Metaphors in Abstract Thought

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Metaphors in Abstract Thought

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‘The Shining’, Stephen King *(directed by Stanley Kubrick)*

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Chapter 1

General Introduction

It is etched in my memory how my grandmother described my grandfather absorbed by a book describing the human body as a factory. This book survived the bombing of Rotterdam in WOII, so it was a precious possession. He fell under the spell of this book that in great detail explained the complex mechanisms of the human body as if it were a factory and he used it as inspiration for jokes that better remain unmentioned. A metaphor is commonly used to explain complex things such as a human body. Generations of cognitive psychology students become overloaded with metaphors for memory. For instance, memory is often described as analog to a wax tablet (as in the first sentence of this introduction), a library, a storehouse, or computer. In this dissertation we investigated whether metaphors are not merely used explicitly to explain complex mechanisms (e.g., human body, memory), but play an essential role in thinking.

In order to show how complex the human mind is, we will start with a seemingly simple sentence from the fairy tale "Hansel and Gretel" recorded by the brothers Grimm.

"Hansel and Gretel were trying to find their way through the dark forest."

Even children are able to comprehend this sentence without obvious effort. Several processes are needed for comprehension, however, and these processes need to be coordinated in just the right way. First the comprehender needs to know a language (in this case English). Second, the comprehender needs to understand the situation the sentence refers to. For comprehenders who have never seen a *forest*, it would be hard to imagine what a forest is. However, for the comprehender who has wandered through a forest or has seen it on a picture it is easier to imagine what Hansel and Gretel are finding their way through.

In order to understand what is going on in the world and function appropriately people need semantic knowledge. As in the example above, in order to understand the sentence, knowledge about the meaning of the individual words, as well as knowledge about *forest*, *darkness*, *girls*, *boys*, *finding a way* etcetera is essential. Understanding fairy tales is not essential for surviving, but imagine being in a dark forest yourself. If a bear would approach, it is essential to know that it is a dangerous animal and that the appropriate reaction would be to remain still and ignore the bear rather than to pet. This might be an extreme example, but even back at home after having escaped from the bear one would not be safe without being packed with semantic knowledge. Dangerous things could happen with gas cookers, knives, cleaning products, radiators, and blenders should appropriate semantic knowledge lack. Even if one would leave these products untouched, there is a good chance that one would die from starvation without knowledge about buying, preparing, or opening packages of food. Moreover, even though seemingly not directly related to survival, it would be disastrous living without the knowledge of *time*.

Fortunately, people have semantic knowledge about entities in the world. One important characteristic of semantic knowledge of concepts is that they are categorizations (Murphy, 2002). For instance, every forest is recognized as a forest even if that particular forest has never been seen before; a bear in real life is recognized as a bear even if one has only seen a bear on pictures; and a potato knife and a butcher knife are both recognized as knifes. Knowledge about experiences in the past can be adopted for entities from the same category that people might encounter in the future. Such semantic knowledge is also referred to as a mental representation. People use mental representations of concepts continuously to recognize entities and structure behavior, and most of the time this happens without conscious control.

Some concepts can not be experienced directly because they have no physical properties. For instance, *good*, *bad*, *power*, *love,* and *time* are not physically present but need to be inferred from other perceptions. Concepts like these are referred to as abstract concepts and are opposite to concrete concepts. Since mental representations are a basic need for human beings to function properly, it is not surprising that they have been a topic of substantial interest in cognitive psychology as well as philosophy.

Concrete concepts

Concrete concepts refer to entities that are physically present in the world (e.g., *forest*, *bear*, *knife*). Past experiences with concepts form mental representations that can be used to recognize objects and act upon them appropriately in future situations (Murphy, 2002). But how are these mental representations formed? Recent theories assume that the mental representations of concepts are grounded in experience (Glenberg, 1997; Barsalou, 1999, 2008, 2009; Goldstone & Barsalou, 1998). The main idea of these theories is that mental representations are formed by perception and interaction of the body with the environment and that these perceptual and motor features are preserved in mental representations of concepts. During each experience with a certain object (e.g., knife) the sensory-motor system receives information through the senses (e.g., shiny blade) and gets feedback of interaction of the body with a certain object (e.g., cutting with a knife). The records of neural states of the sensory-motor system are in turn involved in the mental representation of real concepts (e.g., forest) and imaginary concepts (e.g., blue bear) by the process of simulation. During a simulation features from different modalities (e.g., vision, audition, haptics, olfaction, gustation) are preserved. There is recent evidence that mental representations have modality specific characteristics (e.g., Barsalou, Simmons, Barbey & Wilson, 2003; Pecher, Zeelenberg & Barsalou, 2003; Van Dantzig, Pecher, Zeelenberg & Barsalou, 2008). For instance, Pecher, Zeelenberg and Barsalou (2003) found that when people had to verify properties (e.g., *A marble can be cool*) they were faster when they first had to verify another property from the same modality (e.g., *Peanut butter can be sticky*) than when they first had to verify another property from a different modality (e.g., *Bed springs can be squeaking*). This finding shows that switching from one modality to another takes time in a conceptual task, and thus provides evidence for the view that perceptual properties are simulated. Other behavioral evidence has been found for the simulation of concepts (e.g, Borghi, Glenberg & Kaschak, 2004; Kaschak et al., 2005; Richardson, Spivey, Barsalou, & McRae, 2005; Stanfield & Zwaan, 2001; Zwaan & Madden, 2005; Zwaan, Stanfield, & Yaxley, 2002; Zwaan, Taylor, & De Boer, 2008). For instance, Zwaan, Stanfield, and Yaxley (2002) found that participants were faster to name a picture of an eagle when its shape matched (e.g., wings folded) with the intended shape mentioned in a sentence that preceded the picture (e.g., *The ranger saw the eagle in its nest*) than when it mismatched with the intended shape mentioned in a sentence that preceded the picture (e.g., *The ranger saw the eagle in the sky*). This shows that participants simulated the sentence during sentence comprehension. In addition, neurobiological studies found that action verbs (e.g., grasp) activated the motor system (e.g., Boulenger, Hauk, & Pulvermüller, 2009; Hauk, Johnsrude, & Pulvermüller, 2004; Tettamanti et al., 2005) and that visual attributes (e.g., round-orange) activated brain areas that are related to processing of visual features of objects (Hoenig, Sim, Bochev, Herrnberger, & Kiefer, 2008).

In sum, there is evidence from recent studies that concrete concepts are grounded in experience. These studies support the idea that when people experience, think, or read about a concept (e.g., forest) they simulate the concrete experience with the concept by activating parts of the sensory-motor system (e.g., walking) preserving modality specific information (e.g., smell of trees, rustling leaves, touch of moist). In addition, imaginary concepts such as a *blue bear*, are simulated as well by making new combinations of patterns in the sensory-motor system of concepts (e.g., *bear* and *blue*). But what about abstract concepts that are not physically present in the world like *good*, *bad*, *power*, *love* and *time*? Next we turn to the question of how abstract concepts can be represented using the same simulation system.

Abstract concepts

The role of concrete situations

One solution for the grounding problem of abstract concepts is that they are situated in concrete situations (e.g., Barsalou, 1999; Barsalou & Wiemer-Hastings, 2005). Barsalou and Wiemer-Hastings (2005) investigated the content of some abstract concepts. They analysed the properties of three abstract concepts (*truth*, *freedom*, *invention*) that were generated by participants. They found that the properties of abstract concepts focused on social, event, and introspective content as well as on content in physical settings. These results show that properties from concrete experiences are important for the description of abstract concepts. In turn, these concrete properties from specific experiences with abstract concepts might play an important role during simulations of abstract concepts (e.g., Barsalou, 1999; Barsalou & Wiemer-Hastings, 2005). For instance, the concrete experience that someone helped out (e.g., the white duck helped Hansel and Gretel to cross the river and escape from the bear) could be simulated for the abstract concept *good*.

The role of introspection

A second solution for the grounding problem of abstract concepts is the idea that they are partly represented by introspective states (e.g., Barsalou, 1999). As found by Barsalou and Wiemer-Hastings (2005), introspective states were reported as an important feature of abstract concepts. Introspective states, such as emotions (e.g., happiness), drive states (e.g., hunger), and cognitive operations (e.g., comparing two imagined objects), are assumed to activate patterns of the sensory-motor system. Records of these sensory-motor patterns might be involved in the simulation process of abstract concepts (e.g., Barsalou, 1999; Barsalou and Wiemer-Hasting, 2005). For instance, the abstract concept *good* goes together with the introspective state of feeling happy and relaxed. Sensory-motor activation of the emotions is recorded by introspective experiences with happy and relaxed. Simulations of these introspective experiences are in turn involved in simulation of *good*.

The Conceptual Metaphor Theory

Another theory that can provide a solution for abstract concepts is the Conceptual Metaphor Theory (CMT) (Lakoff & Johnson, 1980, 1999). Lakoff and Johnson (1980) investigated metaphorical sentences used in daily speech, such as *He is in a superior position*, *He is under my control*, *His power rose,* and *His power is on the decline*. They found that people systematically use concrete concepts (e.g., *vertical space*) to talk about abstract concepts (e.g., *power*). Lakoff and Johnson (1980, 1999) used linguistic expressions as a source of evidence for the way mental representations of abstract concepts are structured. They claimed that concrete concepts are used to represent abstract concepts (Lakoff & Johnson, 1980, 1999).

Lakoff and Johnson (1980, 1999) built the CMT on the assumption that concrete concepts are represented by image schemata (Johnson, 1987) formed in childhood (Mandler, 1992). Image schemata are records of sensory-motor activities, and are formed during concrete experiences. For example there is an *up-down* image schema formed during concrete experience with *vertical space* (e.g., walking on a ladder). In turn these image schemata (e.g., *up-down* image schema) are used for the mental representation of concepts (e.g., *verticality*) and are active in several situations (e.g., imagining that the witch is bigger than Hansel and Gretel). The Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999) claims that abstract concepts are also mentally represented by the same image schemata by means of conceptual metaphors (see also Gibbs, 1994). In language concrete concepts (e.g., *vertical distance*) are systematically used to talk about abstract concepts (e.g., *power*). For instance, in the examples above, the metaphorical mapping *power is verticality* (*powerful is up* and *powerless is down*) is used in all sentences. The systematicity of metaphorical mappings in language is used as evidence that, while preserving the image schematic structure (e.g., *up-down* image schema), concrete concepts (e.g., *verticality*) are transferred to the mental representation of abstract concepts (e.g., *power*) (Lakoff & Johnson, 1980, 1999; Gibbs, 1994). This transfer of inferences from the concrete concept to the abstract concept is possible by the mechanism of conceptual mapping. Conceptual metaphors are formed by experience in which both the abstract (e.g., power) and concrete (e.g., verticality) concept co-occur (C. Johnson, 1997; M. Johnson, 1987). For instance, at first Hansel and Gretel were small children captivated by the witch (*powerless is down*), but when they grew older Gretel became big and strong enough to throw the witch into the oven and they escaped (*powerful is up*). The focus of the present dissertation will be on the Conceptual Metaphor Theory (CMT) (Lakoff & Johnson, 1980, 1999)[1].

Abstract thinking is metaphorical

Since metaphors are manifested in many ways in the world, it does not seem implausible that people think in metaphors as well. Metaphors are concepts that are used to explain other concepts. Metaphors can be used in language, art, gestures, commercials, rituals, industrial designs, fairy tales, etc. For instance, the path through the forest that Hansel and Gretel took could be interpreted as a metaphor for life. The adventures they experienced could be interpreted as a metaphor for the growing up processes of a boy and a girl. At first they were vulnerable and naive, easy to seduce by a house made of candies and gingerbread which made them fall into the hands of the witch. In real life, young people can be seduced and fall into the hands of bad people such as drug dealers as well. At the end of the story they manage to escape from the witch and find the right direction back through the forest. The journey through the forest in this fairy tale can be interpreted as a metaphor for a journey through life in which pitfalls and dangers have to be defeated. Fairy tales or other fictive stories are just occasionally encountered in life. In order to provide a plausible explanation for abstract concepts, a theory needs to be able to explain representations during everyday cognition, and not just during special cases of understanding. According to Lakoff and Johnson (1980), daily language can be used indeed as a source of evidence about how mental representations of concepts are structured. They found that various metaphorical mappings (e.g., *bad is down*, *good is up*, *power is up*, *love is warmth*, *time is space*) are systematically used in common daily language. Lakoff and Johnson (1980, 1999) used this linguistic evidence to claim that mental representations of abstract concepts are formed by concrete concepts through the process of conceptual mapping.

The logic behind conceptual metaphors

So why should we think in metaphors? Concrete concepts can be formed directly by sensory-motor experiences with concrete objects in the world. Since abstract concepts are not physically present in the world they can only be experienced indirectly. In concrete experiences in which abstract concepts are present, other concrete concepts are present as well. For instance, children that are small have concrete experiences with older and bigger children bossing them around and adults who have authority. The correlation of the perceivable length of a person and the amount of authority could be fundamental in the development of the conceptual metaphor *power is up*.

According to the Conceptual Metaphor Theory many conceptual metaphors are directly formed by correlation of abstract and concrete concepts in one experience (Lakoff & Johnson, 1980, 1999, M. Johnson, 1987). C. Johnson (1997) claimed that the co-occurrence of two concepts in one experience during childhood causes *conflation* of the concepts, by which he means that the concepts are considered as being one. Later on in development the two concepts would be differentiated into two mental representations while keeping metaphorical links intact. Grady (1997, as cited in Lakoff & Johnson, 1999) called these metaphors that are formed by direct experience *primary metaphors*. According to Grady these primary metaphors need to be distinguished from complex metaphors. For example the primary metaphor *power is up* is formed by experiences in which the concept *power* is correlated with the concept *verticality*. The concrete concepts in such primary metaphors are built out of a single image schema. Image schemata are conceptual structures representing spatial relations and movements in space and are formed by interaction of our body and senses with objects in the world during our childhood (Mandler, 1992) and in turn are used to comprehend entities in the world (M. Johnson, 1987; Lakoff & Johnson, 1999). During conceptual mapping, these image schemata (e.g., the *up-down* image schema) of concrete concepts (e.g., *verticality*) are preserved and inherited by the mental representation of abstract concepts (e.g., *power*) (e.g., Lakoff & Johnson, 1980; Gibbs, 1994). Thus, mental representations of abstract concepts make use of the same image schemata as the mental representation of concrete concepts, which allows concrete and abstract concepts to be equally grounded in experience.

Complex metaphors are built up from multiple primary metaphors (Grady, 1997, as cited in Lakoff & Johnson, 1999). This is made possible by the process of *conceptual blending* in which different concepts can be linked together in a mental space (see also Fauconnier and Turner, 1998). An example of a complex metaphor is *life is a journey.* This metaphor is considered complex because it is not directly formed by experiences in which *life* is correlated with *journey*. This complex metaphor is formed through mapping of the primary metaphors *purposes are destinations* and *actions are motions*. These complex metaphors are assumed to be formed by culture. *Life is a journey* is a typical metaphorical mapping used in the western cultures, not only in linguistic expressions. For instance, *life is a journey* is used in the fairy tale Hans and Gretel, and the often used Curriculum Vitae that describes a career literally means *the course of life* (Lakoff & Johnson, 1999).

In sum, the development of conceptual metaphors seems logical from an embodied point of view. Conceptual metaphors are formed through direct concrete experience (primary metaphors) or indirectly through cultural experience (complex metaphors). In turn, conceptual metaphors provide an embodied framework for the mental representation of abstract concepts; abstract concepts could be grounded in concrete experience.

The process of conceptual mapping

According to the CMT (Lakoff & Johnson, 1980, 1999) abstract concepts are understood in terms of concrete concepts by mapping sets of correspondences from mental representations of concrete concepts onto mental representations of abstract concepts. A mental representation of an abstract concept independent of conceptual mapping is described as a "skeleton" (Lakoff & Johnson, 1999) that contains enough information to guide the conceptual mapping process, so that every feature is correctly mapped onto a corresponding feature (Lakoff, 1993). For instance, for the conceptual metaphor *life is a journey*, the *journey* refers to a *purposeful life*, the *traveler* refers to a *person living a life*, the *destination* refers to *life goal,* and the *itinerary* refers to *life plan*. (Lakoff & Johnson, 1999).

Interestingly, it is assumed that multiple metaphors can be used to form the same abstract concept. For instance, the concept *love* is assumed to be formed by the conceptual mappings *love is warmth*, *love is magic*, *love is a nutrient*, *love is a journey, love is closeness, love is war,* etc. (Kovecses, 2000; Lakoff & Johnson, 1980). Each conceptual mapping (e.g., *love is war*) throws light on a different aspect of a concept (e.g., *To win someone's heart*) and thus together make the mental representation of the abstract concept complete.

The "skeleton" of abstract concepts, living up to its name, is empty and needs one or more conceptual mappings to form a rich, elaborated, and grounded mental representation. Without the mental representation of concrete concepts, the abstract concepts can not fully be understood. Other interpretations of the process of conceptual mapping and the grounding problem of the "skeleton" are discussed in the general discussion.

Evidence for conceptual mapping

At first, researchers were focused on conceptual mapping during metaphorical language comprehension, also referred to as the *process claim* of the CMT (McGlone, 1996). For instance, Keysar, Shen, Glucksberg and Horton (2000) found that participants were faster to read metaphorical sentences (e.g., *Tina is currently weaning her latest child*) when primed by a scenario (e.g., *She is a fertile researcher*) containing the same metaphorical mapping (e.g., *ideas are people*), than when primed by a scenario (e.g., *She is a dedicated researcher*) containing no metaphorical mapping. This provided evidence that activation of the conceptual metaphor was helpful for understanding metaphorical sentences.

More interesting are studies that focused on conceptual mapping during conceptual tasks, that show how we might understand abstract concepts, such as *good*, *bad*, *power, love,* and *time* beyond metaphorical language. It has been found that *good* and *bad* might be represented along a vertical dimension (Meier & Robinson, 2004; Crawford, Margolies, Drake & Murphy, 2006) as well as along a luminance dimension (Meier, Robinson & Clore, 2004). Meier and Robinson (2004) found that people were faster to identify a letter presented at the top of the screen when they first categorized a positive word than a negative word, whereas people were faster to identify a letter at the bottom of the screen when they first categorized a negative word than a positive word. Additionally, Meier, Robinson, and Clore (2004) found that participants' performance on a categorization task was better for positive words written in white compared to black, whereas participants' performance on the categorization task was better for negative words presented in black compared to white. The white duck in the fairy tale "Hansel and Gretel", literally presented the metaphorical mapping *good is white*.

Other studies showed evidence that the concept *verticality* (*up-down* image schema) might be conceptually mapped onto *power* (Giessner & Schubert, 2007; Schubert, 2005; Zanolie et al., 2010). For instance, Zanolie et al. (2010) found that participants were faster to identify a letter at the top of the screen after categorizing a powerful word (e.g., *king*) than a powerless word (e.g., *servant*), whereas participants were faster to identify a letter at the bottom of the screen after categorizing a powerless word than a powerful word. ERP measures indicated that this effect was due to increased spatial attention for trials in which the position of the letter (e.g., *top* vs. *bottom*) was congruent with the assumed conceptual mapping (*up* vs. *down*) of the preceding word (e.g., *king* vs. *servant*) than for trials in which the position of the letter was incongruent. The differences in height between the witch and the children literally reflect the metaphor *power is up*. In congruence with the metaphor, when the children got older and had grown in height as well, the balance of power reversed, so that the children became more powerful than the witch.

The role of image schemata for the concept of *love* has not been investigated directly by previous research (but see Chapter 7). Nevertheless, studies have shown that the related concept *emotional bond* might be partly represented by *closeness* (Williams & Bargh, 2008a) and that *temperature* might be mapped onto *social judgment*, *generosity* (Williams & Bargh, 2008b) and *social exclusion* (Zhong & Leonardelli, 2008). In the fairy tale Hansel and Gretel are literally brought to a place far from home in the cold forest by their father and stepmother (*social exclusion is cold*, see Zhong & Leonardelli, 2008). Nevertheless, the two children literally stayed close together during the story (*emotional bond is closeness*, see Williams & Bargh, 2008a).

Another important finding is that *time* might be partly represented by *space*. It is found that when people had to estimate the duration of a stimulus, they were influenced by the displacement of the stimuli on the screen in congruence with the conceptual mapping *time is space* (Casasanto & Boroditsky, 2008). The bigger the displacement of the stimuli (e.g., moving dot), the higher the estimated duration (controlled for real duration). The metaphor *life is a journey* was literally present in the fairy tale, in which the *path* they were taking referred to their *lives*, and thus also referred to the *time* passing by in their *lives*.

Other conceptual mappings investigated previously in conceptual tasks are *similarity is closeness* (Casasanto, 2008), and *divinity is verticality* (e.g., Meier, Hauser, Robinson, Freisen, & Scheldahl). Individual differences have been found for the conceptual mappings *morality is verticality* (Meier, Sellbom, & Wygant, 2006) *mood is verticality* (Meier & Robinson, 2005), *valence is horizontality* (Casasanto, 2009), and *power is verticality* (Moeller, Robinson, & Zabelina, 2008; Robinson, Zabelina, Ode, & Moeller, 2008). In sum, previous research has shown that some conceptual mappings are active while people understand metaphorical sentences and abstract concepts during conceptual tasks.

Outline of the dissertation

The aim of the dissertation was to investigate the Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999). In Chapter 2 we focused on the *process claim* of the Conceptual Metaphor Theory and in Chapter 3 to 6 we focused on the claim of the CMT that conceptual metaphors go beyond language comprehension.

Are conventional metaphorical sentences understood by conceptual mapping?

Chapter 2 focused on the *process claim* of the CMT (see McGlone, 1996; Gibbs, 1994). Previous studies found that priming with metaphorical mappings speeded up reading times for target sentences with the same metaphorical mapping (e.g., Keysar, Shen, Glucksberg, & Horton, 2000). In Chapter 2 we were particularly interested in the role of the vehicle (concrete concept) in the comprehension process of the topic (abstract concept) in a metaphorical sentence. Since previous studies used prime sentences with the metaphorical mapping, it is not clear whether priming effects were due to activation of the vehicle alone or whether the effect was due to activation of the metaphorical mapping as a whole. We wanted to investigate whether prior activation of the vehicle alone is helpful for understanding the topic. In order to answer this question, we primed conventional metaphorical sentences (e.g., *This gadget will save you hours*) with literal sentences containing the vehicle or concrete concept (*I can't afford this expensive couch*) of a metaphorical mapping (*time is money*). The literal sentence either contained the vehicle of the target sentence (e.g., *money*) or not. Since the prime-target pairs were not embedded in one scenario, the priming effect could not be due to semantic relatedness. Moreover, by using literal sentences to prime metaphorical sentences, the priming effect could not be due to lexical relatedness of a topic-vehicle structure. In Experiment 1 we found that participants read metaphorical sentences faster when primed by a literal sentence containing the vehicle compared to a literal sentence not containing the vehicle. Unfortunately, the stimuli were not controlled on several factors (sentence length, order of vehicle and topic, position of vehicle and topic)[2]. Most important, the location of the topic in the sentence varied widely, and could be before, after, or together with the vehicle. Therefore, distinguishing between priming of the vehicle and priming of the topic was problematic. In Experiment 2, in which we used better controlled stimuli, we found neither a priming effect for overall sentence reading, nor an effect in the segment with the topic. Still, this null-effect in Experiment 2 is difficult to interpret. One explanation is that the vehicle is not helpful for understanding a topic in a metaphorical sentence. An alternative explanation could be that other factors in language (e.g., irrelevant information mentioned in the sentences) have overshadowed the priming effect. Future research should focus on the stronger claim of the CMT, namely, that concrete concepts are used to understand abstract concept beyond language comprehension. Other material than (metaphorical) language and other techniques should be used to investigate this research question.

Are abstract concepts understood by conceptual mappings?

In Chapter 3 to Chapter 6 we focused on the stronger claim of the CMT, which proposes that concrete concepts partly structure the mental representation of abstract concepts. These studies were set up in such a way that we could exclude alternative explanations due to linguistic factors or to strategies. Linguistic factors, such as semantic or lexical relatedness or polysemy of the abstract words (Murphy, 1996) might be confounding factors. First, we controlled for linguistic factors, by using non-linguistic materials in the studies of Chapter 3 and 4. In Chapter 5 we did use linguistic stimuli, but these stimuli only had a literal meaning. Moreover, the target task was an unrelated letter identification task. Thus, the metaphorical mapping was not presented in linguistic form. In Chapter 6, linguistic stimuli were used (in Experiment 1), but again the image schema was manipulated by non-linguistic material. Thus, linguistic factors could not have influenced the results.

Another pitfall that we tried to avoid was the use of strategies, such as explicit use of the metaphorical mapping or response alignments. Participants who are not certain about their response may use metaphorical mappings explicitly, especially if there is very little task-relevant information. A study by Van de Bos, Lind, Vermunt, and Wilke (1997) indicated that lack of sufficient relevant information might increase the strategic use of irrelevant information in a justice judgment task. In previous studies that investigated the role of image schemas such uncertainty may also have induced participants to use the irrelevant image schemas (e.g., Casasanto & Boroditsky, 2008). All experiments in Chapters 3 to 6 minimized strategic use of the metaphorical mapping by using simple decision tasks in which the participants had sufficient information to make correct responses. Moreover, in almost all studies we can exclude effects due to alignment of binary features (Proctor & Cho, 2006) because we manipulated a dimension (e.g., distance) at more than two levels (e.g., far, medium and near) or we used a task in which data were averaged over the two response options (e.g., letter identification task) so that each response was equally likely in all conditions.

The studies in Chapter 3 investigated whether *similarity* is partly represented in terms of *closeness* (with *similar is near* and *dissimilar is far*). In Experiments 1 and 2 participants had to decide whether two squares presented at different distances from each other had similar or dissimilar colours. We found that participants performed better on similar trials presented nearer each other and on dissimilar trials presented further from each other. In Experiments 3 and 4 we found that participants' performance on a distance decision task was not influenced by the similarity of the colours of two squares. This showed that closeness is partly mapped onto similarity but not vice versa.

The studies in Chapter 4 investigated whether *categories* is partly represented in terms of *containers* (with *same category is in bounded region* and *different categories are not in same bounded region*). In Experiments 1, 2, and 4 pictures were presented at different positions (inside or outside) with respect to a frame. Participants decided whether the two pictures were from the same category (e.g., both animals) or different categories (one animal and one vehicle). We found that participants performed better on pictures from the same category presented both inside the frame, than when one was presented outside the frame, whereas there was no such effect for pictures from different categories. In Experiment 3 participants had to decide whether one picture belonged to the Animal category or not. We found that participants responded faster to pictures belonging to the category in focus (animal) when presented inside the frame compared to outside the frame, whereas there was no such effect for pictures belonging to categories out of focus (vehicle and food). The effect of the frame on the category decision task showed that *containers* is partly mapped onto *categories*.

In Chapter 5 the focus was on the mental representation of the abstract concept *quantity*. We investigated whether *situational quantity* and *simple numbers* were partly represented by *verticality* (*up-down* image schema). In Experiments 1 and 3 we found that participants identified letters better at the top of the screen after they made a quantity decision over a sentence in which the amount was a lot (e.g., *The man ate half of a pie after dinner*) compared to a little (e.g., *The guests ate half of a pie after dinner*), whereas participants identified letters slightly better at the bottom after they made a quantity decision over a sentence in which the amount was a little compared to a lot. In contrast, in Experiments 1 and 2 we found no effect of the quantity decision over numbers (e.g., 45, 90) on the identification task of letters presented at the top or bottom. These result indicated that *situational quantity* is partly represented by *verticality*, but *simple numbers* is not.

In Chapter 6 we attempted to investigate the abstract concept *love*. We focused on two conceptual mappings *love is warmth* and *love is closeness.* In Experiment 1 participants decided whether a word was positively related to love (e.g., *kiss*, *passion*, *caring*) or negatively related to love (e.g., *rejection*, *supercilious*, *mislead*) responding with their hands while resting one arm on a warm pack and one arm on a cold pack. We found that participants who were aware of the manipulation responded faster to positive love words but slower to negative love words with their warm side compared to cold side. However, participants who were not aware of the manipulation showed

Chapter 1

no interaction between love and temperature. In Experiment 2 participants had to decide whether two portraits of famous people belonged to a love couple (e.g., Brad Pitt and Angelina Jolie) or not (Ozzy Osbourne and Princes Maxima). The portraits were presented at different distances from each other (near, medium, far). Only three participants reported to be somewhat aware of the manipulation. We found that performance of unaware participants on the love decision task (love couple vs. non-couple) was not influenced by the distance between the presented portraits. Thus, surprisingly, we found no evidence that *love* is partly represented by *warmth* or *closeness*. We discussed whether our null-results could be due to the complexity of the mental representation of *love* rather than to the absent role of *warmth* and *closeness*.

Finally, in Chapter 7 a summary of the main findings of the studies is provided. Additionally, we discuss interpretation problems of the CMT and we suggest a mission for future studies to clarify the process of conceptual mapping and the structure of the mental representation of abstract concepts. In closing, we will end with the conclusion of this dissertation.

Footnotes

1. The terminology used in descriptions of the CMT is sometimes confusing. *Metaphorical mappings*, *conceptual mappings*, and *conceptual metaphors* are used interchangeable for mental representations of abstract concepts structured by concrete concepts. Moreover, many other terms are used for the same mechanism (e.g., *metaphorical concepts*, *metaphors*, *metaphorical structuring* in Lakoff & Johnson, 1980; *cross-domain mappings* in Lakoff, 1993; *mapping*, *metaphorical system*, *figurative thought*, Gibbs, 1994; *metaphorical understanding*, *metaphorical projection*, Johnson, 1987).
   In general, in the current dissertation *conceptual mapping* will be used to talk about the mechanism underlying the mental representation of abstract concepts, *conceptual metaphors* will be used to talk about the mental representation of abstract concepts according to the CMT, and *metaphorical mapping* will be used to talk about the phenomenon that concrete concept are used metaphorically for an abstract concept in general (thus not merely thinking, but also in language and in other domains). Other terms for *conceptual mapping* (e.g. cross-domain mapping) will be avoided as much as possible.
   Various terms for concrete concepts and abstract concepts are used as well. (*concrete domain* vs. *abstract domain*, *vehicle* vs. *topic* , *source* vs. *target*). Throughout this dissertation the terms *concrete concept* and *abstract concept* are used. In order to better distinguish between the concepts themselves and terms that refer to concepts in the metaphorical expression we used the terms *vehicle* and *topic* in Chapter 2. Additionally, when the mental representation of the concept is meant, the concept is sometimes written in italic (e.g., *power*).
2. In Experiment 1 of Chapter 2 we used the same conventional metaphorical sentences discussed by Lakoff and Johnson (1980) that were used as evidence for the Conceptual Metaphor Theory.

Chapter 2

Comprehension of Conventional Metaphors: Does the Vehicle Help?

Abstract

In the present study we investigated whether activation of the vehicle (e.g., money) of a metaphorical mapping (e.g., *time is money*) is helpful to comprehend the topic of conventional metaphorical sentences. In Experiments 1 and 2 participants read metaphorical sentences (e.g., *This gadget will save you hours*) that were preceded by a literal sentence that used the same vehicle (e.g., *money* in *I can't afford this expensive vase*) or different vehicle (e.g., *up* in *She went to the top floor*). In Experiment 1 we found that participants read metaphorical sentences faster after a sentence containing the same vehicle compared to a different vehicle. In Experiment 2 we did not replicate this effect with better controlled stimuli. The null-effect is hard to interpret, since language contains many factors that are hard to control. Future research should focus on the role of concrete concepts in understanding abstract concepts beyond language comprehension.

When someone would say that *She is made of tougher stuff and won't go to pieces easily* the comprehender will probably not presume that someone is talking about the female looking Terminator, the T-X in *Terminator 3: Rise of the machines* (directed by Jonathan Mostow, 2003). Expressions like the one above need to be understood metaphorically and not literally (provided that it is not about a T-X). Without much effort people understand what is meant: *She will not be offended easily by other people*. The underlying metaphorical mapping for the example is *the mind is a brittle object* (Lakoff & Johnson, 1980) in which the abstract concept *mind* is called the *topic* and the concrete concept *brittle object* is called the *vehicle*. According to the Conceptual Metaphor Theory (CMT) (Lakoff & Johnson, 1980) the concrete concept (or *vehicle*) is necessary to understand the abstract concept (or *topic*). In the light of the CMT we wanted to investigate the role of the concrete vehicle for abstract metaphor comprehension.

The basic idea of the CMT (Lakoff & Johnson, 1980) is that metaphorical sentences like *it's been a long bumpy road* are understood by the mechanism of conceptual mapping. Conceptual mapping is explained as the process in which the mental representation of the vehicle of the metaphor, e.g., *journey*, is used to understand the topic of the metaphor, e.g., *love*. Lakoff and Johnson (1980, 1999) used the term *conceptual mapping* and *conceptual metaphors* because they propose that *metaphorical mappings* like *love is a journey* are conceptual and occur even beyond language comprehension. The basic claim of the CMT is that the concrete vehicle partly structures the mental representation of the abstract topic and that this mental representation of the vehicle is necessary to fully understand the topic (Lakoff & Johnson, 1980, 1999; Johnson, 1987).

Recent studies tried to uncover the mechanism that underlies metaphorical sentence comprehension. For instance, Boulenger, Hauk and Pulvermüller (2008) found that an idiom with a motion verb (e.g., *John grasped the idea*) or a literal sentence with the same motion verb (e.g., *John grasped the object*), activated similar parts in the pre-motor and motor cortex that controlled arm movements. These results suggest that both metaphorical sentences (e.g., grasping ideas) and literal sentences (e.g., grasping objects) are simulated by the sensory-motor system. In turn, these results might indicate that the vehicle or concrete concept (e.g., objects) is active during comprehension of the topic or abstract concept (e.g., ideas).

In contrast, the results of Bergen, Lindsay, Matlock, and Narayanan (2007) suggested that abstract concepts in language (e.g., *the cost*) are not understood by concrete concepts (*space*). In the study of Bergen et al. participants were faster to identify an object at a position (e.g., *top*) that was congruent with the motion of the verb (e.g., *upward motion*) mentioned in a literal sentence (e.g., *the mule climbed*) that preceded the object. On the other hand, when a sentence with a motion verb (e.g., *climbed*) was used in a metaphorical sentence (e.g., *the cost climbed*) participants' performance on the object identification task was not influenced. Thus, *space* was only active during comprehension of sentences with concrete movements of concrete concepts (e.g., *mule*) but not for abstract movements of abstract concepts (e.g., *cost*).

