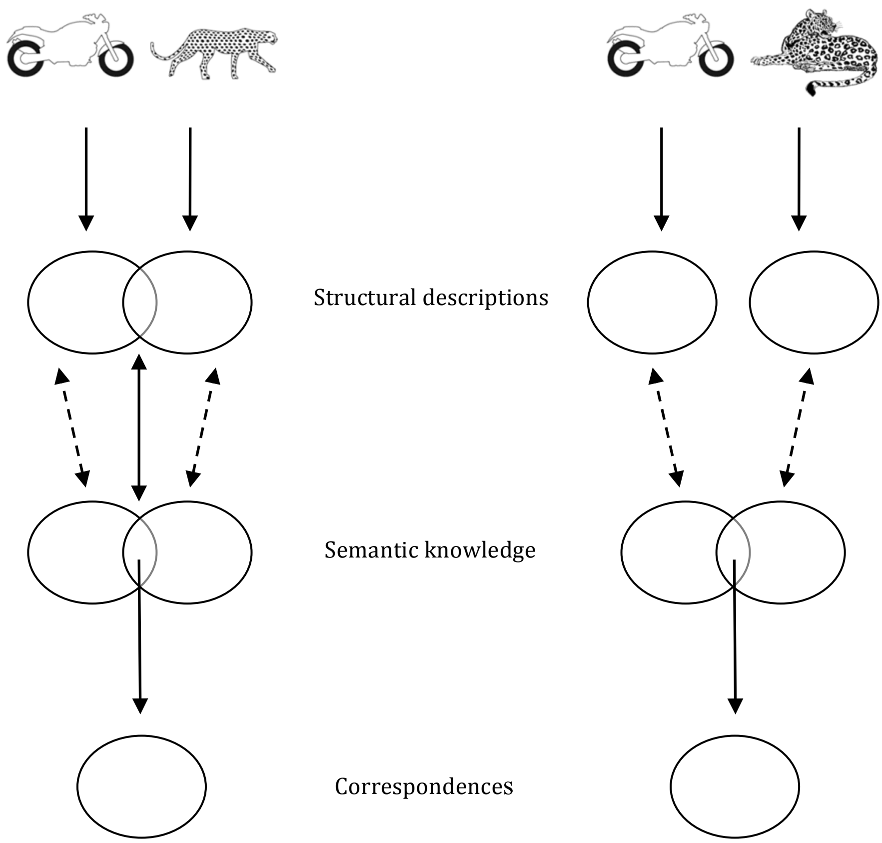


Figure 4.1. A model of object comparison derived from the HIT framework as proposed by Humphreys and Forde (2001). The model incorporates two basic levels of the HIT framework; the structural description level (involving perceptual knowledge of the objects) and the semantic knowledge level (involving stored semantic knowledge of the objects). The top-down as well as bottom-up processing results in the finding of correspondences between the two objects that are similar in shape (left) or dissimilar in shape (right).

structural description level will reinforce the objects' similarity in shape. If, on the other hand, the depictions of the cheetah and the motorcycle are shaped differently, they activate different structural descriptions (see Figure 4.1, right). As a result, there will be less direct activation of shared semantic knowledge. Finding correspondences based on semantic knowledge could therefore be impeded, or at least not facilitated by the structural descriptions. Furthermore, the feedback will only reinforce their shape *dis*similarity, which also might make it harder to find perceptual correspondences.

Thus, if overlapping structural descriptions stimulate the activation of shared semantic knowledge, then similarity in shape between two objects might facilitate finding perceptual and, more interestingly, conceptual correspondences between the two. Similarity in shape might thus facilitate the process of creating ad hoc categories, and hence metaphoric processing of the presented objects.

The present experiment aims at testing this hypothesis. We investigate whether similarity in shape facilitates the *construction* of metaphoric relations between pairs of depicted objects. Participants are presented with pairs of pictures, which are either similar in shape or not. By shape we mean the outline of the picture of a particular object, rather than the inherent shape of the object. Thus, we are interested in similarities between objects such as motorcycles and cheetahs in the way that they are depicted, and not in the way that they might look like each other in reality. As it will become clear in the description of our materials, shape similarity between the objects is manipulated according to several object-depictment factors, such as *orientation* to create similar outlines and *distance from viewing point* to create similarity in size (see Schilperoord, Maes, & Ferdinandusse, 2009). The two pictures are presented sequentially to allow participants to interpret the first picture freely before the second picture appears. When the first picture is presented, the participants' task is to produce characteristic features of the depicted object. Once the second picture appears, the participants' task is to produce correspondences between the two objects.

For the present task, it is essential that the participants produce their thoughts out loud as spontaneously as possible. Thinking out loud makes subject extremely aware of the experimental task they are supposed to perform. To ensure spontaneous responses it seemed prudent to used 10- to 12-year-olds as participants. Furthermore, 10-year-olds can reliably interpret most types of metaphors, even those that require fairly precise conceptualizations, and therefore they have the ability to interpret metaphors in a likewise manner as adults do (Gentner, 1988; Johnson & Pascual-Leone, 1989).

The main hypothesis that we put to the test is that similarity in shape facilitates the production of correspondences between objects. That is, we predict participants to produce *more* correspondences for similarly shaped depictions of objects than for dissimilarly shaped depictions, and we predict the production of the first correspondence to be *faster* for similarly shaped depictions of objects than for dissimilarly shaped depictions. These predictions follow from the shared structural descriptions to the shared semantic knowledge (indicated by the solid double-headed arrow in Figure 4.1) as posited by HIT. With regard to the nature of the produced correspondences, we expect increased numbers of both conceptual and perceptual correspondences for similarly shaped depictions of objects as compared to dissimilarly shaped depictions. That is, for similarly shaped depictions, finding conceptual correspondences is expected to be facilitated as a result of the activation of shared semantic knowledge, and finding perceptual correspondences could be facilitated as the feedback process emphasizes shape similarity.

Method

Participants

Forty children (21 girls and 19 boys) participated in the study. The mean age was 11.2 years, ranging from 10.8 to 12.5 years. Eight additional children were tested, but were excluded from the sample because they did not complete all trials due to computer failure (six children) or because of problems with recording their speech onset times due to weak speech signals (two children).

Materials

The experimental materials consisted of 14 picture sets, each containing one target object and two source objects (see Figure 4.2 and Appendix 4.1). The pictures were simple black and white line drawings, placed in an area of 200 x 200 pixels. All source objects were natural objects, whereas all target objects were artifacts. The shape of the source object was depicted either similar (+Shape) or dissimilar (–Shape) to the target object. We used natural objects (animals, human beings, body parts, etc.) as source objects, because according to Humphreys and Forde (2001, p. 471) the shape of natural objects conveys more information about their identity than the shape of artifacts. Most types of natural objects have a high perceptual overlap, and therefore small differences in the shape of natural objects are highly informative. For example, the shape of a cow provides more crucial information about the specific type of animal – a cow and not a horse – than the precise shape of a kettle about the type of kettle does.

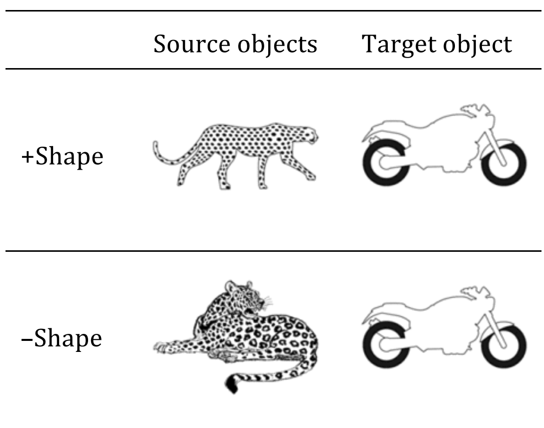


Figure 4.2. Example picture set with two picture pairs: +Shape and –Shape.

Shape context matching test

Manipulations of object shape were pretested by both subjective ratings of shape similarity and by the use of a Shape Context Matching program that computes shape similarity (Belongie, Malik, & Puzicha, 2002; and see Chapter 2). For the subjective ratings of shape similarity, we conducted an experiment in which participants rated the perceptual similarity of the object pairs. Seventeen participants (10 females and 7 males with a mean age of 27 years, ranging from 25 to 35) were instructed to move a slider along a track from 0 (dissimilar) to 1 (similar) to indicate their judgment about the shape similarity of the object pairs. The results show a significant difference between the ratings for the +Shape (.62) and the –Shape pairs (.23); $t(16)=11.40$, $p < .001$. To test shape similarity objectively, we conducted a Shape Context Matching metric on the object pairs. The procedure allowed us to compare the shape distance of the two picture pairs of each set. Corroborating the subjective ratings of shape similarity, the analysis showed a significant difference between the shape distance for the +Shape (.18) and the –Shape (.23) pairs; $t(13)=2.55$, $p < .05$. We also conducted a correlation analysis between the subjective ratings and the computational metric, expecting a negative correlation (higher subjective ratings should correspond to smaller shape distance). This was confirmed; $r = -.51$, $p < .01$. As a result of the analysis, no sets had to be removed from the experimental materials.

Prototypicality test

To rule out prototypicality of the source pictures as a possible confounding factor causing differences in the correspondences reported, we conducted a prototypicality test. Ten participants (5 females and 5 males with a mean age of 27 years, ranging from 23 to 31) were asked to choose the most prototypical picture from the two source pictures. A chi-square analysis showed that prototypicality was evenly distributed over the +Shape (54.3%) and –Shape (45.7%) source pictures; $\chi2$ (1, N = 140) = 1.029, p = .31. Seven +Shape source pictures (i.e., item 3, 5, 7, 9, 10, 11, and 13) and five –Shape source pictures (i.e., item 1, 4, 8, 12, and 14) were judged to be the most prototypical depictment of the object. The remaining two items were judged evenly prototypical. It can thus be assumed that prototypicality will not affect the production of correspondences.

Design

The experiment had a 2 (Shape: +Shape vs. –Shape) x 2 (List: List 1 vs. List 2) design, with Shape as within-subjects factor and List as between-subjects factor. Both lists contained the 14 picture sets, but List 1 showed participants the odd numbered sets in the +Shape condition and the even numbered sets in the –Shape condition. This was reversed for List 2.

Procedure

The participants were randomly assigned to one of two experimental lists. They were told that they were going to play two games at the same time with the experimenter; a computer game (the experimental task) and a name finding game (the distraction task). Each experimental trial consisted of a source and a target task. For the source task, participants were instructed that when the picture (the source) was presented, they had to produce as many characteristic features as they could within a 15-s time span and that they would hear a beep when time was up. Successively, the second picture (the target) was presented. For the target task, they were instructed to mention as many correspondences between target and source picture as they could within a 20-s time span. In between each experimental trial, participants played the distraction game. In this game, participants had to look for names of their classmates which were hidden in a square of random letters. The goal of this distraction game was to control for interference effects between the picture pairs.

E-Prime software[1] was used to control the presentation durations of the prime and target picture, to randomize the 14 picture pairs, and to collect vocal latencies with a voice key.

[1] See http://www.pstnet.com/eprime.cfm

Data Analysis

The participants' speech production was recorded on tape and transcribed into written protocols. We segmented the protocols into source features (i.e., the results of the source task) and source-target correspondences (i.e., the results of the target task). For example, the utterance "they are fast, yes very fast, they are dangerous and both are on the ground" for the cheetah-motorcycle pair was segmented into three source-target correspondences, namely in terms of speed, danger, and the property of being on the ground. This way, the number of source features and source-target correspondences was counted for each trial. We also measured the overlap between the source features and the correspondences by counting the number of times that a feature was mentioned for the source object and that the same feature was used to express a correspondence between the source and the target.

Furthermore, we analyzed the nature of the produced correspondences. We distinguished between *relational* correspondences and *property* correspondences. According to Estes (2003), Wisniewsky (1997), and Wisniewsky and Love (1998), noun-noun combinations can be interpreted either in terms of a relation or a property. For example, a *robin hawk* can be interpreted as a relation such as "a hawk that preys on robins" or as a property such as "a hawk with a red breast." For the former interpretation the hawk's action is related to the robin, whereas in the latter interpretation the hawk's perceptual properties are related to the robin. The object-object combinations in the present experiment were interpreted in a similar manner. A motorcycle that is preceded by the picture of a cheetah can be interpreted as a relation "a motorcycle that accelerates very fast" or as a property "a motorcycle with a slender shape." In this light, Gentner and Kurtz (2005) propose that entities can be assigned to a relational category or an entity (i.e., property) category. By relational categories, they mean a category whose membership is determined by a common relational structure rather than by common properties. Entity categories, on the other hand, are characterized by high intrinsic similarity among members, such as perceptual properties. That is, the members of an entity category share features that directly refer to the object. Relational categories are characterized by giving meaning to particular relational structures. The members of this type of category are conceptually similar. Furthermore, to describe correspondences between members from an entity category, concrete nouns can be used, for instance, "they both have *wings*." Correspondences between members from a relational category can be expressed by verbs, for example, "they both *accelerate* very fast."

The latter contrast is expressed in language in a fairly straightforward way. When expressing a correspondence between two objects, concrete nouns are often preceded by (conjugations of) the auxiliary verbs *to be* or *to have*. Accordingly, the presence of auxiliary verbs can serve as a cue for property correspondences. So, correspondences such as "both *are* round" and "they both *have* wings" were coded as property correspondences. The presence of action verbs can indicate relational correspondences. Hence, we coded "this actually *protects* your head and the shell *protects* as well" and "they both *spin*" as relational correspondences.

The source-target correspondences were scored as property or relational correspondences by two independent scorers. Kappa's interrater reliability test produced an almost perfect consistency between the two raters (.98, $p < .001$). Only for a small number of correspondences (n=38 out of 1437) both raters found that the auxiliary verb cue did not indicate a property correspondence, for example, for expressions such as "they both *are* very fast." These expressions were subsequently recoded as relational correspondences.

Results

Table 4.1 shows the means and standard deviations of the speech onset times, the number of source features, the number of source-target correspondences, and the number of overlapping features and correspondences, for the two pictorial conditions (+Shape and –Shape).

Table 4.1. Means (and SDs) for the speech onset times, features, correspondences, and overlapping features, per item.

	Onset (s)*	Features	Correspondences*	Overlap**
+Shape	2.63 (1.10)	3.94 (.96)	2.52 (.88)	.89 (.47)
–Shape	2.98 (1.38)	3.83 (1.02)	2.37 (.87)	.64 (.46)

Note: * = $p < .05$, ** = $p < .01$.

Speech Onset Time

Speech onset time was defined as the time lapse between the presentation of the second picture (the target) and the start of speech sounds produced by the participant. Latencies that exceeded the 20-s time span for mentioning correspondences were considered outliers and excluded from the analysis (2.7%). In addition, onset times that deviated more than two standard deviations from the overall mean were also excluded from the analysis (7.3%). In total, 10% of the data were omitted.

We performed a repeated-measures ANOVA, with Shape as within-subjects factor and List as between-subjects factor. The analysis revealed a main effect of Shape: $F(1,38) = 6.90$, $p < .05$, $\eta^2_p = .15$. Speech onset times were shorter for the similarly shaped pairs (2.63 s) than for the dissimilarly shaped pairs (2.98 s). There was no effect of List ($F < 1$).

Features, Correspondences, and Overlap

Analyses were done by means of a repeated-measures ANOVA, with Shape as within-subjects factor and List as between subjects-factor. For the variables features, correspondences, and overlap, there was no effect of List ($F < 1$).

The analysis of source features showed no effect of Shape ($F < 1$). This indicates that the perceptual difference between the +Shape and the –Shape source pictures does not lead to differences in the number of features mentioned.