The Conceptual Metaphor Theory could be interpreted in different ways (e.g., Murphy, 1996; McGlone, 2006). For instance, conceptual mappings can be interpreted as a mechanism that is used to understand metaphorical language or as a mechanism that is used to reason about abstract concepts. If conceptual mappings are used to comprehend metaphorical language, effects of a conceptual mapping should be found exclusively during processing of metaphorical sentences (Gibbs, 1992, 1994). On the other hand, if conceptual mappings are used to reason about abstract concepts, effects of a conceptual mapping should also be found during processing of abstract concepts without linguistic materials, such as a power judgement task on animal pictures (e.g., Boot & Pecher, 2010; Casasanto & Boroditsky, 2008; Schubert, 2005). In the present study we will focus on the *process claim* of the CMT (Gibbs, 1992, 1994, see also McGlone; 2006). The *process claim* focuses on the role of conceptual mapping during metaphorical language comprehension. In the light of the process claim of the CMT we were interested whether the vehicle is helpful to understand the topic of a metaphorical sentence.

Studies that investigated the process claim of the CMT have shown mixed results. Glucksberg and McGlone (1999) found no support for the process claim of the CMT. They presented a list of conventional or novel metaphorical expressions to participants and asked them to give an interpretation. They found that participants did not consistently use the conceptual metaphor in their interpretations. It could be argued that this measurement was not sufficiently sensitive for this research question. Although participants did not use the conceptual metaphor literally in their response, they might still have used the conceptual metaphor in a more implicit way for understanding.

A study by Keysar, Shen, Glucksberg, and Horton (2000) found some support for the process claim of the CMT. Participants had to read scenarios that ended with a target sentence. The scenario could either contain conventional metaphors (e.g., *She is a prolific researcher, conceiving an enormous number of new findings each year*), novel metaphors (e.g., *She is a fertile researcher, giving birth to an enormous number of* *new findings each year*) or no metaphors (e.g., *She is a dedicated researcher, initiating an enormous number of new findings each year*). The target sentence that followed was a conventional metaphorical sentence from Lakoff and Johnson (1980) (e.g., *Tina is currently weaning her latest child*) that contained the same metaphorical mapping (e.g., *ideas are people*) as used in the scenarios with metaphors. Keysar et al. (2000) found no differences between the reading times of the target sentence that followed a scenario with conventional metaphorical sentences or a scenario without metaphorical sentences. However, they did find that the target sentence was read faster when primed by a scenario with novel metaphorical sentences than when primed by a scenario without metaphorical sentences (or with conventional metaphorical sentences). This seems to indicate that novel metaphorical sentences do activate the conceptual mapping (e.g., *ideas are people*), which in turn speeds up reading time for a conventional metaphorical sentence, whereas conventional metaphorical sentences do not activate the conceptual mapping.

Thibodeau and Durgin (2008) found similar effects when they used novel metaphors as target sentences. They found that both scenarios with novel (e.g., *I was sizzling*) and conventional metaphors (e.g., *I was fuming*) speeded up reading time for novel target sentences (e.g., *Otherwise my boiler would burst*) compared to scenarios without metaphorical expressions (e.g., *I was furious*). In another experiment Thibodeau and Durgin (2008) also found that participants read target sentences faster when preceded by a scenario containing the same metaphorical mapping (e.g., *anger is heat*) than when preceded by a scenario containing a different metaphorical mapping (e.g., *anger is a dangerous animal*). In sum, the studies of Keysar et al. (2000) and Thibodeau and Durgin (2008) showed that metaphorical sentences (conventional or novel) activate conceptual mappings that results in faster processing of novel and conventional metaphorical sentences referring to the same metaphorical mappings.

Previous studies that investigated the process claim of the CMT investigated whether conceptual mappings were active during comprehension of the complete metaphorical sentences (e.g., Glucksberg & McGlone, 1999; Keysar et al., 2000; McGlone, 1996; Nayak & Gibbs, 1990; Thibodeau & Durgin, 2008). For instance, Keysar et al. and Thibodeau and Durgin provided evidence that the metaphorical mappings were active during online comprehension of metaphorical sentences. In these studies, the prime sentences contained the same metaphorical mappings as the target sentences. In other words, the prime contained both the concrete vehicle and abstract topic. Even though priming with the conceptual mapping resulted in faster comprehension times of metaphorical sentences compared to unrelated primes, it is not clear whether this was due to activation of the concrete vehicle, abstract topic, or the metaphorical combination of the two. Therefore, the role of the concrete vehicle by itself in comprehending the abstract topic of metaphorical sentences remains unclear. In the present study we were interested whether people would use the concrete vehicle during online comprehension of the abstract topic in a metaphorical sentence. We used a reading time paradigm like Keysar et al. and Thibodeau and Durgin in order to measure online comprehension. Instead of priming with metaphorical sentences that both contained the concrete vehicle and the abstract topic, we used literal sentences that contained only the concrete vehicle.

The reason for focussing on the role of the vehicle is that the CMT (Lakoff & Johnson, 1980, 1999) assigns an important role to the concrete vehicle for the comprehension process of the abstract topic. In fact, conceptual mapping is described as the process in which the concrete concept is used to understand the abstract concept. Translated to the *process claim*, this would mean that the vehicle is used to understand the topic. In the present study we focused on the role of the concrete vehicle by using literal prime sentences containing merely the vehicle that were semantically unrelated to the metaphorical target sentence. The prime sentences should activate the vehicle of a conceptual metaphor in a literal sense. For instance, the prime sentence *I can't afford this expensive vase* referred to the vehicle *money* of the metaphorical mapping *time is money* used in the target sentence *This gadget will save you hours*.

Other theories than the CMT of metaphorical sentence comprehension (see Bowdle & Gentner, 2005 for an overview) do not suggest a predominant role of the vehicle in the comprehension process, and thus do not predict a priming effect in the present paradigm. For instance, the category view (e.g., Glucksberg & Keyser, 1990; Glucksberg, 1998; Glucksberg & Haught, 2006; Jones & Estes, 2005; Jones & Estes, 2006) and the analogical view (e.g., Gentner, Bowdle, Wolff & Boronat, 2001 as cited in Bowdle & Gentner, 2005; Murphy, 1996) both suggest that the topic and vehicle should be activated simultaneously in order to comprehend a metaphorical sentence. According to the category view, a metaphorical sentence (e.g., *lawyers are shark*) can be understood when a post-hoc category is formed by selecting relevant features and deselecting irrelevant features (e.g., *vicious*, *predatory* but not *fast swimmer*). This selection process, and thus formation of the post-hoc category, can only occur when both the topic and vehicle are activated. According to the analogical view, a metaphorical sentence (e.g., *lawyers are shark*) can be understood when the relational structure (e.g., *harming others*) of the vehicle (e.g., *shark*) and topic (e.g., *lawyer*) are aligned. This alignment process can only occur when both the topic and vehicle are active. On the other hand, according to the CMT the vehicle partly structures the topic. Thus, priming with the vehicle (e.g., *money*) of the presumed conceptual mapping (e.g., *time is money*) should be sufficient to understand the topic (e.g., *time*) in the metaphorical sentence (e.g., *This gadget will save you hours*). In the present design effects of lexical priming and semantic priming could be excluded as well. First, lexical priming was avoided because the literal prime sentence had no topic-vehicle structure as the metaphorical target sentence. Second, semantic priming could not occur, because the prime and target sentence were not part of a scenario and their meanings were unrelated.

Since we wanted to examine the claims of the CMT, we used the sentences that Lakoff and Johnson (1980) provided as examples of conceptual mappings as the underlying mechanism of comprehension. We expected that if the vehicle of a conceptual mapping plays a predominant role in the comprehension process of the topic in a metaphorical sentence, activation of the vehicle would speed up reading time for the conventional metaphorical sentence.

Experiment 1

Method

Participants

The participants were 48 native speakers of English. They were recruited from the campus of Emory University in Atlanta and included students and employees at the Emory University in Atlanta.

Material

We selected 130 metaphorical target sentences from Lakoff and Johnson (1980), Kövecses (2000), and Gibbs (1994). The metaphorical sentences had different abstract concepts as topics (e.g., *love, time, argument*) and different concrete concepts as vehicle (e.g., *nutrient, money, war*). For each metaphorical target sentence (e.g., *This gadget will save you hours*) we created a literal prime sentence. In the Match Condition the vehicle of the target sentence (e.g., *money*) was the literal subject (e.g., *I can't afford this expensive vase*) in the prime sentence. In the Mismatch Condition prime sentences were paired with unrelated target sentences. Participants received half of the targets in the Match and half in the Mismatch Condition. The Match Condition and Mismatch Condition were counterbalanced between subjects.

Additionally we created 20 literal filler sentences. For the 20 filler sentences and 28 target sentences we created simple questions about content of the sentences (e.g., *Is it an efficient thing to use?*). All the sentences except the questions were divided into segments. The segments contained 1 to 4 words. The number of segments per sentence ranged from 2 to 6. An additional sentence and question about the sentence was created as an example in the instruction. Some examples of experimental stimuli are shown in Table 1.

Table 1. *Some examples of the stimuli used in Experiment 1.*

No.	Condition	Sentence
1	Match Prime	The basketball hoop was hanging too high.
	Mismatch Prime	They got back to the hotel after a long walk.
	Target	The number of books printed each year keeps going up.
2	Match Prime	While on a diet she was craving something fried.
	Mismatch Prime	The mole disappeared into the ground.
	Target	He was given new strength by her love.
	Question	Does he have a good relationship?
3	Filler	It was still dark when he left for work this morning.
	Question	Did he leave for work late in the morning?

Procedure

Participants were tested on individual PCs, separated by walls, in groups ranging from 1 to 2. Participants were told that they had to read sentences carefully and that yes/no questions would be asked about the content of some of the sentences. A moving window paradigm was used in which for each sentence participants could control the speed of reading by pressing the space bar for the next segment to be presented on the screen. The words of the segment parts of the sentence that were still hidden were presented by dashes (-----------). Some sentences were followed by a question which was presented until a response was given. Participants could respond to the question with the y-button (“yes”) or the n-button (“no”). Feedback was provided for the questions. After a correct answer “correct!” in blue colored letters and after an incorrect response “incorrect” in red colored letters appeared at the bottom right of the sentence for 1500ms. The experiment started with 18 practice sentences and 10 practice questions. The practice trials were followed by the 130 prime-target pairs of which half were presented in the Match and the other half in the Mismatch Condition, mixed with 20 fillers and 48 questions. All filler sentences and

28 of the target sentences were followed by a question. The stimuli were presented in semi random order.

Results

We performed a paired sample *t*-test over the reading times of target sentences (sum of all segments). Target sentences that were followed by a question that were incorrectly answered were removed (0.95%). Additionally, outliers that fell outside 2 standard deviation from the subject's mean were removed as well (5.91%). Means and standard errors are shown in Figure 1. We found a significant Matching effect, $t(47) = 2.56$, $SEM = 14.0$, $p < .025$. Participants read sentences in the Match condition faster than in the Mismatch condition.

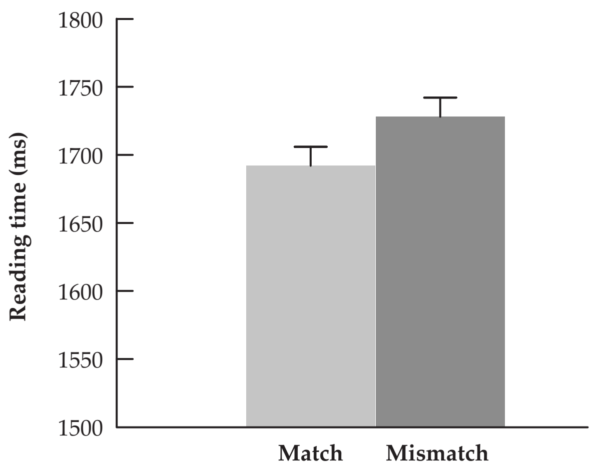

Figure 1. *Mean reading times in milliseconds for target sentences in Experiment 1. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994).*

In order to locate the position on which the effect was present, we analyzed different segments separately. It might be that the *vehicle* and the *topic* are processed differently. We decided to perform distinct analyses over the reading times of the segments with the *vehicle*, *topic* and *final segment*. In 41 sentences the topic and vehicle appeared in the same segment (e.g., *His life contained/a great deal of sorrow*), in 76 sentences the topic was in the last segment (e.g., *He's seeking/his fortune*), in 47 sentences the vehicle was in the final segment (e.g., *The reasoning/is shaky*) and in 30 sentences the topic and vehicle were both in the last segment (e.g., *He is/high-minded*).

Paired sample t-tests showed no significant effect in the segment with the topic, $t < 1$, nor in the segment with the vehicle, t (47) = 1.15, p > .25, nor in the final segment, $t < 1$.

Experiment 2

In Experiment 1 we found that participants read metaphorical sentences (e.g., *The idea just won't sell*) faster when they were primed with a literal sentence about the vehicle of the metaphorical sentence (e.g., *commodities* in *The theatre still has a lot of tickets*). Unfortunately we were not able to locate the effect in the reading times for vehicle or topic. The separate analyses for the segments with the topic and vehicle showed a null effect. There was also no evidence that the effect was located in the final segment of the sentence. These null-effects might have been due to noise caused by several confounding factors. Since we used the exact same sentences as Lakoff and Johnson (1980), Kövecses (2000), and Gibbs (1994) we could not control for sentence length (ranging between 2 and 6 segments) and the position and order of the vehicle and topic. Some sentences started with the topic (N = 27), some with the vehicle (N = 62), and for some sentences the vehicle and topic were in the same segment (N = 41), or even presented in one word (e.g., *I'm in top-shape*). The differences in sentence length, and position and order of topic and vehicle might have caused noise in the data that could have led to null-effects for the separate segments. Therefore, it is hard to interpret the overall Matching effect we found for total reading times of the target sentences.

The aim of Experiment 2 was to clarify the results of Experiment 1 by controlling for confounding factors. We created sentences that were equally long (5 segments) with the topic and vehicle always in the same positions and order (abstract topic in the second segment and concrete vehicle in the fourth segment). We presented the topic before the vehicle so that the vehicle could not influence the reading time of the segment with the topic. If the vehicle in the target sentence would precede the topic, this vehicle could be used to understand the topic in both the Match and Mismatch condition. In that case, we would not be able to investigate the effect of the concrete concept (vehicle) on processing the topic.

Moreover, with these stimuli we could examine an alternative explanation for the Matching effect in Experiment 1. The Matching effect in Experiment 1 could have been due to activation of the vehicle instead of activation of the topic. Since the concrete concept and the vehicle are the same concept expressed by semantically and lexically related words, such an effect would not be surprising. By presenting the topic and vehicle in separate segments we could isolate the effects in the topic segment and the vehicle segment.

If we would find a Matching effect in the topic segment, this would provide stronger evidence that the vehicle is helpful to understand the topic. Second, if we would merely find a Matching effect in the vehicle segment instead, this would mean that the Matching effect in Experiment 1 was due to faster comprehension of the vehicle in the Match Condition. Moreover, we could also investigate how far in the sentence the Matching effect would continue.

Method

Participants

Sixty psychology students at the Erasmus University Rotterdam who professed to speak Dutch fluently participated for course credits.

Material

We created 128 prime-target sentence pairs. Target sentences were newly created or translated from Lakoff and Johnson (1980), and adjusted so that each sentence was 5 segments long with the topic in the second and the vehicle in the fourth segment. As in Experiment 1 different vehicles and topics were used in the sentences. Prime-targets pairs for the Match Condition were created such that the vehicle (e.g., money) of the metaphorical target sentence (e.g., *Daar wil ik mijn tijd liever niet aan verspillen als het kan,* Dutch translation of *I don't want to waste my time with that if it's possible*) was literally used in the prime sentence (e.g., *Hij geeft te veel geld uit aan uitgaan sinds zijn vriendin bij hem weg is,* Dutch translation of *He is spending too much money on going out since his girlfriend left him*). In the Mismatch Condition primes were paired with unrelated targets. Participants received half of the targets in the Match and half of the targets in the Mismatch Condition. The sets of sentences used in the Match and Mismatch Condition were counterbalanced between subjects.

Similarly as in Experiment 1 we created 20 literal filler sentences and 48 questions. All sentences (except the questions) were divided into 5 segments, each segment containing 1 to 5 words. In all target sentences the topic was in the second segment and the vehicle was in the fourth segment. For example in the target sentence *Toen er iets in hem van binnen knapte veranderde alles* (Dutch translation for *When something inside him snapped, everything changed*) the second segment *iets in hem* (Dutch translation for *something inside him*) refers to the topic *mind* and in the fourth segment *knapte* (Dutch translation for *snapped*) refers to the vehicle *brittle object.*

One sentence and question about the sentence was created as an example in the instruction. Some examples of experimental stimuli are shown in Table 2.

Table 2. *Some examples of the stimuli used in Experiment 2 with English translations.*

No.	Condition	Sentence
1	Match Prime	De jongen klauterde bij de buren langs de regenpijp naar de bovenste verdieping. *The boy climbed along the neighbours' drainpipe to the top floor.*
	Mismatch Prime	De steenkolenmijn in Limburg was na jaren goed gediend te hebben uitgeput. *The coal mine in Limburg was exhausted after years of good service.*
	Target	Van die schrijver zal het aantal verkochte boeken elk jaar blijven stijgen voorspelde de uitgever. *The number of sold books of that writer will keep going up each year predicted the publisher.*
2	Match Prime	De kettingen uit de sieradendoos kreeg mijn moeder niet meer uit de klit. *My mother could not disentangle the necklace from the jewelry box anymore.*
	Mismatch Prime	Met Sinterklaas zetten kinderen hun schoen die dan gevuld wordt met pepernoten. *During Santa Claus children will put out their shoes so that they can be filled with candies.*
	Target	Hij probeerde het mysterie met veel moeite te ontrafelen in zijn eentje. *He tried to unravel the mystery with a lot of effort on his own.*
	Question	Zocht hij met de hulp van anderen de oplossing van het mysterie? *Was he looking for a solution for the mystery with the help of others?*
3	Filler	De frisbee vloog over de hoofden van de meisjes en viel daarna in het zand. *The frisbee flew over the heads of the girls and fell in the sand after that.*
	Question	Was er iemand geraakt met de frisbee? *Had anyone been hit by the frisbee?*

Procedure

Participants were tested on individual PCs, separated by walls, in groups ranging from 1 to 4. The procedure was the same as in Experiment 1 except that the instructions, sentences, questions, and feedback were in Dutch and the sentences all had 5 segments. When a sentence was followed by a question, participants could respond with "yes" or "no" by pressing the j-button or the n-button. If the participants answered the question correctly "goed" (Dutch equivalent of "correct") in blue colored letters appeared at the bottom right of the screen for 1500 ms. If the participants answered the question incorrectly, "fout" (Dutch equivalent of "correct") in red colored letters appeared at the bottom right of the screen for 1500 ms.

Results

The reading times of target sentences (sum of all segments) were submitted to a paired sample *t*-test. Target sentences that were followed by a question that were incorrectly answered were removed (1.53%). Additionally, outliers that fell outside 2 standard deviations from the subject's mean were removed as well (4.42%). Means and standard errors are shown in Figure 2. There was no significant Matching effect, $t(59) < 1$.

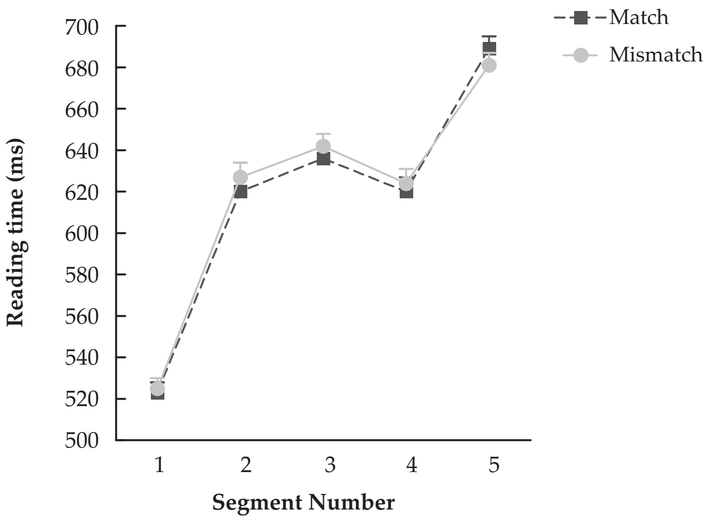

Figure 2. *Mean reading times in milliseconds for the five segments of the target sentences in Experiment 2. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994).*

Next we performed a 2 (Matching: Match vs. Mismatch) by 5 (Segment: 1, 2, 3, 4, 5) repeated measures ANOVA over reading times excluding outliers (4.95%). Again we found no main effect of Matching, $F(59) < 1$, nor an interaction effect, $p < .20$. We only found a main effect of Segment, $F(4,236) = 76.93$, $MSE = 5366.5$, $p < .001$. Paired sample t-test over all the five segments separately showed no significant Matching effect, all *p*'s > .20

Discussion

In the present study we investigated whether activation of a concrete vehicle (e.g., *money*) that is part of a conceptual metaphor (e.g., *time is money*) would help to understand the abstract topic in a conventional metaphorical expression that refers to a metaphorical mapping (e.g., *time is money*). In Experiments 1 and 2 participants read metaphorical sentences that were primed by literal sentences. In Experiment 1 we found that participants read metaphorical sentences (e.g., *This gadget will save you hours*) faster when they were primed with a literal sentence (e.g., *I can't afford this expensive vase*) about the vehicle of the metaphorical sentence (e.g., *money*). In contrast, in Experiment 2 we found no effect of the literal sentence on processing of the metaphorical sentence.

In Experiment 1 we used the same conventional metaphorical sentences that Lakoff and Johnson (1980) used as evidence for the CMT. These sentences had different lengths and the topic and vehicle were presented at different positions in the sentences. Even though we found a Matching effect for sentence reading times in Experiment 1, we could not differentiate between effects due to priming of the vehicle and effects due to priming of the topic in the target sentences because separate analyses of the segments showed no effects. Since the metaphorical sentences of Gibbs (1994), Kövecses (2000), Lakoff and Johnson (1980) used in Experiment 1 appeared to be inappropriate to examine the *processing claim* of the CMT (e.g., Gibbs, 1992, 1994) we created new, better controlled sentences for Experiment 2. In Experiment 2 we controlled for sentence length and position and order of topic and vehicle. All sentences were five segments long, with the topic in the second segment and the vehicle in the fourth segment. With these controlled stimuli, we excluded noise due to confounding factors and were able to study the effect in the segment of the topic (and vehicle). Interestingly, in Experiment 2 we did not obtain an effect of conceptual mapping.

Studies that investigated whether conceptual mappings are activated during processing of metaphorical language used paradigms in which participants had to interpret or judge metaphorical expressions (e.g., Glucksberg & McGlone, 1999; McGlone, 1996; Nayak & Gibbs, 1990). During the process of interpretation and judgement other mechanisms might have played a role. We were interested whether participants used the concrete vehicle of a conceptual mapping during online processing of the abstract topic in a conventional metaphorical sentence. We did this by using reading time as a measurement of processing as was done in studies by Keysar, Shen, Glucksberg and Horton (2000) and Thibodeau and Durgin (2008).

In contrast to the present study, Keysar et al. (2000) and Thibodeau and Durgin (2008) did find an effect of conceptual mapping during metaphorical sentence comprehension. The difference in results might be due to the fact that Keysar et al. and Thibodeau and Durgin used scenarios with or without the same metaphorical mapping as was used in the target sentences whereas we used literal sentences that were semantically unrelated to the target sentences with or without the vehicle as primes. Keysar et al. and Thibodeau and Durgin found that when people were primed by scenarios with metaphorical expressions (conventional or novel) processing times were faster for metaphorical expressions (conventional or novel) compared to when people were primed by scenarios without metaphorical expressions. They claimed that this effect was due to the fact that conceptual metaphors are required to process metaphorical expressions.

In the present study we were particularly interested whether the vehicle by itself would help to comprehend the topic in a conventional metaphorical sentence. Previous studies (Keysar et al., 2000; Thibodeau & Durgin; 2008) showed that the metaphorical mapping, and thus a combination of the topic and vehicle, could speed up reading times of a conventional metaphor. These studies could not clarify the isolated role of the vehicle in the comprehension process of conventional metaphors.

In order to investigate the role of the vehicle in comprehending the topic, we used literal prime sentences that only contained the vehicle of the metaphorical mapping used in the target sentence. In contrast with other theories, metaphorical sentence comprehension (e.g., see Bowdle & Gentner, 2005 for an overview) the CMT claims that the vehicle is directly helpful to understand the topic (in a conventional metaphorical sentence). Furthermore, the prime target pairs were not embedded in one scenario as in Keysar et al. (2000) so that the priming effect of the vehicle on reading time of the topic could be isolated from semantic priming.

Unfortunately, it is hard to interpret the null-effect in Experiment 2. One interpretation for the null-effect in Experiment 2 is that people do not use the vehicle to understand the topic in conventional metaphors. Nevertheless, Experiment 2 differed from Experiment 1 on other aspects that might have caused a null-effect. The difference in population (American versus Dutch) and language (English versus Dutch) could not be responsible for the null-effect since we used conventional metaphors commonly used in daily speech of these languages in both experiments. On the other hand, in order to control for confounding factors in Experiment 2, we were forced to create target sentences of great length that may have sounded unnatural (though grammatically correct) and contained irrelevant information (besides the topic and vehicle). For instance, the target sentence *It was inconvenient that her thoughts frequently wandered to the party during the exam* could have activated aspects (e.g., *exam*, *party*) other than the conceptual mapping (e.g., *ideas are moving objects*). Besides that, we created primes with similar lengths (e.g., *In the middle of heather there was a little house occupied by old people who appreciated the silence*) that contained irrelevant information as well (e.g., *old people*, *silence*, *heather*). The activation of irrelevant information and the unnaturalness of target sentences might have overshadowed the Matching effect. In sum, it seems that different factors in language were hard to control. In the present study it appeared that language is not the right tool to investigate the CMT. Nevertheless, when investigating the *process claim* of the CMT, which was the focus of the present study, linguistic (metaphorical) material is inevitable to use.

Since linguistic materials are hard to control on several factors, it might be interesting for future research to focus on the stronger claim of the CMT that goes beyond language comprehension. The Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999) clearly claims that conceptual metaphors are not restricted to language processing. Metaphors are assumed to be embedded in the structure of mental representations of concepts. People might not only talk in terms of metaphors, but also think in terms of metaphors. Lakoff and Johnson (1980) used metaphorical language as a source of evidence to claim that people understand abstract concepts in terms of concrete concepts. To investigate the claim that metaphorical mapping in language originates from the way our mental representations are structured other materials than (metaphorical) language and different techniques should be used. Future studies should focus on this strong claim by using tasks that interact with the conceptual system, but sidestep the linguistic system. Decision or judgment tasks with non-linguistic materials have been used in recent studies that investigated conceptual mapping during comprehension of concepts (e.g., Boot & Pecher, 2010; Casasanto & Boroditsky, 2008; Schubert, 2005). For instance Schubert (2005) found that pictures of animals presented at the top of the screen were judged to be more powerful than pictures of animals presented at the bottom of the screen. These results show that people behave in line with the metaphorical mapping *power is up* as is found in language, for instance in the sentences *He's at the peak of his career* and *She will rise to the top*. Another example of a recent study that investigated conceptual mapping during comprehension of concepts was done by Casasanto and Boroditsky

(2008) who found that participants estimated duration times of a stimulus to be longer when the visual displacement of the stimulus (moving dot) was larger than when it was smaller, providing evidence for the mapping *time is space*.

To conclude, in the present study we did not find evidence that the vehicle is helpful to understand the topic in a conventional metaphorical sentence. In Experiment 1 we found that reading times for metaphorical sentences preceded by the vehicle were shorter than when not preceded by the vehicle of the sentence. However, when we controlled for several factors in Experiment 2, we did not replicate the vehicle priming effect. Still, the null-effect in Experiment 2 is hard to interpret, because the controlled stimuli were more complex. Future studies should focus on the stronger claim of the CMT (Lakoff & Johnson, 1980, 1999) that goes beyond language using other stimuli than (metaphorical) language.

Chapter 3

Similarity is Closeness: Metaphorical Mapping in a Conceptual Task

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Abstract

The Conceptual Metaphor Theory states that abstract concepts are represented by image schemas from concrete concepts. In the present study we investigated the mapping for *similarity is closeness* using tasks with non-linguistic materials. In Experiments 1 and 2 participants decided whether two squares were similar or dissimilar in colour. The spatial distance between the squares was varied. Performance to similar colours was better at shorter distances, whereas performance to dissimilar colours was better at longer distances. In Experiments 3 and 4 participants made distance decisions to similar and dissimilar colours squares. Performance was not affected by similarity. These results show that metaphorical mappings can be found even beyond the context of linguistic metaphors and that the mapping between *similarity* and *closeness* is asymmetrical.

"Gravitation can not be held responsible for people falling in love." (2007, http://www.quotationpage.com/quotes/Albert_Einstein/) In this quote Albert Einstein refers to the metaphor *love is a physical force*. Metaphorical expressions are not only restricted to witty statements or poetic language, but are common phenomena in daily conversations. The use of metaphors in language is not only common but is found to be very systematic too. Concrete concepts (e.g., *physical force*) are consistently used for abstract concepts (e.g., *love*) in various metaphorical expressions (e.g., *They were attracted to each other)*. The systematicity of metaphorical expressions led Lakoff and Johnson (1980) to speculate that this is not merely a linguistic phenomenon, but originates in mental representation. They proposed a structural mental mapping of metaphors in their Conceptual Metaphor Theory (M. Johnson, 1987; Lakoff & Johnson, 1980, 1999; also see Gibbs, 1994).

The Conceptual Metaphor Theory (Johnson, 1987; Lakoff & Johnson, 1980, 1999; also see Gibbs, 1994) goes beyond language and makes claims about the mental structure of concepts. Their claims of structural mental mapping of metaphors fits with embodied theories of mental representation. According to these theories the mental representation of concepts depends on the way the body is constructed and interacts with the concepts (e.g., Barsalou, 1999; Glenberg, 1997; Goldstone, 1994). The body interacts with and perceives objects (e.g., a chair) in the world and by this sensory-motor experience (e.g., seeing a chair, sitting on a chair) a mental representation of that concept (e.g., *chair*) is formed. In contrast to concrete concepts (e.g., a chair), abstract concepts (e.g., value) are not physically present in the world. The elusiveness of abstract concepts makes it impossible to perceive or physically interact with them. Despite the fact that bodies cannot interact with nonphysical objects, however, some theories have proposed that abstract concepts are also based on sensory-motor experience. (e.g., Lakoff & Johnson, 1980; Barsalou, 1999; Barwise & Perry, 1983, Langacker, 1986). The Conceptual Metaphor Theory of Lakoff and Johnson (1980) deals with the problem that abstract concepts are nonphysical by proposing that we represent abstract concepts in terms of concrete concepts by metaphorical mapping. The physical experience with concrete concepts enables their mental representations to be grounded in bodily experiences. These experiences result in the formation of image schemas. Image schemas are conceptual structures that represent spatial relations and movements in space. They are the building blocks of mental representation which develop during childhood (Mandler, 1992). Image schemas of concrete concepts are mapped onto abstract concepts. This metaphorical link between concrete and abstract concepts is formed by co-occurrence of the two concepts in one experience during childhood (e.g., C. Johnson, 1997). For example, the observation that similar objects are often clustered together (e.g., trees, dishes) gives rise to the metaphorical mapping *similarity is closeness* (Grady, 1997, in Lakoff and Johnson, 1999.) A mapping of concrete concepts onto abstract concepts makes it possible for the mental representation of abstract concepts to be grounded in experience as well (Johnson, 1987; Lakoff & Johnson, 1980, 1999; Gibbs, 1994).

Lakoff and Johnson (1980) made a distinction between more basic metaphors (which they divided into orientational metaphors, e.g., *happy is up* and ontological metaphors, e.g., *inflation is an entity*) and structural metaphors. Grady (1997, in Lakoff & Johnson, 1999) elaborated this idea in his Theory of Primary Metaphor. He distinguished *primary metaphors* that are composed of a single image schema and *complex metaphors* that are composed of more than one primary metaphor (Lakoff and Johnson, 1999). The Conceptual Metaphor Theory has been investigated in quite a number of studies with primary metaphors (Boroditsky, 2000; Boroditsky & Ramscar, 2002; Casasanto, & Boroditsky, 2008; Casasanto, 2007a; Casasanto, 2007b; Casasanto, 2008; Meier, Hauser, Robinson, Friesen & Schjeldahl, 2007; Meier & Robinson, 2004; Crawford, Margolies, Drake, & Murphy; 2006; Schnall & Clore; 2004; Meier & Robinson; 2006; Meier & Robinson, & Clore 2004; Chiao, Bordeaux & Ambady, 2004; Schubert, 2005; Giessner & Schubert, 2007; Van Dantzig, Boot, Giessner, Schubert, & Pecher, 2008). In the present study we investigated the primary metaphor *similarity is closeness*. This primary metaphor is composed of the *near-far* image schema.

According to the Conceptual Metaphor Theory (Lakoff & Johnson, 1980) mapping of a concrete concept onto an abstract concept is asymmetrical. An abstract concept needs the representation of a concrete concept and not vice versa. The reason for this asymmetry lays in the richness of the concrete concept that is acquired by sensory experience. This sensory experience is exactly what abstract concepts lack. Metaphorical representations of abstract concepts provide a solution for this lack by filling up the poor representation of the abstract concepts. On the other hand, Grady (1997, 2005) uses the conceptual integration or "blending" theory of Fauconnier and Turner (1998) to explain the mapping of metaphors. According to Grady, in the mental representation of primary metaphors, abstract and concrete concepts are equally richly elaborated. Although this may seem to eliminate the need to make a blend in the first place, Grady still agrees that there is asymmetry of mapping at least for primary metaphors.

In the present study we investigated whether this asymmetry also holds for the conceptual mapping *similarity is closeness*. In the same way as people talk about similarity in terms of closeness and not vice versa, they should understand similarity in terms of closeness and not vice versa. For example the sentence *These colours are close* can be interpreted literal as well as metaphorical, but *The two cities are similar* can only be interpreted literally and does not mean that there is a small distance in kilometres between the cities. Evidence for asymmetry has been found for other concepts (Boroditsky, 2000; Casasanto and Boroditsky 2008; Cassasanto, 2007a; Meier & Robinson, 2004; Meier, Robinson, & Clore, 2004; Van Dantzig et al., 2008). Casasanto and Boroditsky (2008) and Casasanto (2007a) obtained evidence of asymmetry with non-linguistic materials. Participants had to estimate the duration time of the presentation of a stimulus or the length (stationary line) or displacement (e.g., growing line, moving dot) of that same stimulus presented on the screen. The kind of decision that participants had to make on the stimulus (duration time or estimating length/displacement) was randomly assigned on each trial. They found that participants estimated duration times to be longer for longer lines or stimuli with bigger displacements (e.g., moving dot or growing line) than for smaller lines or stimuli with smaller displacements (e.g., moving dot or growing line). They did not find evidence for the opposite mapping; the duration time had no influence on the estimation of the length and displacement of the stimuli. Thus, they found that estimating the duration of a stimulus (*time*) was influenced by spatial displacement (*space*), but not vice versa. This supports the claim of Lakoff and Johnson (1980) that the conceptual metaphor *time is space* is asymmetrical.

Another issue in the present study is that we wanted to exclude that the effects were due to metaphorical language. There are a number of theories about metaphorical comprehension, which describe how we comprehend metaphorical *language* (e.g., Gentner, 1983; Glucksberg & Keysar, 1990). These theories and related ones about metaphorical comprehension consider how metaphorical *expressions* are understood and not how mental representations of the abstract concepts themselves are structured. According to these theories mental representations of concrete and abstract concepts are self-sufficient and a connection between the two concepts (according to a different process depending on the theory) arises only during comprehension of metaphorical expressions. Thus the representations are presumed to be independent of each other in a non-linguistic context. In contrast to theories about metaphorical comprehension the Conceptual Metaphor Theory has clear predictions for tasks with non-linguistic materials. Although Lakoff and Johnson

(1980) used language as an important source of evidence for conceptual mappings, their claim is that image schemas are essential to give structure and meaning to abstract concepts. Thus we should expect to find activation of the image schema even in tasks that do not present metaphoric language. Actually, some researchers have argued against the use of language stimuli in tests of Conceptual Metaphor Theory because linguistic evidence for the CMT leads to a circular argument (e.g., Murphy, 1996). In addition, Murphy argues that some words that are used in literal and metaphorical contexts may in fact be polysemous (see also Barsalou & Hale, 1993). A word like *rise* can refer to both the physical meaning and the non-physical meaning (e.g., *Inflation is rising*). Thus, metaphorical expressions like these can be due to polysemy rather than to an underlying metaphorical mapping. In the case of the metaphor *similarity is closeness* the word *close* would both activate the literal meaning, which belongs to the concept *closeness* and the metaphorical meaning, which belongs to the concept *similarity*. Because studies that use language require processing of the concepts in language, it is unclear whether these studies measured the role of metaphor in representation of abstract concepts or measured the lexical link between the concepts.

Others have also recognized the importance of this issue and used designs in which no linguistic stimuli were presented (e.g., Casasanto & Boroditsky, 2008; Giessner & Schubert, 2007; Meier, Hauser, Robinson, Friesen & Schjeldahl, 2007). For example, Meier et al. (2007) investigated the conceptual metaphor *divinity is verticality* using God-like, Devil-like and neutral images. In the study phase, the pictures were presented randomly at different locations on the screen. In the test phase, participants had to recall the location of the images. Participants remembered God-like images at a higher location than neutral images and Devil-like images at a lower location than neutral images. The results of experiments using non-linguistic material like those of Meier et al. (2007) provide evidence for the Conceptual Metaphor Theory.

A third issue we investigated in the present study was the automaticity of the conceptual mapping. According to the theory, the image schema (e.g., *verticality*) is essential to understand the abstract concept (e.g., *divinity*). The image schema is part of the representation of the abstract concept, and causes the abstract concept to be grounded in sensory-motor experience. Therefore, the representation of the abstract concept should be affected by manipulations that also affect the image schema. Moreover, we should expect automatic activation of the conceptual mapping when participants process the abstract concept. We consider the conceptual mapping to be automatic when it will be active during processing of the abstract concept even in a context in which it is inefficient or even harmful for performance.

Evidence for automaticity of the activation of the conceptual mapping for understanding an abstract concept might be found in a task in which participants have no uncertainty about what the response should be. In other domains it has been shown that irrelevant features affect judgments in conditions of uncertainty (e.g., Van den Bos, 2003; Van den Bos, Lind, Vermunt, & Wilke, 1997, for the domain of justice). The same mechanisms may be at work in some studies that investigated the role of image schemas. For example, in the study of Meier et al. (2007) participants had to recall the location of a picture. Since recalling the exact position of a picture on the screen is a difficult task with an almost infinite number of possible responses, participants may have used other (irrelevant) features such as the meaning of the picture. Studies that have investigated *similarity is closeness* (Breaux & Feist, in press; Casasanto, 2008) asked participants to give similarity ratings (e.g., on a scale of 1 to 9) for pairs of stimuli that were presented sequentially where it was probably quite hard to decide between say a 2 or a 3 as the correct response. This may have introduced the kind of uncertainty that would be susceptible to influences of irrelevant features such as the distance between the stimuli. This may have been especially the case for the stimuli used by Breaux and Feist, which were four colours that were all about equally similar to each other. In our present study, we presented the concepts simultaneously and simply asked participants to say whether the stimuli were similar or different. The task was made very easy by presenting stimuli that were either very similar or very different. Thus we hoped to eliminate the influence of any strategic use of the image schema on performing the task. This allowed us to investigate the role of image schemas for the representation of abstract concepts.

In the present study the stimuli we used were squares of colours. Breaux and Feist (in press) also used colours as stimuli. There were two important differences between our experiment and theirs. First, we used different colour pairs. Breaux and Feist used pairs of shades of blue and green that were not very different in similarity. Our stimuli presented pairs of different colours that were either very similar or not similar at all. Second, we used a different task. Rather than asking participants to give a similarity rating as Breaux and Feist did (see also Casasanto, 2008), we used a speeded similar/dissimilar decision task. In this way we wanted to eliminate the use of the conceptual mapping due to uncertainty. First, by the use of a simple decision task with clear responses we minimized the use of the irrelevant dimension (distance). Second, the irrelevant information (distance) was not helpful for performance. In the decision task distance was orthogonally crossed with similarity and feedback was provided after each trial. If participants would use distance to speed up their performance they would soon find out that this was counteractive, because distance was not predictive of the correct response. A second advantage of a simple decision task is that it could be performed without the need to compare perceptual details. If perceptual details have to be compared distance may have the opposite effect (Casasanto, 2008).

In Experiment 1, participants made similarity decisions to colour squares presented near to or far from each other. The similarity decision task should activate the concept *similarity* and the different distances between the squares should activate the concept *closeness*. According to the CMT in order to understand the concept *similarity* people need to activate the mental representation of *closeness*. This is the process of conceptual mapping in which *near* is mapped onto *similar* and *far* onto *dissimilar*. If *similarity is closeness* is a conceptual mapping and not merely a linguistic phenomenon, and if this conceptual mapping is automatic and essential to perform the task we would expect to find an interaction effect. Performance for similar colours should be better when they are presented near than when they are presented far, whereas performance for dissimilar colours should be worse when they are presented near than when they are presented far.

Experiment 1

Method

Participants

Thirty psychology students received course credits for participating.

Materials

The stimuli were 18 pairs of coloured squares (each 4 by 4 cm). The nine similar pairs each consisted of 2 different hues of the same colour, the nine dissimilar pairs each consisted of 2 different colours. Eight judges (who did not participate in the experiment proper) rated the similarity of the colours on a scale ranging from 1 (*almost the same*) to 7 (*totally different*). The similar colours were judged as very similar (mean scores ranging from 1.3 to 2.9) and the dissimilar pairs were judged as very dissimilar (mean scores ranging from 5.9 to 6.8). We counterbalanced for position of colour (right vs. left) and for distance (near vs. far). In the Near condition the distance between the two squares was 1 cm. In the Far condition the distance between the two squares was 8 cm. The squares were vertically centred. Each pair was used 4 times (once in each position by distance combination) which resulted in 72 trials (18 x 2 x 2). An additional set of 20 colour pairs was used for practice.

Procedure

Participants were tested on individual PCs, separated by walls, in groups ranging from 1 to 4. Participants were told that they had to decide if two colours were similar or dissimilar. On each trial, two squares filled with different colours or hues were presented. Each trial started with a fixation point (+) that was presented in the centre of the screen for 1000 ms. Then the two squares appeared vertically in the centre and horizontally near or far from each other for 1800 ms or until a response was given. Participants used the z-button and m-button to respond. The mapping of keys with response was counterbalanced. If participants gave an incorrect response, "Fout" (*incorrect*) appeared in red in the centre of the screen. If participants did not respond after 1800 ms, "Te Laat" (*Too Late*) appeared in red in the centre of the screen. The feedback was presented for 1500 ms. Between each trial a blank screen was presented for 500 ms. First participants received 20 practice trials to familiarize them with the range of similarity used in the experiment. After a brief break the 20 practice trials were followed by the 72 experimental trials.

Results

Mean reaction times and error rates are presented in Table 1. We performed a 2 (Similarity: Similar and Dissimilar) by 2 (Distance: Near and Far) repeated measures ANOVA on the reaction times and error rates. We only analyzed the correct reaction times that fell within 2 standard deviations from the subject's mean. This resulted in removal of 4.7% of the reaction times. In the reaction times we obtained a significant interaction, $F(1, 29) = 11.81$, $MSE = 10820.7$, $p = .002$. Post-hoc LSD comparisons (see Loftus & Masson, 1994) showed that participants were faster to respond to similar colours when they were presented near each other compared to far from each other, $t(29) = 4.70$, $MSE = 5.5$, $p < .001$. However, participants were faster to respond to dissimilar colours when presented far from each other compared to near each other, $t(29) = 2.17$ $MSE = 5.5$, $p = .02$. In the error rates we did not find an interaction effect between Distance and Similarity, $F < 1$. Note that very few errors were made.

Table 1. *Mean reaction times in milliseconds and error rates in the similarity decision task in Experiment 1. Standard errors are shown in parenthese.*

	Reaction times		Error rates	
Distance	Similar	Dissimilar	Similar	Dissimilar
Near	493 (14)	527 (15)	.032 (.010)	.033 (.010)
Far	519 (15)	515 (16)	.040 (.012)	.038 (.013)

Discussion

In Experiment 1 we found that participants' performance on the similarity task was influenced by the irrelevant position of the colours. We found interaction effects in the reaction times. Performance was faster to similar colours that were near each other compared to far from each other, whereas performance was faster to dissimilar colours that were far from each other compared to near each other. The results we found in this paradigm support the idea that the concrete concept *closeness* is mapped automatically onto the abstract concept *similarity* even beyond the boundaries of language comprehension.

Experiment 2

In Experiment 2 we wanted to extend our findings. The manipulation of similarity and distance in Experiment 1 each involved two levels. It is possible that participants aligned the binary values close/similar and distant/dissimilar and responded faster when the stimuli were thus aligned than if the opposite combinations were presented. Therefore we introduced a more graded manipulation of distance as was done by Casasanto (2008). If participants in Experiment 1 used such alignment, the interaction between distance and similarity should disappear. If the effect is due to activation of the image schema, however, there should still be an interaction.

Method

Participants

Forty psychology students from the same subject-pool as Experiments 1 who had not participated in Experiments 1 received course credits for participating.

Material

We used the same pairs of squares as in Experiment 1. The colour pairs were the same and the distance in the far and near condition were the same. We added a third medium distance condition. The medium pairs were presented 4 cm from each other. We counterbalanced for position of colour (right vs. left) and for similarity (similar vs. dissimilar). Each slide was presented two times which resulted in 216 trials (9 x 3 x 2 x 2 x 2) in total. An additional set of 24 colour pairs were used for practice.

Procedure

The procedure was the same as in Experiment 1 except that the trials were divided over two blocks with each 108 trials. Between the blocks participants could take a break.

Results and Discussion

The mean reaction times and error rates of Experiment 2 are presented in Table 2. We performed a 2 (Similarity: Similar and Dissimilar) by 3 (Distance: Near, Medium, Far) repeated measures ANOVA over the reaction times and error rates.

We only analyzed the correct reaction times that fell within 2 standard deviations from the subjects mean. This resulted in a removal of 5.1% of the reaction times. In the reaction times we obtained a significant interaction, $F(2, 78) = 4.29$, $MSE = 590.5$, $p = .017$. In the reaction times of the similar condition we find the expected pattern, reaction times increased as distance increased. Post-hoc LSD comparisons (see Loftus & Masson, 1994) showed that participants were faster to respond to similar pairs in the near compared to far condition, $t(39) = 5.89$, $SEM = 3.8$, $p = .01$. Additionally we found that participants were faster to respond to similar pairs in the near compared to medium condition, $t(39) = 2.90$, $SEM = 3.8$, $p = .01$, and participants were faster to respond to similar pairs in the medium compared to similar pairs in the far condition, $t(39) = 3.00$, $SEM = 3.8$, $p = .01$. Thus, participants became slower to respond to similar colours when the squares were presented further away from each other. In the dissimilar condition participants did not respond significantly different to the different distance conditions. We obtained a main effect of distance, $F(2, 78) = 5.43$, $MSE = 590.5$, $p = .017$. The tests of within-subjects contrasts showed that participants were faster to respond to near pairs, $F(1,39) = 8.84$, $MS = 5467.6$, $p = .005$, and medium pairs, $F(1,39) = 4.56$, $MS = 19192.3$, $p = .039$, compared to pairs presented far from each other, but participants did not respond differently to near and medium pairs, $F(1,19) = 1.23$, $MS = 465.7$, $p = .274$.

In the error rates we also found an interaction effect between Distance and Similarity, $F(2, 78) = 3.25$, $MSE = .002$, $p = .044$. Post-hoc LSD comparisons (see Loftus & Masson, 1994) showed that participants were more accurate to similar pairs in the near compared to far condition, $t(39) = 2.4$, $SEM = .005$, $p = .05$ and participants were also more accurate to dissimilar pairs in the medium condition compared to near condition. $t(39) = 2.2$, $SEM = .005$, $p = .05$.

Table 2. *Mean reaction times in milliseconds and error rates in the similarity decision task in Experiment 2. Standard errors are shown in parentheses.*

	Reaction times		Error rates	
Distance	**Similar**	**Dissimilar**	**Similar**	**Dissimilar**
Near	503 (11)	524 (10)	.026 (.005)	.032 (.005)
Medium	514 (11)	520 (10)	.030 (.006)	.021 (.004)
Far	525 (11)	525 (12)	.038 (.007)	.023 (.005)

While we obtained the expected interaction effect in the reaction times and error rates the effect seemed to be predominantly present in the similar condition. However, interpretation of the interaction is complicated by the influence of main effects (Rosnow & Rosenthal, 1989). In order to interpret the interaction effect correctly we calculated the residuals (by subtracting the means or simple effects from the condition cells) as recommended by Rosnow and Rosenthal. The residuals of the cells are shown in Table 3.

Table 3. *The residuals of the reaction times in the similarity decision task in Experiment 2.*

Distance	Similar	Dissimilar
Near	-6	6
Medium	1.5	-1.5
Far	4.5	-4.5

The residuals in the condition cells showed that the participants' reaction times for both the similar and dissimilar pairs were indeed influenced by the three distances in a graded fashion. In particular, increasing distance had a gradually interfering effect for similar pairs and a gradually facilitating effect for dissimilar pairs. In addition to Experiment 1, these results of Experiment 2 with graded distance further support the idea that the concrete concept *closeness* is mapped automatically onto the abstract concept *similarity*.

Experiment 3

According to the Conceptual Metaphor Theory the mapping of concrete concepts onto abstract concepts is asymmetrical. (Johnson, 1987; Lakoff and Johnson, 1980, 1999; Gibbs, 1994, 1996). The asymmetry of conceptual mapping makes sense in an embodied point of view. Through conceptual mapping the mental representations of abstract concepts can join in the rich sensory-motor representation of concrete concepts. Evidence for asymmetry has been found for other concepts (e.g. *time is space*, Casasanto and Boroditsky, 2008). In Experiment 3 we examined the asymmetry of the mapping of *similarity is closeness*. We used the same stimuli as in Experiment 1. Participants had to decide whether the two squares of colours were presented near or far from each other instead of making a decision about the similarity. If the mapping of *similarity is closeness* is asymmetrical, we would expect no interaction effect. The similarity of colours should not effect distance decisions.

Method

Participants

Thirty students of the Erasmus University Rotterdam from the same subject-pool as Experiment 1 who had not participated in Experiment 1 received course credits or a chocolate bar for participating.

Material

We used the same stimuli as in Experiment 1.

Procedure

As in Experiment 1, participants were tested on PCs, separated by walls, in groups ranging from 1 to 4. The procedure was the same as Experiment 1 with the exception of the task. Participants were told that two squares could be presented in two different distances and that they had to decide whether they were *near* or *far* from each other. They first received 20 practice trials to familiarize them with the range of distances used in the experiment. Again the mapping of the z and m-keys with response was counterbalanced.

Results and Discussion

The mean reaction times and error rates of Experiment 3 are presented in table 4. We performed a 2 (Distance: Near and Far) by 2 (Similarity: Similar and Dissimilar) repeated measures ANOVA over the reaction times and error rates.

We only analyzed the correct reaction times that fell within 2 standard deviations from the subjects mean. This resulted in a removal of 4.4% of the reaction times. There was no interaction effect in reaction times, $F < 1$, nor in the error rates, $F(1,29) = 3.028$, $MSE = .002$, $p = .092$.

Table 4. *Mean reaction times in milliseconds and error rates in the distance decision task in Experiment 3. Standard errors are shown in parentheses.*

	Reaction times		**Error rates**	
Distance	**Similar**	**Dissimilar**	**Similar**	**Dissimilar**
Near	417 (15)	413 (14)	.014 (.005)	.025 (.008)
Far	408 (14)	406 (14)	.016 (.005)	.012 (.004)

Thus, the similarity of colours did not influence distance decisions. This provides evidence that the mapping between *similarity* and *closeness* is asymmetrical.

In addition we performed a combined analysis of Experiment 1 and 2. In the reaction times we found a three-way interaction effect (Similarity x Distance x Task), $F(2,58) = 9.33$, $MSE = 6081.2$ $p = .003$. In the error rates we did not find a significant three-way interaction effect, $F < 1$. Although the absence of an effect of similarity on distance judgment is based on a null effect and should be interpreted with caution, the interaction indicates that at least the effects are different.

Experiment 4

There is an alternative explanation, however, because the reaction times were lower in Experiment 3 than in Experiment 1. In Experiment 3 we used the same stimuli as in Experiment 1, but apparently, the task in Experiment 3 was much easier to perform than in Experiment 1. This may have been due to differences in variation of the relevant dimensions. The relevant feature in Experiment 1 (*similarity*) was more variable (nine similar and nine dissimilar pairs) than the relevant feature in Experiment 3 (one far and one near configuration). Therefore, in order to have a more balanced comparison of the two tasks, in Experiment 4 we adjusted the stimuli so that the variability for the relevant and irrelevant features of the task was comparable with those of the task in Experiment 1. In Experiment 4 we used only two colour pairs (one similar pair and one dissimilar pair) and more distances (ten near and ten far).

If the null effect in Experiment 3 was due to asymmetry of the conceptual mapping of *similarity is closeness* and not to differences in task difficulty, processing time of the concepts or saliency of features in the stimuli, we would again expect no interaction effect in Experiment 4. The similarity of colours should not affect decisions in the distance decision task.

Method

Participants

Thirty psychology students from the same subject-pool as Experiments 1 , 2 and 3 who had not participated in Experiments 1, 2 and 3 received course credits for participating.

Material

The stimuli were 20 pairs of squares (each 2 X 2 cm). The ten near pairs were presented 2 cm from each other and the ten far pairs were presented 4 cm from each other. On the screen there were three rows of 12 position slots each above each other, creating a total of 36 locations (note that these slots were invisible). The middle row was vertically and horizontally centred, the top row was situated 3 cm above, and the bottom row was situated 3 cm below the middle row. On each trial two different position slots were used from the same row. This way, the positions of the squares were always horizontally aligned. For the near condition we created pairs with positions that were separated by 2 cm (one square) and for the far condition we created pairs with positions that were separated by 4 cm (two squares). We used each of the 36 locations in both the near and the far condition in such a way that the position of an individual square was not predictive of the correct response. The squares in the near and far condition could either have similar colours or dissimilar colours. The dissimilar colours were purple and yellow (participants judged this colour pair the most dissimilar, $M = 6.8$ on a scale of 1 to 7) and the similar colours were two different hues of orange (M = 1.6). We counterbalanced for position of colour (right vs. left) and for similarity (similar vs. dissimilar). Each distance pair was presented four times which resulted in 80 trials (20 x 2 x 2) in total. An additional set of 18 pairs was used for practice. Instead of being presented next to each other the practice pairs of squares were presented above each other and were vertically aligned. The distances, size and colours were the same as the experimental trials.

Procedure

The procedure was the same as in Experiment 3.

Results and Discussion

The mean reaction times and error rates of Experiment 4 are presented in Table 5. As can be seen, reaction times are now more comparable to those of Experiment 1, indicating that the task difficulty was more similar than that of Experiment 3. We performed a 2 (Distance: Near and Far) by 2 (Similarity: Similar and Dissimilar) repeated measures ANOVA over the reaction times and error rates.

We only analyzed the correct reaction times that fell within 2 standard deviations from the subjects mean. This resulted in a removal of 4.6% of the reaction times. There was no interaction effect, $F < 1$, only a main effect of distance, $F(1,29) = 17.68$, $MSE = 15653.3$, $p < .001$. Far responses were slower than close responses. In the error rates we found no interaction effect or main effects, all $Fs < 1$.

Table 5. *Mean reaction times in milliseconds and error rates in the distance decision task in Experiment 4. Standard errors are shown in parentheses.*

	Reaction times		Error rates	
Distance	**Similar**	**Dissimilar**	**Similar**	**Dissimilar**
Near	513 (15)	556 (16)	.027 (.006)	.024 (.006)
Far	532 (15)	553 (15)	.035 (.007)	.026 (.006)

Thus, the similarity of colours did not influence distance decisions. Even though caution should be taken when interpreting null results, this provides further support for the idea that the mapping between *similarity* and *closeness* is asymmetrical. The results from Experiments 3 and 4 also show that the interaction effect that was found in Experiment 1 was not due to alignment of the two stimulus dimensions. If participants had used such alignments, we also would have expected symmetrical effects

General Discussion

In the present study we examined if the distance between two colour squares influenced performance in a colour similarity decision task. In Experiments 1 and 2 we found an interaction effect between distance and similarity. Participants responded faster to similar colours that were presented near each other compared to far from each other, whereas participants responded faster to dissimilar colours that were presented far compared to near each other.

Experiments 3 and 4 addressed whether or not this effect of distance on the similarity decision task is asymmetrical. In Experiments 3 and 4we found that the similarity of colours of two squares had no influence on distance decisions. This shows that the conceptual mapping is asymmetrical; *similarity* borrows the mental representation of *closeness* but not vice versa. This study followed the prediction of the conceptual mapping *similarity is closeness* (Lakoff & Johnson, 1980, 1999). In addition, these experiments show that the conceptual mapping is automatically activated in a task that used non-linguistic stimuli.

The present results are consistent with other recent findings that support the *similarity is closeness* image schema mapping (Casasanto, 2008; Breaux & Feist, in press). In these studies a variety of stimuli were used (words, objects, colours). An important difference between these studies and our present study is that we minimized uncertainty about what the correct response was. Because the differences between the similar and dissimilar pairs in our present study were very obvious this task was easy to perform. By minimizing the uncertainty about the response, we minimized the strategic use of irrelevant features (distance) to perform the task (e.g., Van den Bos, 2003; Van den Bos, Lind, Vermunt, & Wilke, 1997). Another factor that discouraged participants to use irrelevant features of the stimulus (distance) is that this irrelevant feature was not helpful to perform the task. Irrelevant features (e.g., distance) might be helpful in judgment tasks, especially when no feedback is provided. Without feedback, participants might continue to use this irrelevant information because it facilitates performance. In our task the use of the irrelevant feature would have resulted in high error scores. As the error rates were very low in Experiments 1 and 2, it is unlikely that distance was strategically used to make similarity decisions. Therefore, our results provide strong evidence for the *similarity is closeness* image schema mapping.

Interestingly, Casasanto (2008) and Breaux and Feist (in press) obtained the opposite results if the task was to make perceptual similarity judgments. They found that stimuli were judged to be less similar if they were presented near each other than when they were presented further apart. They suggested that the metaphorical mapping may be limited to situations in which conceptual similarity judgments are made. It is possible that similarity ratings for perceptual judgments are affected by noticing more differences in perceptual details if stimuli are near each other than if they are far. Noticing more differences would result in lower similarity ratings. In our present study this may not have played a role, because the difference between similar and dissimilar stimuli was very clear, and participants made binary responses rather than ratings on a scale from 1 to 9.

Our study is in line with prior studies of the Conceptual Metaphor Theory. Whereas some prior results might be explained by metaphorical language, however, our results show that the metaphorical mapping is part of the concept itself. When making a decision on the similarity of colours, participants must have activated the concept *similarity*. That this concept was primed by the actual distance between the stimuli indicates that distance is part of the concept. Moreover, the fact that we found an effect in a speeded and easy decision task indicates that distance is a core part of the concept of similarity.

In Experiment 3 and 4 we looked at the asymmetry of the metaphorical mapping *similarity is closeness*. In line with previous studies that looked at other metaphors (Casasanto & Boroditsky, 2008; Meier & Robinson, 2004; Van Dantzig et al., 2008; Meier, Robinson, Clore 2004) we found that the mapping between *similarity* and *closeness* is asymmetrical. Thus it seems that we need the representation of the concrete concept *closeness* to understand the abstract concept *similarity*, but not vice versa. This finding of asymmetry is compatible with the Conceptual Metaphor Theory (Lakoff & Johnson, 1980) and in line with embodied theories of mental representation (e.g., Barsalou, 1999; Glenberg, 1997; Goldstone, 1994). According to embodied theories, mental representations of concepts are constructed by simulating bodily interaction with these concepts (e.g., Barsalou, 1999; Glenberg, 1997; Goldstone, 1994). Although this bodily interaction explanation works well for concrete concepts (e.g., chair), it does not work for abstract concepts (e.g., value). This problem that abstract concepts are nonphysical can be solved by asymmetrical conceptual mapping (Lakoff & Johnson, 1980; see also Grady, 1997, 2005). The mental representation of a concrete concept is built up of image schemas that are elaborated and rich with sensory-motor experiences. This rich and elaborated mental representation can be used to understand an abstract concept with a poorer representation by means of conceptual mapping. This conceptual mapping is asymmetrical since it makes no sense to use other concepts when the mental representation of concrete concepts is sufficient to understand the concept.

To conclude, in the present study we found evidence that the conceptual mapping *similarity is closeness* is fundamental to the concept of similarity. The effect is automatic and not due to linguistic associations. Moreover, the mapping was found to be asymmetrical. These findings support the Conceptual Metaphor Theory of Lakoff and Johnson (1980, 1999).

Chapter 4

Representation of Categories: Metaphorical use of the Container schema

A modified version of this chapter is accepted for publication as: Boot, I. & Pecher, D (in press). Representation of categories: metaphorical use of the container schema. *Experimental Psychology.*

Abstract

In the present study we investigated whether the mental representation of the concept *categories* is represented by the *container* image schema (Lakoff & Johnson,1980). In Experiments 1, 2 and 4 participants decided whether two pictures were from the same category (animal or vehicle) and in Experiment 3 whether one picture was from the Animal or Non-Animal category. Pictures were presented inside or outside the frame that should activate the *container* schema. We found that performance to pictures was influenced by the frame in congruence with the metaphorical mapping (*same category – inside bounded region; different category - not in same bounded region*). These results show that the concept *categories* is metaphorically represented by *containers*.

Recent theories have postulated that mental representations and sensory-motor processing share mechanisms. According to these theories, the mental representations of concepts are determined by the sensory-motor experiences that an organism has (e.g., Barsalou, 1999; Glenberg, 1997; Goldstone, 1994). Concrete concepts are physical entities in the world (e.g., *garbage can*). The body has physical experiences with such concepts by perception (e.g., seeing or touching a garbage can) and interaction (e.g., throwing something in the garbage can, or taking a full garbage bag out of the garbage can). According to theories of grounded cognition, such sensory-motor experiences form the mental representation of a concept (e.g., *garbage can*). In contrast, abstract concepts (e.g., *ideas*) are not physical entities in the world. Even though our bodies can not have direct physical experiences with abstract concepts, however, some theories provide a framework in which mental representations of abstract concepts can still be grounded in sensory-motor experience. (e.g., Barsalou, 1999; Barsalou & Wiemer-Hastings, 2005; Barwise & Perry, 1983; Lakoff & Johnson, 1980; Langacker, 1986). Lakoff and Johnson's Conceptual Metaphor Theory (CMT) has been one of the most influential of such frameworks. Lakoff and Johnson claim that people represent abstract concepts in terms of concrete concepts by metaphorical mapping. In the present paper we investigated how a particular abstract concept, *categories*, is represented. In the light of the Conceptual Metaphor Theory, we specifically investigated the idea that people represent the abstract concept *categories* in terms of the concrete concept *containers*. Metaphorical mapping such as those between *categories* and *containers* may explain how even abstract concepts could be represented by sensory-motor experiences (e.g., Barsalou, 1999; Barwise & Perry, 1983, Langacker, 1986).

Since researchers recognize the importance of categories for organizing concepts it has been the focus of much research and model development (e.g., Rosch & Mervis, 1975; Rosch, 1975, 1978; Medin & Schaffer, 1978; Nosofsky, 1986; Ross & Murphy, 1999). Research shows that people base categorization decisions on the similarity between an exemplar and the category prototype (Rosch and Mervis, 1975; Rosch ,1975, 1978) or the other exemplars that belong to the category (Medin & Schaffer, 1978; Nosofsky, 1986). As a consequence, categorization is graded, which means that some exemplars are central to a category (e.g., a dog is a clear case of an animal) and others are borderline cases (e.g., a sponge is not such a clear case of an animal). Despite these conclusions from scientific research, it seems that the layperson's view on categorization is that of categories as containers.

Lakoff and Johnson (1980) studied metaphorical sentences in which an abstract concept was understood in terms of another, more concrete concept. For example, in the sentence "Are tomatoes *in* the fruit or vegetable category?" the abstract concept *categories* is understood in terms of the concrete concept *container*. According to the CMT, a metaphor is not merely a figure of speech, but is derived from conceptual mapping. In other words, concrete concepts (e.g., *container*) are mapped onto abstract concepts (e.g., *category*).

It has been proposed that the mental representations of concrete concepts are built up out of image schemata (M. Johnson, 1987). These conceptual structures are described as representing spatial relations and movements in space and are argued to be formed by interaction of our body and senses with objects in the world during our childhood (Mandler, 1992) and in turn be used to comprehend concepts in the world (M. Johnson, 1987; Lakoff & Johnson, 1999). For instance, activation of the *container* schema should make experiences like pouring water in a cup (a container being filled) coherent. This example describes how concrete concepts could be grounded in our experience and how mental representations might be richly structured by image schemata. According to the CMT, abstract concepts that can not be experienced by interaction and perception could nevertheless be as richly represented as concrete concepts through metaphorical mapping (Lakoff & Johnson, 1980, 1999; M. Johnson, 1987; Gibbs, 1994). This means that image schemata could be used both literally and metaphorically. This versatility of image schemata might provide a means for experiential grounding of concrete as well as abstract concepts.

Interestingly, the CMT provides a theory about the origins of conceptual metaphors. Some conceptual metaphors, called primary metaphors (Grady, 1997 as cited in Lakoff & Johnson, 1999) are directly formed by correlation of the two concepts in one experience (Lakoff & Johnson, 1980, 1999, M. Johnson, 1987; C. Johnson, 1997), whereas others, called complex metaphors, are build up from primary metaphors (Grady, 1997 as cited in Lakoff & Johnson, 1999). For instance, experiences in which objects from the same category (e.g., tools) appeared in the same bounded region (e.g., tool-box) could have attributed to the formation of the primary metaphor *categories are containers*. On the other hand, a complex metaphor such as *life is a thief* are built up from primary metaphors such as *valued aspects of experience are precious possessions*.

There is now a growing body of evidence in support of the Conceptual Metaphor Theory, such as for the conceptual metaphor *time is space* (Boroditsky, 2000; Casasanto & Boroditsky, 2008), *similarity is closeness* (Boot & Pecher, in press; Casasanto, 2008), *good is up* (Meier & Robinson, 2004; Crawford, Margolies, Drake, & Murphy, 2006) and *power is up* (Giessner & Schubert, 2007; Moeller, Robinson & Zabelina, 2008; Schubert, 2005; Zanolie, Van Dantzig, Boot, Wijnen, Schubert, Giesner & Pecher, 2010), *social attachment is closeness* (Williams & Bargh, 2008a) and *affection is warmth* (Williams & Bargh, 2008b; Zhong & Leonardelli, 2008). In the present study we wanted to extend these findings to the conceptual metaphor *categories are containers*. Importantly, we wanted to investigate whether the *container* image schema would be activated even in the absence of any linguistic expression that might contain the metaphor.

According to Lakoff and Johnson (1980) metaphorical language is a reflection of the way mental representations of abstract concepts are structured. The metaphorical link between the concrete and abstract concept is assumed to be fixed and exists independently of language. If the metaphorical mapping is indeed conceptual rather than linguistic, we should expect to find an effect of the image schema that is metaphorically mapped onto the abstract concept in a task without linguistic stimuli. By using a language-free design to examine the CMT, we can avoid potential problems that complicate interpretation of evidence for conceptual metaphors. For example, Murphy (1996) argued that linguistic evidence for the CMT leads to a circular argument. Another problem he raised was that some words used in literal and metaphorical context (e.g., attack) are polysemous (see also Barsalou & Hale, 1993). Some expressions might not be metaphorical (e.g., *he attacked every weak point in my argument* from Lakoff & Johnson, 1980) but simply use the more abstract meaning of a polysemous word (e.g., *attack*). The multiple meanings of a word in a seemingly metaphorical expression makes conceptual mapping redundant. In order to investigate the role of image schemata for representations of abstract concepts, it is important that language that might express image schemata is avoided. So far, only a few studies have used paradigms with non-linguistic material and obtained evidence for the role of image schemata in representations of abstract concepts (e.g., Boot & Pecher, in press; Casasanto, 2008; Casasanto & Boroditsky, 2008; Crawford, Margolies, Drake, & Murphy, 2006; Meier, Hauser, Robinson, Friesen & Schjeldahl, 2007; Schubert, 2005). For instance, whereas Meier and Robinson (2004) used words to activate *valence* Crawford, Margolies, Drake and Murphy (2006) used pictures instead of words to activate *positive* and *negative valence*. In the present study, we also used pictures to activate the concept of interest. The concept *categories* was activated by pictures from different categories (e.g., *animal* and *vehicle*) or the same category (e.g., two animals or two vehicles). The *container* image schema was activated through pictorial presentation as well; a black frame that included (in the container) or excluded (out of the container) the pictures. In this way we minimized effects due to activation of possible polysemous words (e.g., *in* and *out*) or lexical associations.