The analysis of source-target correspondences showed an effect of Shape: $F(1,38) = 4.37$, $p < .05$, $\eta^2_p = .10$. Participants produced more correspondences per item for similarly shaped pairs (2.52) than for dissimilarly shaped pairs (2.37).

The analysis of overlapping features also showed an effect of Shape: $F(1,38) = 14.43$, $p < .01$, $\eta^2_p = .28$. This indicates that there was more overlap between the features and the correspondences for similarly shaped pairs (.89) than for dissimilarly shaped pairs (.64).

Type of Correspondence

We performed a separate repeated-measures ANOVA on the property and relational correspondences. Table 4.2 shows the means and standard deviations of the number of property and relational correspondences for the two pictorial conditions (+Shape and –Shape).

There was no effect of List ($F < 1$) for both types of correspondences. The analysis showed no effect of Shape on the number of property correspondences: $F(1,38) = 1.48$, $p = .23$. This indicates that the difference between the +Shape and –Shape source pictures did not affect the number of property correspondences mentioned. The analysis of the relational correspondences revealed no effect of Shape as well: $F(1,38) = 1.44$, $p = .24$. This shows that there was no difference in the number of relational correspondences produced for the similarly and dissimilarly shaped objects pairs. So, the increased number of source-target correspondences for the

Table 4.2. Means (and SDs) for the property and relational correspondences, per item.

	Property correspondences	Relational correspondences
+Shape	1.07 (.55)	1.45 (.57)
–Shape	1.00 (.51)	1.37 (.56)

similarly shaped pairs cannot be reduced to either an effect of Shape on property correspondences or on relational correspondences.

Leaving the factor Shape aside, a paired-samples *t*-test was conducted to compare the mean number of property and relational correspondences per item. There was a significant difference in the mean number of property correspondences (1.04) and relational correspondences (1.41): $t(559)=5.59$, $p < .001$. Overall, participants produced more relational correspondences than property correspondences per item.

A chi-square analysis showed that there was no relation between the type of the first mentioned correspondence for the similarly shaped (128 property and 145 relational correspondences) and dissimilarly shaped pairs (129 property and 143 relational correspondences): $\chi 2$ (1, N = 545) = .16, p = .90.

Discussion

The purpose of the present study was to examine the role of shape in processing visual metaphors. We tested the prediction that similarity in shape results in overlapping structural descriptions and, thereby, semantic knowledge which facilitates the production of correspondences between the presented objects. We expected more correspondences (both property and relational correspondences) and shorter speech onset times for similarly shaped object pairs than for dissimilarly shaped object pairs. Our results confirmed this expectation. Participants were significantly faster in finding and producing a correspondence when the objects had similar shapes, as compared to when the objects did not look alike. Furthermore, similarity in shape resulted in the production of more correspondences between the objects. These results can indeed be explained by the direct link between the overlap in structural descriptions and the overlap in semantic knowledge. The activation of shared semantic knowledge facilitates finding correspondences.

In theory, both results could also be caused by differently highlighted affordances. That is, different shapes highlight different affordances (i.e., possible actions or functions). Research by Zwaan, Stanfield, and Yaxley

(2002), for example, has shown that the recognition of an object that was previously mentioned in a sentence is influenced by the object's implied shape (see also Stanfield & Zwaan, 2001). In their experiment, participants read sentences like "The ranger saw the eagle in the sky" or "The ranger saw the eagle in its nest," which were followed by a line drawing of the object described in the sentence, in this case an eagle with outstretched wings or an eagle with folded wings, respectively. Participants recognized the pictures faster if the implied shape of the objects in the sentences matched the shape of the object in the pictures. To make sure that the difference in speed and the amount of produced correspondences found in the present experiment was the result of the perceptual manipulation rather than the effect of differently highlighted affordances, we conducted an additional analysis in which we compared the nature of the source features and the source-target correspondences in more detail. First, we checked what the most prominent source-target correspondence (based on a possible action or function) was for each item set. Subsequently, we assessed whether any differences in the occurrence rates of the correspondences reported after the +Shape and –Shape source pictures were influenced by affordances displayed by the different source objects. For example, for the swan-airplane item (i.e., item 4, Appendix 4.1), the correspondence with the highest occurrence rate, and therefore the most prominent correspondence, was "to fly." This verb was mentioned 16 times as correspondence for the +Shape pair and 20 times for the -Shape pair. Subsequently, we checked the number of times that "to fly" was mentioned as a feature for the different source pictures. For the +Shape source picture, we found 19 occurrences and for the -Shape picture, we found 10 occurrences. Hence, for this item, the shape manipulation highlighted the affordance "to fly" differently for the two source pictures, but it did not influence the number of correspondences based on this affordance. We conducted this analysis for all items and found that there was no positive correlation between the activated affordances and the correspondences that were based on these affordances; $r = -.19$, $p = .52$. So, the differently highlighted affordances have not influenced the difference in correspondences reported after the different source pictures.

Yet another factor that could have influenced the search for correspondences is the amount of visual component parts of the +Shape and –Shape source objects. That is, a particular picture might be more informative (i.e., when more meaningful parts can be extracted) than its +Shape or –Shape counterpart. To rule out any effect of this difference on the reported correspondences, we compared the number of component parts that the participants mentioned for the +Shape and –Shape source pictures. According to Tversky and Hemenway (1984), sentences containing the verb *to have* express partonomic relations. So, identical to the type of correspondence analysis, we distinguished between property and relational features based on the presence of conjugations of *to be* and *to have* or action verbs, respectively. Subsequently, we subcoded the property features as partonomic or not, based on whether the features did (or could) contain the verb *to have*. Our analysis showed that there was no difference between the mean number of parts mentioned for the +Shape (1.68) and –Shape (1.80) source pictures per item; $F(1,38) = 1.38$, $p = .25$. We take this result as evidence that the difference in visible component parts did not influence the difference in correspondences reported after the +Shape and –Shape source pictures. It thus seems that the perceptual feature *shape* affected the search for correspondences, rather than differently highlighted affordances or differences in visible component parts.

Regarding the nature of the produced correspondences, there were no differences between the proportions of both the *property* and *relational* correspondences for the similarly and dissimilarly shaped object pairs. The finding regarding property correspondences seems rather surprising since it seems reasonable to assume that the actual visual presentation of the objects attracts the participants' attention to perceptual features such as shape, texture, and part-whole structure. Moreover, since the source and target objects were not shown simultaneously, the source object might have operated as a prime object. In this light, Biederman and Cooper (1991; Biederman & Cooper, 1992) propose an interesting account on perceptual recognition of a presented object after object priming. Their research shows that the nature of object priming is visual, rather than conceptual, as there was much less priming to an object that had the same name but a different shape as compared to an object that had the same name and the same shape. As a result, we might expect the +Shape source objects to operate as a better prime for the target picture than their –Shape counterpart. However, the visual priming did not result in the finding of more property correspondences. The priming might have resulted, though, in speeded recognition of the target objects, which subsequently resulted in shorter speech onset times.

The finding that participants overall produced more relational correspondences than property correspondences might be explained by studies on verbal metaphor processing. Gentner (1988) and Gentner and Clement (1988) have shown that people prefer relational interpretations over attributive (i.e., property) interpretations, even if the metaphor can be interpreted both attributively and relationally. It thus seems that also for visual metaphors people have the tendency to construct relational interpretations.

In sum, the findings of the present study suggest that similarity in the shape of two objects activates shared semantic knowledge. Interpreting a visual metaphor – comparing objects from different categories in order to create an ad hoc category – is therefore facilitated by similarity in shape.

For future research, it might be interesting to investigate whether features of an object can be primed by the shape of an object stemming from a different category, which does not possess the primed feature. Both the fact that relational features are not present in the visual representation of objects and our finding that the increased number of correspondences for the similarly shaped pairs emerges from a combination of increased property and relational correspondences suggest that similarity in shape activates features other than only perceptual ones. So if shape indeed can activate object features that concern semantic knowledge, then it should be possible to prime such features with shape.

Another very interesting alley for future research would be to investigate developmental aspects of visual metaphor interpretation. Research by Gentner (1988) on metaphor understanding in children has shown that 9- to 10-year-olds share the preference of adults to interpret metaphors relationally. Younger children, however, do not share this relational focus. Interestingly, such a developmental change seems to be absent for interpretations based on property features. For visual metaphors, however, we might expect such a shift to be present, as younger children, for instance, have a strong reliance on object shape for lexical extension, with an increasing attention to function with age (Gentner, 1978; Graham, Williams, & Huber, 1999; Landau, Smith, & Jones, 1998). This perceptual focus might result in more interpretations based on property resemblance, decreasing with age.

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Appendix 4.1

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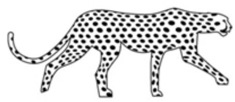
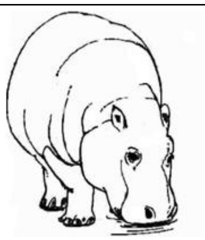
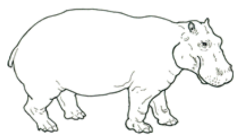
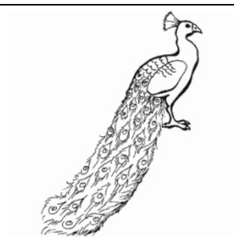
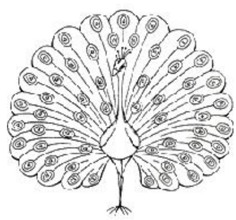
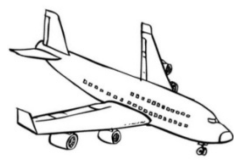
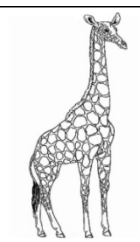
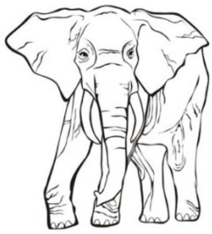
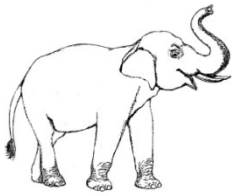
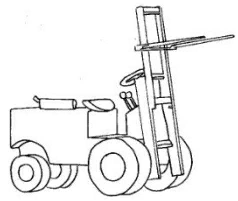
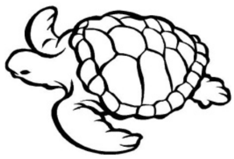
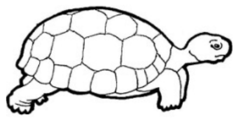
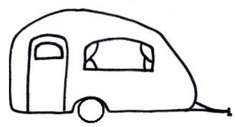
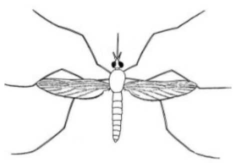
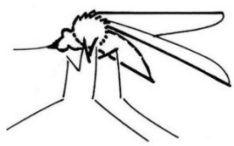
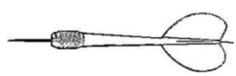
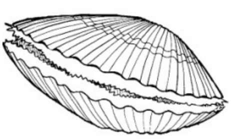
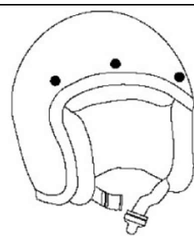
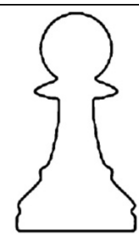
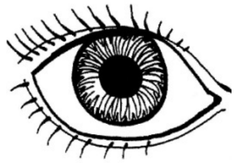
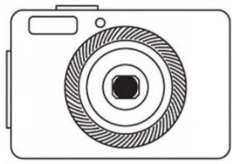
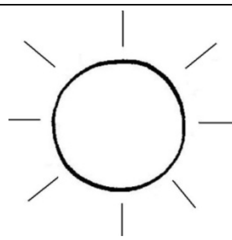
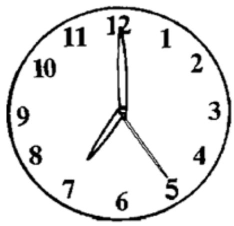
1			
2			
3			
4			
5			

Set	–Shape Source	+Shape Source	Target
6			
7			
8			
9			
10			

Set	–Shape Source	+Shape Source	Target
11			
12			
13			
14			

Chapter 5
The role of shape in mental representations of similes

Abstract

People mentally represent the shapes of objects. For instance, the mental representation of an eagle is different when one thinks about a flying or resting eagle. The present study examined the role of shape in mental representations of *similes* (i.e., metaphoric comparisons). We tested the prediction that when people process a simile they will mentally represent the entities of the comparison as having a similar shape. We conducted two experiments in which participants read sentences that either did (experimental sentences) or did not (control sentences) invite to compare two entities. For the experimental sentences, the ground of the comparison was explicit in Experiment 1 ("*X has the ability to Z, just like Y*") and implicit in Experiment 2 ("*X is like Y*"). After having read the sentence, participants were presented with line drawings of the two objects, which either were similarly or dissimilarly shaped. They judged whether both objects were mentioned in the preceding sentence. For the experimental sentences, recognition latencies were shorter for similarly shaped objects than for dissimilarly shaped objects. For the control sentences, we did not find such an effect of similarity in shape. These findings suggest that a perceptual symbol of shape is activated when processing similes.

This chapter is based on:

Van Weelden, L., Schilperoord, J., & Maes, A. (In press). Evidence for the role of shape in mental representations of similes. *Cognitive Science*.

Introduction

The Perceptual Symbol Theory assumes that people activate perceptual representations during language comprehension (Barsalou, 1999). For example, if we talk about a table, we typically activate the representation of an object with a flat surface and four legs. This representation is the residue of our perceptual experiences with, in this case, a table. According to Barsalou (1999), such a representation is defined by the combination of several *perceptual symbols* for different components of the referent (e.g., the color, shape, orientation, and type of wood of the table). There is an analogue relationship between these perceptual symbols and the referent. That is, the way an object is mentally represented is related to the way such an object is perceived in reality. For example, if the table is turned upside down, so too will the representation. This implies that if one reads a sentence stating that a table is turned upside down, then the mental representation will contain information about this specific orientation of the table. So, any transformation of the referent implied by the sentence should cause analogous transformation in its representation.

Stanfield and Zwaan (2001) found evidence for this hypothesis in their study on the effect of implied orientation on mental representation. They presented participants with sentences such as "He hammered the nail into the wall" and "He hammered the nail into the floor." Subsequently, participants saw a line drawing of the object mentioned in the sentence (i.e., the nail). The object was presented either in horizontal or vertical orientation, creating a match or mismatch with the representation evoked by the preceding sentence. They found faster recognition responses for pictures matching the orientation of the object implied by the sentence. Hence, their study shows that a perceptual symbol of *orientation* is activated in language comprehension and offers support for the theory of perceptual symbol systems.

Research by Zwaan, Stanfield, and Yaxley (2002) has shown that people also create a perceptual symbol for the *shape* of the object. In their experiment participants were presented with sentences like "The ranger saw the eagle in the sky" or "The ranger saw the eagle in its nest," which were followed by a line drawing of the object described in the sentence, in this case an eagle with outstretched wings or an eagle with folded wings. Participants recognized the picture faster if the implied shape of the object in the sentence matched the shape of the object in the picture. So, this study shows that the shape of objects is related to their function or action (e.g., outstretched wings correspond to flying).

The shape of objects has been found to play an important role in the categorization of objects as well (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Sloutsky, 2003; Tversky & Hemenway, 1984). Related work has shown that similarly shaped objects are perceived to have similar functions and hence tend to be assigned to the same conceptual category (Gentner, 1978; Landau, Smith, & Jones, 1998; and see Chapter 2 and 4). For example, in Chapter 2 we showed that finding a conceptual relation between two objects that stem from different conceptual categories is facilitated by similarity in shape between the two objects.