Lakoff and Johnson's (1999; see also Murphy, 1996) CMT makes a strong claim that the mental representation of the concrete concept is necessary to fully understand the abstract concept. If concrete concepts need to be activated to understand abstract concepts, then the conceptual mapping should get activated in any situation in which the abstract concept needs to be understood. Non-linguistic studies so far almost always used paradigms in which the stimuli contained features of the concrete concept (e.g., *space*) as well as the abstract concept (e.g., *time*). The features of the concrete concept were irrelevant to the task, whereas the features of the abstract concept were relevant. For instance, in the study of Casasanto and Boroditsky (2008) participants made estimations of the time of presentation of a visual stimulus (e.g., a dot). Responses were influenced by the spatial displacement of the dot, which was an irrelevant feature for the presentation duration. The bigger the displacement of the stimuli on the screen the longer participants estimated the presentation duration of the stimuli (controlled for real duration time). First, with this study Casasanto and Boroditsky (2008) showed that the conceptual mapping *time is space* is not only active during language processing (as shown by Boroditsky, 2000) but also during processing of visual non-linguistic materials. Second, and more importantly, they showed that even though spatial displacement was irrelevant for estimating presentation duration, participants' performance was still affected by it. These results suggest that people use the mental representation of *space* in order to fully understand *time*.

An important question is whether the image schema plays a role during representation of the abstract concept or during selection of the response. According to the CMT, image schemata are part of the representation of the abstract concept. There is some evidence, however, that irrelevant information can sometimes affect responses in situations with high uncertainty. For example, participants' judgments of justice in conditions of uncertainty (e.g., when there is no information about the others' outcome) was influenced by irrelevant information (e.g., affect, Van den Bos, 2003; Van den Bos, Lind, Vermunt, & Wilke, 1997). In studies investigating activation of image schemata during processing of abstract concepts a similar type of uncertainty might play a role as well. When participants have to choose from many response options (e.g., ratings on a Likert scale) and are uncertain about the accuracy of their choice, irrelevant information may affect responses. For instance, Schubert

(2005) asked participants to judge animal pictures on respect on a scale from 1 (not at all) to 9 (very much). The pictures of the animals could be presented at the top or bottom of the screen. He found that participants gave higher ratings to powerful animals when presented at the top compared to the bottom of the screen. These results provide evidence that *power* is partly represented by *verticality*. In addition, however, participants might have used irrelevant information (i.e., picture position) to facilitate performance (i.e., judging animals on respect) in cases where they were uncertain about the correct response. Because judging animals on respect is subjective and perhaps unusual for the participants, it is possible that the irrelevant information (position of picture) might have influenced the response selection in congruence with the metaphorical mapping (e.g., animals presented at the top are more powerful than animals presented at the bottom). In sum, while it is obvious that the metaphorical mapping (e.g., *power is up*) was active during performance, it is unclear whether the image schema affected representation or response selection.

In the present study we tried to minimize such response uncertainty. In Experiment 1 participants decided whether two pictures were from the same or different categories. We used only two categories that were easy to distinguish (*animals* and *vehicles*). Additionally, we provided feedback to give confidence about the accuracy of responses. Because this task was very easy, and uncertainty was minimized, it was unlikely to induce the use of irrelevant information during response selection. The irrelevant information in our task was the position of a rectangular frame that was presented with the pictures. Both or only one picture could be presented inside the frame. The frame visualized a bounded region that should activate the *container* schema in its concrete meaning. The task itself should activate the concept *categories* that in turn should activate the *container* schema. The congruent trials were those in which the activation of the *container* schema matched for the irrelevant frame and the category decision (*things from the same category are in the same bounded region* or *things from different categories are not in the same bounded region*). Incongruent trials were those in which the *container* schema mismatched for the irrelevant frame and the category decision (*things from the same category are not in the same bounded region* or *things from different categories are in the same bounded region*). Equal numbers of congruent and incongruent trials were presented so that the irrelevant information (frame) was not predictive or helpful to select the correct response, which should further discourage participants from using the irrelevant information. If we still obtained an effect of the image schema on categorization decisions in congruence with the metaphorical mapping, this would support the idea that the *container* image schema is an essential part of the representation of the concept *category*.

In summary, our aim of the present study was to investigate the mental representation of the concept *categories*. In the light of the CMT we examined whether *categories* is metaphorically represented by *containers*. Additionally, we examined whether this metaphorical mapping is non-linguistic and occurs during mental representation of the abstract concept rather than during response selection. The conceptual metaphor *categories are containers* is of special interest, because it has not been investigated previously.

Moreover, two important factors were controlled in order to exclude confounding effects. First, the target pictures were centred on the screen and the distance between them was identical between trials. In this way eye movements were minimized and the conceptual mapping *similarity is closeness* could not influence outcomes (see Boot & Pecher, in press; Cassasanto, 2008). Second, differences in visual complexity between trials in which both pictures were presented inside the frame and trials in which one was outside the frame could not affect the predicted interaction because both configurations appeared in both the congruent and incongruent condition.

If the concept of *categories* is conceptually represented by *containers*, we would expect to find an interaction. Performance for pictures from the same category should be faster when presented both inside the frame than when one was outside the frame, whereas performance for pictures from different categories should be worse when presented both inside the frame than when one was outside the frame.

Experiment 1

Method

Participants and Design

Forty psychology students participated. They received course credits or a chocolate bar as a reward for their effort. Position of the pictures with respect to the frame and same vs. different category were manipulated within subjects, type of categorization was manipulated between subjects. In order to counterbalance the materials over the experimental conditions, twenty participants decided whether two pictures were both animals or not, the other 20 participants decided whether two pictures were both vehicles or not.

Materials

We selected 10 different pictures of animals and 10 different pictures of vehicles from Stanfield and Zwaan (2001), Zwaan, Stanfield and Yaxley (2002), Bonin , Peereman, Malardier, Meot, and Chalard (2003, http://leadserv.u-bourgogne.fr/bases/pictures/), Pecher, Zanolie and Zeelenberg (2007), and similar line drawings found on the internet. All animals were mammals with four feet (e.g., elephant, rabbit). All vehicles had four wheels and a motor (e.g., bus, car). We created 10 different pairs of animals (using each animal two times) and 10 different pairs of vehicles (using each vehicle two times), and 10 different pairs of an animal with a vehicle. The pairs were presented next to each other in the centre of the screen, so that one picture was on the left and one on the right of the centre. The relative position of the two pictures was counterbalanced across repetitions of the pair. The pictures were presented together with a frame that was a black lined square of 8 cm by 8 cm. This frame was either presented in the middle so that both pictures were inside the container, or moved 4 cm to the left or right from the centre, so that only one picture was in the container and one outside. For each pair we created two identical slides in which the container was in the middle, one with the container on the right and one with the container on the left. In the Animal condition the vehicle pairs were not used, and in the Vehicle condition the Animal pairs were not used. Each slide was presented twice. This resulted in 320 trials for each condition. Additional 16 practice trial slides with another set of pictures of animals and vehicles were created. The congruent trials were the slides with two objects from the same category presented both inside the container and slides in which the pictures were from different categories and one was presented inside and the other outside the container. Incongruent trials were slides in which both pictures were animals or vehicles but one was presented outside and the other inside the container and slides in which the pictures were from different categories and both presented inside the container. Examples of the four conditions are shown in Figure 1.

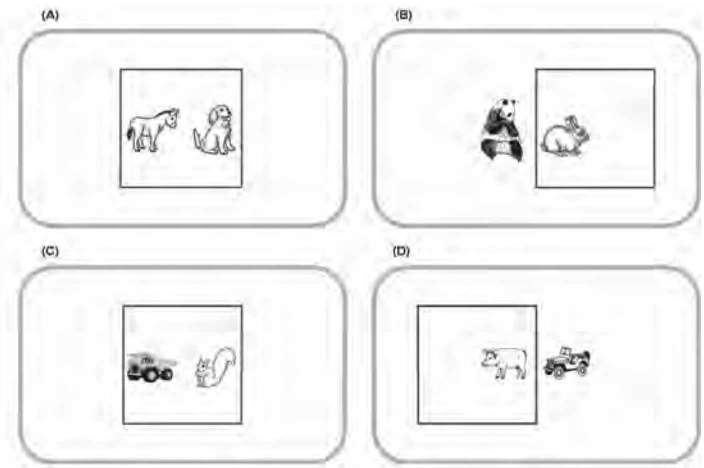

Figure 1. *The four conditions of Experiment 1 in the Animal Task. In the Same-In Condition both Animal pictures were presented in the frame (A), in the Same-In-Out Condition one animal picture was presented in and one outside the frame (B), in the Different-In Condition an animal and a vehicle picture were both presented in the frame (C) and in the Different-In-Out Condition one of the pictures (animal or vehicle) was presented in and one outside the frame (D). The pairs of pictures were horizontally centred. The frame was either presented in the centre or 4 cm from the centre to the left or right on the screen.*

Procedure

The instruction and stimuli were presented on a computer screen. Participants were told that two categories were used in this experiment; animals and vehicles. Participants were randomly assigned to the Animal or Vehicle Condition. In the Animal Condition participants had to decide if the two pictures presented together on the screen were both animals or not. In the Vehicle Condition participants had to decide whether the two pictures were both vehicles or not. They were told to use the z-button and m-button to respond on a QWERTY keyboard. The mapping of the responses to buttons was counterbalanced. The pictures were presented with the frame at different positions. Participants were told to ignore the frame. They started with the 16 practice trials. Each trial started with a fixation point (+) presented for 500 ms. Then the target slide appeared for 1800 ms or until a response was given. Feedback was given for incorrect answers (*Fout* – Dutch translation for *Incorrect*) and responses slower than 1800 ms (*Te langzaam* – Dutch translation for *Too slow*) which remained on the screen for 1500 ms. There was no delay between the trials. After the practice trials the 320 experimental trials were presented in random order. The same procedure was used for the experimental trials as for the practice trials.

Results

We analyzed all reaction times of correct responses within 2 standard deviations from each subject's mean. This trimming procedure resulted in a removal of 5.6% of the correct reaction times in the Animal Condition and 4.8 % in the Vehicle Condition. The means and error rates with the within-subject standard error of the mean (See Loftus & Masson, 1994) for each Task Condition are shown in Figure 2.

The reaction times and error rates were submitted to a 2 (Category: Same vs. Different) x 2 (Container: Both Inside vs One Outside) repeated measures ANOVA with Task (Animal vs. Vehicle) as a between factor. In the reaction times we obtained an interaction effect of Category and Container, $F(2, 38) = 25.79$, $MSE = 180.3$, $p < .001$. This interaction effect was not significantly different between the Animal Task and the Vehicle Task, $F < 1$. With paired sample t-tests with Bonferroni correction for multiple comparison we found that participants responded faster to pictures from the same category that were both presented inside the container than when one was presented outside the container, $t(19) = 7.50$, $SE = 3.0$, $p < .001$, whereas participants did not respond differently to pictures from different categories both presented inside the container or one outside, $p > .25$. Furthermore we found that participants responded faster to pictures if they were presented both inside the container than when one was presented outside the container, $F(2, 38) = 23.61$, $MSE = 234.9$, $p < .001$. We also found an overall effect of Category, $F(2, 38) = 14.80$, $MSE = 528.5$, $p < .001$. The interaction effect of Category and Task Condition, $F(2, 38) = 5.03$, $MS = 2657.9$, $p < .05$ shows that only in the Animal Task Condition participants responded faster to pictures from the same category than to pictures from different categories, $F(1, 19) = 16.16$, $MSE = 606.3$, $p < .01$, while in the Vehicle Task Condition there was no difference in reaction times between the Same and Different Category, $F(1, 19) = 1.51$, $MSE = 450.0$, $p > .10$.

In the error rates we found an interaction effect of Category and Container, $F(2, 38) = 10.47$, $MSE = .004$, $p < .005$. This interaction effect was not significantly different for the Animal Task and the Vehicle Task, $F < 1$. With paired sample t-tests with Bonferroni correction for multiple comparison we found that participants responded more accurately to pictures from the same category that were both presented inside the container than when one was presented outside the container, $t(19) = 3.50$, $SE = .004$, $p < .005$, whereas participants did not respond differently to pictures from different categories that were both presented inside the container or one outside the container, $t(19) = 1.00$, $SE = .005$, $p > .10$.

Furthermore we found an overall effect of Category, $F(2, 38) = 14.81$, $MSE = .000$, $p < .001$. The interaction effect of Category and Task Condition, $F(2, 38) = 6.44$, $MS = .002$, $p < .025$ shows that only in the Animal Task Condition participants responded more accurately to pictures from the same category than pictures from different categories, $F(1, 19) = 17.01$, $MSE = .000$, $p < .0025$ while in the Vehicle Task Condition there was no difference in error rates between the Same and Different Category Conditions, $F(1, 19) = 1.07$, $MSE = .000$, $p < .30$.

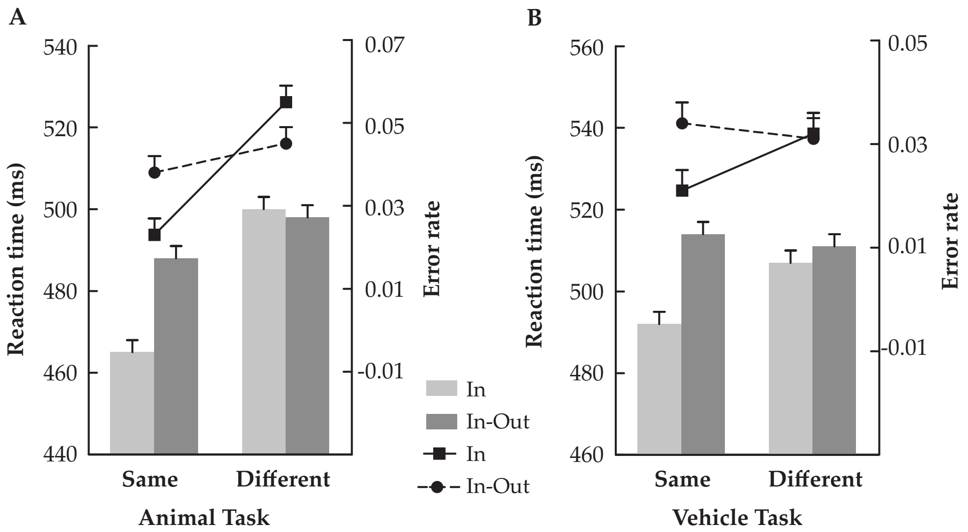

Figure 2. *Mean reaction times in milliseconds and error rates for the Animal Task Condition (A) and Vehicle Task Condition (B) in Experiment 1. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994) for each Task Condition.*

We obtained the expected interaction effect in both the reaction times and error rates. With paired sample *t*-test we found that this interaction effect was predominantly present in the same category condition. According to Rosnow and Rosenthal (1989), means or simple effects influence the condition cells' content. The direction of the interaction effects can be interpreted correctly by calculating the residuals (by subtracting the means or simple effects from the condition cells) as recommended by Rosnow and Rosenthal. The residuals of the cells are shown in Figure 3.

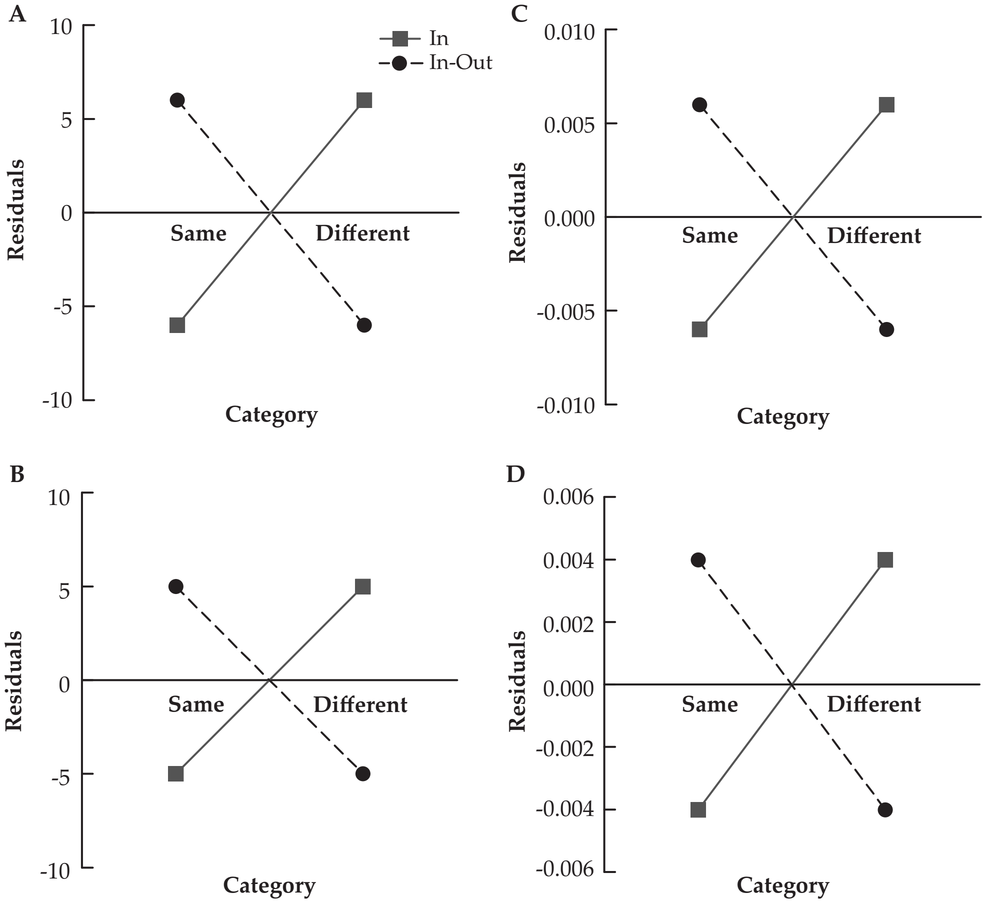

Figure 3. *The residuals of the interaction of Experiment 1 for the reaction times (A) and error rates (B) in the Animal Task and the reaction times (C) and error rates (D) in the Vehicle Task.*

The residuals in the condition cells showed that the participants' reaction times for both the same and different category pairs were influenced by the position of the frame. Performance was better to pictures from the same category when presented in the frame compared to one outside the frame, whereas performance was better

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to pictures from different categories when one was presented outside the frame compared to both in the frame.

Discussion

Experiment 1 showed that the frame (*container*), even though it was irrelevant for the task, still influenced the category decision task. We obtained an interaction effect in both the reaction times and accuracy. Performance was better to pictures from the same category when both rather than one was presented inside the container, whereas performance was not different to pictures from different categories when both compared to one was presented inside the container. These results support the idea that the concept *categories* is metaphorically represented by the image schema *containers*.

Experiment 2

In Experiment 2 we wanted to replicate and extend the findings of Experiment 1. We used the same paradigm as in Experiment 1, but with a different set of pictures. In Experiment 1 the pictures were from a small subcategory of Animal (four legged mammals) and Vehicle (motor driven vehicles). Thus, the same category pictures were visually quite similar. In Experiment 2 we used more varied pictures from different subcategories. For example for Animals, besides four legged mammals, we used also winged animals, an insect, fish, and reptiles and for Vehicles, besides four wheeled transport, we used also aviations, boats and non-motorized transport. By using a more varied set of pictures that were visually less similar we examined whether the conceptual mapping would generalize to broader categories.

Method

Participants

Forty psychology students who did not participate in Experiment 1 received course credits for participating.

Materials

We selected 20 line drawings of animals and 20 line drawings of vehicles from the same sources as in Experiment 1. We made 20 different pairs of animals (using each animal two times) and 20 different pairs of vehicles (using each vehicle two times), and 20 different pairs of an animal with a vehicle. The animals and vehicle pictures were diverse, belonging to different subcategories within their category (e.g., fish, peacock, zebra; airplane, skateboard, ambulance). The picture pairs were presented with a container as in Experiment 1. Again we counterbalanced the position of the picture (left vs. right) and manipulated the position of the container (left, middle, right). Each slide was presented only once. This resulted in 320 trial slides for each task condition (Animal or Vehicle condition). Additionally, 16 practice trial slides with another set of pictures of animals and vehicles were created. Congruent and incongruent trials were defined as in Experiment 1.

Procedure

The procedure was the same as in Experiment 1.

Results and Discussion

We analyzed all reaction times of correct responses within 2 standard deviations from each subject's mean. This trimming procedure resulted in a removal of 4.9% of the correct reaction times in the Animal Condition and 4.6% in the Vehicle Condition. The means and error rates with the within-subject standard error of the mean (See Loftus & Masson, 1994) for each Task Condition are shown in Figure 3.

We performed the same analyses as in Experiment 1. For the reaction times we found an interaction of Category and Container, $F(2, 38) = 12.01$, $MSE = 226.7$ $p < .01$. This interaction effect was not significantly different between the Animal Task and the Vehicle Task, $F(2, 38) = 1.89$, $MS = 428.0$, $p > .10$. Participants were faster to respond to pictures from the same category (Animal or Vehicle) when they were presented both inside the container than when one was presented outside the container, $t(19) = 5.33$, SE = 3.1, $p < .001$, whereas participants did not respond differently to pictures from different categories presented both inside the container or one outside, $t < 1$, $p > .25$.

Furthermore participants were faster to respond to pictures that were presented both inside the container than when one was presented outside the container, $F(2, 38) = 13.39$, $MSE = 192.9$, $p < .01$, and there was an interaction effect for Category and Task Condition, $F(2, 38) = 20.59$, $MS = 21666.2$, $p < .001$. In the Animal Task condition participants were faster to respond to pictures from the same category than pictures from different categories, $F(1, 19) = 23.27$, $MSE = 729.7$, $p < .001$, whereas in the Vehicle Task condition participants were faster to respond to pictures from different categories than to pictures from the same category, $F(1, 29) = 4.41$, $MSE = 1375.3$,

$p < .05$. This might suggest that the vehicle pictures were harder to process than the animal pictures.

For the error rates we did not find an interaction effect of Container and Category, $F < 1$. We did find a main effect of Category, $F(2, 38) = 9.53$, $MSE = .004$, $p <.005$. Participants responded more accurately to pictures from the same category than from different categories. We also found an interaction effect of Category and Task Condition, $F(2, 38) = 4.62$, $MS = .004$, $p < .05$. In the Animal Task Condition participants responded more accurately to pictures from the same category than from different categories, $F(1, 19) = 12.05$, $MSE = .001$, $p < .005$, while in the Vehicle Task Condition the difference was not significant, $F < 1$.

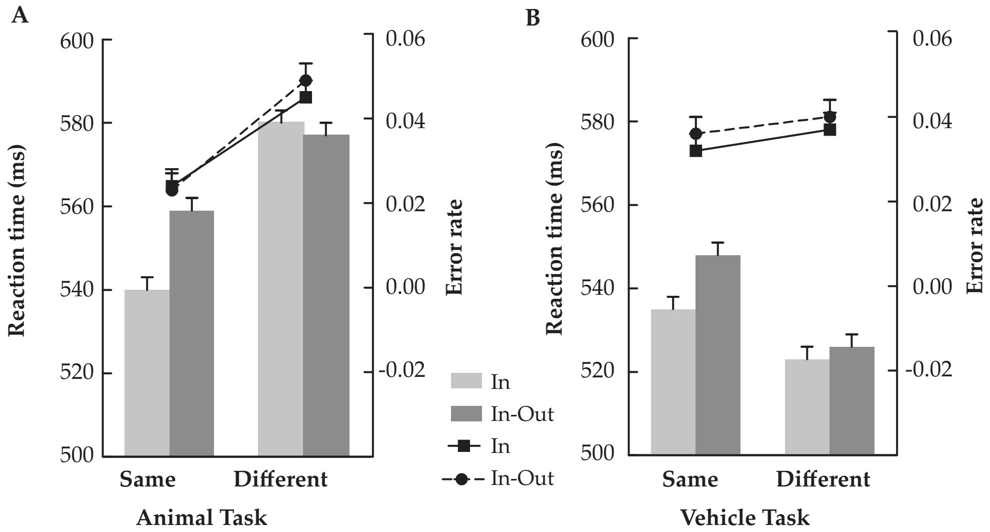

Figure 4. *Mean reaction times in milliseconds and error rates for the Animal Task Condition (A) and Vehicle Task Condition (B) in Experiment 2. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994) for each Task Condition.*

As in Experiment 1 we found that the interaction effect in the reaction times was predominantly present in the same category condition. Besides the interaction effect of Category and Container, we found a main effect and another interaction effect. This again could have influenced means or simple effects in the condition cells' content. (Rosnow & Rosenthal, 1989). We calculated the residuals in order to interpret the direction of the interaction effect correctly. The residuals of the cells are shown in Figure 5.

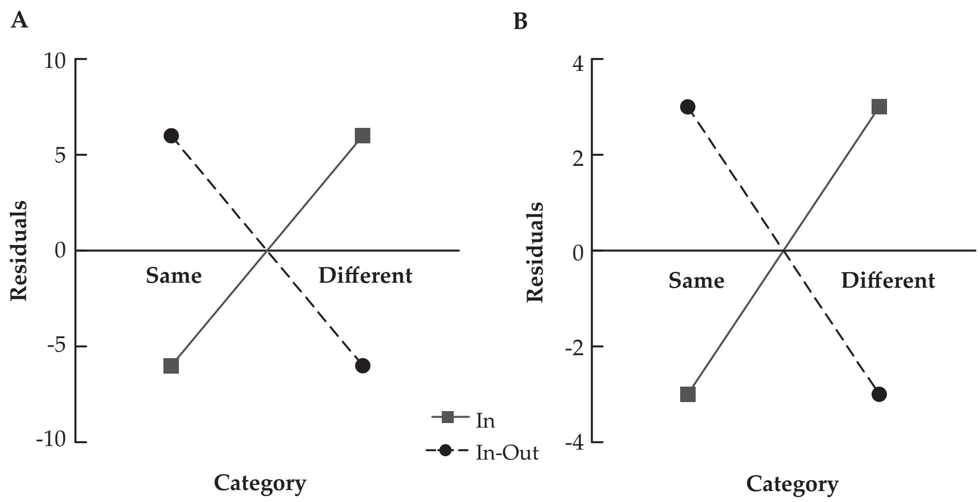

Figure 5. *The residuals of the interaction of Experiment 2 for the reaction times in the Animal task (A) and the reaction times in the Vehicle Task (B).*

The residuals in the condition cells showed that the participants' reaction times for both the same and different category pairs were influenced by the position of the frame. Participants responded faster to pictures from the same category (Animal or Vehicle) when both compared to one were presented inside the frame, whereas participants responded faster to pictures from different categories when one compared to both was presented inside the frame. Although there might have been a difference in visual complexity between the trials in which one picture was presented outside and one presented inside the frame compared to trials in which both pictures were presented inside the frame, such potential difference would cause a main effect of frame position rather than an interaction. Thus, it cannot explain the significant interaction effect between Category and Container.

Thus, the results of Experiment 2 showed that the container influenced the reaction times in the category decision task even with less similar pictures from different subcategories within the categories. This provides further evidence that the concept *categories* is metaphorically represented by *containers*.

Experiment 3

In Experiments 1 and 2 two pictures were presented both inside the frame or one inside and one outside the frame. Although these results are consistent with the metaphorical mapping of *containers* on *categories*, there is an alternative explanation. The frame around the picture could have induced a visual grouping effect. The performance on pictures from the same category might have been facilitated by this visual grouping effect of the frame. In Experiment 3 we presented one picture at a time for which participants had to decide whether it represented an animal or not. The picture was presented inside or outside the frame. Since we present each picture individually there was no visual grouping effect. Although we used only one picture, and the task was different from Experiment 1 and 2, we still were able to manipulate congruency of the frame position with the image schema. In Experiment 3 we made sure that the focus was on one specific category. Participants had to decide whether the picture presented an animal or not. We used exemplars from various other categories as non-animals to prevent participants from switching their focus category (e.g., vehicle or non-vehicle if all non-animals had been vehicles). Whenever a single picture was presented, this picture would be judged as *belonging to the category* or *not belonging to the category*. According to the CMT, belonging to the category should be represented by being inside the bounded region and not belonging to the category should be represented by being outside the bounded region. Thus, in the animal decision task a picture of an animal inside the frame or a picture of a non-animal outside the frame are congruent trials, and a picture of an animal outside the frame or a picture of a non-animal inside the frame are incongruent trials.

As in Experiment 1 and 2 the congruent and incongruent conditions in Experiment 3 were equal in visual complexity. As shown in Figure 6 in half of the congruent and half of the incongruent trials the picture was inside the frame and in half of the congruent and half of the incongruent trials the picture was outside the frame. Therefore differences in visual complexity again are not correlated with image schema congruency. If the results in Experiment 1 and 2 were not merely due to a visual grouping effect we expected a similar interaction between category and frame position in Experiment 3.

Method

Participants

Forty psychology students who did not participate in Experiment 1 or 2 received course credits for participating.

Materials

We selected the same 10 line drawings of animals as were used in Experiment 1. In addition we selected 10 line drawings of non-animals (vehicles, vegetables, and fruit) from the same sources as in Experiment 1. The single pictures were presented with a container as in Experiment 1 and 2. We manipulated the position of the container (left, middle, right). Each picture was presented eight times; four times with the container in the middle, two times with the container on the left, and two times with the container on the right. In this way there were an equal number of pictures presented inside the container as outside the container. This resulted in 320 trials. Additionally, 16 practice trial slides with a different set of pictures of animals and vehicles were created. The congruent trials were the slides with an animal picture presented inside the container and slides with a non-animal picture presented outside the container. Incongruent trials were slides with an animal picture presented outside the container and slides with a non-animal picture presented inside the container. Examples of the four conditions are shown in Figure 6.

Procedure

The instruction and stimuli were presented on a computer screen. Participants were instructed to decide whether a picture belonged to the animal category or not. They were to use the z-button and m-button to respond. The mapping of the responses to buttons was counterbalanced. Each picture was presented with the frame at different positions. Participants were told to ignore the frame. They started with the 16 practice trials. Each trial started with a fixation point (+) presented for 500 ms. Then the target slide appeared for 200 ms followed by a blank screen for 1000 ms or until a response was given. Feedback was given for incorrect answers (*Fout* – Dutch translation for *Incorrect*) and responses slower than 1200 ms (*Te langzaam* – Dutch translation for *Too slow*) which remained on the screen for 1000 ms. There was no delay between the trials. After the practice trials the 320 experimental trials were presented in random order. Participants could take a break after 160 experimental trials. During the break overall feedback was given over the 160 trials and participants were encouraged to do better if they made more than 4 errors. The same procedure was used for the experimental trials as for the practice trials.

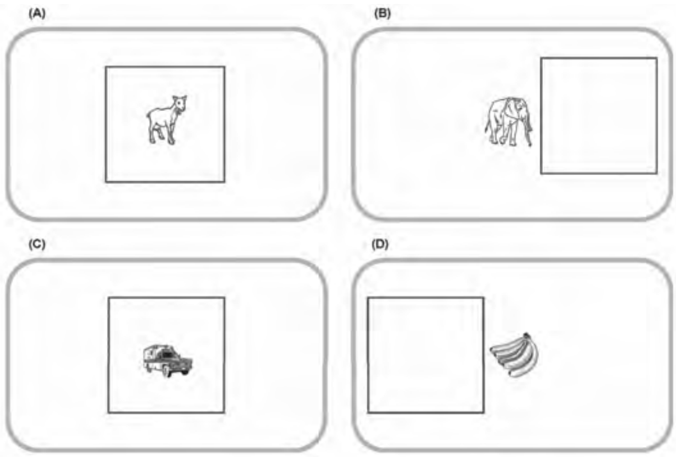

Figure 6. *The four conditions of Experiment 3. In the Animal-In Condition an Animal picture was presented in the frame (A), in the Animal-Out Condition an animal picture was presented outside the frame (B), in the Non-Animal-In Condition Non-Animal picture was presented in the frame (C) and in the Non-Animal-Out Condition a Non-Animal picture was presented outside the frame. The pictures were horizontally centred. The frame was either presented in the centre or 6 cm from the centre to the left or right on the screen.*

Results and Discussion

We analyzed all reaction times of correct responses within 2 standard deviations from each subject's mean. This trimming procedure resulted in a removal of 4.2% of the correct reaction times. The means and error rates with the within-subject standard error of the mean (See Loftus & Masson, 1994) for each Task Condition are shown in Figure 7.

The reaction times and error rates were submitted to a 2 (Category: Animal vs. Non-Animal) x 2 (Container: Inside vs. Outside) repeated measures ANOVA. For the reaction times the interaction effect of Category and Container approached significance, $F(1, 39) = 3.00$, $MSE = 247.4$, $p < .10$. Paired samples t-tests with Bonferroni correction for multiple comparison showed that participants were faster to respond to an animal picture when presented inside the container than when presented outside the container, $t(19) = 3.35$, $SE = 2.8$, $p < .0025$, whereas participants did not respond differently to a non-animal picture presented inside or outside the container, $t < 1$. Furthermore, participants were faster to respond to animal pictures than to non-animal pictures, $F(1, 39) = 17.95$, $MSE = 504.4$, $p < .001$, and participants were faster to respond to a picture presented inside the container than a picture presented outside the container, $F(1, 39) = 11.51$, $MSE = 85.7$, $p < .0025$.

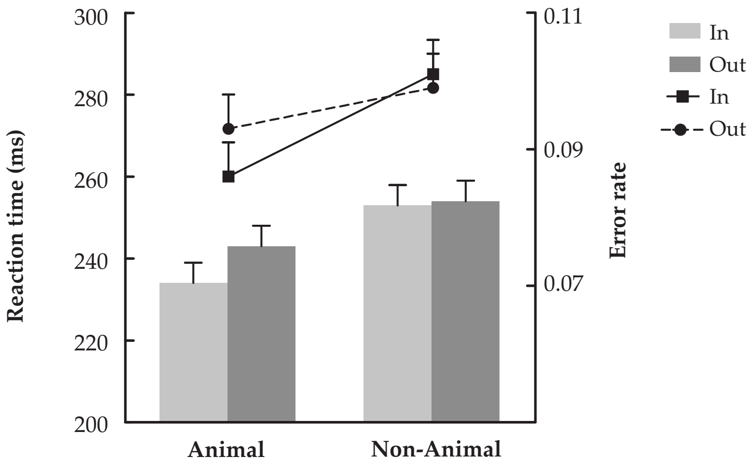

Figure 7. *Mean reaction times in milliseconds and error rates for the category decision tasks in Experiment 3. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994).*

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For the error rates we did not find an interaction effect of Container and Category, $F < 1$, nor a main effect of Category, $F(1, 39) = 1.55$, $MSE = .003$, $p > .10$, nor a main effect of Container, $F < 1$. As in Experiments 1 and 2 we also calculated the residuals, these are shown in Figure 8.