Along similar lines, Desmarais, Dixon, and Roy (2007) showed that visually similar objects paired with similar actions were confused more often in memory than when these objects were paired with dissimilar actions. In their experiment, participants were shown a novel object accompanied by its nonword label, and an action was performed on the object. During test trials, participants were asked to name the object that was placed in front of them. Participants made more errors in identifying similarly looking objects that were paired with similar actions than with dissimilar actions. This confusion of similarly looking objects with similar actions arises from interference as they are assigned to the same conceptual category. Objects that have the same function or ability to perform the same action are expected to look similar as well.

The purpose of the experiments reported here is to elaborate on these findings by studying the role of shape in mental representations of sentences that invite readers to compare two concepts in order to find conceptual correspondences between them. This way, we combine the aforementioned theories on the role of shape in mental representations and the relation between shape and conceptual knowledge in object comparisons.

We are particularly interested in the role of shape in mental representations of two compared concepts that stem from *different* categories as they generally do not share perceptual features, unlike concepts that belong to the same taxonomic category (e.g., animals or fruits) (Rosch et al., 1976). A cognitive mechanism that structures our reasoning, experience, and everyday language by the comparison of concepts from distinct conceptual categories is *metaphorical mapping* (Gibbs, 2006; Lakoff & Johnson, 1980a, 1980b, 1999). Metaphorical mappings arise naturally, automatically, and unconsciously through every day experiences by means of conflation (Grady, 1997). For example, pouring wine in a glass and seeing the level rise results in the metaphoric relation of "*more is up*." In everyday language, this metaphor is manifested in sentences like, *"The price of cucumbers is very high"* or *"Inflation has risen."* As opposed to this indirect use of metaphor, metaphors can also be expressed more directly using the syntactic structure of a comparison, such as "*The mind is (like) a computer*" (Steen, Dorst, Herrmann, Kaal, & Krennmayr, 2010). As such, they highlight correspondences between the source and target concept, for instance that the mind (target) processes information in a similar manner as a computer (source) does. So, in interpreting a metaphor, we need to map our knowledge of the source domain onto the target domain.

There are different approaches to how these metaphoric mappings take place. The first approach to metaphor comprehension is that metaphors are comparisons that highlight similarities between the target and source concept (Bowdle & Gentner, 2005; Ortony, 1979). According to Gentner's (1983) Structure-Mapping Theory, a metaphor is interpreted by (a) aligning the representation of the source and target concept and by (b) mapping particular features from the source onto the target concept. The types of features that are mapped can be common relational structures (e.g., both entities can perform the same action or can be used to accomplish the same goal) or common attributive features (e.g., both entities look similar), with the constraint that people tend to prefer relational similarities over attributive similarities in their interpretations of metaphors (Gentner & Clement, 1988).

The second approach to metaphor comprehension is that metaphors are understood as categorization statements rather than as comparison statements (Glucksberg, 2003). According to this view, metaphors establish taxonomic relations between concepts from disparate conceptual domains. Rather than that the target concept is being compared to the source concept to see what they have in common, the target concept is assigned to the metaphoric category activated by the source concept. For instance, in interpreting "*My job is a jail,*" all features characterizing the metaphoric category elicited by 'jail' (i.e., an unpleasant and confining situation) are mapped onto the concept of 'job.' According to Glucksberg, McGlone, and Manfredini's (1997) Interaction Property Attribution Model, source concepts do not elicit just one metaphoric category but rather a number of possible metaphoric categories (i.e., a lonely place or a situation that excludes you from society).

Bowdle and Gentner's (2005) Career of Metaphor hypothesis reconciles these two approaches and proposes that there is a shift in type of mapping (i.e., from comparison to categorization) as metaphors become conventionalized. Novel metaphors involve source concepts that are not (yet) associated with a metaphoric category and, therefore, they are processed as comparisons, in which the target concept is compared to the source object. Conventional metaphors, on the other hand, involve source terms that, due to recurrent use, already refer to a metaphoric category. Conventional metaphors can therefore be processed through categorization, by seeing the target concept as member of the category that is activated by the source concept.

Interestingly, these different comprehension strategies can also be evoked by different linguistic structures. Conventional metaphors typically take the structure of a *metaphor*: "*An X is a Y*." This structure is identical to the structure of a literal categorization, such as "An orange is a fruit." Akin to a literal categorization, a metaphor invites to classify the target concept as a member of the category that is represented by the source concept. Novel comparisons typically take the structure of a *simile*: "*An X is like a Y*," which is grammatically similar to a literal comparison, such as "An orange is like a mandarin." The comparative term *like* invites to compare the two concepts mentioned in the sentence. Hence, simile comprehension involves an online comparison process.

Shape might play an important role in this comparison process. That is, we know that in interpreting metaphoric relations, people have a preference for conceptual similarities (i.e., common relational structures) over perceptual similarities (i.e., common attributive features) (Gentner & Clement, 1988) and that conceptually similar objects are expected to look similar as well (Desmarais et al., 2007). Accordingly, thinking of conceptual similarities between concepts might result in a mental representation of similarly looking objects. Hence, in the present study, we hypothesize that the identification of conceptual similarity during simile comprehension leads to an assumption of shape similarity, resulting in a mental representation of two similarly shaped objects.

In sum, where Zwaan et al. (2002) studied the effect of implied shape resulting from a specific event description on the mental representation of single objects, we study the effect of implied shape resulting from a sentence structure that invites to compare two objects on the mental representation of pairs of objects. We predict that when people process a simile they will mentally represent the entities of this comparison as having a similar shape. In order to test this prediction, we examine the effect of similarity in shape on recognition latencies to two simultaneously presented pictures of the objects, either similar or dissimilar in shape, that were mentioned in a preceding sentence which either did (very explicitly in Experiment 1 and rather implicit in Experiment 2) or did not invite to compare the two entities.

Experiment 1

In Experiment 1, an experimental group receives explicit comparison sentences. That is, participants receive similes explicitly describing a conceptual similarity between two objects, for example "*A forklift lifts heavy* *things, just like an elephant*." A control group receives sentences with a sentential structure that does not invite to compare two objects. That is, participants of this group receive sentences describing a locational relation between two entities, such as "A forklift was located in front of an elephant." Both groups of participants will then be presented with two line drawings of the mentioned objects. The two drawings either have a similar or dissimilar outline. Participants are asked to judge as fast as possible whether the two presented objects were mentioned in the preceding sentence. If a metaphoric relation implies shape similarity between entities, then recognition latencies should be faster for objects that are similar in shape as compared to objects that are not similar in shape. For the location sentences, the sentence structure does not invite to compare the two entities and therefore, for these sentences, we do not expect differences between the recognition latencies to the similar and dissimilar shaped objects.

Method

Participants

Sixty-nine Tilburg University undergraduates (51 women and 18 men) participated in this study for course credit. Their mean age was 21 years, ranging from 18 to 30. All participants were unaware of the purpose of the experiment and had normal or corrected-to-normal vision. None of the participants had participated in the materials pretest (see next section).

Materials

We created 80 Dutch sentences: 20 (explicit) similes and 20 location sentences (see the Appendix 5.1 for the Dutch sentences and English translations) and 40 filler sentences. The similes described a conceptual correspondence between two entities from different conceptual categories in an "*X has the ability to Z, just like Y*" construction. The conceptual correspondence was made explicit in the sentence (i.e., "*has the ability to Z"*) so that the participants could not relate the entities solely on perceptual features. We created the sentences either with an action verb (1) or with a conjugation of the verb *to be* followed by a conceptual characteristic (2). The location sentences were created with the intention to mention both the target and source entity, but to prevent that the two entities were compared to each other in any way. Therefore, the location sentences only described a spatial relation between the target and the source entity. In order to create state-of-affairs, we used sentences with verbs expressing a state of being (3) and/or with action verbs in the past tense (4). We avoided using prepositions of location such as "next to" or "opposite of," because the actual presentation of the target object was "next to" or "opposite of" the source object. These prepositions could elicit expectations about the visual presentation of the objects, which could affect the recognition latencies. Instead, we used prepositions such as "in front of," "above," or "behind." The experimental sentences required a "yes" response. Therefore, an equal number of filler sentences mentioned a source entity that differed from the object that was presented in the picture, and thus required a "no" response.

(1) Een motor trekt heel snel op, net als een luipaard.
A motorcycle accelerates very fast, just like a leopard.
(2) Een pion is van relatief lage waarde, net als een soldaat.
A pawn is of relatively little value, just like a soldier.
(3) Een bulldozer stond op een mier.
A bulldozer stood on top of an ant.
(4) Een helikopter zweefde boven een libel.
A helicopter hovered above a dragonfly.

We used 20 experimental picture sets, each containing one target object and two source objects (see Appendix 5.2), and 20 filler picture pairs, each consisting of one target and one source object.[1] The pictures were simple black-and-white line drawings, placed in an area of 200 x 200 pixels. The shape of the source object was depicted either similar (+Shape) or

[1] Fourteen of the twenty experimental picture sets were also used in the study presented in Chapter 4.

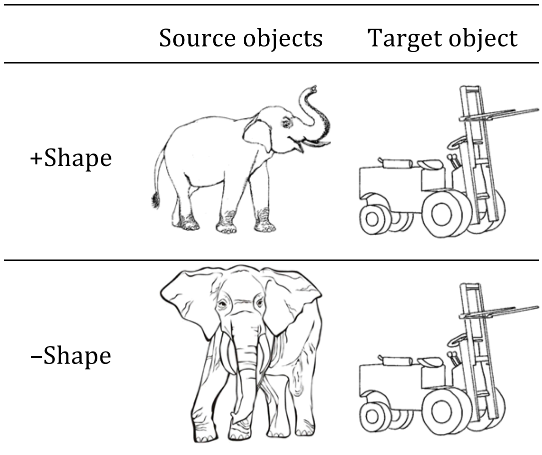


Figure 5.1. Example picture set with two picture pairs: +Shape and –Shape.

dissimilar (–Shape) to the target object, see Figure 5.1. By shape we mean the outline of the picture of a particular object.

Shape similarity pretest. Manipulations of object shape were pre-tested by subjective ratings of shape similarity. The same pretest was used as we presented in Chapter 4. Yet where we analyzed the similarity ratings of fourteen picture sets in Chapter 4, for the present study we analyzed the ratings of the twenty picture sets. A T-test revealed a significant difference between the ratings for the +Shape (.63) and the –Shape pairs (.26); $t(16)=12.16$, $p < .001$.

Affordance pretest. Gibson's (1977, 1979) Theory of Affordances postulates that objects are not only perceived in terms of their shapes and spatial relationships but also in terms of their affordances, that is, the object's possible function. For example, we sometimes use our T-shirt to clean our glasses. The nature of the shirt (i.e., a 'square' of soft absorbent fabric) affords that we can use it that way. So, the shape and affordances of an object are inseparable. The +Shape and –Shape source objects therefore highlight different affordances. This might make the conceptual feature described in the metaphoric sentence more or less apparent in the subsequently presented source object. For example, the feature "to fly" is more apparent for the +Shape variant of the swan (i.e., the flying swan) than for the –Shape variant (i.e., the sitting swan). These differently highlighted affordances might affect the recognition latencies for the +Shape and –Shape object pairs. To control for this effect, we looked at the produced source features of Chapter 4. Based on this, we were able to choose conceptual features that were mentioned equally often for two shape versions of the source objects. For the swan-airplane pair, for instance, we chose therefore for the feature "to land softly" rather than "to fly."[2]

Prototypicality pretest. Another factor that might affect the recognition latencies for the +Shape and –Shape object pairs is the prototypicality of the different shapes of the source objects. The source objects from the similarly shaped pairs might have a more prototypical shape than the source objects from the dissimilarly shaped pairs, or the other way around. This might make it easier to identify and recognize source objects from one of the two shape conditions. To control for this effect, we used same pretest as we presented in Chapter 4. Yet where we analyzed the similarity ratings of fourteen picture sets in Chapter 4, this time we analyzed the ratings of the twenty picture sets. A chi-square analysis did not reveal a difference between the prototypicality of the +Shape (54.3%) and –Shape (45.7%) source pictures; $\chi2$ (1, N = 200) =.50, p =.48.

Design

The experiment had a 2 x 2 x 2 design, with Type of Sentence (levels: Simile and Location) and List (levels: List 1 and List 2) as between-subjects factors and Shape (levels: +Shape and –Shape) as within-subjects factor. The two lists counterbalanced picture sets and Shape condition.

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[2] Because in Chapter 4 only sets 1 to 14 were used, we had no production data of sets 15 to 20. For these sets, we made sure that the conceptual feature was not afforded by the shapes of one of the source objects.

Procedure

Participants were instructed to read each sentence and subsequently decide if the objects that followed were mentioned in the preceding sentence. They were also told that reaction times were being measured and that it was important to make their decisions as quickly as possible. During each experimental trial, participants first saw a fixation cross in the center of the screen for 1000 ms. Subsequently, the sentence appeared, which either did or did not mention both objects presented later. Participants pressed the "yes" button when they had understood the sentence after which another fixation cross appeared in the center of the screen for 500 ms, followed by the simultaneous presentation of the two object pictures. The picture of the target object was always presented on the left side and the picture of the source object on the right side. Participants then had to determine whether both objects were mentioned in the preceding sentence. They produced their response by pressing a key on a button panel. The "yes" response key was always located on the dominant hand side of the participants. Immediately after their judgment, feedback indicated whether the answer was correct, incorrect, or given too late, that is, after more than 2 seconds. Directly following the feedback, the next trial started with a fixation cross on the screen.

Participants were assigned to one of the four conditions (Type of Sentence x List) in the same order as they came to the lab. Participants were instructed that they were going to take part in a reaction time experiment and that it was important for them to make the decisions about the pictures as quickly as possible. Each participant saw 20 sentence-picture pairs, requiring "yes" responses, and 20 filler pairs, requiring "no" responses. The experiment started with five practice trials to familiarize the participants with the task.

E-Prime software[3] was used to control the presentation durations of the fixation crosses and pictures, to randomize the sentence-picture pairs, and to collect the recognition latencies.

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[3] See http://www.pstnet.com/eprime/cfm.

Results and discussion

We conducted a 2 x 2 x 2 analysis of variance (ANOVA), with Type of Sentence (levels: Simile and Location) and List (levels: List 1 and List 2) as between-subjects factors and Shape (levels: +Shape and –Shape) as within-subjects factor, on the recognition response latencies. Table 5.1 displays the median response latencies. The analyses of the response latencies focused on the response latencies of the correct responses; 3.4% of the data was excluded for this reason. Following Stanfield and Zwaan (2001) and Zwaan et al. (2002), we used the median correct response time per participant per condition in the analyses to decrease the effects of extreme outliers[4].

Table 5.1. Median object response latencies in ms (standard deviations in parentheses) for Experiment 1 and Experiment 2

	Shape		
Type of Sentence	+Shape	–Shape	/d/
	Experiment 1		
Location	791 (149)	802 (145)	11
Simile (explicit)	730 (133)	793 (188)	63
	Experiment 2		
Simile (implicit)	725 (144)	757 (142)	32

We did not find an effect of List on response latency ($F < 1$). Neither the two-way interactions between List and Shape ($F(1, 65) = 2.83$, $p = .10$) and List and Type of Sentence ($F < 1$) nor the three-way interaction between List, Type of Sentence, and Shape ($F < 1$) was significant. As a result, we excluded the factor List from the rest of the analyses.

[4] Analyses done on the means yielded the same pattern of results as the analyses on the medians

There was an effect of Shape on response latency: Responses were faster for objects that were similar in shape (761 ms) than for objects that were dissimilar in shape (797 ms), $F(1, 67) = 8.94$, $p < .01$, $\eta^2_p = .12$. The effect of Type of Sentence was not significant ($F < 1$). The analysis did show that the two factors interacted, $F(1, 67) = 4.68$, $p < .05$, $\eta^2_p = .07$. Post hoc analyses revealed that for the simile sentences response latencies were significantly faster for objects that were similar in shape (730 ms) as compared to objects that were dissimilar in shape (793 ms), $F(1, 37) = 13.30$, $p < .01$, $\eta^2_p = .26$. Yet for the location sentences it did not matter whether two objects were similar or dissimilar in shape ($F < 1$).

These results show that for the similes recognition latencies were shorter for similarly shaped objects than for dissimilarly shaped objects. For location sentences, however, we did not find any differences in recognition latencies to the two types of object pairs. This indicates that the recognition of two objects that were mentioned in a simile (of which the sentential structure invites to compare the two entities) was influenced by the similarity in shape of the two objects, and that this is not the case for the recognition of two objects that were mentioned in a location sentence (which sentential structure does not invite to compare the two entities). These findings support the hypothesis that people mentally represent the entities of a simile as having a similar shape.

The invitation to compare the concepts was quite explicit in the similes used in the present experiment, as the conceptual 'ground' of the metaphoric relation was already given in the sentences. Yet similes can be more implicit as well in that they leave the task of finding conceptual correspondences to the reader. An effect of similarity in shape for these implicit similes would strengthen our interpretation of the results.

Experiment 2

Experiment 2 examines the role of shape in mental representations of implicit similes, of which the typical "*An X is like a Y*" structure leaves the nature of the correspondence is unspecified. If we assume that people indeed have a preference for metaphoric interpretations based on conceptual correspondences and that the identification of this type of similarity indeed invites to the assumption of shape similarity, then we should find the same results as we did in Experiment 1.

Method

Participants

Thirty-three Tilburg University undergraduates (21 women and 12 men) participated in this study for course credit. Their mean age was 21 years, ranging from 18 to 29. All participants were unaware of the purpose of the experiment and had normal or corrected-to-normal vision. None of the participants had participated in Experiment 1 or the materials pretest.

Materials and procedure

The 20 experimental picture sets and 20 filler picture pairs were identical to those of Experiment 1. Yet the experimental sentences had an "*An X is like a Y*" construction, for example "*A motorcycle is like a leopard*." Compared to Experiment 1, the conceptual (or perceptual) correspondence between the target and source concept was left implicit, rather than explicitly stated.

The procedure was the same as in Experiment 1, however this time the between-subjects factor Type of Sentence was not included. Hence, participants were only assigned to one of the two lists in the same order as they came to the lab.

Design

The experiment had a 2 x 2 design, with List (levels: List 1 and List 2) as between-subjects factors and Shape (levels: +Shape and –Shape) as within-subjects factor. The two lists counterbalanced picture sets and Shape condition.

Results and Discussion

We conducted a 2 x 2 analysis of variance (ANOVA), with List (levels: List 1 and List 2) as between-subjects factor and Shape (levels: +Shape and –

Shape) as within-subjects factor, on the recognition response latencies. Table 5.1 displays the median response latencies. The analyses of the response latencies focused on the response latencies of the correct responses; 3.7% of the data was excluded for this reason.

Again, we did not find an effect of List on response latency ($F < 1$). There was also no two-way interaction between List and Shape ($F(1, 31) = 2.22$, $p = .15$). As a result, we excluded the factor List from the rest of the analysis. The analysis showed an effect of Shape on response latency: Responses were faster for objects that were similar in shape (725 ms) than for objects that were dissimilar in shape (757 ms), $F(1, 32) = 4.64$, $p < .05$, $\eta^2_p = .13$.

Similar to the findings of Experiment 1, this finding shows that the recognition of two objects that were mentioned in an "*An X is like a Y*" sentence was influenced by the similarity in shape of the two objects. The recognition of the mentioned objects was faster for the similarly shaped objects as compared to the dissimilar shaped objects. These findings provide additional support for the hypothesis that people mentally represent the entities of a simile as having a similar shape.

General discussion

The purpose of the present study was to examine whether a perceptual symbol of *shape* is activated when processing similes (i.e., metaphoric comparisons). We tested the prediction that the invitation to identify conceptual similarities between the source and target concept leads to an assumption and representation of shape similarity. Hence, for the task in which participants read similes (with or without explicit conceptual correspondence) and subsequently had to determine whether two presented objects were mentioned in the preceding sentences, we expected shorter recognition latencies to similarly shaped objects as compared to dissimilarly shaped objects. Our results confirmed this expectation. For the similes presented in both Experiment 1 and 2, participants were faster in recognizing similarly shaped objects as compared to dissimilarly shaped objects. Furthermore, such an effect was absent for the control sentences, which did not invite to compare the two mentioned concepts. Thus, our results indeed suggest that a perceptual symbol of *shape* is activated when processing similes.

Though we conducted an affordance pretest, one might argue that for some of the experimental items the similarly shaped source object fitted the conceptual ground of the simile better than its dissimilarly shaped counterpart, which could have influenced the obtained results. A follow-up analysis without the potentially confounding items (i.e., item 1, 3, 4, 5, 11, 14, and 20) however still showed an effect of Shape for both the explicit and implicit similes, and for the control sentences the effect remained absent.[5] Thus, our finding that the recognition of two objects mentioned in a simile was influenced by their similarity in shape was not caused by such an affordance bias.

Our study seems to broaden the insights of Zwaan and colleagues (2001; 2002) on the activation of visual information in mental representations in two ways. First, just like context (e.g., "X in the sky") can evoke a perceptual symbol of *shape*, our study shows that *comparative sentence structures* (i.e., "*X has the ability to Z, just like Y"* and "*X is like Y"*) can evoke such a symbol as well. Second, where Zwaan et al. (2002) show the effect of implied shape (through context) on the mental representation of single objects, our study shows the effect of implied shape (through metaphorical relations) on the mental representations of *multiple* objects.

Interestingly, recent work by Vandeberg, Eerland, and Zwaan (2012) on the strength of a visual representation in memory showed that reading about a present object (e.g., "Jennifer saw a water fountain") results in a stronger visual representation of the object (i.e., the water fountain) than when reading about an absent object (e.g., "Jennifer saw no water fountain"). If we apply this our results, then this may predict that explicitly mentioned conceptual correspondences resulted in stronger visual representations than the 'syntactic' invitation to find conceptual correspondences. Closer inspection of our findings suggests that this indeed

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[5] Explicit simile: $F(1, 37) = 9.43$, $p < .01$, $\eta^2_p = .20$.
Implicit simile: $F(1, 32) = 5.90$, $p < .05$, $\eta^2_p = .16$.
Control sentences: $F(1, 30) = 1.15$, $p = .29$.

might be the case. As can be seen in Table 5.1, there was a 63-ms effect for the explicit similes and a 32-ms effect for the implicit similes. Given that the recognition latencies to the similarly shaped objects were almost equal for both types of similes, the latencies to the dissimilarly shaped objects seem to be increased for the explicit similes. This might be the result of additional cognitive processing. As proposed, the explicit conceptual correspondences might have underlined the commonalities between the two concepts, thereby creating a stronger visual representation. As a result, the presented dissimilarly shaped objects may have been highly incongruent with this representation, leading to prolonged recognition latencies.

The findings of the present study also align with findings on the role of shape in comparing objects. In Chapter 2 we showed that finding a conceptual relation between two (conceptually different) objects is facilitated by shape similarity. Furthermore, in Chapter 4 we showed that similarity in shape facilitates the process of interpreting visual metaphors. Both findings confirmed the hypothesis that similarity in shape affects conceptual (and metaphorical) processing. So, shape similarity seems to suggest conceptual similarity. The present study shows that this relationship also works the other way around. That is, the conceptual correspondence suggested by the "*An X has the ability to Z, just like a Y*" and "*An X is like a Y*" structures results in a mental representation of two similarly shaped objects. Hence, conceptual similarity suggests shape similarity.

This two-way interaction between perceptual and conceptual information can be represented theoretically by extending Humphreys and Forde's (2001) Hierarchical Interactive Theory (HIT) which models the identification process of visual objects. The theory posits three types of stored knowledge of objects: (1) structural descriptions, (2) semantic knowledge, and (3) name representations. When we see an object, its visual features activate a *structural description* that captures information about the object's outer appearance. Structural descriptions spread activation to stored *semantic knowledge* of the object. The main tenet of HIT is that activated semantic knowledge feeds back to structural descriptions; first, visual information provides access to non-visual semantic information, and, second, this semantic information reinforces visual information of the object.

Based on this theory, in Chapter 4 we predicted that similarity in shape between visual objects facilitates finding conceptual correspondences as the overlapping structural descriptions activate semantic knowledge that is relevant to both objects, see the top-down arrows in Figure 5.2. The experiments presented here offer evidence for the reverse of this process, see the bottom-up arrows in Figure 5.2. They show that the structure of a simile, which invites readers to search for conceptual correspondences (i.e., overlapping semantic knowledge), comes with the assumption of overlapping structural descriptions (i.e., visual features), which suggests the construction of similarly shaped mental representations.

To what degree can our findings be applied to the comprehension of all metaphors? Due to the experimental control of our experiments, we studied metaphorical comparisons between concrete concepts, whereas metaphors and similes typically employ abstract concepts as the target and concrete or physical concepts as their base. It seems reasonable to assume that readers activate shape when they mentally represent two concepts, as shape is one of the most intrinsic characteristics of objects. Obviously, *similarity* in shape only applies if a concrete shape can be activated for both the target and the source concept, or, in HIT terminology, when a structural description can be activated for both. For example, in interpreting a metaphor like "*Democracy is like a delicate flower*," it is hard to see how shape would be relevant, as a structural description of democracy is hard to conceive. Yet even if structural descriptions can be activated for both concepts, *similarity* in shape might be more appropriate for some comparisons than others. Consider for example Shakespeare's "*It is the east, and Juliet is the sun*." Although we can activate a shape for Juliet, we probably do not assume she is round like the sun. For these cases it might well be that, initially, an assumption of overlapping structural descriptions is activated, but that this assumption needs to be suppressed for the final interpretation of the metaphor. Evidence for the role of *executive control* in analogy

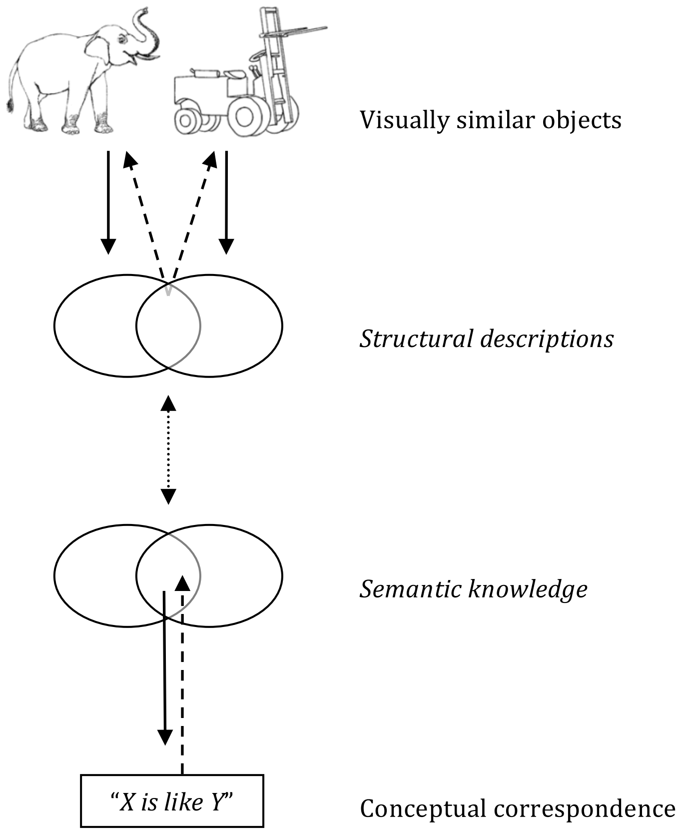

Figure 5.2. A model of how perceptual similarity (i.e., structural descriptions) affects conceptual knowledge (i.e., semantic knowledge), derived from the HIT framework as proposed by Humphreys and Forde (2001). Based on the results of the studies in this chapter, the top-down visual objects processing model of Chapter 4 is extended by a bottom-up process modeling the way in which a verbal invitation to create conceptual correspondences suggests similarly shaped mental representations of visual objects.

comprehension might support this idea. Executive control is defined as a set of cognitive processes that, instead of representing mental states directly, influence and organize such states in the context of some internal goal (Elliott, 2003). Research has shown that executive control plays a central role in situations where salient associations come immediately to mind, but are not relevant to the analogy problem (Richland, Morrison, & Holyoak, 2006; Thibaut, French, & Vezneva, 2010). In interpreting metaphors like "*Juliet is the sun*," shape associations might come to mind, but as the metaphor crucially depends on relational correspondences additional cognitive processing is needed to adjust the mental representation.

On the other end of the scale, there are metaphors which are crucially dependent on mental imagery, like image (or resemblance) metaphors (Gibbs & Bogdonovich, 1999; Lakoff, 1987; Urena & Faber, 2010). In this type of metaphor, conventional mental images are mapped onto other conventional mental images. As shape is an important ingredient of mental images, it is likely to assume that our results typically apply here. Consider for example this metaphor in André Breton's poem *Free Union*, "*My wife whose waist is an hourglass*." We understand this metaphor only by the mapping of the shape of an hourglass onto the waist of a woman. Thus, these metaphors show that perceptual attributes (like shape) can be crucial in the interpretation of metaphors.

Our results, however, show that the role of perceptual similarity goes beyond cases in which similarity is the only ground of the metaphoric comparison: Shape is involved in metaphor processing irrespective of whether or not it has a meaningful link with the conceptual correspondences involved in the comparison.

Yet shape is not the only perceptual feature relevant in metaphor processing. Many other perceptual features (e.g., size, verticality, distance, and color) are known to have strong metaphorical meaning as well (e.g., Boot & Pecher, 2010; Casasanto, 2008; Schubert, 2005). Abstract concepts might activate one of these perceptual features. For example, the mental representation of *love* could contain the color red and *life* might be represented as an increasing rather than a decreasing line. So, the mental representation of abstract-concrete or abstract-abstract pairs of concepts might involve similarity in terms of perceptual features as well.

The concepts used in our study call for ad hoc comparisons as the combinations of target and source concepts are rather novel. We assume that this process is different in the case of comprehension of conventional metaphors. Hence, an interesting alley for future research would be to investigate the effect of conventionality on the mental representations of metaphoric sentences. As described in the Introduction, Bowdle and Gentner's (2005) Career of Metaphor hypothesis proposes that there is shift in type of mapping (i.e., from comparison to categorization) as metaphors are conventionalized. These different types of mappings might result in different mental representations. That is, for conventional metaphors, the target concept can directly be assigned to the metaphoric category which is activated by the source concept. For novel metaphoric relations, however, the target concept needs to be compared to the source concept in order to find similarities between the two. As shown by the present study, this comparison process results in a mental representation of similarly shaped objects. Yet when processing conventional metaphors, this comparison process is superfluous as the source concept is already associated with a metaphoric category. As a consequence, the role of shape in mental representations of conventional metaphors might be less prominent. A neat way to test this hypothesis would be to design an experiment using Bowdle and Gentner's (2005, Experiment 3) in vitro conventionalization paradigm. In the study phase of this paradigm, participants receive triads of novel similes using the same source concept. The first two similes of each triad contain different target concepts, but are similar in meaning. For the third simile, the participant has to fill in the target term. This way, the novel source concept becomes conventionalized. The test phase following this study phase could then be identical to the present experiment. To investigate whether there are differences in the role of shape in the mental representations of novel and conventional similes, a between-subjects factor would test differences in recognition latencies between participants who performed only the test phase (novel condition) or both the study and test phase (conventional condition).