Experiment 3 showed that the frame (*container*) influenced the reaction times in the category decision task even when only one picture was presented. Thus, the results of Experiment 3 show that the effects obtained in Experiments 1 and 2 were not due to a grouping effect. We also found a main effect of frame position. Since we used an equal number of congruent and incongruent trials for each frame position, the frame position by itself cannot have caused the interaction effect. The present results provide further evidence that the concept *categories* is metaphorically represented by *containers*.

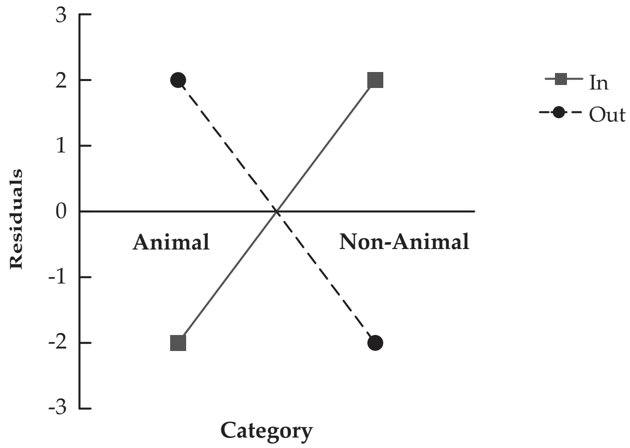

Figure 8. *The residuals of the marginal interaction effect of the reaction times of Experiment 3.*

Experiment 4

In the next experiment we wanted to eliminate one other alternative explanation. In Experiments 1, 2, and 3 participants had to make a binary decision (Same/Different Category or Animal/Non-animal) over stimuli with binary values (Both Inside/ One Outside or simply Inside/Outside). To simplify the task, participants might have taken advantage of these binary values by aligning them (e.g., Same Category with Both Inside). Such alignment of polarities has been suggested by Proctor and Cho (2006) as an explanation for a variety of binary decision tasks. There are two reasons why such alignment seems unlikely in the present series of experiments. First, each combination of binary values was equally likely, so there was no benefit to participants to use a specific alignment. Second, if participants used such alignment they should have made many errors. In contrast to this prediction, however, the error rates were extremely low (well below 0.1% in most cases). Nevertheless, to exclude alignment as an explanation we performed Experiment 4 in which container position was manipulated at more than two levels. In Experiment 4 pictures from the same category and different categories were not only presented *both inside* or *one outside* the frame (as in Experiments 1 and 2) but also *both outside* the frame. If participants in Experiment 1 and 2 used alignment of the binary values, the interaction effect between category (same vs. different) and container (both inside vs. one outside) should disappear.

On the other hand, if the image schema affects performance, we expect to obtain again an interaction between category and frame position. Moreover, we expect the effect of frame position to be graded. In terms of the metaphorical mapping, two things inside the container are members of the same category, whereas something outside the container is not in the same category as something inside the container. However, two things outside the container might be members of the same or different categories (e.g., two things that are not food could be two animals or one animal and one vehicle). Therefore, we expect that same category decisions will be fastest when both pictures are inside the container, slowest when one picture is inside the container, and somewhat intermediate when both pictures are outside the container. For different category decisions the effect should be opposite. As in the previous experiments visual complexity was equated for the congruent and incongruent trials and thus should not affect the predicted interaction effect.

Method

Participants

Thirty psychology students who did not participate in Experiments 1, 2, or 3 received course credits for participating.

Materials

We selected the same line drawing (10 animals and 10 vehicles) as in Experiment 1. The same 10 pairs of animals (using each animal two times) and 10 pairs of an animal with a vehicle were used as in the Animal condition of Experiment 1. The pictures were presented together with the frame in the same way as in Experiment 1 with an additional third condition in which the frame was moved 8 cm to the left or right from the centre, so that none of the pictures was in the container. Again, the relative position of the two pictures was counterbalanced across repetitions of the pair, but without mirroring the pictures as we did in Experiment 1. Each slide was presented twice. This resulted in 480 trials. Additionally, 18 practice trial slides with the same set of pictures as in the practice trials of the Animal Condition of Experiment 1 were created. Examples of the six conditions are shown in Figure 9.

Procedure

The procedure was the same as in the Animal Condition of Experiment 1. After the 18 practise trials, the 480 experimental trials were presented in random order. Participants could take a break after 240 experimental trials.

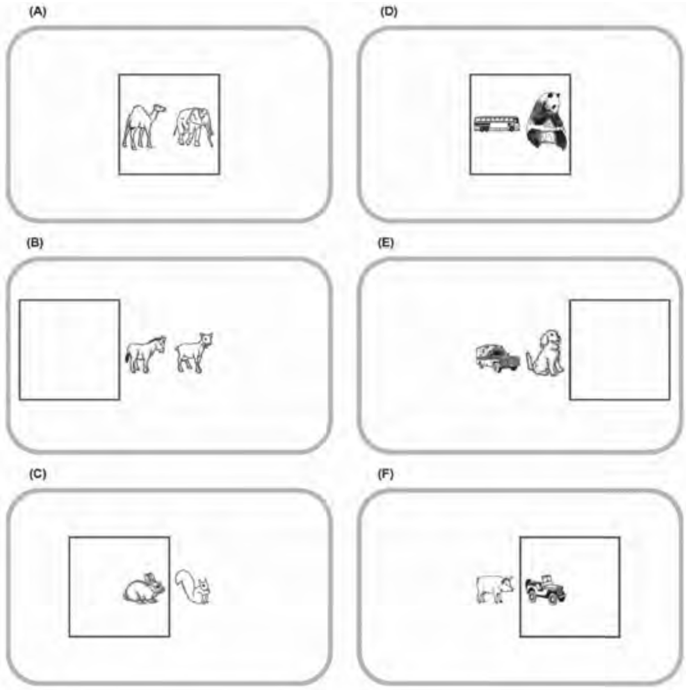

Figure 9. *The six conditions of Experiment 4. In the Same-In Condition two animal pictures were presented in the frame (A), in the Same-Out Condition both animal pictures were presented outside the frame, (B), in the Same-In-Out Condition one animal picture was presented in and one outside the frame (C) in the Different-In Condition an animal and a vehicle picture were both presented in the frame (D) in the Different-Out Condition both the animal picture and the vehicle picture were presented outside the frame, (E),and in the Different-In-Out Condition one of the pictures (animal or vehicle) was presented in and one outside the frame (F). The pairs of pictures were horizontally centred. The frame was either presented in the centre, 4 cm from the centre to the left or right on the screen, or 8 cm from the centre to the left or right on the screen.*

Results and discussion

We analyzed all reaction times of correct responses within 2 standard deviations from each subject's mean. This trimming procedure resulted in a removal of 4.7% of the correct reaction times. The means and error rates with the within-subject standard error of the mean (See Loftus & Masson, 1994) for each Task Condition are shown in Figure 10. All t-tests used a Bonferroni correction for multiple comparisons.

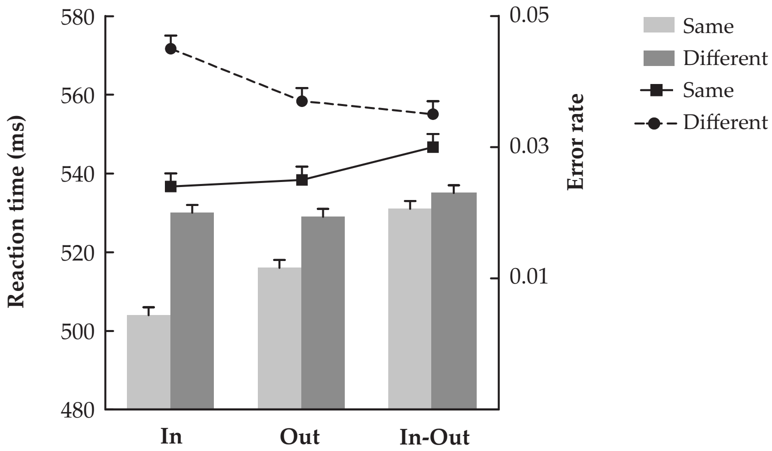

Figure 10. *Mean reaction times in milliseconds and error rates for the category decision tasks in Experiment 4. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994).*

The reaction times and error rates were submitted to a 2 (Category: Same vs. Different) x 3 (Container: Both Inside, Both Outside, One Outside) repeated measures ANOVA. In the reaction times we obtained an interaction effect of Category and Container, $F(2, 58) = 13.44$, $MSE = 137.6$, $p < .001$. This interaction was due to significant effects of frame position on same category decisions. Participants responded faster to pictures from the *same category* that were both presented *inside* the container ($M = 504$) than when *one was presented outside* the container ($M = 531$), $t(29) = 7.00$, $SE = 3.8$, $p < .001$. Additionally we found that the effect in the *same category* condition of the three positions of the frame was graded. Participants responded faster when the pictures from the s*ame category* were *both presented outside* the container ($M = 516$) than when *one was presented outside* the container ($M = 531$), $t(29) = 6.38$, $SE = 2.3$, $p < .001$, and when they were *both presented inside* the container (M = 504) than when they were *both presented outside* the container (M = 516) , $t(29) = 3.75$, $SE = 3.2$, $p < .005$. In contrast, reaction times to pictures from different categories were not significantly affected by frame position, all *p*s > .05.

Furthermore, we found a main effect of Container, $F(2, 58) = 34.27$, $MSE = 107.4$, $p < .001$. Participants responded faster to pictures presented *both inside* the container ($M = 517$) compared to *both outside* ($M = 523$), $t(29) = 2.62$, $SE = 2.08$, $p < .05$, and *one outside* the container ($M = 533$), $t(29) = 7.92$, $SE = 2.0$, $p < .001$. Participants were also significantly faster to respond to pictures presented *both outside* compared to *one* *outside* the container, $t(29) = 6.21$, $SE = 1.61$, $p < .001$. Moreover, participants were faster to respond to pictures from the same category (two animals) than to pictures from different categories (one animal and one vehicle), $F(1, 29) = 10.04$, $MSE = 928.3$, $p < .005$.

In the error rates we found an interaction effect of Category and Container, $F(2, 58) = 5.26$, $MSE = .0002$, $p < .01$. Participants made slightly less errors to pictures from the *same category* that were *both presented inside* the container ($M = .024$) than when *one was presented outside* the container ($M = .030$), this difference approached significance, $t(29) = 2.26$, $SE = .003$, $p < .10$. The other differences were in the predicted direction, but none of these were significant.

Furthermore, we found a main effect of Category, $F(1, 29) = 22.53$, $MSE = .0003$, $p < .001$. Participants responded more accurate to pictures from the same category (two animals) than to pictures from different categories (one animal and one vehicle). As in Experiment 1, 2 and 3 we also calculated the residuals, these are shown in Figure 11.

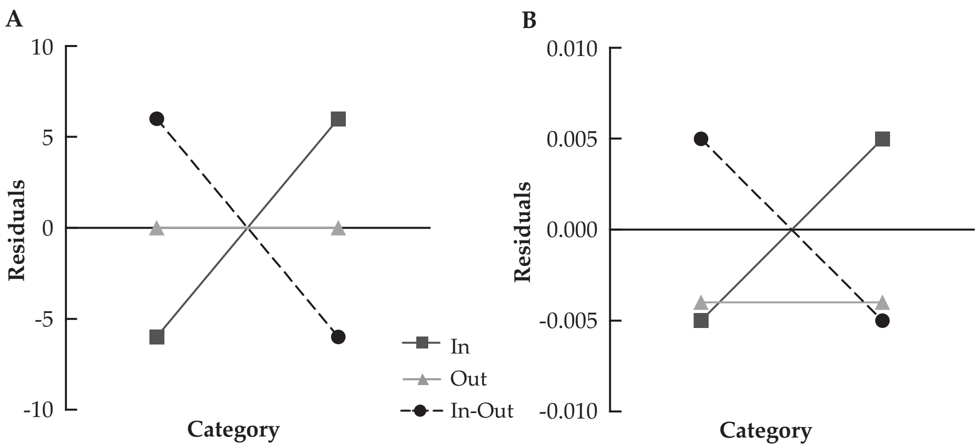

Figure 11. *The residuals of the interaction of Experiment 4 for the reaction times (A) and error rates (B).*

The present experiment showed that the frame (*container*) influenced the reaction times in the category decision task in a graded fashion across three different positions, consistent with the metaphor. These results tell us that the effects obtained in the previous Experiments were not due to alignment of binary values, a visual grouping effect or visual complexity. The interaction between category and container is still present when we used a third value. These data are in line with the idea that we use image schemata of concrete concepts to understand abstract concepts.

General Discussion

In the present study we investigate the mental representation of *categories* in the light of the Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999). The CMT holds that abstract concepts (e.g., *categories*) are metaphorically represented by concrete concepts (e.g., *containers*). Participants had to perform a category decision task on pictures that were presented together with a container. In Experiments 1 and 2 category decisions were affected by whether both pictures were inside the container or not. Experiment 3 showed that the container also influenced performance on the decision task when only a single picture was presented, excluding the visual grouping explanation. In Experiment 4 we controlled for binary alignment and again obtained an effect of the position of pictures relative to the container. These findings are congruent with the idea that the concept *categories* is metaphorically represented by the concept *containers*. Because our paradigm used pictorial material and an easy task in which the correct response was absolutely clear these results are not likely to be due to activation of linguistic metaphors or use of irrelevant information for response selection.

Besides the expected interaction effect, a main effect of Container was obtained in the reaction times for all experiments. Participants responded faster when pictures were presented inside the container than when one or both pictures were presented outside the container. A possible explanation is that the frame drew people's visual spatial attention more to what was inside the frame than to what was outside. This main effect of Container may explain why responses to pictures from different categories were not faster when one picture was outside the container (congruent condition) than when the pictures were both inside the container (incongruent condition). Probably, the effect of congruence was counteracted by the main effect of Container.

The interaction effects in the present study are consistent with previous research investigating the metaphorical mapping of other abstract concepts with non-linguistic materials. Several studies have shown interactions between concrete and abstract concepts using visual stimuli that contained both the concrete and abstract concept (Boot & Pecher, in press; Casasanto, 2008; Casasanto & Boroditsky, 2008;

Meier, Hauser, Robinson, Friesen, & Schjeldahl, 2007; Schubert, 2006; Crawford et al., 2006, Breaux & Feist, 2008). These effects were congruent with the metaphor (e.g., participants judged animals as more powerful when presented higher compared to lower on the screen). When non-linguistic materials are used, results are no longer due to the use of metaphorical language. In the present study the obtained congruency effects support the idea that metaphorical mapping is conceptual. In some of these previous studies it was not clear whether it was the mental representation of abstract concepts or the response selection process that was affected by image schemata. In some judgment and estimation tasks there may be uncertainty regarding the correct response, for example because participants have too little information or because a response has to be given on a scale with many options. This uncertainty about the correct response might encourage participants to use irrelevant information (e.g., vertical position). The use of irrelevant information in conditions of uncertainty has been shown in the domain of justice (e.g., Van den Bos, 2003; Van den Bos et al., 1997). In the present study such uncertainty was minimized. Moreover, the irrelevant feature (the frame) was not helpful for performance. Nevertheless, participants' performance was influenced by the frame in congruence with the *container* image schema (Lakoff & Johnson, 1999; Lakoff & Núñez, 2000). In addition to recent studies these findings provide evidence for the Conceptual Metaphor Theory of Lakoff and Johnson (1980, 1999). In the present study we found evidence for the conceptual metaphor *containers are categories*. This is assumed to be a primary metaphor, which some researchers have argued is formed directly through everyday experience (Grady, 1997, as cited in Lakoff & Johnson, 1999). There are many more proposed primary metaphors that are assumed to arise from correlations between an abstract and a concrete concept in one experience. For example, when a child is piling up blocks, both the concept *quantity* and *verticality* are active and should become correlated (the addition of blocks on top of the pile also enlarges the number of blocks). In this particular experience the primary metaphor *quantity is verticality* is assumed to be nourished (M. Johnson, 1987) and can be extended to more abstract concepts (e.g., *Prices keep going up*). In this way the abstract concepts are grounded in sensory-motor experiences of concrete concepts (Lakoff & Johnson, 1980, 1999).

Next to these primary metaphors Grady introduced more complex metaphors (e.g., *life is a thief*). Complex metaphors are described as indirectly formed by experience. So far, research that investigated the CMT in language-free designs always investigated primary metaphors. Thus recent evidence for CMT relies basically on findings of primary metaphors. According to Lakoff and Johnson (1999) complex metaphors can be fixed in the mental structure as a conceptual mapping as well. If this is true we should find similar effects of concrete concepts onto abstract concepts for complex metaphors. Unfortunately investigating complex metaphors is a lot more complicated since multiple image schemas are assumed to be active during processing of the abstract concept.

At present it is still an open question to what extent the CMT holds for all metaphors found in language. From an embodied point of view, primary metaphors as fixed mental structures seem more plausible than complex metaphors and multiple metaphors. In fact, for a number of primary metaphors (e.g., *similarity is closeness*, *power is up*, *time is spatial movement*) experimental evidence is available that supports the idea that abstract concepts are understood by conceptual metaphorical mapping, as has been shown in the present study. Although the evidence suggests that the role of primary metaphors is widespread, there are still many primary metaphors that have not yet been investigated. To our knowledge, the present study is the first to provide evidence for the mapping of *containers* on *categories*.

The evidence for the role of primary metaphors has implications for theories on sensory-motor grounding of cognition. Such theories propose that mental representations of concepts are grounded in sensory-motor experience (e.g., Barsalou, 1999; Glenberg, 1997; Goldstone, 1994). In line with this view, the CMT framework proposes that image schemata are formed when the body interacts with concepts in the world. These image schemata construct the mental representation of concepts (Lakoff, 1987). Since abstract concepts are not physical entities, the body cannot perceive or interact with these concepts. The CMT framework (Lakoff & Johnson, 1980, 1999) provides a solution for the mental representation of abstract concepts. In situations where the two concepts co-occur (e.g., kitchen tools and socks are put in different drawers) participants can interact with the concrete concept (e.g., *containers*) while the abstract concept (e.g., *categories*) is present. The correlation between the concepts in this situation provokes a metaphorical link between the concrete and abstract concept. Later, in situations where only the abstract concept is present (e.g., reasoning about categories) this metaphorical link causes the mental representation of the concrete concept (e.g., *container schema*) to be used to understand the abstract concept in that situation. By this mechanism of conceptual mapping, the image schemata can be used metaphorically as well.

Although image schemata refer to basic bodily experiences, they do not represent full and rich sensory-motor experiences. Besides the *container* image schema, the concept *categories* has other features, such as the fact that there is visual similarity among exemplars or that exemplars of a category have the same function. In addition to image schemata, abstract concepts might also be represented by simulations of introspective experiences and specific situations in which the abstract concept plays a role (Barsalou, 1999; Barsalou & Wiemer-Hastings, 1995). Together with these proposals, the growing body of evidence for the role of image schemata supports the idea that, like those for concrete concepts, mental representations of abstract concepts can be grounded in sensory-motor experiences.

Chapter 5

Situational Quantities go Up and Down but Numbers Don't

A modified version of this chapter has been submitted for publication as: Boot, I. & Pecher, D (2010). *A vertical mental number line: differences between situational quantities and simple numbers.* Manuscript submitted for publication.

Abstract

Everyday speech suggests that people think of quantities as vertical positions (e.g., a high amount). We investigated whether this is true for situational quantities, which relate to other entities, and simple numbers, which are entities by themselves and supposedly are represented on a horizontal mental number line. In three experiments participants made quantity decisions on simple numbers (e.g., 5) or situational quantities presented in concrete sentences (e.g., 5 bananas in a dessert), followed by identification of target letters presented at the top or bottom of the screen. Quantity interacted with spatial position only for situational quantities but not for simple numbers. We conclude that the mental representations of simple number and situational quantity are represented by different spatial schemas.

If you would ask someone whether seven pairs of shoes is a lot or a little, the person would probably say that this depends on the context. For example it would be a little to have in a shoe shop but a lot to bring on a weekend to Paris (at least for sensible people). The mental representation of situational quantities like this example might be different from that of simple number (e.g., *7*). Simple numbers are more abstract (e.g., mathematics) and have absolute values (*7* is always *7*). In contrast, situational quantities refer to concrete situations and have relative values instead, depending on the entity and context. In the present paper we investigated this difference in mental representation.

Many researchers have argued that simple numbers are represented on a mental number line, a horizontal line with small numbers on the left and large numbers on the right of the continuum. Evidence for such representational schema is provided by the SNARC (Spatial Numerical Association of Response Code) effect (e.g., Dehaene, Bossini, & Giraux, 1993; but see Landy, Jones, & Hummel, 2008), the *numerical distance effect* (e.g., Moyer & Landauer, 1967), and biased response and attention effects (Fischer, Castel, Dodd & Pratt, 2003; Salillas, El Yagoubi & Semenza, 2008). For example, people respond to small numbers faster with their left than with their right hand but the opposite is found for large numbers.

Given such horizontal representation of numbers, it is surprising that in daily speech people often use vertical rather than horizontal words to talk about quantities. For example, people might say *prices are high, mortgage rates dropped, incomes can rise* or *heat is turned up or down* (M. Johnson, 1987; Lakoff & Núñez, 2000; Bergen, Lindsay, Matlock & Narayanan, 2007). Why would they not say that *incomes are moving to the right* and *heat is turned left*? The systematic way in which vertical terms are used for quantities suggests that they are represented in terms of verticality (Lakoff & Johnson, 1980).

Evidence for the horizontal mental number line has been obtained with simple numbers (e.g., 2). An important difference between such numbers in SNARC experiments and linguistic expressions about quantity is that simple numbers are used as entities by themselves in purely numerical contexts, whereas in linguistic expressions numbers are used in a more everyday context where they modify some entity in terms of relative quantity (e.g., nine apples is many as a snack, but few as a supermarket's stock). Thus, simple numbers have absolute and abstract values, whereas situational quantities are relative and more concrete. In concrete experiences, quantity and verticality often appear together. For example, when a child is building a block tower, the height of the tower will rise in accordance with the number of blocks. Such embodied experiences might be essential in the formation of mental representations (e.g., Barsalou, 1999; Glenberg, 1997; Goldstone, 1994). Experiences with simple numbers, on the other hand, may be more often horizontal such as on a keyboard or number line display in school (Landy et al., 2008). Thus, it is possible that the vertical experiences with concrete quantities do not carry over to abstract number representations but instead are replaced by a horizontal representation.

The relation between situational quantities and simple numbers and the role of verticality is not only of theoretical interest, but also has implications for education. In schools students learn at least two different types of mathematics: abstract computations and story problems. Although both skills require understanding and calculations some children are better at solving computations and others at solving story problems (e.g., Marshall, 1984). Because computation deals with simple numbers whereas story problems deal with situational quantity such individual differences could be due to differences in representational formats.

In the present study we investigated the role of verticality in mental representations of situational quantity and simple numbers. In a series of experiments participants made relative judgments about quantity in concrete contexts (*is 9 apples few or many to eat?*) or about simple numbers (*is 61 more or less than 50?*). We then measured the activation of verticality in a perceptual task, letter identification. Specifically, we investigated whether *few* and *many* judgments differentially affected identification of visual stimuli in low or high spatial positions. Following Meier and Robinson (2004) who obtained a differential effect of valence on identification of stimuli in high and low positions, we expected that vertical representations of quantity would lead to better performance for stimuli in congruent than incongruent spatial positions.

Experiment 1

In Experiment 1 we presented sentences in which different quantities were mentioned. Participants had to decide whether the quantity was a *few* or *many* (the Dutch words *weinig* and *veel* were used, which do not refer to height and can be used for both singular and plural nouns). Whether the quantity was a few or many depended on the context it was presented in. The same absolute quantities appeared in the Few (e.g., *The man had two books on the bookshelves.*) and the Many condition (e.g., *The man read two books a day.*). Thus, participants could not make strategic use of the size of the simple number but had to judge the quantity in context. Quantity decisions were followed by identification of a letter *p* or *q* which appeared at the top or bottom of the screen (as in a study by Meier & Robinson, 2004).

If *quantity* is represented by *verticality* we expect that attention would shift to the *top* when the quantity in the sentence was *many* and to the *bottom* when the quantity in the sentences was a *few*. This attention shift would facilitate responses to targets in the congruent position. It should be noted that we did not use quantities that explicitly referred to vertical space (e.g., *the tree was 6 meter*). Neither did we use verbs nor nouns that referred to vertical space (e.g., *dropped*, *up*). Thus, any effect on vertical attention was due to the representation of the concept quantity rather than to the literal orientation of objects mentioned in the sentence.

Method

Participants

Thirty-two undergraduate psychology students at the Erasmus University Rotterdam received course credit for participating. All participants were fluent speakers of Dutch.

Materials

All instructions and materials were in Dutch. We created 40 sentences in the Few condition containing a relatively small quantity and 40 sentences in the Many condition containing a relatively large quantity (examples shown in Table1). The same absolute quantities were used in the Few and Many conditions, so whether it was a *few* or *many* depended on the sentence context and not on the absolute number. Different kinds of quantity indications were used (e.g., *100 meters*, *10 minutes, 10 euro*). No words were used that referred to vertical position or movement. Across participants, sentences were counterbalanced over the target letter identity, target letter position and block order. Twenty-one additional sentences were created for practice and instruction.

Table 1. *Some examples of the material used in the sentence task of Experiment 1 and 3. In Experiment 3 a Referent or a Referent Filler preceded the prime in the Few and Many Condition. Only English equivalents are given.*

Example No.	Condition	Condition	Sentence
1.	**Few**	**Referent**	Two pies were gotten for the guests.
		Referent Filler	The foursome finished ½ of a pie.
		Prime	The guests ate ½ of a pie.
	Many	**Referent**	The man often ate a slice of pie after dinner.
		Referent Filler	The family finished ½ of a pie.
		Prime	The man ate ½ of a pie after dinner.
2.	**Few**	**Referent**	Most dishes take ½ an hour of preparation.
		Referent Filler	Within 15 minutes he had washed the dishes.
		Prime	Within 15 minutes she had made dinner.
	Many	**Referent**	It is possible to feed the fish in 6 seconds.
		Referent Filler	She had done the shopping for dinner within 15 minutes.
		Prime	Within 15 minutes she had fed the fish.
3.	**Few**	**Referent**	People often park their car 10 cm across the parking line.
		Referent Filler	The glass was filled up to 1 cm beneath the rim.
		Prime	The man parked his car 1 cm across the parking line.
	Many	**Referent**	A nurse sometimes injects 1 mm wide of the vein.
		Referent Filler	The secretary stapled the paper 1 cm under the top.
		Prime	The nurse injected 1 cm wide of the vein

Procedure

Participants were tested individually on PCs separated by walls. Participants responded by pressing a button on a response box that had five aligned buttons. Four different response mappings were used, such that participants used two fingers of each hand to respond, and used one hand for each task. Response mapping was varied between subjects. Buttons were labeled with the letter *V* (*veel* – Dutch for *many*) the letter *W* (*weinig* – Dutch for *few*), the letter *p* and the letter *q*. Participants were instructed to decide if quantities in sentence contexts were *few* or *many*. A sentence was presented in the center of the screen until a response was made. Then, 200 ms after the response, the letter *p* or *q* was presented at the top or bottom of the screen which had to be identified as quickly and accurately as possible. The next trial started 500 ms after the response to the target was made or after the feedback. Feedback (*fout* – Dutch for *error*) was provided for 1500 ms after incorrect responses to the letter targets. Twenty practice trials preceded the 80 experimental trials. The experimental sentences were presented in random order in two blocks, with the restriction that sentences that contained the same quantity were presented in different blocks. Between the two blocks participants could take a break and feedback on their accuracy in the first block was provided.

Statistics

A 2 (Position: Top and Bottom) by 2 (Quantity: Many and Few) repeated measures ANOVA on the reaction times and error rates was performed to examine the influence of quantity on target identification. Only reaction times of correct responses on the prime and target that fell within 2 standard deviations from the subject's mean were included in the analyses. All *t*-tests are performed with post-hoc LSD comparisons (Loftus & Masson, 1994).

Results

Four items were removed from the analysis because fewer than 60% of the participants gave the intended correct answer (Two in the Many and two in the Few Condition). Incorrect responses (8.1%) and remaining outliers (4.2%) were excluded. Mean reaction times and error rates for all experiments are presented in Figure 1. In the reaction times we obtained a significant interaction, $F(1, 31) = 4.61$, $MSE = 825.4$, $\eta^2 = .13$, $p < .05$. Participants were faster to identify a letter presented at the top when they first read a sentence in which the quantity was many compared to a few, $t(31) = 5.08$, $SEM = 5.08$, $\eta^2 = .24$, $p < .0001$. Responses to letters at the bottom of the screen were not different between conditions, $t(31) = 1.49$, $SEM = 5.1$, $\eta^2 = .03$, $p > .10$. Responses to letters were faster in the Many than in the Few condition, $F(1, 31) = 7.53$, $MSE = 1453.8$, $\eta^2 = .20$, $p < .025$. There was no significant effect of letter position, $F(1, 31) = 12856.68$, $MSE = 3340$, $\eta^2 = .11$, $p < .10$.

In the error rates we also obtained an interaction effect between position and quantity, $F(1, 31) = 5.06$, $MSE = .000$, $\eta^2 = .14$, $p < .05$. None of the other effects reached significance.

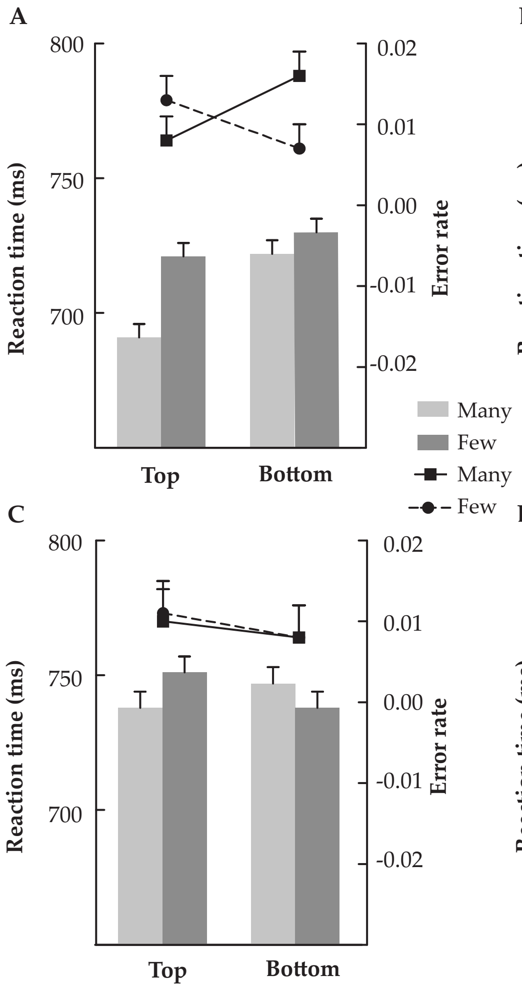

Figure 1. *Mean reaction times in milliseconds (bars) and error rates (lines) of the identification task (p/q) of Experiment 1 (A), Experiment 2 (B), Experiment 3 with sentence primes (C) and Experiment 3 with simple number primes (D).*

Experiment 2

Next we investigated if the quantity-position congruency effect could be replicated with simple numbers instead of situational quantity. In order to keep the quantity judgment task similar to that in Experiment 1, participants compared each number to 50 (the numbers 0-100 were used) to make quantity judgments.

Method

Participants were 32 students from the same pool who had not participated in Experiment 1. The procedure was the same as in Experiment 1, except that the numbers 0-49 and 51-100 were used and participant judged whether the number was a few or many compared to 50. Twenty numbers were selected for practice; the remaining 80 numbers were selected as experimental trials. Counterbalancing was the same as in Experiment 1, and in addition odd and even numbers were also counterbalanced across letter position.

Results

Incorrect responses (5.3%) and remaining outliers (4.6%) were removed. In the reaction times we obtained no interaction effect, $F < 1$ nor in the error rates, $F(1, 31) = 1.13$, $MSE = .001$, $\eta^2 = .04$, $p > .25$

In a second analysis we investigated if the quantity judgments were affected by the numerical distance between the referent and the number. We submitted the trimmed RTs to a repeated measures ANOVA (with 5 levels of Distance, 1 = closest, 5 = most distant) and obtained a numerical distance effect with these materials, $F(4, 124) = 5.21$, $MSE = 28005.6$, $\eta^2 = .14$ $p < .05$. The error rates showed no significant effect, $F(4, 124) = 1.20$, $MSE = .002$, $p > .25$. The numerical distance effect indicates that numbers do have some spatial representation, however, the lack of congruency effects on letter identification suggests that this representation is more likely horizontal than vertical.

Experiment 3

In the next experiment we controlled for two differences between Experiment 1 and 2. First, in Experiment 1 the reference point was implicit, whereas it was explicitly provided in Experiment 2. Second, the reference point was variable in Experiment 1 because it depended on the context. In Experiment 2, however, it was fixed (i.e., it was always 50). In Experiment 3 we again presented the sentences from Experiment 1 and simple numbers as in Experiment 2, but an explicit reference point was given for both types of stimuli. In addition, the value of the reference point varied between trials for both types of stimuli.

Method

Participants were 32 students from the same pool who had not participated in Experiments 1 and 2. In one block, the materials and procedure were the same as in Experiment 1 except that the quantity sentence was preceded by a referent sentence. For each sentence two different referent sentences were selected. On experimental trials, the referent contained a *different quantity* in the *same context* as the prime sentence. To prevent participants simply comparing the amount without considering the context, half of the sentences were used as fillers that had the *same* quantity in a *different* context. Sentences used as experimental trials and fillers were counterbalanced between subjects. In the other block, the materials and procedure were the same as in Experiment 2 except that each number was preceded by a referent number. Referent numbers could be at large or small numerical distances from the prime numbers, and were chosen such that the absolute size of the referent was not predictive of the response. Participants were instructed to press the middle button (labeled *sentence1/number1*) after they processed the referent (sentence or number) and to use it as a comparison for the next stimulus. Assignment of sentences to experimental and filler trials was counterbalanced across participants, as was the order of sentence and number blocks. At the end of the experiment we asked participants whether they had any hypotheses about the purpose of the experiment.

Results

None of the students guessed the purpose of the experiment correctly. Incorrect responses (4.4 % in the Sentence Task and 5.0 % in the Number Task) and remaining outliers (3.8 % in the Sentence Task and 7.0 % in the Number Task) were removed. For trials that were preceded by sentences, the interaction effect between quantity and target position approached significance, $F(1, 63) = 3.60$, $MSE = 2349.9$, $\eta^2 = .46$, $p = .062$. Participants responded faster to a letter at the top when they first read a sentence in the Many condition compared to the Few condition, $t(63) = 2.22$, $SEM = 6.06$, $\eta^2 = .37$, $p < .05$, whereas participants responded slightly faster to a letter at the bottom when they first read a sentence in the Few compared to the Many condition $t(63) = 1.57$, $SEM = 6.06$, $\eta^2 = .14$, $p > .05$. In the error rates we obtained no significant interaction effect, $F < 1$.