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Appendix 5.1

Set	Simile (explicit; Experiment 1)
1	Een motor trekt heel snel op, net als een luipaard. *A motorcycle accelerates very fast, just like a leopard.*
2	Een jeep gaat door het water, net als een nijlpaard. *A jeep goes through water, just like a hippo.*
3	Een waaier vouwt uit, net als (bij) een pauw. *A fan unfolds, just like a peacock.*
4	Een vliegtuig landt zachtjes, net als een zwaan. *An airplane lands softly, just like a swan*.
5	Een vuurtoren is van verre te zien, net als een giraf. *'A lighthouse can be seen from far away, just like a giraffe.'*
6	Een heftruck tilt zware dingen, net als een olifant. *A forklift lifts heavy things, just like an elephant.*
7	Een caravan is een verplaatsbaar huis, net als (bij) een schildpad. *A caravan is a movable house, just like a turtle*.
8	Een dartpijltje prikt, net als een mug. *A dart stings, just like a mosquito.*
9	Een helm beschermt, net als een schelp. *A helmet protects, just like a shell.*
10	Een pion is van relatief lage waarde, net als een soldaat. *A pawn is of relatively little value, just like a soldier.*

Continues on next page.

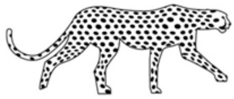
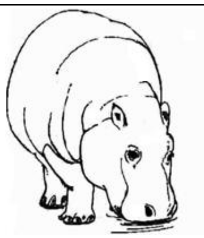
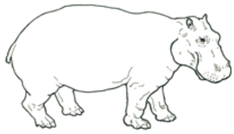
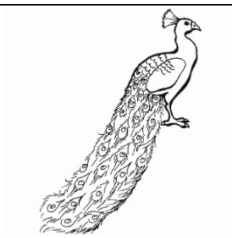
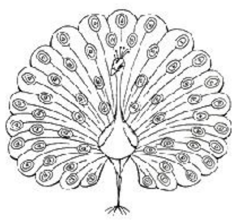
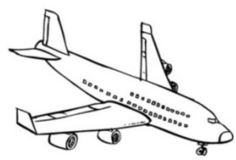
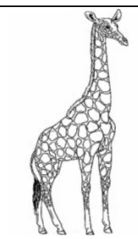
Set	Simile (implicit; Experiment 2)	Location (Experiment 1)
1	Een motor is als een luipaard. *A motorcycle is like a leopard.*	Een motor stond voor een luipaard. *A motorcycle stood in front of a leopard.*
2	Een jeep is als een nijlpaard. *A jeep is like a hippo.*	Een jeep bevond zich achter een nijlpaard. *A jeep was located behind a hippo.*
3	Een waaier is als een pauw. *A fan is like peacock.*	Een waaier lag voor een pauw. *A fan lay in front of a peacock.*
4	Een vliegtuig is als een zwaan. *An airplane is like a swan.*	Een vliegtuig landde net voor een zwaan. *An airplane landed just in front of a swan.*
5	Een vuurtoren is als een giraf. *A lighthouse is like giraffe.*	Een vuurtoren stond voor een giraf. *A lighthouse stood in front of a giraffe.*
6	Een heftruck is als een olifant. *A forklift is like an elephant.*	Een heftruck bevond zich voor een olifant. *A forklift was located in front of an elephant.*
7	Een caravan is als een schildpad. *A caravan is like a turtle.*	Een caravan stond op een schildpad. *A caravan stood on top of a turtle.*
8	Een dartpijltje is als een mug. *A dart is like a mosquito.*	Een dartpijltje bevond zich boven een mug. *A dart was located above a mosquito.*
9	Een helm is als een schelp. *A helmet is like a shell.*	Een helm lag over een schelp. *A helmet covered a shell.*
10	Een pion is als een soldaat. *A pawn is like a soldier.*	Een pion stond voor een soldaat. *A pawn stood in front of a soldier.*

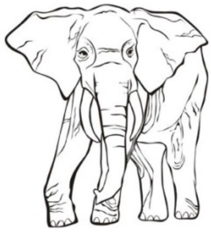
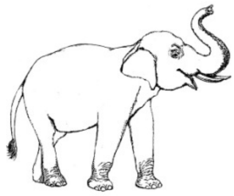
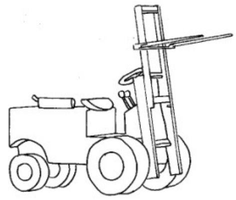
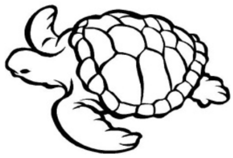
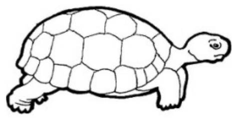
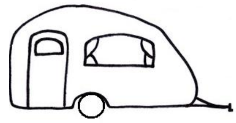
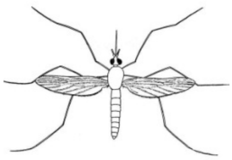
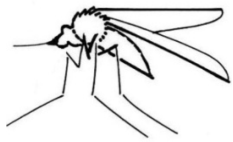
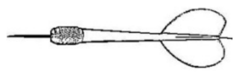
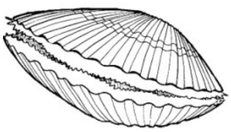
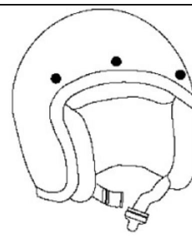
Set	Simile (explicit; Experiment 1)
11	Een fotocamera stelt scherp, net als een oog. *A camera focuses, just like an eye.*
12	Een tol draait snel rond, net als een ballerina. *A spinning top spins very fast, just like a ballerina.*
13	Een klok geeft de tijd aan, net als de zon. *A clock indicates the time, just like the sun.*
14	Een computermuis wijst iets aan, net als een hand. *A computer mouse points at something, just like a hand.*
15	Een vlieger zweeft op de wind, net als een meeuw. *A kite floats on the wind, just like a seagull.*
16	Een helikopter zweeft bewegingloos in de lucht, net als een libel. *A helicopter hovers motionless in the sky, just like a dragonfly*
17	Een weg is onvoorspelbaar, net als een slang. *A road is unpredictable, just like a snake.*
18	Een bulldozer is heel sterk, net als een mier. *A bulldozer is very strong, just like an ant.*
19	Een kantoorgebouw is een centrum van bedrijvigheid, net als een bijenkorf. *An office building is a centre of activity,* *just like a beehive*.
20	Een wekker maakt je wakker, net als een haan. *An alarm clock wakes you up, just like a rooster.*

Continues on next page.

Set	Simile (implicit; Experiment 2)	Location (Experiment 1)
11	Een camera is als een oog. *A camera is like an eye.*	Een fotocamera hield je voor een oog. *A camera was held in front of an eye.*
12	Een tol is als een ballerina. *A spinning top is like a ballerina*.	Een tol stond achter een ballerina. *A spinning top stood behind a ballerina.*
13	Een klok is als de zon. *A clock is like the sun.*	Een klok stond in de zon. *A clock stood in the sun.*
14	Een computermuis is als een hand. *A computer mouse is like a hand.*	Een computermuis lag onder een hand. *A computer mouse lay under a hand.*
15	Een vlieger is als een meeuw. *A kite is like a seagull.*	Een vlieger belandde achter een meeuw. *A kite landed behind a seagull.*
16	Een helikopter is als een libel. *A helicopter is like a dragonfly.*	Een helikopter zweefde boven een libel. *A helicopter hovered above a dragonfly.*
17	Een weg is als een slang. *A road is like a snake.*	Op een weg bevond zich een slang. *'On a road, a snake was located.'*
18	Een bulldozer is als een mier. *A bulldozer is like an ant*.	Een bulldozer stond op een mier. *A bulldozer stood on top of an ant.*
19	Een kantoorgebouw is als een bijenkorf. *An office building is like a beehive*.	In een kantoorgebouw bevond zich een bijenkorf. *'In an office building, a beehive was located.'*
20	Een wekker is als een haan. *An alarm clock is like a rooster.*	Een wekker stond achter een haan. *An alarm clock stood behind a rooster.*

Appendix 5.2

Set	–Shape Source	+Shape Source	Target
1			
2			
3			
4			
5			

Set	–Shape Source	+Shape Source	Target
6			
7			
8			
9			
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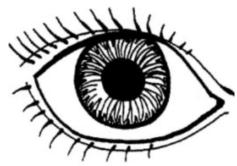
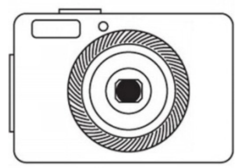
11			
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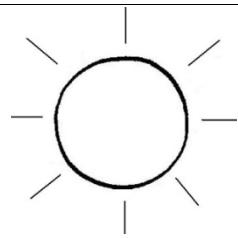
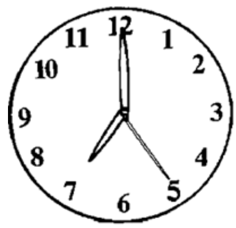
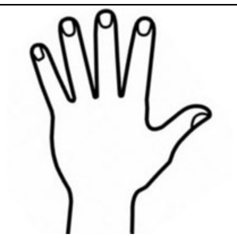
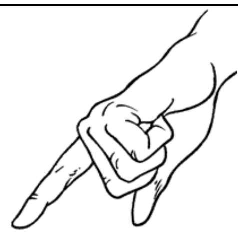
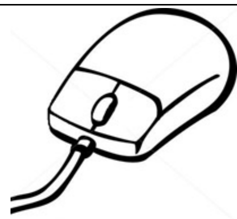
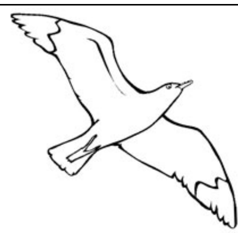
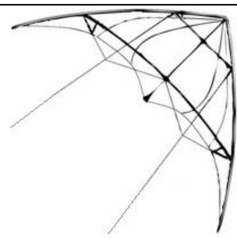
13			
14			
15			

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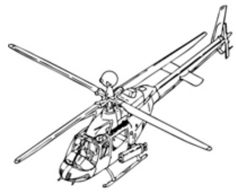
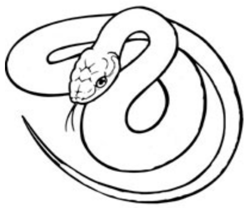
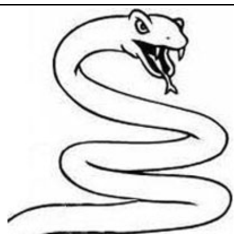
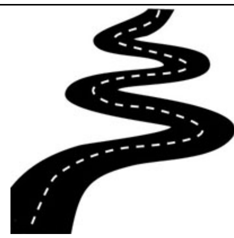
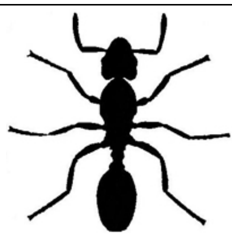
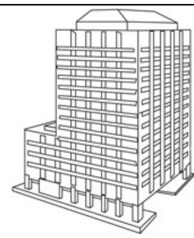
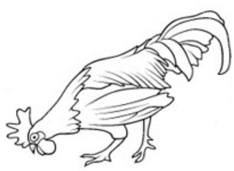
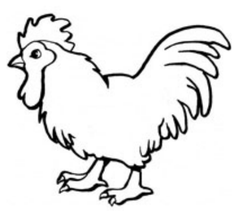
16			
17			
18			
19			
20			

Chapter 6
Discussion & Conclusion

In this dissertation we addressed the question how perceptual grouping, induced by similarity in shape, affects cross-domain mapping in visual metaphor processing. In addition, we looked at how perceptual grouping affects the character (i.e., attributive or relational) of the mapped features. We focused on perceptual grouping as a result of similarity in object shape. Each of the four studies evaluates the role of shape in a different situation: (1) in comparing functions of objects, (2) in semantic memory organization of objects, (3) in the search for metaphorical relations between objects, and (4) in mental representations of similes. In this section, we will summarize the findings of these four studies and discuss how these findings provide an answer to our main questions. We will also discuss some implications of our findings and suggest directions for future research.

Study 1 – Chapter 2

The first study assessed how similarity in shape affects the process of comparing functions of objects. In Experiment 1 and 2, participants had to answer the question whether two objects could be used for the same purpose. We found that participants produced more correct responses, were faster in doing so, and gave more extreme similarity judgments when the shape of objects was congruent with the objects' function (i.e., when objects had similar functions and similar shapes, or different functions and different shapes), as compared to when the two types of knowledge were incongruent (i.e., when objects had similar functions but different shapes, or different functions but similar shapes). These findings show that for functionally similar objects, the process of comparing objects benefits from similarity in shape, whereas for functionally different objects, similarity in shape results in a moment of confusion. These findings support the idea that similarity in shape serves as a basic level of object categorization (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). The similar appearance of the objects gives rise to the expectation that the objects are member of same conceptual category. If the objects indeed belong the same category, the expectation is confirmed and the categorization process is speeded up. However, if the objects turn out to be functionally different, the expectation is contradicted and additional processing is needed in order to categorize the objects.

In Experiment 3, we assessed the nature of these additional processing costs. Using a production task, we aimed at getting insight into the effect of shape on the actual production of correspondences. By asking the participants to describe an object in terms of another object, we implicitly asked them to look for correspondences between the objects. The number of mentioned correspondences was found to increase as a result of similarity in shape for both the functionally similar and functionally different objects. Shape similarity had an effect on the type of correspondences as well. Not surprisingly, more perceptual correspondences were produced. More interestingly, shape similarity also resulted in more conceptual correspondences. However, this only occurred in cases of functionally different objects. The absence of this result in cases of functional similarity suggests that shape similarity only stimulates finding a conceptual link if this link is not already present.

Study 2 – Chapter 3

The results of study 1 suggest that the role of shape in the categorization of objects is more prominent for objects stemming from different conceptual categories than for objects stemming from the same category. Therefore, in study 2 we investigated whether shape information is encoded differently in our semantic memory for objects from the same conceptual category (e.g., fruits) than from different conceptual categories (e.g., fruits and flowers).

Using the PI-paradigm (Wickens, 1970), we had participants remember and recall four triads of objects. The characteristics of the triads either remained the same, causing buildup of interference, or changed at the fourth triad, establishing a release from interference. Experiment 1 showed that if such a change concerned a shift in conceptual category, an additional shift in shape did not affect (the magnitude of) the release from interference. Thus, if objects can be categorized using both conceptual and shape information, then shape information is overruled by conceptual information. Experiment

2 showed that if the conceptual category was kept constant and the change comprised a shift in shape only, then release from interference was established through this shift of shape. So, if conceptual information cannot be (satisfactorily) used to recall the objects from memory, then the objects' shape comes into play. Hence, this study shows that object shape indeed plays a leading role in the process of categorization if conceptual information does not suffice.

Study 3 – Chapter 4

The results of study 1 and 2 indicate that similarity in shape plays a role in object categorization in situations where there is no overarching conceptual category present. This suggests that similarity in shape also plays a role in the cognitive process of cross-domain mapping by which objects from disparate conceptual domains are related to each other; the process that grounds *visual metaphor* interpretation. We investigated this matter in study 3.