For trials that were preceded by numbers, the interaction effect was not significant in the reaction times, $F < 1$, or in the error rates, $F(1, 63) = 1.65$, $MSE = .001$, $\eta^2 = .244$, $p > .20$. A main effect showed that participants responded faster to letters at the bottom than at the top, $F(1, 63) = 8.24$, $MSE = 1672.8$ $\eta^2 = .48$, $p < .01$. In addition, a marginal main effect of quantity showed that participants were more accurate to identify the letter in the Few than in the Many condition, $F(1,63) = 3.72$, $MSE = .001$ $\eta^2 = .48$, $p = .058$.

Discussion

We found that identification of targets at different vertical positions was influenced by quantity presented in a sentence context but not by simple numbers. When a sentence referred to a relatively large quantity performance was better for stimuli at the top of the screen, and when a sentence referred to a relatively small quantity performance was better for stimuli at the bottom of the screen. This indicates that vertical spatial attention was affected by the vertical representation of situational quantity. Whether a simple number was relatively large or small, however, did not affect vertical spatial attention. This suggests that the mental representations of situational quantity and simple numbers use different spatial orientations.

The interaction between situational quantity and spatial position was not due to the response itself, as has been suggested for the SNARC effect (Landy et al., 2008). First, the target response (p or q) was unrelated to letter position, quantity decision, and the congruency between position and quantity. Even potential response mapping between the response on the prime (few or many) and response on the target (p or q) could not explain the interaction with the position of the target. Second, if the interaction effect of quantity with position was due to response-mapping we should have obtained the interaction effect for both situational quantities as well as for simple numbers.

Finally, the interaction effect could not be explained by simulation of other aspects of the sentence content, because we did not use quantities that are literally vertical (e.g., *the tree is 6 meters*) or any other words referring to vertical space (e.g., *dropped*). Therefore the interaction effect is most likely due to a vertical representation of the concept quantity.

The difference in representation between situational quantity and simple numbers might be explained by differences in spatial experiences with the two related concepts. Children's early experiences with concrete quantities are often vertical, as in taller piles of blocks or higher levels of milk in a glass with larger quantities. In this way *situational quantity* can be grounded in concrete experience with *verticality*. Simple numbers, however, are often visually depicted in horizontal sequences (e.g., numbers on a ruler, calendar, keyboard, or in educational materials). Thus the number symbols themselves might be grounded more strongly in horizontal orientations.

These differences between situational quantity and simple numbers have implications for development and education. Students' understanding of abstract numbers may be separate from their understanding of quantities as they use them in their daily life. Research has shown that number representation gradually develops into a linear one (Siegler & Opfer, 2003). In the present study we replicated the *numerical distance effect* (e.g., Moyer & Landauer, 1967) which shows such a sequential depiction of numbers. Other studies have also obtained support for the use of a mental number line during arithmetic (Booth & Siegler, 2008; Siegler & Opfer, 2003; Pinhas & Fischer, 2008). Moreover, as the linearity of the mental number line develops children's ability to do arithmetic increases (e.g., Siegler & Opfer). Booth and Siegler found that providing children with a visual image of the mental number line with their addends and sums in it during new arithmetic problems enhanced arithmetic learning. These findings suggest that the representation of numbers along a (linear) horizontal line enhances arithmetic skills. On the other hand, other researchers showed that embedding mathematical problems in a more embodied setting (Sterm & Lehrndorfer, 1992; Wyndhamn & Säljö, 1997) increased performance. Moreover, realistic mathematics education (RME) (Tsai & Chang, 2009; Van Den Heuvel-Panhuizen, 2003) is based on the idea that students might understand mathematical problems better if they first practice with daily-life problem situations. The RME models are aimed at creating mappings between numbers in realistic contexts and simple numbers in mathematics. The present results show that the underlying representations are different indeed. The question remains whether understanding of mathematics will be improved by focusing instructions on the more abstract representation of numbers (the horizontal number line) as in Booth and Siegler (2008) or by increasing the similarity between the representations as in Realistic Mathematical Education (Tsai & Chang, 2009; Van Den Heuvel-Panhuizen, 2003).

The present results also suggest that individual differences in mathematical skills might be caused by differences in students' mental representations of quantity and numbers. As aforementioned, Siegler and Opfer (2003) obtained a correlation between the development of linearity of the mental number line and performance on arithmetic tests. These relations might also be used to explain sex differences in mathematic skills. For example, Marshall (1984) found that girls are better in solving computations whereas boys are better in solving story problems. Such sex differences could be due to differences in mental representations.

Our study addresses the question of how abstract concepts are represented. We found evidence that *verticality* plays a role in representing *quantity*. Since we used situational quantities along different dimensions (e.g., amounts, duration, horizontal distance, girth) it seems that the activation of the *verticality* schema to comprehend *quantity* is independent of the actual dimension. This supports the idea that *verticality* is part of the mental representation of the concept *quantity* itself. In a study that was similar to the present one, Bergen, Lindsay, Matlock and Narayanan (2007) investigated whether people would shift attention (top or bottom) after listening to sentences about *quantity* with motion verbs referring to *verticality* (e.g., *The cost climbed*, *The percentage dropped*.). However, they obtained no effect of attention shift. Since they used explicit vertical motion verbs the absence of an effect is surprising. There are two differences between their study and the present one that might explain their null finding. First, Bergen et al. used quantities that that have no perceptual qualities (e.g., *prices*) whereas in the present study concrete quantities (e.g., *5 bananas*) were used. It is unlikely that this difference played a role, however, because in the present study we did not use quantities that were physically vertical. Thus, it is more likely that the abstract concept quantity has a vertical orientation, and should have affected performance in both studies. Second, in the study of Bergen et al. (2007) participants listened to the sentences with abstract quantities and therefore activated the meaning of the whole sentence. In contrast, the present study focused participants' attention towards the concept *quantity* by asking participants to make quantity judgments. Possibly, participants in our study activated the concept quantity more strongly than those in the Bergen et al. study, which might explain the difference.

To conclude, in the present study we found evidence that *situational quantity* is represented by *verticality* but *simple numbers* are not. This study is an extension on previous studies that found evidence for horizontal representation of simple numbers (e.g., Dehaene, Bossini, & Giraux, 1993; Fischer, Castel, Dodd & Pratt, 2003; Salillas, El Yagoubi & Semenza, 2008). The current evidence for an additional vertical representational format for numerical information contributes to our understanding of number representation. Moreover, we found that situational quantity is represented differently than simple numbers. Understanding this difference can contribute to the development of educational methods that optimize students' performance on mathematics by taking differences between situational quantity and simple numbers into account.

Chapter 6

Conceiving Love:
Getting Warm or Out of Reach?

Abstract

We investigated whether *love* is grounded in concrete experiences (warmth and closeness). In Experiment 1 participants decided whether a word was positively or negatively related to love while resting one arm on a warm and one arm on a cold pack. Only participants who were aware of the link between *love* and *temperature* in the experiment responded faster to *negative love* words with the *cold* side than the *warm* side, and faster to *positive love* words with the *warm* side than the cold side. In Experiment 2 participants decided whether two portraits presented at three different distances depicted a famous love couple or not. Distance did not interact with couple decisions. These results show that the mental representation of love is more complex than a composition of concrete features.

My heart is on fire and *they are so close* are very common utterances about love. But do these expressions tell us how love is mentally represented? Are *warmth* and *closeness* a part of the concept *love*?

A highly influential theory about mental representations of concepts is the Perceptual Symbol Theory (e.g., Barsalou, 1999, 2008, 2009). Mental representations of concepts consist of perceptual symbols. These perceptual symbols are records of sensory and motor information that are formed by experience. Mental representations are dynamic simulations of possible experience. Evidence for such sensory-motor simulation of concepts has been found (e.g, Borghi, Glenberg, & Kaschak, 2004; Kaschak et al, 2005; Richardson, Spivey, Barsalou, & McRae, 2005; Stanfield & Zwaan, 2001; Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008; Zwaan & Madden, 2005; Zwaan, Stanfield & Yaxley, 2002).

The Perceptual Symbol System (e.g., Barsalou, 1999) and other embodied theories (e.g., Glenberg, 1997; Goldstone & Barsalou, 1998) claim that all concepts are grounded in experience. How might these theories explain the mental representations of abstract concepts that are not physically present in the world such as *love*, *power* and *time*? Since abstract concepts such as *time* can not be perceived or interacted with, it seems hard to imagine how they can be simulated by activation of sensory-motor patterns. Nevertheless, some theories provide an embodied solution for the mental representation of abstract concepts (e.g., Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005; Coulson, 2001; Lakoff & Johnson, 1980, 1999). Even though abstract concepts are not physical present in experience they do occur in concrete situations. For instance, imagine a couple sitting on a couch being upset because they have had an argument. There is a large amount of space between the two while they are discussing the argument. After some minutes they find out that their argument is based on a misunderstanding and realize how much they love each other. They hug each other and the rest of the evening they remain sitting close together which gives a literal warm feeling. In this concrete situation the concept *love* co-occured with experiences of concrete concepts, such as *warmth* and *closeness*. It is assumed that concrete concepts that co-occur in experience (e.g., *warmth* or *closeness*) might play a role in structuring the mental representation of an abstract concept (e.g., *love*) (e.g., Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005; Coulson, 2001; C. Johnson, 1997; M. Johnson, 1987; Kövecses, 2000; Lakoff & Johnson, 1980, 1999). Sensory-motor patterns assumed to be involved in the mental representation of concrete concepts (e.g., Mandler, 1992) are in turn involved in the mental representation of abstract concepts as well (e.g., M. Johnson, 1987). According to these theories the mental representation of *love* should consist of sensory-motor patterns (e.g., Barsalou, 1999) that were once activated by physical features that were present as background (e.g., Coulson, 2001) or that co-occurred (e.g., Lakoff & Johnson, 1980, 1999) with *love* in concrete experiences. Lakoff and Johnson (see also Kövecses, 2000) have mentioned several concrete concepts that may structure the mental representation of love (e.g., *closeness*, *warmth*, *nutrient*, *magic*). In this study we focused on two concrete features mentioned in the example above that might play a role in the mental representation of *love*; *closeness* and *warmth*.

Although the mental representation of the concept *love* itself has never been investigated, there are some studies about social concepts related to *love* and the role of *distance* (Williams & Bargh, 2008a) and *temperature* (Williams & Bargh, 2008b; Zhong & Leonardelli, 2008). Williams and Bargh (2008a) primed participants with three different distances by using a Cartesian-plane coordinate system. They were asked to locate two points in the Cartesian-plane of which coordinates were given (e.g., *(2, 4)* and *(-3, -1)*). These points could be close, intermediate or far from each other. After locating the points participants had to make judgments about social concepts. In one experiment participants rated the strength of their bonds to their family members and hometown. Williams and Bargh (2008a) found that participants primed with distant coordinates rated a weaker bond to their family and hometown than participants primed with close coordinates. This finding suggests that *emotional bond* is represented partly by *closeness*.

In another study Williams and Bargh (2008b) investigated whether the experience of temperature could influence interpersonal warmth. In Experiment 1 they found that participants who had been holding a hot coffee cup shortly before the target task rated an unknown person described in a story as a warmer person than participants who had been holding an iced cup. In Experiment 2 participants had to evaluate either hot or cold therapeutic pads. After their evaluation participants were told that they could choose between two rewards for their participation; either a gift for themselves or a gift to a friend. They found that participants who evaluated the cold pads more often chose for a gift for themselves than a gift to a friend, whereas participants who evaluated hot pads more often chose for a gift to a friend than a gift to themselves as a reward. These experiments show that affection is modulated by temperature.

Zhong and Leonardelli (2008) found a similar association between social exclusion and temperature but in an opposite direction (i.e., from abstract to concrete). In Experiment 1 they found that when people had recalled a past experience of *social* *exclusion* they estimated the room temperature as being colder than participants that had recalled a past experience of *social inclusion*. In Experiment 2 participants had to perform a virtual ball-tossing exercise. Participants were told that they were connected online with two other participants. In reality they were not connected to other participants but assigned to an exclusion or control condition. Participants in the exclusion condition received the ball only two times and were excluded during the rest of the game. In the control condition participants received the ball intermittently during the exercise. After that, participants had to rate how much they desired certain products. They found that participants in the exclusion condition desired warm food and drinks more than those in the control condition.

The studies described above investigated concepts that were closely related to *love*. Evidence for involvement of concrete concepts (e.g., *space*, *closeness*, *verticality*) in the mental representation of other types of abstract concepts (e.g., *time*, *similarity*, *power*) has been found as well (e.g., Boot & Pecher, 2010; Casasanto & Boroditsky, 2008; Schubert, 2005). The aim of the present study is to investigate the role of *warmth* and *closeness* for the mental representation of *love*.

In Experiment 1 we first investigated whether *love* is partly represented by *warmth*. Participants had to decide whether words were positively related to love (e.g., *attractive*, *hearty*, *sweet*) or negatively related to love (e.g., *rejection*, *deceit*, *haughty*) by responding with their left or right hand. We used the distinction *positively versus negatively related to love*, instead of *love versus hate*, because *hate* also includes *aggression*, which might be correlated with *heat* as well (e.g., Kövecses, 2000). The words that were negatively related to love were related to neglect, emotional unresponsiveness or emotional insensitivity. These concepts are associated to the concept *cold* (e.g., Zhong & Leonardelli, 2008). We expected that the decision task would activate the concept *love* when a word was presented with a positive meaning of love (e.g., social acceptance) and *no love* when a word was presented with a negative meaning of love (e.g., social neglect).

While participants were performing this decision task they rested their arms on one warm (left or right) and one cold pack (right or left). These packs should activate the concept *temperature* (or *cold-warm* image schema). If the mental structure of *temperature* is part of the mental representation of *love*, the temperature of the packs would influence performance. In line with concrete experiences with *love*, *warmth* should activate the mental representation of *love* (e.g., sitting close to your beloved one co-occurs with the sensation of body-heat), whereas *coldness* should activate the mental representation of *no love* (e.g., preferring to avoid physical contact after an argument co-occurs with a lack of the sensation of body-heat). Taking these bodily experiences with *love* into account, we expected that performance would be better when participants had to respond to positive love words with the warm side than with the cold side, and to negative love words with the cold side than with the warm side.

Experiment 1

Method

Partcipants

Forty psychology students received course credits for participation.

Materials

The stimuli were 64 words. Twenty judges who did not participate in the experiment rated words on hate and love on a scale ranging from 1 (related to hate) to 7 (related to love). Additionally the authors judged the words on aggressiveness. Hate words that were related to aggression (e.g., hostility) were removed. The 32 negative love words were judged as related to hate but were unrelated to aggression (mean scores ranging from 1.06 to 3.95) and the positive love words were judged as related to love (mean scores ranging from 3.95 to 6.8). The stimuli used in the experimental trials are shown in Appendix B. An additional set of 10 words was used for practice.

We used reusable cold/warm packs that had been frozen in a freezer (between -10 and +5 degrees Celsius) or warmed up in the microwave (between +35 and +40 degrees Celsius). The packs were put in clean cotton covers. Participants got one warm and one cold pack under their right and left arms. We counterbalanced for position of the warm and cold pack (right vs. left) between subjects.

Procedure

Participants were tested on individual PCs, separated by walls in groups ranging from 1 to 3. Participants were told that they had to decide whether a word was positively or negatively related to love. During this task they had to rest their lower arms with rolled-up sleeves on the packs that were lying on the table in front of the keyboard. Each trial started with a fixation point (+) that was presented in the centre of the screen for 500 ms. Then the word appeared in the centre of the screen for 2000 ms or until a response was given. Participants used the z-button and m-button to respond. If participants gave an incorrect response, “Fout” (*incorrect*) appeared in red in the centre of the screen. If participants did not respond after 2000 ms, “Te Laat” (*Too Late*) appeared in red in the centre of the screen. The feedback was presented for 1500 ms. The experiment consisted of two blocks with a break in between. In each block all 64 words were presented twice in random order. Between the blocks the key-mapping was reversed. Before each block participants received 10 practice trials so that they could learn the key-mapping. The position of the cold and warm packs stayed at the same position between the blocks and was counterbalanced only between participants. Thus, one block was congruent and one block was incongruent depending on the key-mapping. The order of the two blocks and thus the order of the congruent and incongruent blocks was counterbalanced between subjects.

At the end of the experiment participants were interviewed about the purpose of the experiment.

Results

Mean reaction times and error rates are presented in Figure 1. Nineteen participants were aware of the manipulation and 21 participants were unaware. We performed a 2 (Love: Positive vs. Negative) by 2 (Temperature: Warm vs. Cold) repeated measures ANOVA with Awareness (Aware vs. Unaware) as between subjects factor on the reaction times and error rates. We only analyzed the correct reaction times that fell within 2 standard deviations from the subject’s mean. This resulted in the removal of 5.13 % of the reaction times. In the reaction times the two way interaction (Love x Temperature) was not significant, $F < 1$.

There was a marginal three-way interaction, however, with the factor Awareness, $F(2, 38) = 3.74$, $MS = 11309.1$, $p = .060$. The performance of unaware participants on positive and negative words was not influenced by Temperature, $F < 1$. In contrast, participants who were aware of the manipulation were influenced by Temperature, $F(1, 18) = 5.59$, $MSE = 2437.5$, $p < .05$. A post-hoc LSD comparison (Loftus & Masson, 1994) showed that aware participants responded faster to Positive Love words with the Warm side than the Cold side, $t(18) = 2.09$, $SEM = 11$, $p < .05$, whereas they responded faster to Negative Love words with the Cold side than with the Warm side, $t(18) = 2.78$, $SEM = 11$, $p < .01$. Furthermore, we found an overall effect of Love, $F(2, 38) = 98.64$, $MSE = 1221.0$, $p < .001$. Participants responded faster to Positive Love words than Negative Love words.

In the Error Rates there was no three-way interaction (Love x Temperature x Awareness), $F(2, 38) = 2.81$, $MS = .002$, $p > .10$. We obtained a main effect of Love,

$F(2, 38) = 6.86$, $MSE = .002$, $p < .025$. Participants responded more accurately to Positive Love words than Negative Love words.

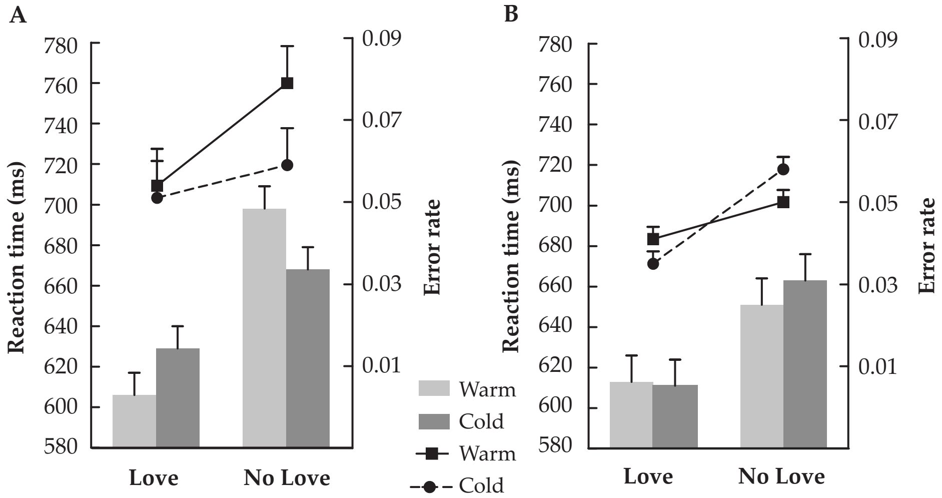

Figure 1. *Mean reaction times in milliseconds and error rates of aware participants (A) and unaware participants (B) for the love decision tasks in Experiment 1. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994) for each Task Condition.*

Experiment 2

In Experiment 1 we investigated whether *love* is partly represented by *warmth*. We found only an interaction effect between *love* and *warmth* for the group of people that were aware of the link between the positive and negative love words and the temperature of the packs. Aware participants performed better on the positive love words with their warm side than cold side, whereas aware participants performed better on negative love words with their cold side than warm side. These results only partly provide evidence that *warmth* might play a role in the mental representation of *love*.

The aim of Experiment 2 was to investigate whether *love* is partly represented by *closeness*. *Closeness* and *warmth* are related when they co-occur with *love*. When two lovers hold each other their bodies will get warmer by body-heat and this warmth is correlated with physical closeness; The closer two lovers are, the more warmth they will experience from each other's body-heat. On the other hand, when someone had an argument with a beloved one, bodily contact will be avoided (*distant*) and the temperature will not rise (*cold*).

In order to investigate the role of *closeness* in the mental representation of *love* we used a different set of materials. We used two portraits of famous heterosexual people presented at different distances on a screen. Participants had to decide whether the portraits represented a love couple or not. We expected that the decision task would activate the concept *love* when pictures presented a love couple (e.g., Brad Pitt and Angelina Jolie) and *no love* when pictures presented a non-couple (e.g., Ozzy Osbourne and Angelina Jolie). The portraits were presented near, intermediate, or far from each other. We used three distances to avoid effects that might be due to alignment of binary values (see Proctor & Cho, 2006). These three different distances should activate the concept *closeness* (or *near-far* image schema).

In Experiment 2 we used two simultaneously presented portraits instead of single words for two purposes. First, we needed at least two stimuli to manipulate *closeness*. Second, we needed perceptual stimuli instead of linguistic stimuli for several reasons. By using non-linguistic stimuli we could exclude lexical association between words as an explanation. Murphy (1996) claimed that some words might be polysemous, having a literal meaning (e.g., *warm* and *cold* as in *temperature*) and a metaphorical meaning (e.g., *warm* as in *friendly*, and *cold* as in *impersonal*). For instance, in Experiment 1 the negative love words (e.g., *rejection*) could be lexically related to the word *cold* in its metaphorical meaning and positive love words (e.g., *kiss*) could be lexically related to the word *warm* in its metaphorical meaning. Thus, the effect (for aware participants) might be due to a lexical link between *warm* and *positive love words*, and *cold* and *negative love words*. In the same way the words *close* and *far* might be lexically linked to positive and negative love words. Second, the portraits could be counterbalanced as couple and non-couple pairs, which is impossible for words that are determined as positive or negative related to love. Thus, the main effect of Love in Experiment 1 might be due to other factors, such as a difference in frequency between positive and negative love words. By using the same stimuli in all conditions we could exclude confounding effects (such as frequency of stimuli) in Experiment 2.

If the mental structure of *closeness* is part of the mental representation of *love*, the distances between the pictures should influence performance. In line with concrete experiences with *love*, *near* should activate the mental representation of *love*, whereas *far* should activate the mental representation of *no love*. We expected that performance would be better for love-couples presented near than far from each other, and performance would be better for non-couples presented far compared to near each other.

As in Experiment 1 we interviewed participants about the purpose of the experiments afterward. If *love* is partly represented by *closeness* we would expect to find an effect of different distances on performance. On the other hand, if such an effect is due to a conscious link between the two concepts (as seemed to be the case in Experiment 1), we expect not to find an effect for unaware participants.

Method

Partcipants

Thirty-six psychology students received course credits for participation.

Materials

28 portraits of famous people consisting of 14 heterosexual love couples were used. Each portrait was 200 by 200 pixels and gray scaled. In order to assess whether the couples were known to our subject population, we presented pairs of portraits to 24 judges who decided whether the presented pairs were a love couple or not. Each portrait was once presented with their partner and once with an unrelated person. When they gave a "yes" response, they had to rate how famous they thought the couple was on a scale ranging from 1 (not famous) to 5 (very famous). After that they were asked if they could write down the names of the couple. The norming data of the individual experimental stimuli are shown in Appendix A. On average 86.61% were correctly recognized as love couples (false alarm rate 1.49%), correct recall of the names was 84.21%, and the average famous rating was 4.32.

For the experimental trials we created two lists of couples. One list contained couples that were judged as very famous (correctly recognized by 97.40%). A second list contained couples that were judged as less famous (correctly recognized by 72.22%). For the very famous block we created slides with eight different very famous couples. We created eight different non-couple pairs by re-pairing portraits from the couples. Each portrait was used in a couple pair and a non-couple pair. In the less famous block we similarly created slides with six couple pairs and six non-couple pairs. The pictures were presented next to each other at a distance of 8 cm (Distant), 4 cm (Medium), and 1 cm (Close). The position of each single picture (right and left) was counterbalanced within conditions so that every combination of position (right and left) with love (love couple and non-couple) and with distance (distant, medium, close) was used. This resulted in 96 slides for the very famous block and 72 slides for the less famous Block. For each famous love couple we created 2 multiple choice questions (See Appendix C). For example one of the questions for the love couple Ozzy and Sharon Osbourne was *What is the nickname of Ozzy Osbourne? A. Prince of Metal. B. Prince of Darkness. C. Prince of Sabbath.*

Additionally, 36 slides (with 3 different famous couples and non-couples) and 6 multiple choice questions for practice were created.

Procedure

Participants were tested on individual PCs, separated by walls in groups ranging from 1 to 4. Participants were told that the experiment was designed to examine how famous some particular love couples are among students. They were told that on each trial two portraits of famous people would be presented and they would have to decide whether the two people were a love couple or not. After the decision task they had to answer some question about the famous couples. Each trial started with a fixation point (+) that was presented in the centre of the screen for 500 ms. The slide with the portraits appeared in the centre of the screen for 2000 ms or until a response was given. Participants used the z-button and m-button to respond. If participants gave an incorrect response, "Fout" (*incorrect*) appeared in red in the centre of the screen. If participants did not respond after 2000 ms, "Te Laat" (*Too Late*) appeared in red in the centre of the screen. The feedback was presented for 1500 ms. The experiment started with 36 practice trials. Two experimental blocks followed. In one block the 96 very famous slides were presented twice in random order and in the other block the 72 less famous slides were presented twice in random order. Thus, there were (192+144) 336 experimental trials in total. Between the blocks participants could take a break. The order of the two blocks as well as the key-mapping was counterbalanced between subjects.

After the practice trials and after each experimental block participants had to answer two multiple choice questions about each couple that was presented in the preceding block. This resulted in 6 practice questions, 16 questions about very famous couples and 12 questions about less famous couples. At the end of the experiment participants were interviewed about the purpose of the experiment.

Results

Mean reaction times and error rates are presented in Figure 2. We performed a 2 (Love: Couple vs. Non-couple) by 3 (Distance: Distant, Medium, Close) repeated measures ANOVA on the reaction times and error rates. Incorrect responses (8.37 %) and the remaining outliers (4.66%) were removed.

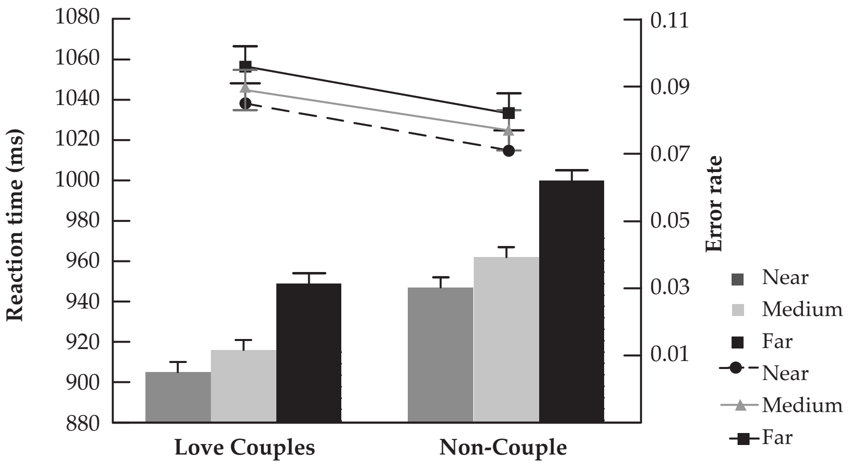

Figure 2. *Mean reaction times in milliseconds and error rates of all participants for the love decision tasks in Experiment 2. The error bars present the within-subject standard error of the mean (Loftus & Masson, 1994) for each Task Condition.*

There was no two-way interaction effect (Love x Distance) in the reaction times nor in the error rates, *Fs* < 1. In the reaction times we found a significant main effect of Love, $F(1, 35) = 59.74$, $MSE = 1946.7$, $p < .001$. Participants were faster to respond to love couples than to non-couples. In the reaction times we also obtained a significant main effect of Distance, $F(2, 70) = 36.09$, $MSE = 1226.3$, $p < .001$. Post-hoc analysis using Bonferroni correction for multiple comparisons showed that participants were marginally faster to respond to Close portraits than Medium portraits, $t(70) = 2.48$, $SE = 5.34$, p = .054, faster to respond to Medium portraits than to Far portraits, $t(70) = 5.14$, $SE = 6.77$, $p < .001$ and faster to respond to Close than Far portraits, $t(70) = 9.08$, $SE = 5.29$, $p < .001$.

Additionally we examined whether Block (highly famous and less famous) influenced the effect of distance on the love decision. We found no three-way interaction effect in the reaction times neither in the error rates, both *Fs* < 1. We did find a main effect of Block in the reaction times, $F(1,35) = 12.99$, $MSE = 11903.6$, $p < .01$, and error rates, $F(1, 35) = 32.89$, $MSE = .007$, $p < .001$. Participants responded faster ($M = 931$, $SE = 15$) and made fewer errors ($M = .063$, $SE = .008$) in the block with very famous people than in the block with less famous people (*M* = 967 *SE* = 17 and *M* = .108, *SE* = .012).

Three participants indicated to be somewhat aware of the purpose of the study. The three participants performed slightly better to love couples in the Medium (*M* = 877, *SE* = 35, *SEM* = 4 and *M* = .053, *SE* = .009, *SEM* = .001) than Far condition (*M* = 936, *SE* = 48 and *M* = .100, *SE* = .015) whereas this difference between the Near condition (*M* = 956, *SE* = 51 and *M* = .020, *SE* = .012) and Far condition (*M* = 965, *SE* = 73 and *M* = .037, *SE* = .009) seemed to be less for the non-couples.

General Discussion

In the present study we investigated whether the mental representation of the abstract concept *love* is grounded in concrete experience. In Experiment 1 we examined whether *temperature* played a role in the representation of *love*. We found only an interaction effect of temperature on the love decision for the group of people that were aware of the link between temperature and positive and negative love words in the experiment. Participants who were aware performed better on positive love words with their warm side compared to cold side, whereas aware participants performed better to negative love words with their cold side compared to warm side. In Experiment 2 we examined whether *distance* played a role in the representation of *love*. We found that the distance between pictures of famous love couples and non-couples did not influence the decision over love couples and non-couples differently.

Love is an abstract concept, because it is not a physical entity, and can not be perceived or interacted with directly. The Conceptual Metaphor Theory assumes that specific concrete concept might play a role in the mental representation of the concept *love* by the mechanism of conceptual mapping. According to the CMT, the mental representation of *love* is formed by multiple metaphors, for example *love is a journey*, *love is warmth*, *love is a nutrient*, *love is magic*, *love is closeness*, etc. (e.g., Kövesces, 2000). Even though there might be more concrete concepts involved in the mental representation of *love*, we decided to focus on the role of *closeness* and *warmth*. There are theoretical and empirical reasons to believe that these two concepts might play a predominant role in the mental representation of *love*. First it seems that these concepts are more obviously present in concrete experience with *love* than other concepts such as *magic* (which was suggested by the CMT as well). *Warmth* and *closeness* are correlated with *love* frequently and in varied situations (e.g., parental love, romantic love etc.). For example a baby loved by a parent will experience body heat and closeness when held by the parents and two beloved ones that hold each other will also experience closeness and warmth. Second, other studies so far only showed evidence that *warmth* and *closeness* play a role for concepts related to love (Williams and Bargh, 2008a, 2008b; Zhong & Leonardelli, 2008)

Even though the concept *warmth* and *closeness* are correlated in a context with *love* (minimizing distance between bodies will result in a higher temperature) we examined their roles separately. In both tasks we used a simple binary decision task in which the correct responses were clear to avoid uncertainty of response. In this way we minimized strategic use of irrelevant features (e.g., Boot & Pecher, 2009).

In Experiment 1 we found an effect only for participants who reported to be aware of the link between *love* and *warmth*; aware people were influenced by temperature whereas unaware people were not influenced by temperature in making love decisions. Since there were only three people aware of the link between *love* and *closeness* in Experiment 2, we could not provide a definite explanation of the results in this group. We showed, however, that unaware people were not influenced by closeness in making a love decision.

In contrast with the present study, previous studies that investigated the mental representation of other abstract concepts did find that concrete concepts played a role. (e.g., Boot & Pecher, 2010; Casasanto & Boroditsky, 2008). For instance, Boot and Pecher (2010) found evidence that *similarity* is partly represented by *closeness*. The question that arises from the discrepancy between previous studies and the present study is whether there is something special about love compared to other abstract concepts.

The null-effect for unaware participants in both experiments could be an indication that *love* is not partly represented by *warmth* or *closeness*. An alternative explanation is that in some circumstances as in the present experiments, *closeness* and *warmth* do not play a predominant role in the mental representation of love, whereas in others circumstances they do. Studies about sensory-motor simulation of concrete concepts showed that mental representations are flexible and change according to the situation (e.g, Stanfield & Zwaan, 2001; Van Dantzig, Pecher, Zeelenberg & Barsalou, 2008) As we mentioned before, love can co-occur in a variety of concrete situations. The features that are important in one situation (e.g., *magic* and *war* at the beginning of a love affair) may differ from the features that are important in another situation (e.g., *closeness* and *journey* in a relationship). It might be that in Experiment 1 some words (e.g., *fidelity*) activated situations (e.g., *wearing a ring*), in which warmth was not predominantly present, and thus influenced the mental representation of *love* in such a way that warmth did not affect it. In Experiment 2, the focus was on love relationships, which might have activated concrete situations (e.g., marriage, parenthood) and other concrete concepts (e.g., *journey*) that overshadowed the role of *closeness*. Moreover, there might be individual differences in the mental representation of love between people. Some features (e.g., independence, excitement) might be more important to some people in a relationship, whereas other features (e.g., security, confidence) might be more important for others in a relationship. In turn, individual differences might have been a confounding factor that could have affected the influence of warmth and closeness on the decision tasks. Another point is that some concrete features that co-occur with love might be intertwined with each other, at least in some situation. For instance, in the situation in which a mother feeds her child, the concepts *love*, *warmth*, *closeness* and *nutrient* co-occur. It might be that the relations between these concrete concepts are important as well in the mental representation of love. It would be interesting to investigate whether a combination of concrete concepts, for instance, *warmth* and *closeness*, does have an effect on processing of love. In future studies, manipulation of temperature and distances in one experimental design might show whether *warmth* and *closeness* play a role in the mental representation of *love* when they interact with each other.