In the experiment, participants had to fulfill two successive tasks. For the first task, participants were presented with a picture of a source object for which they had to produce characteristic features. For the second task, they were presented with a picture of a target object. The task was then to produce correspondences between that target object and the previously presented source object. The objects were members of disparate conceptual categories and were presented either similarly or dissimilarly shaped. When the target and source objects had similar shapes, participants found more correspondences and needed less time doing so, than when the objects had dissimilar shapes. The increase of correspondences could not be allocated to either perceptual or conceptual correspondences. So, both the search for perceptual *and* conceptual correspondences seems to benefit from similarity in shape. Hence, this study shows that similarity in shape facilitates finding metaphoric relations between objects from disparate domains of knowledge.

We explained our findings in terms of a model of object comparison derived from Humphreys and Forde's (2001) Hierarchical Interactive

Theory (HIT). The model incorporates two basic levels: the structural description level (involving perceptual knowledge of the objects) and the semantic knowledge level (involving stored semantic knowledge of the objects). In case of similarly shaped objects, the structural descriptions of the two objects overlap. These overlapping features activate conceptual, or semantic, knowledge that is relevant to both objects. Additionally, common perceptual knowledge is activated as well, as the semantic level gives feedback to the structural description level. As such, this model reconciles two theories; objects that look alike are assumed to have the same functions (Ortiz, 2010; and see Chapter 2) and, the other way around, objects that have the same functions or ability to perform the same actions are assumed to look alike as well (Desmarais, Dixon, & Roy, 2007; and see Chapter 5).

Study 4 – Chapter 5

The proposed feedback from the semantic level to the structural description level suggests that the identification of conceptual similarity between two entities might come with an assumption of shape similarity. In study 4, we investigated whether this assumption of shape similarity is reflected in mental representations of similes (i.e., metaphorical comparison statements). We examined whether explicit (i.e., "*X has the ability to Z, just like Y"*) and implicit (i.e., "*X is like Y"*) similes activate representations of similarly shaped objects. To do so, we had participants read the sentences and subsequently decide if two presented object pictures were mentioned in the preceding sentence. We manipulated the objects' similarity in shape. The findings showed that recognition was faster to similarly shaped objects than to dissimilarly shaped objects. This effect was both present for the explicit and implicit similes, but not for control sentences that only described a spatial relation between the objects. Hence, these findings suggest that the identification of conceptual similarities between objects from different conceptual categories evokes a mental representation of similarly shaped objects.

We propose that these findings indeed offer evidence for the bottom-up process of the model presented in study 3. They show that the structure of a simile, which invites readers to search for conceptual correspondences (i.e., overlapping semantic knowledge), comes with the assumption of overlapping structural descriptions (i.e., visual features), which suggests the construction of similarly shaped mental representations.

Conclusion

The aim of the present dissertation was to provide first insights into psychological aspects of visual metaphor processing. We focused on an essential component of metaphor processing in any kind of modality: cross-domain mapping. Research on cross-domain mapping in verbal metaphors has shown that people make both attributive (i.e., perceptual) and relational (i.e., conceptual) mappings, but in the end prefer relational over attributive mappings (Gentner, 1983, 1988; Gentner & Clement, 1988). In the studies presented in this dissertation we investigated whether this relational preference is also present in visual metaphor processing. Existing theories of metaphorical mapping suggest that this process does not depend on output modality (Gibbs, 1994; Lakoff, 1993; Lakoff & Johnson, 1980a). But, the frequent use of perceptual grouping in visual metaphors might lead to a preference for attributive mappings. If this would be the case then output modality would affect the process of mapping.

We investigated whether perceptual grouping as a result of similarity in shape affects cross-domain mapping. The first two studies presented in this dissertation tapped into different components of cross-domain mapping. The first study's focus was on the comparison of objects. The second study investigated the process that follows comparison, which is the categorization of the objects. We found that object shape is automatically engaged in both these processes, especially when the objects stem from disparate conceptual domains. For these pairs of objects, we found that similarity in shape results in confusion. Why do the objects look alike, while they are different? The third study presented in this dissertation gave insight into the types of correspondences that people find for these pairs of objects. One of the findings of this study was that they find perceptual (i.e., attributive) correspondences. This result is rather unsurprising, as the objects look alike. Yet, the results also suggested that shape similarity encourages the search for conceptual (i.e., relational) correspondences, by which an ad hoc category can be created. As such, our research contributes to existing theories of cross-domain mapping by showing that metaphorical mapping (and the preference for relational mapping) is indeed independent of output modality. Our research has also shown that shape similarity is involved in the processing of *verbal* metaphors. We found that if people are encouraged to compare concepts, either implicitly or explicitly, they mentally represent the objects as similarly shaped.

Taken together, similarity in shape seems to be involved in metaphorical processing in two ways. First, in visual metaphors, perceptual grouping as a result of similar object shapes encourages and facilitates the search for conceptual commonalities. Second, in verbal metaphors, the processing of conceptual commonalities activates an assumption of shape similarity. As such, *metaphor* seems to be *in good shape*.

We believe that the present dissertation has accomplished its goal to investigate visual metaphor processing from a psycholinguistic perspective. Whereas most studies on visual metaphor focus either on structural semiotic aspects or on metaphors' communicative and rhetorical possibilities, this dissertation has demonstrated that the processes of interpreting and comprehending visual metaphors can be empirically studied by employing several psycholinguistic paradigms, such as accuracy and response time measurements, concept recall, and picture recognition.

Furthermore, this dissertation adds to the body of evidence in support of the Conceptual Metaphor Theory (Lakoff, 1993; Lakoff and Johnson, 1980a, 1980b; see also Gibbs, 1994) and more in particular the Theory of Primary Metaphor (Grady, 1997). Primary metaphors establish basic cognitive correspondences between concepts and physical experiences. The metaphor that seems to ground our findings is "*THE NATURE OF AN ENTITY IS ITS SHAPE*" (Grady, 1997; Ortiz, 2010). This metaphor expresses the nonlinguistic mapping between the shape of an object and its nature. The result is that if two objects have a similar shape they are perceived to have similar natures as well. Our research has indeed shown that this interaction between similar shapes and similar conceptual features plays an important role in relating objects or concepts from disparate conceptual domains, thereby substantiating theories on primary (and conceptual) metaphors.

The Theory of Primary Metaphor seems to be related to the Perceptual Symbols Theory (Barsalou, 1999). A perceptual symbol is a schematic mental representation of a concept based on sensory experiences. If we talk or read about an object, we activate a mental representation of that object. This mental representation is the residue of the experiences we have had with that object. As such, there is a relation between its outer appearance and the situation in which the object was encountered, for example when performing an action or when being used to accomplish a certain goal. The notion of primary metaphors extends on those sensory-based representations of concepts, as they can be regarded as the foundation of the primary metaphor "*THE NATURE OF AN ENTITY IS ITS SHAPE*". This might explain why our fourth study showed that shape information is activated during the processing of comparative sentence structures. Zwaan, Stanfield, and Yaxley (2002) showed that shape information is activated for one concept, whereas our fourth study showed that shape information is also activated for two concepts that are presented as to be like each other.

Additionally, we believe that our research contributes to further our understanding of *visual literacy*. Visual literacy is defined as "understanding how people perceive objects, interpret what they see, and what they learn from them" (Elkins, 2007). Our research suggests that perceptual similarity between a source and a target object acts as a visual equivalent of the comparative construction 'is like', as in "*an X is like a Y*". The perceptual similarity encourages people to compare the two objects to find out why they *look* alike, just as the construction 'is like' encourages people to compare the two concepts to find out why they *are* alike. Hence, perceptual similarity might be a component of some sort of graphic syntax, just as comparative words are part of a grammatical system used to concatenate words in sentences (cf. Cohn, 2010; 2012).

Future directions

At the end of each of the preceding chapters, we already provided ideas for future research. For example, in Chapter 4 we proposed that it would be interesting to include *the relational shift* (Gentner, 1988) in a future production experiment. As younger children have a strong reliance on object shape and therefore do not share older children's relational focus, the facilitating effects of shape similarity might work out differently for younger children. Furthermore, in Chapter 5 we proposed to explore the effects of *metaphor conventionality* (Bowdle & Gentner, 2005) on mental representations of metaphoric expressions. As conventionalization is suggested to result in a shift in type of mapping (i.e., from comparison to categorization), the role of shape might be different in mental representations of novel versus conventional metaphors. Some additional avenues for further research are presented below.

A question that might be interesting to address is whether the facilitating effects of similarity in shape also holds for other visual modes. In our studies we have shown that similarity in shape of object *pictures* facilitates finding metaphorical relations. How about similarity in shape of *hand gestures*? If it is indeed the case that similarity in shape results in overlapping structural descriptions that activate shared conceptual features (cf. Humphreys & Forde, 2001), then the actual overlap in structural descriptions can be expected to be more important than the mode in which the stimulus materials were presented. Therefore, it would be interesting to see whether similarly shaped gestures would also facilitate the identification of metaphorical relations. Similar to the experimental design of study 3, participants could be asked to produce correspondences between two objects. However, this time, an experimenter would say the names of the two objects out loud. The speech production would be accompanied by gestures either depicting similar or dissimilar shapes of the source and target objects. For example, for the road-snake item (i.e., item 17, Appendix 5.2), we could present similar shaped gestures, such as a gesture depicting the curved shape of a road and a similar gesture depicting the curved shape of a snake, or dissimilar shaped gestures, such as the same target gesture for a road and a gesture depicting the shape of a snake when it is rolled up. For such a manipulation, it is of course very important to make sure that the information level and typicality of the gestures is equal for the different source gestures. To investigate how these co-speech gestures (Kendon, 2004) influence the amount of correspondences mentioned, we would compare the similarly shaped gesture condition to the dissimilarly shaped gesture condition. Additionally, we could also compare both conditions to a baseline condition in which gestures would be absent.

Secondly, we would like to address the question whether the effects of perceptual similarity are *feature specific*. In the present research, we have exclusively employed the feature of shape, as this is a very prominent visual feature. Yet, other features such as color, orientation, and texture might result in overlapping structural descriptions as well. Consider Figure 6.1. In this advertisement for a car brand, a car is included in an array of sunbathing chairs to communicate the message that driving this car can help you unwind just like relaxing by the pool on a sunbathing chair. In this image, orientation is used to perceptually align the objects. As can be seen, the manipulation of this feature seems to contribute to perceptual grouping. Therefore, it would be interesting to investigate whether similarity in orientation facilitates finding metaphorical relations as well. In doing so, we could use a similar experimental paradigm as in study 3. Rather than manipulating the objects' shape, we would then manipulate the objects' orientation only.

Thirdly, as can be seen in Figure 6.1, sometimes multiple source objects are presented, rather than just one. In this light, Schilperoord, Maes, and Ferdinandusse (2009) propose the *principle of object reduplication*. This principle predicts that one image of an object represents a token, whereas image duplication changes this token into a type, thereby indicating a category. Based on this principle, Schilperoord et al. propose that the presentation of multiple source objects will lead to the cognitive process of categorization, whereas the presentation of a single source object will be processed as a comparison. It would be interesting to investigate whether object reduplication indeed affects the way that the source and target

Figure 6.1. An advertisement for a car brand.

objects are related to each other. We could present participants with either a one-to-one or a one-to-many template and ask them to verbalize why the target object is similar to the other presented object(s). Types are generally said to be abstract and tokens to be concrete. The production of abstract or concrete correspondences between target and source objects might indicate categorization or comparison, respectively. Thus, if multiple source objects represent a category and one source object represents a token, then the correspondences mentioned for the former may be more abstract, whereas the correspondences mentioned for the latter may be more concrete.

Lastly, as stated in the Introduction, metaphoric relations between objects cannot only be expressed through the juxtaposition of the target and source object(s), but also by merging the objects into one hybrid object (Phillips & McQuarrie, 2004). In doing so, the perceptual features of the two objects are interwoven, which makes the objects appear to be perceptually highly similar. It would be interesting to investigate processing differences between this *visual template*, called fusion, and the template of juxtaposition. Consider figures 6.2 and 6.3. Both images present an advertisement for a railway company. In Figure 6.2, a high-speed train is merged with an eagle, whereas in Figure 6.3, the two are juxtaposed. The question is whether this structural difference affects the speed and/or understanding of the metaphoric relation between the objects. We can propose two contrasting hypotheses. First, because in fusions the overlap in perceptual features is literally present, one might expect that shared conceptual features are activated faster as compared to juxtapositions. In HIT terminology, for fusions, the overlap in structural descriptions is instantly activated, which directly activates overlapping semantic knowledge. As such, this activation might be faster as compared to juxtapositions for which the overlap in structural descriptions should be mentally represented before overlapping semantic knowledge can be activated. Second, one could argue that before two objects can truly be compared, they have to be mentally represented as two separate objects. For fusions, this would mean that the objects should first be (mentally) disentangled, before they can be compared to each other. This would require additional processing. In juxtapositions, however, the objects are already disposed separately, which would, under this hypothesis, allow for immediate comparison. As a first step in testing these hypotheses, we could design a think aloud study. The stimulus material could be similar to the advertisements presented in Figure 6.2 and 6.3. Participants would be requested to look at the presented advertisement (either a fusion or juxtaposition) and try to come up with the message that was intended by the maker. In doing so, participants would be stimulated to verbalize all their thoughts. As such, we would be able to define differences in the processing steps that lead to the final interpretation of the ad. Hence, such an experiment would provide insight into the effects of varying visual templates on visual metaphor processing.

Figure 6.2. An advertisement for a railway company (adjusted).

Figure 6.3. An advertisement for a railway company (original).

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Summary

Until the early eighties metaphor was considered to be mainly a matter of language and was studied by scholars of rhetoric and literature. Lakoff and Johnson's book *Metaphor We Live By* marked a cognitive turn in metaphor research as from then on the view emerged that metaphor is a matter of thought. One important consequence of this view is that language cannot be the only modality in which metaphoric relations can be expressed. Metaphors can also be expressed visually. This dissertation addresses the question how visual metaphors are processed. We focus on a characteristic that is absent in verbal metaphors, namely the visual characteristics of the objects that comprise the visual metaphor. More specifically, we investigate how perceptual grouping, induced by similarity in shape, affects cross-domain mapping in visual metaphor processing. Each of the four studies evaluates the role of object shape in a different situation: (1) in comparing functions of objects, (2) in the storage of objects in our memory, (3) in the search for metaphorical relations between objects, and (4) in mental representations of similes (i.e., metaphorical comparison statements).

Study 1

The first study assessed how similarity in shape affects the process of comparing functions of objects. In the first experiment, participants had to answer the question whether two objects could be used for the same purpose. In the second experiment, participants were asked to rate two objects' functional similarity on a scale. The experiments showed that participants produced more correct responses, were faster in doing so, and gave more similarity ratings towards the end of the scale when the objects had similar functions and similar shapes, or different functions and different shapes, as compared to when the objects had similar functions but different shapes, or different functions but similar shapes. These findings show that for functionally similar objects, the process of comparing objects benefits from similarity in shape, whereas for functionally different objects, similarity in shape results in a moment of confusion.

The similar appearance of the objects gives rise to the expectation that the objects can be used for the same purpose and therefore are member of same conceptual category. If the objects indeed belong the same category, the expectation is confirmed and the categorization process is speeded up. However, if the objects turn out to be functionally different, the expectation is contradicted and additional processing is needed in order to categorize the objects.

In the third experiment, we assessed the nature of these additional processing costs. Using a production task, we investigated the effect of similarity in shape on the actual production of correspondences. By asking the participants to describe an object in terms of another object, we implicitly asked them to look for correspondences between the objects. The number of mentioned correspondences was found to increase as a result of similarity in shape for both the functionally similar and functionally different objects. Shape similarity had an effect on the type of correspondences as well. Not surprisingly, more perceptual correspondences were produced. More interestingly, shape similarity also resulted in more conceptual correspondences. However, this only occurred in cases of functionally different objects. This study indicates hence that when there is no conceptual link between objects present, perceptual similarity aids in finding one. This study suggests that visual metaphor processing might be aided by similarity in object shape as well.

Study 2

The results of the first study suggest that the role of shape in the comparison and categorization of objects is more prominent for objects stemming from different conceptual categories than for objects stemming from the same category. In the second study, we explored the effect of shape on the storage of objects in our memory. We investigated whether shape information is encoded differently in our memory for objects from the same conceptual category (e.g., fruits) than from different conceptual categories (e.g., fruits and flowers).

To test this, we had participants remember and recall a triad of objects, which was repeated four times. The characteristics of the four triads of objects either remained the same or changed at the fourth trial. The performance on such a recall task is predicted to decrease when the to be remembered objects belong the same category, thus when the characteristics of the object triads do not change. If, however, the characteristics of the (fourth) object triad do change, thereby introducing a new category, then increased performance on the recall task is predicted.

In the first experiment, this change concerned a conceptual shift from fruits to flowers. In addition, this shift was either combined with a shift in shape, or the shape of the fruits and flowers remained the same. This experiment showed indeed that the performance on the recall task increased as a result of the conceptual shift. The performance was, however, unaffected by the additional shape shift. Thus, if objects can be stored in memory using both conceptual and shape information, then shape information seems to be overruled by conceptual information.

In the second experiment, there was a shift of shape as well, but there was no shift in conceptual category. Every triad consisted of fruits, which were either similarly shaped throughout the experiment or changed in shape at the fourth trial. This experiment showed that the performance on the recall task increased as a result of the shift in shape. So, if conceptual information (i.e., the category of fruits) cannot be satisfactorily used to recall the objects from our memory, then the objects' shape comes into play. Hence, this study shows that object shape plays a role in the process of categorization if conceptual information does not suffice. This study suggest that object shape plays an important role in visual metaphor processing as well, as in relating objects metaphorically conceptual information does (at first sight) not suffice to assign the two objects to the same category.

Study 3

The results of first and second study indicate that similarity in shape plays a role in object comparison and categorization in situations where there is no overarching conceptual category present. This suggests that similarity in shape plays a role in the cognitive process of cross-domain mapping by which objects from disparate conceptual domains are related to each other; the process that grounds visual metaphor interpretation. We investigated this matter in the third study.

In the experiment, participants had to fulfill two successive tasks. For the first task, participants were presented with a picture of a source object for which they had to produce characteristic features. For the second task, they were presented with a picture of a target object. The task was then to produce correspondences between that target object and the previously presented source object. The objects were members of disparate conceptual categories and were presented either similarly or dissimilarly shaped. When the target and source objects had similar shapes, participants found more correspondences and needed less time doing so, than when the objects had dissimilar shapes. The increase of correspondences could not be allocated to either perceptual or conceptual correspondences. So, both the search for perceptual *and* conceptual correspondences seems to benefit from similarity in shape. Hence, this study shows that similarity in shape facilitates finding metaphoric relations between objects from disparate domains of knowledge.

We explained these findings with the theory that in case of similarly shaped objects, the perceptual features of the two objects overlap (at least, to some extent) and that these overlapping perceptual features activate conceptual knowledge that is relevant to both objects. In case of dissimilarly shaped objects, there are no (or less) overlapping perceptual features. As a result, there will be less direct activation of shared conceptual knowledge. This theory predicts why it is easier to find conceptual correspondence between similarly shaped objects as opposed to dissimilarly shaped objects.

Study 4

The theory that we proposed in the third study might also predict the opposite relation between perceptual and conceptual similarity. That is, overlapping conceptual features might activate shared perceptual knowledge. This suggests that the identification of conceptual similarity between two entities might come with an assumption of perceptual similarity. We investigated this in the fourth study.

We investigated whether this assumption of perceptual similarity is reflected in mental representations of similes (i.e., metaphorical comparison statements). We examined whether explicit (i.e., "*X has the ability to Z, just like Y"*) and implicit (i.e., "*X is like Y"*) similes activate representations of similarly shaped objects. To do so, we had participants read the sentences and subsequently decide if two presented object pictures were mentioned in the preceding sentence. We manipulated the objects' similarity in shape. The findings showed that recognition was faster to similarly shaped objects than to dissimilarly shaped objects. This effect was both present for the explicit and implicit similes, but not for control sentences that only described a spatial relation between the objects. Hence, these findings suggest that the identification of conceptual similarities between objects from different conceptual categories evokes a mental representation of similarly shaped objects.

We propose that these findings indeed offer evidence for the opposite process of the theory presented in the third study. Our findings show that the structure of a simile, which invites readers to search for conceptual correspondences, comes with the assumption of overlapping perceptual features, which suggests the construction of similarly shaped mental representations.

Conclusion

We investigated how perceptual grouping, induced by similarity in shape, affects cross-domain mapping in visual metaphor processing. The first two studies presented in this dissertation tapped into different components of cross-domain mapping. The first study's focus was on the comparison of objects. The second study investigated the process that follows comparison, which is the storage in memory, or the categorization, of the objects. We found that object shape is automatically engaged in both these processes, especially when the objects stem from disparate conceptual domains. The third study presented in this dissertation gave insight into the types of correspondences that people find for these pairs of objects. One of the findings of this study was that they find perceptual correspondences.

This result is rather unsurprising, as the objects look alike. Yet, the results also suggested that shape similarity encourages the search for conceptual correspondences, by which a metaphoric category can be created. Our research has also shown that shape similarity is involved in the processing of *verbal* metaphors. We found that if people are encouraged to compare concepts, either implicitly or explicitly, they mentally represent the objects as similarly shaped.

Taken together, similarity in shape seems to be involved in metaphorical processing in two ways. First, in visual metaphors, perceptual grouping as a result of similar object shapes encourages and facilitates the search for conceptual commonalities. Second, in verbal metaphors, the processing of conceptual commonalities activates an assumption of shape similarity. As such, *metaphor* seems to be *in good shape*.

Samenvatting

Tot aan het begin van de jaren tachtig van de vorige eeuw werd metaforiek voornamelijk beschouwd als een talig fenomeen dat vooral bestudeerd werd door retorici en literatuurwetenschappers. Het verschijnen van Lakoff en Johnson's boek *Metaphors We Live By* markeerde een grote verandering in de studie van metaforen, omdat metaforiek vanaf dat moment werd gezien als een fundamentele eigenschap van de menselijke cognitie. Een belangrijke consequentie van dit idee is dat taal niet de enige modaliteit is waarin metaforische relaties tot uitdrukking kunnen worden gebracht. Metaforen kunnen ook in *visuele* taal uitgedrukt worden. In dit proefschrift staat de vraag centraal hoe visuele metaforen verwerkt en geïnterpreteerd worden. De nadruk in dit onderzoek ligt daarbij op een karakteristiek die uniek is voor de visuele modaliteit: de perceptuele eigenschappen van de objecten die als doel- en brondomein van een metafoor fungeren. Meer in het bijzonder wordt onderzocht hoe de perceptuele groepering, gebaseerd op vormovereenkomsten tussen objecten, de projectie van eigenschappen van het bron- naar het doeldomein – de zogenaamde *cross domain mapping* – beïnvloedt. In vier studies wordt achtereenvolgens nagegaan hoe de vorm van objecten betrokken is (1) bij het functioneel vergelijken van objecten; (2) bij de opslag van objectinformatie in het geheugen; (3) bij het identificeren van metaforische relaties tussen objecten; en (4) in mentale representaties van talige uitgedrukte similes – metaforische vergelijkingsexpressies.

Studie 1

In de eerste studie gingen we na hoe vormovereenkomst tussen objecten het proces beïnvloedt van het vergelijken van de functies van de objecten. In het eerste experiment kregen participanten telkens paren van objecten te zien waarvan de visuele weergave al dan niet de overeenkomst in vorm benadrukte. De helft van de getoonde paren bevatten objecten die tot een gelijke categorie behoorden (een banjo en een gitaar of een banjo en een trommel, bijvoorbeeld), terwijl de andere helft van de paren objecten toonden die tot verschillende categorieën behoorden (een banjo en een lepel of een banjo en een zonnebril, bijvoorbeeld). De taak van de proefpersonen was om zo snel mogelijk te beoordelen of de getoonde objecten voor hetzelfde gebruikt konden worden. In het tweede experiment werden dezelfde objectparen als in het eerste experiment aan participanten getoond, maar nu dienden ze de functionele overeenkomsten op een 9-puntsschaal aan te geven. De resultaten van de twee experimenten lieten zien dat proefpersonen objecten uit één categorie sneller en vaker als functioneel gelijk beoordeelden wanneer er sprake was van overeenkomst in vorm, dan wanneer ze niet op elkaar leken. Ook werden in het tweede experiment hogere schaalwaarden op de functionele overeenkomst gevonden voor gelijkvormig weergegeven objectparen dan voor ongelijkvormig weergegeven objectparen. Een tweede uitkomst was dat objecten uit verschillende categorieën maar met dezelfde vorm ook eerder en vaker als functioneel gelijk werden beoordeeld dan wanneer ze niet op elkaar leken. Ook hier werden in het tweede experiment hogere schaalwaarden gevonden voor gelijkvormig weergegeven paren van objecten. Met name de laatste uitkomsten zijn voor het doel van dit onderzoek van belang omdat ze steun bieden aan de gedachte dat functionele cross-domain mappings, dus het leggen van metaforische relaties tussen objecten, gestimuleerd worden door vormverwantschap.

De uiterlijke overeenkomsten leiden tot de verwachting dat de objecten voor soortgelijke doelen gebruikt kunnen worden. Daarvan is sowieso sprake als de objecten tot dezelfde categorie behoren (beide zijn muziekinstrumenten), maar de vorm-functie relatie speelt ook een rol als de objecten uit twee verschillende categorieën behoren (één muziekinstrument en één stuk kookgerei). Overigens bleken de reactietijden in het eerste experiment langer voor objecten uit verschillende categorieën. De verklaring die daarvoor voorgesteld wordt, is dat de overeenkomst in vorm en de verschillen in functie aanvankelijk leiden tot een incoherentie die met additionele verwerkingstijd ‘opgelost’ moet worden.

Het derde experiment was opgezet om na te gaan waaraan die addionele verwerkingstijd besteed wordt. Aan de hand van een productietaak – proefpersonen moesten correspondenties produceren voor de paren van objecten, wederom met en zonder uiterlijke overeenkomsten – werd onderzocht welke invloed vormverwantschap had op de productie van correspondenties. De resultaten van dit experiment wezen uit dat participanten meer correspondenties produceerden wanneer er sprake was van vormverwantschap; een uitkomst die gevonden werd zowel voor functioneel gelijke als functioneel verschillende objectparen. Vormverwantschap bleek ook een effect te hebben op de aard van de geproduceerde correspondenties. Zoals te verwachten was werden er meer vormcorrespondenties geproduceerd voor de gelijkvormig weergegeven objecten. Interessanter was de bevinding dat ook het aantal functionele correspondenties toenam in die conditie, en dat vooral voor objecten die uit verschillende functionele categorieën afkomstig waren. Deze uitkomst suggereert dat, als er geen functie-overeenkomst is tussen objecten, de vormverwantschap als een stimulans werkt om naar zulke functionele overeenkomsten op zoek te gaan. Visuele metaforiciteit zou dus gestimuleerd kunnen worden door vormovereenkomsten.

Studie 2

De resultaten van de eerste studie bieden steun aan de gedachte dat de rol van objectvorm in het vergelijken en categoriseren van objecten prominenter is wanneer de objecten uit verschillende categorieën afkomstig zijn dan wanneer ze uit dezelfde categorie komen. De tweede studie werd uitgevoerd om na te gaan hoe perceptuele eigenschappen van objecten betrokken zijn in de opslag van informatie in het geheugen. Specifiek werd onderzocht of vorm-informatie op verschillende wijzen in het geheugen wordt opgeslagen voor objecten uit dezelfde categorie (soorten fruit) versus objecten afkomstig uit verschillende categorieën (soorten fruit en soorten bloemen).

Om dit te onderzoeken werd een experimentele taak gebruikt waarbij proefpersonen telkens een drietal objecten te zien kregen die ze zich moesten herinneren. Dit werd vier maal herhaald, zodat de proefpersonen uiteindelijk twaalf objecten te zien kregen. De experimentele stimulus betrof de laatste (vierde) set van drie objecten. Die objecten behoorden ofwel tot dezelfde categorie als de eerste drie sets van drie objecten (fruit – fruit), of juist niet (fruit – bloemen). De voorspelling is dat voor die vierde set de herinnertaak minder goed zal gaan als de categorie dezelfde blijft, en beter wordt als de categorie verandert.

In het eerste experiment omvatte de vierde set van objecten altijd een verandering in categorie (van fruit naar bloemen). Die verandering ging echter al dan niet vergezeld van een verandering in de vorm van de getoonde objecten. In de helft van de sets waren de bloemen perceptueel overeenkomstig met de fruitobjecten weergegeven; in de andere helft juist verschillend daarvan. De resultaten wezen uit dat de herinnertaak voor de experimentele vierde set inderdaad beter werd uitgevoerd na de categoriële verandering, maar dat die prestaties niet werden beïnvloed door de verandering in vorm. Dit lijkt erop te wijzen dat als objecten in het geheugen opgeslagen kunnen worden op basis van zowel categoriële als vormelijke eigenschappen, het eerste type informatie dan belangrijker is dan het tweede. Anders gezegd, de vormverandering voegt niets toe aan de categoriële verandering.

Om de rol van vormverandering verder na te gaan, werd in het tweede experiment de categoriële informatie constant gehouden. De proefpersonen zagen ditmaal uitsluitend fruitobjecten die ze zich moesten herinneren. Voor de vierde set waren de objecten in de helft van de gevallen gelijk in vorm aan de voorafgaande objecten, en in de andere helft juist niet. De uitkomsten wezen uit dat de prestaties op de herinnertaak voor de vierde set wel degelijk beïnvloed werden door de vorm-factor. Wanneer de vorm veranderde werden betere geheugenprestaties gemeten dan wanneer de vorm constant bleef. Dit resultaat lijkt erop te wijzen dat in situaties waarin categoriële informatie niet gebruikt kan worden voor het herinneren, mensen overschakelen op vorm-informatie (indien aanwezig). Met andere woorden, objectvorm speelt een rol in het proces van categoriseren wanneer functionele informatie niet voorhanden is. Met het oog op de onderzoeksvraag van dit proefschrift kan deze uitkomst als volgt geïnterpreteerd worden. Objectvorm speelt een rol in metaforische verwerking van objecten omdat ook hierbij functioneel-categoriële informatie aanvankelijk niet voldoende is om de objecten in één categorie te plaatsen.

Studie 3

De resultaten van de eerste twee studies wijzen uit dat overeenkomst in vorm vooral betrokken is in de processen van vergelijken en categoriseren wanneer er geen omvattende categorie voorhanden is waarin de twee objecten geplaatst kunnen worden. Dit suggereert dat overeenkomst in vorm betrokken is in het cognitieve process van cross-domain mapping waarmee objecten uit verschillende conceptuele domeinen gelinkt worden; het proces dat ten grondslag ligt aan de verwerking en interpretatie van visuele metaforen. De derde studie is opgezet om hier meer zicht op te krijgen.