Moreover, in contrast to the present results, other studies have obtained evidence that *temperature* and *closeness* might play a role in the mental representation of love-related concepts. Williams and Bargh (2008a, 2008b) showed that temperature influenced participants' judgement of an unknown person and generosity towards a friend and that distance influenced participants' judgement about their bond with family members and hometown. It might be that the concepts that Williams and Bargh investigated were just certain aspects of the concept of love. As we mentioned before, the mental representation of concepts might change according to a situation. Thus, the findings of Williams and Bargh might be due to the fact that in certain concrete situations (e.g., judging someone, being generous, judging an emotional bond) some concrete concepts (e.g., temperature, closeness) do play a role. In contrast, for the concept of love in a broader sense other concrete concepts might play a more predominant role.

In Experiment 1 we obtained an effect of temperature for aware participants. One possible explanation is that when people became aware of the link they coupled the warm side to positive love words and the cold side to negative love words. Subsequently, they performed better to congruent trials (hand with warm

arm for positive love word and hand with cold arm for negative love word) than to incongruent trials (hand with warm arm for negative love word and hand with cold arm for positive love word). Interestingly, it seemed that for participants who were aware of the link it was harder to make the incongruent coupling. Although the present data cannot show whether participants made the coupling because they were aware or whether they were aware because they made the coupling, they suggest that the effect itself is more likely to be located in the response stages than in the representational stages.

To conclude, we found evidence for a role of *temperature* in representing *love* only for participants who were aware of this link. We did not find evidence for a role of *closeness* in representing *love*. These results indicate that the mental representation of the concept love is more complex than simple concrete features that are correlated with love in concrete experience.

Appendix A. *The words in the two conditions with English equivalents used in the Love decision task in Experiment 2.*

Positive love words		Negative love words	
aanbidden	*adore*	afkeer	*aversion*
aantrekkelijk	*attractive*	afkeuren	*reject*
aardig	*friendly*	afwijzing	*rejection*
adorabel	*adorable*	antipathie	*antipathy*
beminnelijk	*amiable*	arrogant	*arrogant*
bewonderen	*admire*	aversie	*aversion*
date	*date*	bedonderen	*cheat*
dierbaar	*precious*	bedrog	*deceit*
gehecht	*devoted*	bitterheid	*bitterness*
genegenheid	*affection*	concurrent	*competitor*
hartelijk	*hearty*	depressief	*depressed*
hartstocht	*passion*	hooghartig	*haughty*
intiem	*intimate*	kleineren	*belittle*
kameraad	*companion*	kortaf	*abrupt*
knuffel	*cuddle*	minachten	*disdain*
lief	*sweet*	misleiden	*mislead*
maatje	*pal*	mislukking	*failure*
omhelzing	*embrace*	neerkijken	*look down on*
passie	*passion*	negeren	*ignore*
romantiek	*romance*	ongevoelig	*insensitive*
schattig	*charming*	onteren	*dishonour*
snoezig	*cute*	ontmoedigen	*discourage*
streling	*caress*	onverschillig	*uninterested*
sympathie	*sympathy*	pijn	*pain*
tederheid	*tenderness*	star	*uncompromising*
trouw	*fidelity*	stug	*stiff*
verlangen	*desire*	verachten	*despising*
verliefd	*in love*	vernederen	*humiliating*
vriend	*boyfriend*	verwaand	*supercilious*
vriendin	*girlfriend*	walgelijk	*disgusting*
zoen	*kiss*	wrok	*grudge*
zorgzaam	*caring*	zakelijk	*impersonal*

Appendix B. *The pairs of famous love couples used in Experiment 2 with their norming rates.*

	Names of Famous Love Couples	**Perc. Faces known**	**Perc. Name recall**	**Celebrity Rating (1 to 5)**
Very Famous	Brad Pitt & Angelina Jolie	100	100	5
	David & Victoria Beckham	91.67	91.67	4.86
	Ozzy & Sharon Osbourne	95.83	95.83	4.35
	Rafael & Sylvie van der Vaart	100	100	4.08
	René & Natasja Froger	95.83	91.67	4.22
	Barack & Michelle Obama	100	100	4.96
	Marco & Leontine Borsato	95.83	95.83	4.26
	Prince Willem & Princes Maxima	100	100	4.92
Less Famous	Tom Cruise & Katie Holmes	87.5	83.33	4.62
	Bill & Hillary Clinton	75	70.83	4.67
	Prince Charles & Camilla Parker	75	70.83	4.11
	Prince Friso & Mabel Wisse Smith	75	66.67	3.78
	René Angélil & Céline Dion	70.83	70.83	3.65
	Tygo Gernandt & Eva van Weideveren	50	41.67	3

Chapter 7

Summary and General Discussion

The current dissertation concerns the role of concrete concepts in understanding abstract concepts. More precisely, the Conceptual Metaphor Theory (CMT) of Lakoff and Johnson (1980, 1999) was put under the microscope. This Conceptual Metaphor Theory claims that mental representations of abstract concepts (e.g., *time*) are conceptualized in terms of concrete concepts (e.g., *money*). Lakoff and Johnson argued that systematic use of metaphorical expressions points to this conceptual mapping. Metaphorical expressions are not limited to poetry or other literary forms, but can be observed frequently in everyday language. They assumed that systematic use of conventional metaphorical expressions refers to the structure of the conceptual system that lies behind it (e.g., Lakoff, 1993). For instance, sentences such as *I spend a lot of time studying,* or *This new computer will save me hours* are assumed to refer to the metaphorical mapping *time is money* that originates from the mental structure of the two concepts. In other words, the mental representation of the concept *money* is mapped onto the concept *time*. A conceptual mapping refers to a set of conceptual correspondences between two concepts and can be interpreted in different way (e.g., Murphy, 1996; McGlone, 2006, Boroditsky 2000). In the studies reported in the current dissertation we investigated whether a concrete concept (e.g., closeness) plays a role in the mental representation of an abstract concept (e.g., similarity).

Summary of the main findings

Are conventional metaphorical sentences understood by conceptual mapping?

In Chapter 2 we focused on the *process claim* (e.g., Gibbs, 1994; see also McGlone, 2006) of the Conceptual Metaphor Theory (CMT) (Lakoff & Johnson, 1980, 1999). The main question in Chapter 2 was whether activation of the concrete concept or vehicle (e.g., *money*) of a conceptual metaphor (e.g., *time is money*) would be helpful to understand the topic (e.g., *time*) in a conventional metaphorical sentence (e.g., *This gadget will save you hours*). In two experiments participants read conventional metaphorical sentences (e.g., *She was starved for his affection*) that contained a metaphorical mapping (e.g., *love is a nutrient*) with a topic (e.g., *affection* referred to *love*) and vehicle (e.g., *starved* referred to *nutrient*). These metaphorical sentences were primed by literal sentences (e.g., *The mother made sure the kid got his vitamins*) that contained the same vehicle (e.g., *nutrient*) or contained an unrelated vehicle (e.g., *Her wallet was completely empty* containing the vehicle *money*). We expected that if the concrete concept or vehicle is helpful to understand the abstract concept or topic of conventional metaphorical sentences, priming the vehicle with literal sentences should speed up reading time for the topic in the metaphorical sentences. In Experiment 1 we used conventional metaphorical sentences from Lakoff and Johnson (1980), Kövecses (2000), and Gibbs (1994) to ensure that we used sentences that are assumed to activate the conceptual metaphor. In Experiment 1 we found that participants were faster to read conventional metaphorical sentences when primed by literal sentences that contained the vehicle compared to when primed with a literal sentences that did not contain the vehicle. However, we were unable to locate this effect in the sentence segment that contained the topic. One drawback of using the original metaphorical sentences from the conceptual metaphor publications was that they were not designed for our paradigm. Several factors (sentence length, order of vehicle and topic, position of vehicle and topic) were not controlled and thus could have influenced the results. In Experiment 2 we created a new set of Dutch conventional metaphorical sentences that were controlled for sentence length, position of vehicle and topic and order of vehicle and topic. All sentences (primes and targets) were 5 segments long and in all target sentences the topic was mentioned in the second and the vehicle in the fourth segment. With these new materials we found no evidence that the vehicle in the literal sentence primed the whole metaphorical sentence or the segment with the topic.

At first, these results seem to imply that the vehicle or concrete concept is not helpful for understanding the topic or abstract concept in a conventional metaphorical sentence. If that is true, then the conceptual mappings were not necessary to comprehend conventional metaphorical sentences, and thus the results would not support the process claim of the Conceptual Metaphor Theory. In contrast, conventional metaphorical sentences might be understood directly and literally. As Keysar, Shen, Glucksberg, and Horton (2000) indicated, Lakoff and Johnson (1980) discussed conventional and novel metaphors as equally metaphorical and stated that both types of metaphor need conceptual mappings for understanding. For example *I'm depressed* is also considered to be metaphorical (Lakoff & Turner, 1989 in Keysar et al., 2000), whereas it seems more plausible to assume that *depressed* is a polysemous word referring to two different meanings (Keysar et al., 2000, Murphy, 1996; Jackendoff & Aaron, 1991, as cited in Keysar et al., 2000). The conventional metaphors used in the studies of Chapter 2 might have contained words with polysemous meaning as well. Thus, sentences such as *I've lost all hope for a solution* (Experiment 1) and *Het was lastig dat haar gedachten telkens weer naar het feest gingen tijdens haar tentamen* (*It was inconvenient that during the exam her thoughts frequently* *went to the party*) (Experiment 2) could have been interpreted literally. Even though we found no evidence that conventional metaphorical sentences were understood by conceptual metaphors, it is still possible that novel metaphorical expressions are understood by conceptual metaphors.

An alternative interpretation for the results in Experiment 2 is that other uncontrolled factors caused noise in the data. The target sentences were forced into a consistent structure (in order to control for length and order effects), and as a result some of them may have sounded unnatural even though they were grammatically correct. In addition, the sentences contained irrelevant information besides the topic and vehicle (e.g., *party*, *exam*). The effect of these variable factors might have overshadowed the effect of the conceptual metaphor.

In Sum, the studies of Chapter 2 made us realize that several factors in language are hard to control. As we controlled for some important factors in Experiment 2, other factors became harder to handle (sentence complexity, naturalness, conciseness). Since language seemed not to be an appropriate tool to investigate the CMT, we decided to focus on the stronger claim of the CMT in the next Chapters. According to this stronger claim of the CMT, the mental representation of the concrete concept is also used to understand the abstract concept in situations beyond metaphorical language comprehension. If this claim is true, we should find effects of the concrete concept on processing of the abstract concept in non-linguistic conceptual tasks.

Are abstract concepts understood by conceptual mappings?

In the following chapters of this dissertation, the focus was on conceptual mapping beyond language during comprehension of concepts. The interpretation of the Conceptual Metaphor Theory (Lakoff & Johnson, 1980) adopted in this dissertation is that concrete concepts partly play a role in the mental representation of abstract concepts. Most previous studies investigating conceptual mapping beyond language used language-free designs but may have been affected by potential strategies during task performance. In Chapters 3, 4, 5, and 6 we used simple decision tasks with feedback in which the use of the conceptual mapping was not helpful for performance. Thus, uncertainty about responses was decreased and effects due to strategic use of the conceptual metaphor were minimized (Van den Bos, 2003; Van de Bos, Lind, Vermunt & Wilke, 1997). Moreover, in the current studies we controlled for effects due to alignment of polarities (Proctor & Cho, 2006). When people have to make a binary decision (e.g., similar versus dissimilar colours) and the stimuli contain a binary value (near versus far), alignment of polarities (e.g., similar and near, dissimilar and far) might influence performance and cause the interaction effect. In the current studies we controlled for alignment of binary values by adding extra experiments in which polarity alignment could not explain the effects.

In Chapters 3 to 6 we focused on one abstract concept at a time and one or two conceptual mappings of the abstract concept at a time. We investigated the conceptual mappings *similarity is closeness* (Chapter 3), *categories are containers* (Chapter 4), *quantity is verticality* (Chapter 5) and *love is warmth* and *love is closeness* (Chapter 6). By focussing on one or two conceptual mappings at a time, we were able to use simple decision tasks with which we could thoroughly investigate the conceptual mappings and at the same time control for alternative explanations.

The experiments reported in Chapter 3 investigated whether the metaphorical mapping *similarity is closeness* is active during a conceptual task. In this mapping *similar* is *near*, found in sentences such as *These colours are very close*, and *dissimilar* is *far* found in sentences such as *Over the years our tastes have diverged*. More precisely, Experiments 1 and 2 investigated whether the mental representation of *similarity* is partly represented by *closeness* with its underlying *near-far* image schema and Experiments 3 and 4 investigated one of the assumptions of the CMT that the conceptual mapping should be asymmetric. In Experiments 1 and 2 participants had to decide whether two squares had similar or dissimilar colours. The similar colour pairs were two different hues of a colour (e.g., dark and light blue) and the dissimilar colour pairs were always two different colours (e.g., blue and yellow). Thus the similar and dissimilar colour pairs were very easy to distinguish which made the correct responses obvious. The squares were presented at two different distances in Experiment 1 (Near, Far) and three different distances in Experiment 2 (Near, Medium, Far). The similarity decision task should activate *similar* for similar colour pairs and *dissimilar* for dissimilar colour pairs. We expected that if *similarity* is partly represented by *closeness*, participants' performance would be better for similar colours presented near than far from each other (*similar* is *near*), whereas participants' performance would be better for dissimilar colours when presented far than near each other (*dissimilar* is *far*). Indeed we found that performance for similar colours was better at shorter distances whereas performance for dissimilar colours was better at longer distances. In experiments 3 and 4 the same pairs of colour squares were presented, but this time participants had to decide whether the distance was near or far. According to the Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999) conceptual mappings should be asymmetric. In language the sentence *These colours are close* can be interpreted literally as well as figuratively, but the sentence

These cities are similar can only be interpreted literally. If indeed similarity is partly represented by closeness, but not vice versa, we would expect that the similarity of the colours had no influence on performance of the distance decision task. In line with the assumption of the Conceptual Metaphor Theory we found that participants were not influenced by the similarity of colours when they made a decision over the distance of the squares. The study in Chapter 3 provides evidence that *similarity* is partly represented by *closeness*, and additionally, that this conceptual mapping is asymmetric.

Chapter 4 describes a study that investigated whether the metaphorical mapping *categories are containers* is active during a conceptual task. The metaphorical mapping *categories are containers* can be found in sentences such as *Are tomatoes in the fruit or vegetable category?* (*same category is in same bounded region*) and *Salad is excluded from the fruit category* (*different categories are not in same bounded region*). More precisely, Experiments 1 and 2 investigated whether the mental representation of *categories* is partly represented by *containers* with its underlying *container* image schema (with an *in-out* orientation) and Experiments 3 and 4 were designed to exclude alternative explanations. In Experiments 1 and 2 participants had to decide whether two pictures presented on a screen depicted two things from the same category (two animals or two vehicles) or different categories (one animal and one vehicle). The pictures were presented together with a frame that was a black lined square. This frame was either presented in the middle, so that both pictures were inside the container or moved to the left or right from the centre, so that only one picture was inside the container and one outside. The category decision task should activate *same category* for pictures depicting things from the same category (two animals or two vehicles) and *different category* for pictures depicting things from different categories (one vehicle and one animal). The different positions of the frame should activate the *container* image schema with its *in-out* orientation. If the concept *categories* is represented by *containers*, we would expect that participants' performance on the category decision task should be influenced by the frame. In congruence with the prediction, we found that performance on pictures from the same category was better when presented both inside compared to one inside and one outside, whereas performance on pictures from different categories was not different for different frame positions. The aim of Experiments 3 and 4 was to exclude alternative explanations for the effects found in Experiments 1 and 2. In Experiment 3 we presented one picture at a time in an animal decision task in order to exclude effects due to a visual grouping effect. We found that when the picture belonged to the category in focus (animal) participants responded faster when it was inside the frame than outside the frame, whereas participants did not respond differently to pictures belonging to other categories (vehicle and food). These data showed that even when no visual grouping effect could occur, the position of the frame influenced performance. In Experiment 4 we used the same task as in Experiment 1 and 2, but added a third position of the frame (both outside the frame) to exclude effects due to alignment of binary values. As in experiment 1 and 2, we found that performance on pictures from the same category was better when presented both inside compared to one inside and one outside, whereas performance on pictures from different categories was not different for different frame positions. The study in Chapter 4 provides evidence that *categories* are partly represented by *containers*.

To further examine the Conceptual Metaphor Theory the study reported in Chapter 5 investigated whether the metaphorical mapping *quantity is verticality* is active during a conceptual task, in which *more* is *up*, as in *Prices are high*, and *less* is *down*, as in *Turn the heat down*. We investigated the role of *verticality* in the mental representation of two different quantities, namely *situational quantity* (e.g., *5 bananas in a dessert*) and *simple numbers* (e.g., *5*). Experiment 1 focused on the mental representation of *situational quantity*. Participants had to decide whether a quantity (e.g., *5 bananas*) mentioned in a sentence was few (e.g., *There were five bananas in the crate at the greengrocery*) or many (e.g., *He cut five bananas in pieces through his yoghurt*) in a particular context. After the quantity decision participants had to identify a letter (*p* or *q*) presented at the top or bottom of the screen. The quantity decision task should activate *more* when the quantity in the sentence context was many and *less* when the quantity in the sentence context was a few. The position of the letter in the letter identification task should activate the concept *verticality*, consisting of the *verticality* image schema with its *up-down* orientation. If *situational quantity* is represented by *verticality*, we would expect that quantities that are many in the sentence context and the position of letters presented at the top should both activate the *up* orientation of *verticality*. On the other hand, quantities that are few in the sentence context and the position of letters presented at the bottom should activate the *down* orientation of *verticality*. We expected that if *situational quantity* is partly represented by *verticality*, participants' performance would be better for letters presented at the top when primed by a quantity that is many than when primed by a quantity that is few (*more is up*), whereas participants' performance would be better for letters presented at the bottom when primed by a quantity that is few than when primed by a quantity that is many (*less is down*). In line with this prediction performance for letters at the *top* (*p* or *q*) was better when primed by a quantity that was many compared with few, whereas performance on letters at the bottom was not different. The focus of Experiment 2 was on the mental representation of *simple numbers*. Participants had to perform a quantity decision over simple numbers (*many* is more than 50 and *few* is less than 50) followed by a letter identification task (*p* or *q* at the top or bottom of the screen). We found that performance on the letter identification task was not influenced by simple numbers. In Experiment 3 we controlled for two differences between Experiments 1 and 2. First, in Experiment 1 the reference point for quantity decision was implicit whereas in Experiment 2 it was explicit (50). Second in Experiment 1 the reference point was varied whereas in Experiment 2 it was stable (always 50). To control for these differences a varied referent point (either a number or a sentence) preceded each prime (either a number or a sentence). Participants first saw the referent point (e.g., *78* or *He often cut one banana through his yoghurt*) followed by the prime (e.g., *53* or *He cut five bananas in pieces through his yoghurt*) which they had to compare with the referent in order to make a quantity decision (e.g., *few* or *many*). The quantity decision task was followed by a letter identification task as in Experiment 1 and 2. Again we found an effect for *situational quantity* but not for *simple numbers*. Participants responded faster to a letter at the top when they first read a sentence in which the quantity was many compared to a few, whereas participants responded faster to a letter at the bottom when they first read a sentence in which the quantity was a few compared to many. There was no such interaction when the preceding stimuli were simple numbers. The study in Chapter 5 provides evidence that *situational quantity* is partly represented by *verticality*, but *simple numbers* is not.

Chapter 6 focused on the mental representation of the abstract concept *love*. The concept of *love* has multiple metaphors in language and is assumed to have corresponding conceptual mappings. The CMT fits with recent theories that similarly assume that abstract concepts such as love are grounded in concrete experience (e.g., Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005). We investigated two conceptual mappings *love is warmth* and *love is closeness* that are assumed to be grounded in concrete experience (e.g., Lakoff & Johnson, 1999). In Experiment 1 we investigated whether *love* is partly represented by *warmth* in which *love is warm*, reflected in sentences such as *She is warm-hearted* and *no love is cold*, reflected in sentences such as *He gave an icy stare*. Participants had to decide whether a word was positively related to love (e.g., *attractive*, *sweet*) or negatively related to love (e.g., *disdain*, *rejection*) while resting one arm on a cold pack and one arm on a warm pack. In the love decision task *positive love words* should activate *love*, whereas *negative* *love words* should activate *no love*. The different temperatures of the packs on which participants rested their arms should activate the concept *warmth* with a *warm-cold* orientation. If *love* is represented by *warmth*, we expected that positive love words and the sensation of the warm pack would both activate the *warm* orientation of *warmth*. On the other hand, negative love words and the sensation of the cold pack should activate the *cold* orientation of *warmth*. We expected that if *love* is partly represented by *warmth*, participants' performance would be better for love words when they had to respond with the warm side compared to cold side (*love is warm*), whereas participants' performance would be better for negative love words when they had to respond with the cold side compared to the warm side (*no love is cold*). At the end of the experiments participants were asked about the purpose of the experiment to test whether they were aware of the manipulation. Interestingly, we only found an effect for participants who were aware of the link between temperature and love during the experiment. Aware participants responded faster to positive love words with the warm side than with the cold side, and faster to negative love words with the cold side than with the warm side. In Experiment 2 we investigated whether *love* is partly represented by *closeness* in which *love is near*, reflected in sentences such as *They are close* and *no love is far* reflected in sentences such as *I keep him at arm's length*. Participants had to decide whether two pictures depicting famous people were a love couple (e.g., Brad Pitt and Angelina Jolie) or not (Ozzy Osbourne and Princes Maxima). The pictures were presented at three different distances (near, intermediate, far). In the love decision task *love couples* should activate *love*, whereas *non-couples* should activate *no love*. The different distances between the pictures should activate the concept *closeness*, with a *near-far* orientation. If *love* is represented by *closeness*, we expect that famous love couples and smaller distances between the pictures both activate the *near* orientation of *closeness*. On the other hand, non-couples and greater distances between the pictures should both activate the *far* orientation of *closeness*. We expected that if *love* is partly represented by *closeness*, participants' performance would be better for love couples when presented closer to each other (*love is near*), whereas participants' performance would be better for non-couples when presented further from each other (*no love is far*). At the end of the experiment we again tested whether participants were aware of the manipulation. Only three participants were somewhat aware which made it hard to analyse the effect of awareness. We found no interaction effect between distance and couple status, which means that distances had no different influence on performance for love couples and non-couples. Since we did not obtain an effect for unaware participants in both experiments, the study in

Chapter 6 provides no evidence that *love* is partly represented by *warmth* or *closeness*. Still the null-effect is hard to interpret. An alternative explanation would be that the concept of *love* is complex, more than just the sum of multiple metaphors, in which relations between different concrete concepts such as between *warmth* and *closeness* play an important role.

Discussion

In Chapters 3, 4, and 5 we obtained evidence that the mental representation of abstract concepts (e.g., *similarity*, *categories*, *situational quantity*) are partly structured by concrete concepts (e.g., *closeness*, *containers*, *verticality*). However, in Chapter 2 we could not find evidence that the vehicle (e.g., *money*) of a conceptual mapping (e.g., *time is money*) is helpful in the comprehension process of a topic (e.g., *time*) in a conventional metaphorical sentence (e.g., *This computer will save me hours*). Moreover, in the studies of Chapter 6 we did not find evidence for the conceptual mappings *love is warmth* neither for *love is closeness*.

In order to investigate a theory, it is essential to have a detailed understanding of the restrictions and predictions of the theory. However, the Conceptual Metaphor Theory (Lakoff & Johnson, 1980, 1999) does not provide a model with clear restrictions and predictions. The model that the CMT provides allows different interpretations, which results in different predictions. Thus, thorough investigation of the CMT is difficult since there is often more than one possible interpretation. The major claim of the CMT is that concrete concepts are mapped onto abstract concepts. The CMT adopts an embodied view, especially for primary metaphors. Primary metaphors are described as metaphorical mappings that are a "consequence of the nature of our brains, our bodies, and the world we inhabit" (Lakoff & Johnson, 1999, p. 59). Primary metaphors (e.g., *quantity* is *verticality*) are formed by co-occurrence of two concepts in one experience (e.g., filling a glass with water, Johnson, 1997). The concrete concept consists of sensory-motor inferential structures sometimes called image schemas (e.g., *verticality* schema with an *up-down* orientation), that are formed by bodily interaction with concrete concepts during childhood (Mandler, 1992). When a concrete concept co-occurs with an abstract concept in one experience neural connections between the concepts are formed. This connection is asymmetric. The sensory-motor system that is assumed to be the basis of the mental representation of concrete concepts has more inferential connections, and sends activation to abstract concepts. This explains why metaphorical mappings are assumed to be asymmetric (Lakoff & Johnson, 1999). Primary metaphors are said to be mostly universal, because embodied experiences are mostly universal and unconscious. Complex metaphors are a combination of more than one primary metaphor (Grady, 1997 in Lakoff & Johnson, 1999). In turn, abstract concepts can be a combination of multiple conceptual mappings (e.g., *love is a nutrient*, *love is magic*, *love is warmth*, etc.) (Kövecses, 2000; Lakoff & Johnson, 1980). Although the CMT was developed from linguistic evidence, Lakoff and Johnson (1999) claimed that not all conceptual mappings are expressed in the words of a language.

Still it is unclear how these conceptual mappings work, and how exactly the mental representation of an abstract concept is structured. It is claimed that independent mental representations of abstract concepts exist, which in turn allows that "Abstract thought is largely, though not entirely, metaphorical." (Lakoff & Johnson, 1980, p. 272) but that this is "relatively impoverished and have only a minimal "skeletal" structure" (Lakoff & Johnson, 1999, p. 58). In contrast, this impoverished skeleton is claimed to be sufficiently informative to guide and restrict the mappings of sets of correspondences (Lakoff, 1993). Also it is claimed that "…we probably can do some very minimal…" by "…unsophisticated non-metaphorical reasoning." (Lakoff & Johnson, 1999, p. 59). In general these statements aim at the idea that abstract concepts have a stripped down independent mental representation, but that the extension of one or multiple metaphors is needed to form a complete representation (Lakoff & Johnson, 1980). Such moderate assumptions are alternated with stronger principles like "without such metaphors, abstract thought is virtually impossible" (Lakoff & Johnson, 1999, p. 59) and "We have found that we can not think (much less talk) about time without those metaphors." (Lakoff & Johnson, 1999, p. 166).

Gibbs (1994) used the Conceptual Metaphor Theory as a theory for metaphorical language comprehension, and did not address the question of abstract concepts directly. Gibbs claimed that conceptual mapping plays an important role only during comprehension of (conventional) metaphorical language, and not during literal language. Nevertheless, Gibbs holds an embodied view on how conceptual mappings are formed (see also Gibbs, Lima, & Francoza, 2004). Gibbs, Lima, and Francoza indicated that only some metaphorical language (presumably primary metaphors) and metaphorical (optional) thought is grounded in experience. As discussed in Chapter 2 the view that conceptual mapping is only necessary during metaphorical language comprehension was adopted as the *process claim* of the CMT

(Gibbs, 1994; see also McGlone, 2006). In the present studies, we found no evidence for the *process claim* of the Conceptual Metaphor Theory (Chapter 2).

Additionally, Murphy (1996) provided a weak version of Conceptual Metaphor Theory in which both concrete and abstract concepts have their own independent elaborated mental representation. In that case conceptual mappings seem unnecessary, because abstract concepts do not need the mental representation of concrete concepts for full understanding. He provided a different cause of the existence of conceptual mapping, which is the metaphorical language itself (Murphy, 1996). Thus, the causal relation between conceptual mapping and language in this view is reversed. This weak version does not provide a reason for asymmetry of conceptual mapping (although Boroditsky, 2008, used the asymmetry as evidence for the weak version). Instead of inheriting features from concrete concepts, the mental structures of abstract concepts are assumed to be aligned with the mental structure of the concrete concepts. The lack of an embodied grounding for abstract concepts resulting in symmetrical conceptual mappings is a shortcoming of this weak view.

In the light of recent theories of mental representations that propose that concepts are grounded in experience, the most plausible view is that concrete concepts are asymmetrically mapped onto abstract concepts. Nevertheless, the sparse mental structure of abstract concepts independent of metaphors (Lakoff & Johnson, 1980, 1999) needs to contain sufficient information to guide conceptual mapping (Lakoff, 1993). As Lakoff and Johnson (1980) already indicated, concrete concepts are only partially mapped onto abstract concepts. Not all characteristics of concrete concepts are inherited in the mental representation of abstract concepts. In order to avoid attribution of incorrect characteristics of a concrete concept onto an abstract concept conceptual mapping needs to be guided. The independent mental representation of an abstract concept should be sufficient to constrain the set of correspondences between the concepts (Lakoff, 1993). Nevertheless, in spite of the presumable existence of independent abstract mental representations, conceptual mappings are assumed to be necessary to fully understand abstract concepts, and in some cases non-metaphorical reasoning is impossible (e.g., time, Lakoff & Johnson, 1999).

Still the idea of a "skeleton" mental representation of abstract concepts seems unclear. Obviously, the mental representations of the concepts need to be distinct. Otherwise, the experience of the two concepts, for instance *time* and *money*, would be indistinguishable (Lakoff & Johnson, 1980, Lakoff, 1993). As this is not the case (e.g., people know that time can not be put into a bank account), apparently not all features of concrete concepts are mapped onto the abstract concepts. Lakoff indicated that this is prevented from happening, because the structure of the abstract concept "limits the possibilities for mapping automatically"(Lakoff, p. 216). As Murphy (1996) already indicated, it is not clear how the structure of the abstract concept does that.

Thus, there are two problems. First, it is not clear what the "skeleton" of the abstract concept consists of. Second, it is not clear how conceptual mappings select the right set of correspondences (Murphy, 1996). These problems seem to be intertwined in such a way that only one needs to be resolved to clarify the process of conceptual mapping. For instance, if the mental representations of abstract concepts are sufficiently structured (e.g., contain information that the concept is not physically present in the world) this could provide guidelines for the selection of correspondences (e.g., money can be put in a wallet but time cannot) for the conceptual mapping. Lakoff (1993) suggested this kind of structure for abstract concepts but did not elaborate on this point. On the other hand, if the metaphorical connections between concrete and abstract concepts are specified as metaphorical connections instead of literal connections a clearly structured mental representation of the abstract concept would be redundant. According to this view, the mental representation of the abstract concepts can be interpreted simply as a compilation of metaphorical connections towards concrete concepts. This interpretation was stated by Murphy as the strong view of metaphoric representation. Unfortunately, as Murphy indicated, metaphorical links are problematic, because there is no homunculus that can interpret these metaphorical links.

The most likely option is that the skeleton of the mental structure of the abstract concept should contain some guiding information for the process of conceptual mapping. The remaining question is how a sufficient "skeleton" of an abstract concept can be grounded in experience. One option is that concrete situations in which abstract concepts occur not only play a role in the formation of conceptual mappings (Lakoff & Johnson, 1980, 1999; Johnson, 1987) but also during formation of the "skeleton". Characteristics of these concrete experiences might provide sufficient structure to the skeleton so that conceptual mappings can occur correctly. For example by concrete experience with *time* people learn that time is not physically present in the world (e.g., time can not be put in a wallet or on the bank), but that some characteristics are similar to *money* (e.g., valuable thing that can only be spent once).

If we assume that the "skeleton" of an abstract concept contains sufficient information and that this "skeleton" is grounded in experience, then the most important contribution of the Conceptual Metaphor Theory is an embodied solution for abstract concepts. Image schemata that structure concrete concepts and are formed by bodily experience are mapped onto abstract concepts. Other theories also provide solutions for the mental representation of abstract concepts. (e.g., Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005; Coulson, 2001). As described in Chapter 6, the CMT and other recent theories (e.g., Barsalou, 1999; Barsalou and Wiemer-Hastings, 2005; Coulson, 2001) have indicated the importance of concrete experiences in which (abstract) concepts occur in the formation of the mental representation of these abstract concepts. Concrete features (or concrete metaphors) that co-occur with the abstract concept are assumed to become embedded in and form the mental representation of abstract concepts. As we showed in Chapter 6, it is sometimes hard to distinguish between the Conceptual Metaphor Theory and other theories that assume that concepts are grounded in experience.

Suggestion for future research

In this dissertation we investigated the Conceptual Metaphor Theory by means of metaphorical language comprehension and conceptual tasks. The research question focused on one assumption of the Conceptual Metaphor Theory; do concrete concepts play a role in the mental representations of abstract concepts? In Chapters 3, 4, and 5 we found evidence for this assumption. As described in the discussion, I argue that the process of conceptual mapping and the "skeleton" of the abstract concept are still unclear. Future studies should focus on the core representations of abstract concepts and the process of conceptual mapping. Investigation of aspects of conceptual mapping such as asymmetry and timing might partly clarify the process of conceptual mapping.

First, asymmetry of conceptual mapping is an assumption of the CMT. In Chapter 3 we found evidence for the asymmetry claim for the conceptual mapping *similarity is closeness*. Participants' performance on the *similarity* decision task was influenced by *distance*, whereas participants' performance on the *distance* decision task was not influenced by *similarity* (*closeness* is mapped on *similarity*, but *similarity* is not mapped on *closeness*). Other researchers found similar results. Casasanto and Boroditsky (2008) found that participants' performance on a time duration estimation task was influenced by distance, whereas participants' performance on a distance estimation task was not influenced by time duration (*space* is mapped on *time*, but *time* is not mapped on *space*).