Er werd een experiment opgezet waarin participanten twee taken achtereenvolgens moesten uitvoeren. Voor de eerste taak kregen ze een afbeelding te zien van een bron-object waarvan ze zoveel mogelijk karakteristieke kenmerken moesten produceren. Voor de tweede taak kregen ze vervolgens een afbeelding van een doel-object te zien waarvan ze moesten aangeven welke correspondenties er bestonden met het bron-object dat ze eerder zagen. De twee objecten waren afkomstig uit verschillende categorieën en werden aan de proefpersonen gelijk- of ongelijkvormig gepresenteerd. Uit de resultaten bleek dat de proefpersonen meer correspondenties produceerden, en in kortere tijd, wanneer de objecten gelijkvormig waren dan wanneer ze ongelijkvormig waren. Het toegenomen aantal correspondenties bestond niet uit ofwel perceptuele, ofwel conceptuele correspondenties; de proefpersonen produceerden *zowel* meer perceptuele als conceptuele correspondenties. Deze studie laat dus zien dat vormverwantschap het vinden van metaforische relaties tussen objecten uit verschillende domeinen faciliteert.

We verklaren deze uitkomsten aan de hand van een theorie van objectkennis die stelt dat indien perceptuele kenmerken van objecten (deels) overlappen, die overlap conceptuele kennis activeert die voor beide objecten relevant is. Die overlap is niet aanwezig als de objecten ongelijkvormig zijn met als gevolg dat er in mindere mate sprake is van het activeren van gedeelde conceptuele objectkennis. De theorie voorspelt dat het makkelijker is om conceptuele correspondenties te vinden voor gelijkvormig weergegeven objecten dan voor ongelijkvormig weergegeven objecten.

Studie 4

De theorie die in de derde studie werd voorgesteld voorspelt tevens een relatie tussen perceptuele en conceptuele overeenkomsten in omgekeerde richting: overlappende conceptuele kenmerken van objecten uit verschillende domeinen leiden tot een verwachting van overlappende perceptuele eigenschappen. Dit suggereert dat de identificatie van conceptuele overeenkomsten tussen twee objecten leidt tot de aanname van perceptuele overeenkomst. Of dat inderdaad het geval is, werd onderzocht in de vierde studie.

Onderzocht werd of de aanname van perceptuele gelijkheid aanwezig is in de mentale representatie die mensen van *similes* construeren: metaforische vergelijkingsexpressies. Onderzocht werd of expliciete similes (*"X heeft het vermogen tot Z, net als Y"*) en impliciete similes (*"X is als Y"*) representaties activeren van gelijkvormige objecten. Daartoe lazen participanten zinnen waarin deze relaties tot uitdrukking gebracht werden, waarna ze moesten beoordelen of twee vervolgens getoonde objecten genoemd waren in de zojuist gelezen zin. Vormovereenkomst werd gemanipuleerd. De uitkomsten laten zien dat de objecten sneller herkend werden wanneer ze gelijkvormig werden weergegeven dan wanneer ze ongelijkvormig werden weergegeven. Dat effect werd zowel voor expliciete als impliciete similes gevonden. Het effect werd echter niet gevonden voor controle-zinnen waarin de twee objecten ook genoemd werden, maar dan in een ruimtelijke relatie tot elkaar (*"X staat naast Y"*). Dit wijst erop dat de opgeroepen gedachte aan conceptuele overeenkomsten tussen objecten leidt tot een mentale representatie van gelijkvormigheid.

Deze uitkomst vatten we op als verdere evidentie voor de theorie voorgesteld in de derde studie. De structuur van een simile, expliciet en impliciet, stimuleert lezers te zoeken naar conceptuele overeenkomsten, en dat gaat gepaard met de aanname van overlappende perceptuele kenmerken. Om die reden worden gelijkvormig weergegeven objecten sneller herkend dan ongelijkvormig weergegeven objecten.

Conclusie

Met het onderzoek dat in dit proefschrift is gerapporteerd zijn we nagegaan hoe perceptuele groepering – in de zin van vormovereenkomst in objectweergave – betrokken is bij cross-domain mapping in de verwerking van visuele metaforen. De eerste twee studies betroffen twee verschillende aspecten van cross-domain mapping. De eerste studie richtte zich op de vergelijking van objecten. De tweede studie op het proces dat volgt op vergelijking: de opslag van objectkennis en de categorisatie ervan in het geheugen. Gevonden werd dat objectvorm automatisch betrokken is in deze beide processen, vooral wanneer de objecten afkomstig zijn uit verschillende conceptuele domeinen. De derde studie heeft inzicht opgeleverd in het type correspondenties dat mensen produceren voor deze paren van objecten die wel of niet gelijkvormig zijn. Een tamelijk voor de hand liggende uitkomst van deze studie is dat mensen inderdaad perceptuele correspondenties vinden wanneer de objecten gelijkvormig zijn weergegeven. Minder vanzelfsprekend was de uitkomst dat in die gevallen ook meer conceptuele overeenkomsten geactiveerd worden waarmee een metaforische, *ad hoc* categorie geconstrueerd kan worden. Dit onderzoek heeft daarnaast aan het licht gebracht dat vormverwantschap betrokken is in het verwerken van talige metaforen. We vonden dat wanneer mensen aangemoedigd worden om concepten te vergelijken, zowel expliciet als impliciet, ze de concepten mentaal representeren als gelijkvormig.

Alles bijeengenomen kunnen we concluderen dat vormverwantschap van objecten op twee manieren in metafoorverwerking betrokken is. Ten eerste faciliteert vormverwantschap de productie van conceptuele overeenkomsten in de verwerking van visuele metaforen. En ten tweede leidt de geïnduceerde verwerking van conceptuele overeenkomsten tot de assumptie van vormverwantschap tussen objecten.

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In december van datzelfde jaar mocht ik voor het eerst mijn onderzoek presenteren op een conferentie in Amsterdam. De dag na mijn presentatie kreeg ik een e-mail van Pim dat iemand van de Universiteit van Tilburg op zoek was naar een kandidaat voor een PhD-project over visuele metaforen (visuele wat?) en dat diegene het leuk zou vinden als ik onder de kerstboom besloot te solliciteren. Dat was Fons Maes, mijn promotor. Fons, je hebt weleens gezegd dat ik sindsdien nooit meer zo onbevangen heb gepresenteerd. Nou, ik kan je vertellen dat ik blij ben dat ik me nooit meer zo gevoeld heb als toen. Ik ben nog nooit zo ongelofelijk zenuwachtig geweest! Fons, bedankt voor je uitermate goede begeleiding van afgelopen jaren. Bedankt dat je me de ruimte gaf om mijn eigen onderzoekspad te bepalen toen ik na het eerste jaar even in een dip zat. Bedankt voor alle keren dat je 'ik snap het niet' in de kantlijn schreef. Oh en sorry voor het vele klussen aan mijn woonboot :)

Omdat promotoren soms drukke agenda's hebben, is het fijn als je een copromotor hebt die er altijd voor je is. Joost Schilperoord was dat. Joost, bedankt voor je betrokkenheid in elk stadium van dit proefschrift: je tekende modellen voor me als ik een theorie niet helemaal doorhad, hielp me bij het herschrijven van artikelen, leerde me nieuwe (maar vaak Oudnederlandse of weinig gebruikte Engelse) woorden en je (v/b)ierde met me mee toen mijn proefschrift af was. Joost, bedankt voor alle gezellige uurtjes in de CoffeeCompany. Door jou kreeg 'cc' een andere betekenis. Je maakte de laatste loodjes een stuk lichter! Wel fijn dat mijn proefschrift nu af is, want dan kunnen we eindelijk starten met de cursussen 'Typen terwijl je naar het scherm kijkt,' 'E-mailen vanuit huis,' 'Hoe ga ik computervirusbesmettingen uit de weg,' 'Snelle muisbewegingen' en 'Googlen vanuit het buitenland.'

Naast mijn (co)promotoren zijn er nog vele anderen die hebben geholpen bij het verwezenlijken van dit proefschrift. Rein Cozijn, bedankt voor je begeleiding in het eerste jaar. Marc Swerts, bedankt voor het brainstormen over experimentele paradigma's en voor je positieve feedback, maar vooral voor je Belgische enthousiasme. Diane Pecher, bedankt voor de interessante samenwerking. Eric Postma, bedankt voor het uitvoeren van de shape matching testjes. Het werd me door een paar collega's afgeraden om jouw hoofd op de voorkant van mijn proefschrift te zetten. Ik snap ook niet waarom. Hedy Tjin, bedankt voor het maken van je prachtige illustraties! Marije van Amelsvoort, bedankt voor de fijne samenwerking en de gezellige conferentie-reisjes naar Exeter en Grenoble. Die combi gaat zorgen voor briljant onderzoek! Margot van Mulken, Didier Hodiamont, Ester Šorm, Hans Hoeken, Wilbert Spooren en Gerard Steen, bedankt voor alle discussies en leuke VisMet-meetingen.

Daarnaast zijn er nog collega's die misschien iets minder direct een bijdrage hebben geleverd aan dit proefschrift, maar zeker niet ongenoemd mogen blijven. Anja Arts, je bent de gepassioneerdste buddy die ik kon wensen. Wat is onderwijs geven met jou een feestje! En Lauraine de Lima en Jacintha Buysse, door jullie (en alle andere collega's!) voelt de 4e verdieping een beetje meer als thuis.

Het lijkt misschien strijdig met de vorige alinea's, maar dat schrijven van een proefschrift is een vrij eenzaam gebeuren. Gelukkig zijn er altijd nog je mede-PhD's! Staartmans, Kont, Djorrig, Rudi, Suli en alle anderen, bedankt voor de gezellige PhDingen die gemaakt hebben dat afgelopen 4 jaar voorbij gevlogen zijn! Enkelen hebben daarin een iets grotere rol gespeeld:

Hans Westerbeek, bedankt voor al je ict-hulp, apple-kennis en photoshop-praktijken! Sorry voor alle keren dat ik de deur dichtsmeet ;)

Lisette Mol, aka roomy, aka personal thesaurus (zie verderop), bedankt voor het vertellen van schunnige verhalen en voor het bijbrengen van geweldige liederen zoals 'Alles hat ein Ende nur die Wurst hat zwei', maar ik wil je voornamelijk bedanken voor conversaties als deze:

Lisanne: *Lies?*
Lisette: *Ja?*
Lisanne: *Weet je een ander (Engels) woord voor '...'?*
Lisette: *Ehm... Lees de zin eens op.*
Lisanne: *Nou...* (twijfelend lees ik de zin op)
Lisette: *Ok. Kun je dan niet beter...* (In de tijd dat ze 'ok' zei plaatst ze de door mij gedicteerde zin in de context van mijn onderzoek, herschrijft in haar hoofd de gehele alinea en produceert vervolgens een paar volzinnen die alle problemen van het betreffende stuk tekst in een keer oplossen)
Lisanne: ...

En last but allerminst least, Mandy Visser & Marieke Hoetjes, mijn substitute nimfjes. Ik denk toch wel dat jullie twee het dichtst in de buurt komen bij Jaaps 'Academic Friends' :) Het is altijd fijn als er een paar collega's rondlopen die net iets meer van je leven buiten de uni weten, die daarom snappen waarom je knorrig of verdrietig bent, die gisteren al wisten dat je vandaag een kater zou hebben en die met je meevieren wat er te vieren valt. Dat er nog maar veel M&M etentjes (met macarons, chocoladetaartjes, vijfsterren-gerechten, wijntjes en bovenal veel roddels) in mijn agenda mogen staan!

Ik heb altijd geprobeerd om alle uren die in dit proefschrift zijn gaan zitten niet ten koste te laten gaan van het zien van vrienden en familie. Ik ben een meisje van veel (soms heel stellige) woorden, maar als het gaat wat ik voel voor mijn familie, vrienden en liefde, dan blijft het erg stil. Daarom wil ik deze plaats graag gebruiken om die stilte op te heffen en te zeggen wat ik nooit gezegd heb.

Lieve papa en mama, ik wil jullie bedanken voor het geven van een onbezorgde jeugd en onvoorwaardelijke steun! Beiden leken altijd vanzelfsprekend maar naarmate ik ouder word besef ik me dat onze thuissituatie heel bijzonder is. Alles wat Merijn, Wieger en ik bereiken komt door de stabiele basis die jullie ons gaven en nog steeds geven. Jullie hebben het goed gedaan!

Liefste broeders, Mer en Wieg, bedankt dat jullie mijn paranimfen wilden zijn en zo enthousiast reageerden op mijn verzoek. Oké, dat was *na* de typische broer-opmerking “wat moeten we dan doen?”. Laat ik eerlijk zijn. Ik heb jullie niet gevraagd omdat jullie zo goed zijn in het regelen van dingen ;) Ik heb jullie gevraagd omdat ik ontzettend trots ben op het feit dat jullie mijn broers zijn! Wie wil er nou niet op dat podium staan met twee knapperds achter je.

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Wieg, bedankt voor het zijn van mijn 30-centimeter-langere kleine broertje, voor het me met trots voorstellen als je zus aan je vrienden, voor het klussen aan de boot (soms met kater) en voor alle keren dat jij moest huilen als Merijn en ik op ons donder kregen van mama ;)

Oh en allebei wel goed dit proefschrift lezen hè? Voor als ik vragen aan jullie doorspeel tijdens mijn verdediging…

Ondanks deze ‘lovende’ woorden over mijn broers zal ik niet ontkennen dat een zus me soms ook wel leuk had geleken, maar daar heb ik gelukkig mijn schone zusters Judith en Nathalie voor! Ik heb het getroffen met jullie!

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Als allerlaatste wil ik Elbert bedanken. Je bent er *altijd* voor me. "*Life is like a box of chocolates*" indeed and luck was on my side when I picked you.

Publication list

Journal papers

Van Weelden, L., Schilperoord, J., & Maes, A. (In press). Evidence for the role of shape in mental representations of similes. *Cognitive Science*.

Van Weelden, L., Maes, A., Schilperoord, J., & Swerts, M. (2012). How object shape affects visual metaphor processing. *Experimental Psychology, 59*(6), 364-371.

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Working papers

Van Weelden, L., Schilperoord, J., Swerts, M., & Pecher, D. (Submitted). The role of shape in semantic memory organization of objects: An experimental study using PI-release.

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Van Weelden, L., & Mak, P. (2009). De invloed van verwijzingen tussen tekst en beeld op het leesproces. In W. Spooren, M. Onrust & J. Sanders (Eds.), *Studies in Taalbeheersing 3* (pp. 419-428). Assen, The Netherlands: Van Gorcum.

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Van Weelden, L., Schilperoord, J., & Maes, A. (2012). *Metaphors activate object shape* at the EARLI SIG 2 meeting on 'Comprehension of text and graphics', Université Pierre-Mendès-France, Grenoble, France.

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Van Weelden, L., Maes, A., Schilperoord, J., & Swerts, M. (2011). *Learning from pictures: The role of shape in processing visual metaphors* at the 14th Biennial EARLI Conference for Research on Learning and Instruction, University of Exeter, United Kingdom.

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1. Pashiera Barkhuysen. *Audiovisual Prosody in Interaction.* Promotores: M.G.J. Swerts, E.J. Krahmer. Tilburg, 3 October 2008.
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29. Lisanne van Weelden. *Metaphor in Good Shape*. Promotor: A.A. Maes. Co-promotor: J. Schilperoord. Tilburg, 28 June 2013.