In the aforementioned studies the concrete and abstract concept were presented simultaneously in the same the target stimuli. In the study of Chapter 3 the squares with similar or dissimilar colours (*similarity*) were presented at different distances (*closeness*). In the study of Casasanto and Boroditsky (2008) the moving dot (or growing line etc.) (*space*) was presented for a certain duration (*time*). Other studies isolated the concrete and abstract concept in different stimuli and investigated asymmetry by means of priming. For instance, Boroditsky (2000) found the same asymmetry with linguistic materials for different mappings of time, *time is a moving object* (e.g., *The following week*) and *time is a landscape* (e.g., *I left that behind me now*). She found that priming with space related statement (e.g., *M is in front of me*) accompanied with a picture that depicted the statement influenced answers on an ambiguous question about time (e.g., *Next Wednesday's meeting has been moved forward two days. Which day is in the meeting now that it's been moved?)*, whereas time related statements (e.g., *In March, May is ahead of us*) did not influence answers on an ambiguous spatial question about a picture (e.g., *Which one of these widgets is ahead?*). Meier and Robinson (2004) found the opposite asymmetry for the conceptual mapping *valence is verticality* (*positive is up* and *negative is down*). They found that priming with a positive or negative word (valence) influenced performance on identifying a letter at the top or bottom of the screen (verticality), whereas priming with a spatial probe presented at the top or bottom of the screen (verticality) did not influence performance on a valence decision task over words (either positive or negative). Zanolie et al. (2010) and Van Dantzig (2009) found similar results for the conceptual mapping *power is verticality*. It is unclear what causes the inconsistencies in findings about asymmetry of conceptual mapping. Future research might shed light on the process of asymmetrical mappings and the factors that influence asymmetry. Possibly, the direction of the asymmetry effect depends on the design of the experiment, in particular the timing of abstract and concrete concepts. For instance, it could be investigated whether the asymmetry effect of *valence is verticality* and *power is verticality* would change in the same direction as in the study of Casasanto and Boroditsky and the study of Chapter 3 if the concrete (*verticality*) and abstract concepts (*valence*, *power*) are presented simultaneously in one stimulus. Meier and Robinson and Van Dantzig found that the abstract concept (e.g., *valence*, *power*) influenced processing of the concrete concept (e.g., *verticality*), but not vice versa. As Van Dantzig indicated this might be due to the fact that the concrete concept (e.g., *verticality*) has a fast activation and decay, whereas the abstract concept (e.g., *valence*, *power*) has a slow activation and decay. When the decision task over the abstract concept (e.g., valence, power) was presented first, followed by the decision task that activated the concrete concept (e.g., verticality), the abstract concept might still have been active during processing of the concrete concept, and might have influenced performance. On the other hand, when the decision task that activated the concrete concept (e.g., verticality) was presented first, followed by the decision task over the abstract concept (e.g., verticality) activation of the concrete concept might already have decayed during processing of the abstract concept and thus could not influence performance (Van Dantzig, 2009). Interestingly, the results found by Zanolie et al. show that a difference in timing might indeed explain null-effects. Van Dantzig found that a power decision task over words (e.g., *king*, *servant*), influenced identification for letters presented at the top versus bottom (verticality) when the delay between the word and the letter was 200 ms, but Zanolie et al. did not replicate the effect in behavioural data when the delay was variable between 500 and 700 ms. This null-effect in behavioural data might be due to the fact that a longer delay (between 500 and 700 ms) caused the activation of *power* to be almost extinct at the moment of the letter identification task. In contrast, Zanolie et al. did find an effect in de ERP data. This could be due to a higher sensitivity of measurement of ERP recordings compared to behavioural responses. In sum, a small activation of *power* that caused a small effect on the identification task and was observable in the ERP data, could have been too small to observe in the behavioural data.

If abstract concepts are partly represented by concrete concepts, then the differences in timing of activation and decay between abstract and concrete concepts could be an indication of the process of conceptual mapping. The slow timing of activation and decay of abstract concepts might reflect that conceptual mapping is an online process. Thus, in a situation where an abstract concept is needed to be fully understood, sets of correspondences from concrete to abstract concepts are created online. This process might take some time, causing slower activation time of abstract than concrete concepts. Another possibility is that slow timing of activation and decay of abstract concepts might simply reflect that the mental representation of abstract concepts is complex and enriched with (multiple) concrete metaphors that contain much more information than concrete concepts. Future research should focus on this timing issue of abstract concepts and conceptual mappings.

Other important issues that recent studies have focused on are cultural differences (Boroditsky, 2001; Chen, 2006; Casasanto, 2009) and individual differences (Meier, Selbom & Wygant, 2007; Casasanto, 2009) of conceptual mappings. Further research is needed to clarify the relationship between conceptual mappings and differences in experience caused by bodily differences, personality, and cultural background.

Other measures can be used to investigate the earliest stage of activation of conceptual mapping and to differentiate between timing of concrete and abstract concepts. Zanolie et al. (2010) measured ERPs to investigate spatial attention in response to powerful and powerless words. Although there was no effect in behavioural measures, they found an early attention shift effect in the ERPs As we discussed before, the difference between the EEG data and the behavioural data in the study of Zanolie et al. could provide information for the timing of activation of concrete versus abstract concepts. EEG and other measures such as eye-tracking might be more sensitive instruments and thus could be helpful to detect small and early effects that are hard to obtain with behavioural measurements.

Moreover, other measurement techniques, such as fMRI could be used to provide evidence that abstract concepts are understood in terms of concrete concepts and that abstract concepts are grounded in concrete experience. For instance, Boulenger, Hauk, and Pulvermüller (2008) found that the sensory-motor system not only played a role during comprehension of literal sentences, but also during metaphorical sentences. Interestingly, somatotopic activation along the motor strip that referred to movements of the arm was activated during comprehension of literal sentences in which an arm movement was mentioned (e.g., *John grasped the object*) as well as metaphorical sentences in which the same verb was used metaphorically (e.g., *John grasped the idea*). Moreover, somatotopic activation along the motor strip that referred to movements of the leg was activated during comprehension of literal sentences in which a leg movement was mentioned (e.g., *Pablo kicked the ball*) as well as metaphorical sentences in which the same verb was used metaphorically (e.g., *Pablo kicked the habit*). Now that there is evidence for involvement of the sensory-motor cortex during comprehension of metaphorical sentences, it would be interesting to investigate whether comprehension of abstract and concrete concepts beyond language in a conceptual task would activate overlapping neural substrates as well. If we would find that the sensory-motor system is active during comprehension of abstract concepts in a conceptual task, this would provide even stronger evidence that abstract concepts are partly represented by concrete concepts, and thus grounded in concrete experience.

The questions about the mechanism that would underlie conceptual mapping are inextricably bound to questions about the mental representation of abstract concepts. As discussed above, the mental representation would need a "skeleton" independent of metaphors, to guide the conceptual mapping in the first place. Future research should investigate what this “skeleton” is. How is this “skeleton” formed? How does this “skeleton” hold together different parts of concrete concepts to form one consistent abstract concept? What extra information does this “skeleton” contain that distinguishes the abstract from the concrete?

Conclusion

In this dissertation we provided evidence that the use of metaphors is not restricted to poets or story tellers, but is important for every language comprehender. Nor are metaphors merely a linguistic phenomenon, but rather a way of thinking. By means of metaphorical use of concrete concepts we can think of abstract concepts in concrete ways. Additionally, this seems to indicate that the sensory-motor system might not only be involved in the mental representation of concrete concepts but also in the mental representation of abstract concepts. Still many questions arise for the process of conceptual mapping and the mental representation of abstract concepts that need to be resolved in future research. The studies in the current dissertation and other recent studies discussed could be seen as a first step to unravel the mental representations of abstract concepts. To conclude, since abstract concepts cross our path metaphorical thinking is inevitable during the course of life.

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Samenvatting

Metaforen worden vaak gebruikt om ingewikkelde zaken begrijpelijk te maken. In de cognitieve psychologie bijvoorbeeld worden metaforen voor het geheugen gebruikt, zoals *tabula rasa*, *computer*, *bibliotheek* of *opslagplaats*. Ook in het dagelijks leven worden veel metaforen toegepast in bijvoorbeeld reclames, sprookjes, politiek, kunst, poëzie, etc. Indrukwekkender nog is dat metaforen op systematische wijze frequent in ons dagelijks taalgebruik voorkomen. Bijvoorbeeld in zinnen als *Mijn tijd is na 4 jaar op, Ik ga mijn tijd niet verspillen aan tuinieren, Ik steek veel tijd in sporten, Ik besteed mijn tijd liever nuttig* wordt over het abstracte concept *tijd* gesproken alsof het *geld* is. Door de metafoor *tijd is geld* te gebruiken kan taalkundig zowel *geld* als *tijd* verspild worden of ergens aan besteed worden. Wanneer een concreet concept (bv. *geld*) wordt gebruikt als metafoor voor een abstract concept (bv. *tijd*) wordt dit een metaforische *mapping* genoemd (Lakoff & Johnson, 1980). Dit voorbeeld laat zien hoe de metaforische mapping *tijd is geld* zich uit in taal.

Lakoff en Johnson (1980, 1999) werden geïnspireerd door de systematische wijze waarop metaforische *mappings* in taal gebruikt worden. Zij geloofden dat taal als belangrijke bron kon dienen om er achter te komen hoe onze mentale representaties van concepten gestructureerd zijn. Zo dachten ze dat metaforische zinnen niet alleen aantoonden dat mensen spreken over abstracte concepten in termen van concrete concepten, maar dat mensen abstracte concepten ook *begrijpen* in termen van concrete concepten. The Conceptuele Metaforen Theorie van Lakoff en Johnson stelt dat abstracte concepten mentaal gestructureerd worden door middel van/met behulp van concrete concepten (zie ook M. Johnson, 1987; Gibbs, 1994). Zij noemen dit fenomeen *conceptuele mapping* of *conceptuele metaforen*.Conceptuele mapping bestaat uit een set van conceptuele correspondenties (Lakoff, 1993) tussen twee concepten en kan verschillend geïnterpreteerd worden (Murphy, 1996, Boroditsky, 2000). In deze dissertatie onderzochten we of concrete concepten (bv. *dichtbijheid*) een rol spelen in de mentale representatie van abstracte concepten (bv. *gelijkheid*).

Hoofdstuk 2 van deze dissertatie richtte de aandacht op de *process claim* (Gibbs, 1994, zie ook McGlone, 2006) van de Conceptuele Metaforen Theorie (CMT) (Lakoff & Johnson, 1980, 1999). In deze studie onderzochten we of mensen gebruik maken van conceptuele metaforen wanneer ze metaforische zinnen lezen. In meer specifieke bewoordingen, we waren geïnteresseerd in de vraag of het concrete concept (bv. *geld*) van een conceptuele metafoor (bv. *tijd is geld*) kon helpen bij het begrijpen van een abstract concept (bv. *tijd*) in een conventionele metaforische zin (bv. *Daar wil ik liever mijn tijd niet aan verspillen als het kan*). Conventionele metaforische zinnen bevatten algemeen bekende metaforische uitdrukkingen die frequent gebruikt worden in dagelijks taalgebruik. In twee experimenten moesten mensen letterlijke zinnen en conventioneel metaforische zinnen lezen. De letterlijke zinnen gingen over een concreet concept. Bijvoorbeeld de letterlijke zin *While on a diet she was craving something fried* (*Tijdens dat ze op dieet was verlangde ze naar iets gefrituurds*) ging over het concrete concept *voeding*. De conventioneel metaforische zinnen gingen over een abstract concept omschreven door middel van een metaforische mapping. Bijvoorbeeld de conventioneel metaforische zin *He was given new strenght by her love* (*Hij kwam weer op kracht door haar liefde*) ging over het abstracte concept *liefde* omschreven door middel van de metaforische mapping *liefde is voeding*. Als het abstract concept (bv. *liefde*) in een conventionele metaforische zin begrepen wordt door gebruik te maken van een concreet concept (bv. *voeding*) dan zou het lezen van een letterlijke zin met het concrete concept helpen het abstracte concept sneller te verwerken. We onderzochten dit door voorafgaand aan elke conventionele metaforische zin mensen een letterlijke zin te laten lezen die of het concrete concept (bv. *voeding* in de zin *Tijdens dat ze op dieet was verlangde ze naar iets gefrituurds*) bevatte van de metaforische mapping van het abstracte concept (bv. *liefde*) of een ander concreet concept (bv. *beneden* in de zin *the mole dissapeared into the ground* (*De mol verdween in de grond*)). We gebruikten de leestijd van de gehele metaforische zin alsook de leestijd van het afzonderlijke segment met het abstracte concept (bv. *by her love*) als maat voor verwerking.

In Experiment 1 gebruikten we conventionele metaforen van Lakoff and Johnson (1980), Kövecses (2000) en Gibbs (1994) om er zeker van te zijn dat we zinnen gebruikten waarvan wordt aangenomen dat ze conceptuele metaforen zouden moeten activeren. In Experiment 1 vonden we dat proefpersonen sneller een conventionele metaforische zin lazen wanneer ze daaraan voorafgaand een letterlijke zin hadden gelezen dat het concrete concept (bv. *voeding*) van de conceptuele metafoor (bv. *liefde is voeding*) bevatte dan wanneer dit niet het geval was. Ondanks dat we een effect vonden van het concrete concept op het lezen van de metaforische zin, konden we geen effect vinden in het afzonderlijke segment met het abstracte concept (bv. *by her love*). Verscheidene factoren (lengte van de zin, volgorde en positie van het concrete en abstracte concept) waren niet gecontroleerd en dus konden deze factoren de resultaten beïnvloeden. Kortom, de zinnen van Lakoff and Johnson, Kövecses en Gibbs bleken niet geschikt te zijn voor het huidige onderzoek om onze vraagstelling te beantwoorden. In Experiment 2 creëerden we Nederlandse conventionele metaforische zinnen (bv. *Je kunt je leven natuurlijk nooit uitstippelen van tevoren*) gecontroleerd voor lengte van zin, positie en volgorde van concrete en abstracte concepten. Alle zinnen waren 5 segmenten lang en in alle target zinnen verwees de tekst in het tweede segment (bv. *je leven*) naar het abstracte concept (bv. *leven*) en de tekst in het vierde segment (bv. *uitstippelen*) naar het concrete concept (bv. *pad*). Met deze nieuwe stimuli vonden we geen effect van het concrete concept in de letterlijke zinnen op de leessnelheid van het abstracte concept in de metaforische zinnen.

Op het eerste gezicht leek het erop dat dit nul resultaat erop duidde dat het concrete concept niet helpt om het abstracte concept te begrijpen. Als dat waar zou zijn, dan waren de conceptuele mappings niet nodig om conventionele metaforische zinnen te begrijpen en zou de process claim van de CMT niet worden gesteund. Een alternatief voor de process claim is dat metaforische zinnen direct en letterlijk begrepen worden. Lakoff and Johnson (1980) beschouwden conventionele en nieuwe nog niet algemeen gebruikte metaforen even metaforisch die beide conceptuele mappings nodig zouden hebben om begrepen te worden. Bijvoorbeeld, *I'm depressed* (*Ik ben depressief*) wordt beschouwd als zijnde metaforisch (Lakoff & Turner, 1989 in Keysar, Shen Glucksberg en Horton, 2000), terwijl het meer aannemelijk lijkt dat *depressed* (*depressie*) een polyseem woord is, oftewel een woord met twee betekenissen (Keysar et al, 2000, ook Murphy, 1996; Jackendoff & Aaron, 1991 zoals geciteerd in Keysar et al, 2000). Net zo goed als dat het woord *bank* meerdere betekenissen heeft (bv. lang zitmeubel, instelling voor geldomloop) zo zou *depressie* ook meerdere betekenissen kunnen hebben (bv. lage luchtdruk, slechte gemoedstoestand). Tijdens het lezen van de zin *Ik ben depressief* zou de abstracte betekenis van *depressie*, namelijk *slechte gemoedstoestand* of *melancholie,* direct opgehaald kunnen worden uit het lexicon. Hierdoor hoeft er geen conceptuele mapping (bv. *negatief/slecht is beneden*) aan te pas te komen om de zin te begrijpen. De conventionele metaforen die we gebruikten in de studies van Hoofdstuk 2 zouden ook woorden kunnen bevatten met meerdere betekenissen. Op die manier zou het kunnen dat zinnen als *Ik heb alle hoop verloren* (Experiment 1) en *Het was lastig dat haar gedachten telkens weer naar het feest gingen tijdens haar tentamen* (Experiment 2) letterlijk geïnterpreteerd werden. Ondanks dat we geen bewijs hebben kunnen vinden dat de conventionele metaforische zinnen die we gebruikten begrepen werden met conceptuele metaforen, staat de mogelijkheid nog wel open dat nieuwe metaforische zinnen wel begrepen worden met conceptuele metaforen.

Een alternatieve interpretatie van de resultaten in Experiment 2 is dat het effect van conceptuele mapping niet gevonden kon worden doordat de stimuli die we controleerden op de drie genoemde factoren, andere factoren bevatten die voor ruis in de data zouden kunnen hebben gezorgd. De target zinnen moesten allemaal dezelfde structuur hebben (5 segmenten met in het tweede segment het abstracte en in het vierde segment het concrete concept). Hierdoor klonken de zinnen soms onnatuurlijk (maar wel grammaticaal correct). Daarbij bevatten de zinnen naast het abstracte en concrete concept ook irrelevante informatie (bv. *feest*, *tentamen*). Het mogelijke effect van deze variabele factoren zou het effect van de conceptuele metaforen overschaduwd kunnen hebben.

Kortom, in de studies van Hoofdstuk 2 realiseerden we ons dat verscheidene factoren in taal moeilijk te controleren zijn. Toen we in Experiment 2 voor verscheidene factoren controleerden werden de stimuli te complex, klonken de zinnen onnatuurlijk en bevatten ze te veel irrelevante informatie. Aangezien taal niet de meest aangewezen modaliteit bleek te zijn om de CMT mee te onderzoeken, besloten we om in de volgende hoofdstukken ons te focussen op een sterkere aanname van de CMT die boven taalbegrip uitstijgt. Volgens deze sterkere aanname van de CMT wordt de mentale representatie van een concreet concept ook gebruikt om een abstract concept te begrijpen in een situatie waar taalbegrip geen rol speelt. Als deze bewering klopt, zouden we een effect moeten vinden van het concrete concept op de verwerking van een abstract concept gedurende een conceptuele taak.

In de hoofdstukken die volgen concentreerden we ons op conceptuele mapping tijdens het begrijpen van concepten buiten taalbegrip om. De interpretatie van de CMT (Lakoff & Johnson, 1980) die in deze dissertatie wordt aangehouden suggereert dat concrete concepten deels een rol spelen in de mentale representatie van abstracte concepten. De meeste eerdere studies die conceptuele mapping los van taalbegrip onderzochten, gebruikten conceptuele taken vrij van taal (bv. beoordelen van plaatjes). De mogelijke strategieën die tijdens de uitvoer van de conceptuele taken gebruikt konden worden werden over het hoofd gezien In Hoofdstuk 3, 4, 5 en 6 gebruikten we simpele decisie taken met feedback waarin het gebruik van conceptuele mapping de taak niet kon vergemakkelijken zodat deze niet strategisch gebruikt kon worden. Ook zorgden de simpele decisie taken ervoor dat het duidelijk was wat correcte antwoorden waren. Minimalisatie van onzekerheid over wat een correct antwoord is doet de kans op het gebruik van strategieën nog eens verkleinen (Van den Bos, 2003; Van de Bos, Lind, Vermunt & Wilke, 1997). Door de kans te verkleinen dat conceptuele mapping strategisch gebruikt kon worden, konden we onderzoeken of conceptuele mappings automatisch gebruikt worden en dus noodzakelijk zijn voor begrip van abstracte concepten. Daarbij controleerden we in de huidige studies ook voor verbondenheid tussen polariteiten (Proctor & Cho, 2006). Wanneer mensen over een dimensie (bv. kleur) van stimuli (bv. twee vierkantjes) een tweedelige beslissingen moeten maken (bv. of de kleuren gelijkend of verschillend zijn van de vierkantjes)) die nog een andere dimensie (bv. afstand) met tweedelige waarden bevat (bv de twee vierkantjes staan dichtbij of veraf van elkaar afgebeeld op een scherm), kan er een verbinding tussen de polariteiten van die waardes ontstaan (bv. gelijk en dichtbij, verschillend en veraf) en op hun beurt een interactie effect veroorzaken. In de huidige studies controleerden we voor binding tussen tweedelige waardes door gebruik te maken van meer dan twee waardes in het experiment (Hoofdstuk 6), door toevoeging van een controle experiment met meer dan twee waarden (Hoofdstuk 3 en Hoofdstuk 4), of door gebruik te maken van een secundaire impliciete taak (Hoofdstuk 5).

In de Hoofdstukken 3 tot 6 bekeken we één abstract concept per keer en één of twee conceptuele mappings van deze abstracte concepten per keer. We onderzochten de conceptuele mappings *gelijkheid is dichtbijheid* (Hoofdstuk 3), *categorieën zijn containers* (Hoofdstuk 4), *hoeveelheid is verticaliteit* onderverdeeld in *situationele hoeveelheid is verticaliteit* en *simpele cijfers zijn verticaliteit* (Hoofdstuk 5) en *liefde is warmte* en *liefde is dichtbijheid* (Hoofdstuk 6). Door te focussen op één of twee conceptuele mapping per hoofdstuk, konden we simpele decisie taken gebruiken die in staat waren de conceptuele mappings grondig te onderzoeken en op die manier alternatieve verklaringen uit te sluiten.

De conceptuele mappings die we onderzochten waren allen primaire metaforen (Grady, 1997 zoals geciteerd in Lakoff & Johnson, 1999). Dit houdt in dat het betreffende concrete concept (bv. *dichtbijheid* in Hoofdstuk 3) van een conceptuele mapping uit één image schema (bv. *dichtbij-veraf* image schema) opgebouwd is. Image schemata zijn de bouwstenen van concrete concepten (M. Johnson, 1987). Ze worden omschreven als conceptuele structuren die spatiele relaties en bewegingen in de ruimte representeren en gevormd worden door interactie van ons lichaam en zintuigen met objecten in de buitenwereld gedurende onze kindertijd (Mandler, 1992). Deze image schemata worden op hun beurt weer geactiveerd wanneer concrete concepten (bv. de afstand tussen twee punten) begrepen moeten worden. Door middel van conceptuele mapping (bv. *gelijkheid is dichtbijheid* in Hoofdstuk 3) kunnen deze image schemata (bv. *dichtbij-veraf* image schema) niet alleen letterlijk maar ook metaforisch gebruikt worden om abstracte concepten te begrijpen.

Van deze primaire metaforen wordt aangenomen dat ze direct gevormd worden door correlatie van het concrete en het abstracte concept in één ervaring (Lakoff & Johnson, 1980, 1999, M. Johnson, 1987; C. Johnson, 1997). Bijvoorbeeld de ervaring dat gelijkende objecten vaak bij elkaar geclusterd zijn (bv. bloemen, kopjes) zou zorgen voor het ontstaan van de conceptuele mapping *gelijkheid is dichtbijheid*. De voorspelling van de CMT is dat wanneer daarna het abstracte concept begrepen moet worden (bv. wanneer *gelijkheid* van twee kleuren moet worden beoordeeld) gebruik moet worden gemaakt van de representatie van het concrete concept (bv. *afstand*), ondanks dat het concrete concept niet meer gecorreleerd is met afstand in die situatie.

De vier experimenten gerapporteerd in Hoofdstuk 3 onderzochten of de metaforische mapping *gelijkheid is dichtbijheid* actief is gedurende een conceptuele taak. De conceptuele mapping *gelijkheid is dichtbijheid* bestaat uit twee componenten, namelijk *gelijk is dichtbij*, terug te vinden in zinnen als *Deze kleur komt in de buurt van rood,* en *verschillend is veraf*, terug te vinden in zinnen als *Onze smaken liepen uiteen*. In Experiment 1 en 2 onderzochten we of de mentale representatie van *gelijkheid* voor een deel gerepresenteerd wordt door *dichtbijheid*, met de onderliggende *dichtbij-veraf* image schema. In Experiment 3 en 4 onderzochten we of de conceptuele mapping *gelijkheid is dichtbijheid* asymetrisch is, oftwel dat *gelijkheid* deels door *dichtbijheid* wordt gerepresenteerd maar niet dat *dichtbijheid* deels door *gelijkheid* wordt gerepresenteerd. In Experiment 1 en 2 moesten proefpersonen beslissen of twee vierkanten twee gelijke of verschillende kleuren hadden. De gelijke kleuren paren waren twee tinten van één kleur (bv. donker en licht blauw) en de verschillende kleuren paren waren altijd twee verschillende kleuren (bv. blauw en geel). Gelijke en verschillende kleuren paren waren dus gemakkelijk te onderscheiden, wat ervoor zorgde dat de correcte respons altijd duidelijk was. De vierkanten werden op twee verschillende afstanden gepresenteerd in Experiment 1 (dichtbij en veraf) en op drie verschillende afstanden in Experiment 2 (dichtbij, tussenin, veraf). De decisie taak (*gelijkend* of *verschillend*) zou *gelijk* moeten activeren voor gelijke kleur paren en *verschillend* voor verschillende kleur paren. De verschillende afstanden tussen de vierkanten zou het concept dichtbijheid met het onderliggende *dichtbij-veraf* image schema moeten activeren. Als *gelijkheid* is gerepresenteerd door *dichtbijheid*, zouden we verwachten dat de afstand van de vierkanten een verschillend invloed zou uitoefenen op de gelijkende kleurenparen en verschillende kleurenparen. In congruentie met de voorspelling, vonden we dat de prestatie van proefpersonen beter was voor gelijkende kleuren paren die dichtbij elkaar dan veraf van elkaar gepresenteerd werden (*gelijk is dichtbij*), terwijl de prestatie van proefpersonen beter was voor verschillende kleur paren wanneer deze veraf dan dichtbij gepresenteerd werden.

Volgens de CMT (Lakoff & Johnson, 1980, 1999) zouden conceptuele mappings asymmetrisch van aard zijn. In taal bijvoorbeeld kan een zin als *Deze kleur komt in* *de buurt van rood* zowel letterlijk als figuurlijk geïnterpreteerd worden, terwijl de zin *Deze steden zijn gelijkend* alleen letterlijk geïnterpreteerd worden. In Experiment 3 en 4 van Hoofdstuk 3 onderzochten we deze bewering over asymmetrie. Er werden ook vierkanten met gelijkende en verschillende kleuren aangeboden, maar in tegenstelling tot experiment 1 en 2 moesten proefpersonen een beslissing maken over de afstand tussen de vierkanten. Als het waar is dat *gelijkheid* deels door *dichtbijheid* wordt gerepresenteerd maar niet andersom, dan zouden we verwachten dat de gelijkheid van de kleuren geen invloed heeft op de prestatie van de proefpersonen op de *afstand* decisie taak (*veraf* of *dichtbij*). In overeenstemming met de assumptie van de CMT vonden we dat proefpersonen niet beïnvloed werden door de gelijkheid van kleuren wanneer ze een beslissing moesten maken over de afstand tussen twee vierkanten. De studie in Hoofdstuk 3 biedt evidentie dat *gelijkheid* deels gerepresenteerd wordt door *dichtbijheid* en bovendien dat deze conceptuele mapping asymmetrisch is.

Hoofdstuk 4 beschrijft een studie bestaande uit vier experimenten waarin wordt onderzocht of de metaforische mapping *categorieën zijn gesloten ruimtes* actief is gedurende een conceptuele taak. De metaforische mapping *categorieën zijn gesloten ruimtes* kan gevonden worden in zinnen als *Behoren tomaten in de categorie van groenten of fruit?* (*dezelfde categorie is één en dezelfde gesloten ruimte*) en *Sla valt buiten de categorie van fruit* (*verschillende categorieën zijn niet dezelfde gesloten ruimtes*). In Experiment 1 en 2 werd onderzocht of de mentale representatie van *categorieën* deels gerepresenteerd wordt door *gesloten ruimtes* met de onderliggende *container* image schema met een *in-uit* oriëntatie en in Experiment 3 en 4 werden alternatieve verklaringen uitgesloten. In Experiment 1 en 2 moesten proefpersonen beslissen of twee plaatjes in het midden van het computerscherm twee dingen van dezelfde categorie (twee dieren of twee voertuigen) of van verschillende categorieën (één dier en één voertuig) afbeeldden. De twee plaatjes werden samen met een kader (een zwart omlijnd vierkant) gepresenteerd. Het kader zou het concept *gesloten ruimtes* moeten activeren. Het kader kon verschillende posities aannemen; in het midden van het computerscherm zodat alle twee de plaatjes *in* het kader stonden, of links of rechts van het midden, zodat één van de twee plaatjes *uit* het kader was. De *categorie* decisie taak (*dezelfde categorie* of *verschillende categorieën*) zou *dezelfde categorie* moeten activeren bij plaatjes die dingen van dezelfde categorie afbeeldden (twee dieren of twee voertuigen) en *verschillende categorie* bij plaatjes die dingen van verschillende categorieën afbeeldden (één dier en één voertuig). De positie van het kader zou de "*in*" oriëntatie moeten activeren wanneer beide plaatjes in het kader staan en de "*uit*" oriëntatie wanneer één plaatje uit het kader staat. Als het concept *categorieën* gerepresenteerd wordt door *containers*, dan zouden we verwachten dat de prestatie van proefpersonen op plaatjes van verschillende categorieën en dezelfde categorie op verschillende manieren beïnvloed wordt door de posities van het kader. Consistent met de voorspelling vonden we dat de prestatie op plaatjes van dezelfde categorie beter was wanneer ze beide in het kader stonden dan wanneer één erbuiten en één erbinnen stond, terwijl de prestatie op plaatjes van verschillende categorieën niet anders was voor de verschillende posities van het kader. Het doel van Experiment 3 en 4 was om alternatieve verklaringen van Experiment 1 en 2 uit te sluiten. In Experiment 3 boden we één plaatje tegelijk aan waarover een *dier* decisie taak (*dier* of *geen dier*) moest worden uitgevoerd, zodat effecten veroorzaakt door visuele groepering konden worden uitgesloten. De categorie die in focus was in deze dier decisie taak, was de categorie van *dieren*. De response op plaatjes met een dier (behorend tot de dezelfde categorie die in focus is) zou net als de response op twee plaatjes behorend tot dezelfde categorie (Experiment 1 en 2 in Hoofdstuk 3) *dezelfde categorie* moeten activeren. We vonden dat wanneer het plaatje tot de categorie *dieren* behoorde, proefpersonen sneller reageerden wanneer dit plaatje in het kader versus uit het kader was, terwijl proefpersonen niet verschillend reageerden op plaatjes die behoorden tot een categorie die niet van belang was voor de taak (voertuig of voedsel). Dit resultaat laat zien dat zelfs wanneer er geen effect van visuele groepering mogelijk is, de positie van het kader nog steeds invloed heeft op de prestatie. In Experiment 4 gebruikten we dezelfde taak als in Experiment 1 en 2 met als enige verschil dat een derde positie van het kader was toegevoegd om effecten van een koppeling tussen tweedelige waarde te vermijden. Evenals in Experiment 1 en 2 vonden we dat de prestatie op plaatjes van dezelfde categorie beter was wanneer beiden plaatjes binnen het kader afgebeeld waren, vergeleken met wanneer één plaatje binnen en één plaatje buiten het kader afgebeeld was, terwijl de prestatie op plaatjes van verschillende categorieën niet anders was voor de verschillende posities van het kader. De studie in Hoofdstuk 4 levert bewijs dat *categorieën* deels door *containers* gerepresenteerd worden.

Om de Conceptuele Metaforen Theorie verder te onderzoeken, belichtten we in Hoofdstuk 5 de metaforische mapping *hoeveelheid is verticaliteit* middels drie experimenten. Deze metaforische mapping bestaat uit de tweedeling *meer is hoog* dat gereflecteerd wordt in zinnen als "*De prijzen zijn hoog*" en *weinig is laag* dat gereflecteerd wordt in zinnen als "*Zet de verwarming laag*". We onderzochten de rol van verticaliteit in de mentale representaties van twee verschillende hoeveelheden, namelijk *situationele hoeveelheid* (bv. 5 bananen in de yoghurt) en *simpele cijfers* (bv.

5). Experiment 1 concentreerde zich op de mentale representatie van *situationele hoeveelheid*. Proefpersonen moesten beslissen of een genoemde hoeveelheid (bv. 5 bananen) in een specifieke context van een zin weinig was (e.g. *Er lagen 5 bananen in de kist bij de groenteboer*) of veel (e.g. *Hij sneed de vijf bananen in stukjes door de yoghurt*) in een specifieke context. Na de *hoeveelheid* beslissingstaak (*veel* of *weinig*) moesten proefpersonen een letter identificeren (*p* of *q*) die boven- of onderin het scherm gepresenteerd werd. De *hoeveelheid* beslissingstaak zou *meer* moeten activeren wanneer de hoeveelheid in de zin veel is en *minder* moesten activeren wanneer de hoeveelheid in de zin weinig is. De positie van de letter in de *letter* identificatie taak (*p* of *q*) zou het concept *verticaliteit* moeten activeren, bestaand uit de onderliggende *verticaliteit* image schema met een *hoog-laag* oriëntatie. Als de *situationele hoeveelheid* is gerepresenteerd door *verticaliteit*, dan zouden we verwachten dat de verschillende hoeveelheden in de zinnen een andere invloed zou hebben op de prestatie voor letters bovenin dan voor letters onderin het scherm. In lijn met de verwachtingen vonden we dat de prestatie van proefpersonen beter was voor letters bovenin het scherm wanneer de zin die daaraan vooraf werd aangeboden een hoeveelheid bevatte die veel was, vergeleken met weinig (*meer is hoog*) terwijl de prestatie van de proefpersonen op letters onderin het scherm niet verschilde voor de verschillende zinnen.

In Experiment 2 van Hoofdstuk 5 onderzochten we de mentale representatie van simpele cijfers. Proefpersonen moesten een *hoeveelheid* decisie taak (*veel* of *weinig*) uitvoeren over simpele cijfers (*veel* was meer dan 50 en *weinig* was minder dan 50) gevolgd door een letter identificatie taak (*p* of *q* aan de boven of onderkant van het scherm). We vonden dat de prestatie op de *letter* identificatie taak niet werd beïnvloed door de decisie taak over simpele cijfers. In Experiment 3 van Hoofdstuk 5 controleerden we voor twee verschillen tussen Experiment 1 en 2. Het eerste verschil was dat in Experiment 1 het referentiepunt impliciet was terwijl dit in Experiment 2 expliciet was (50). Het tweede verschil was dat in Experiment 1 het referentiepunt varieerde per trial terwijl dit constant was in Experiment 2 (altijd 50). Om te controleren voor deze verschillen, boden we voor elke prime (een cijfer of zin) een ander referentie punt aan (cijfer of zin). Proefpersonen zagen dus eerst het referentiepunt (bv. *78* of *Hij sneed vaak een banaan door zijn yoghurt*) daarna de prime (bv. *53* of *Hij sneed 5 bananen in plakjes door zijn yoghurt)* die met het referentie punt moest worden vergeleken om een hoeveelheid beslissing te maken (bv. *weinig* of *veel*). De *hoeveelheid* decisie taak werd weer gevolgd door een letter identificatie taak zoals in Experiment 1 en 2. Opnieuw vonden we een effect voor *situationele* *hoeveelheid* maar niet voor *simpele cijfers*. Proefpersonen reageerden sneller op een letter aan de bovenkant van het scherm wanneer ze eerst een zin hadden gelezen waarin de hoeveelheid veel was dan wanneer deze weinig was, terwijl proefpersonen sneller reageerden op een letter aan de onderkant van het scherm wanneer ze eerst een zin hadden gelezen waarin de hoeveelheid weinig was vergeleken met wanneer deze veel was. In tegenstelling tot de taak met zinnen, vonden we voor de taak met simpele cijfers geen interactie effect op de letter identificatie taak. De studie in Hoofdstuk 5 biedt evidentie dat *situationele hoeveelheid* deels gerepresenteerd wordt door *verticaliteit*, maar *simpele cijfers* niet.

Hoofdstuk 6, bestaande uit twee experimenten, concentreerde zich op de mentale representatie van het abstracte concept *liefde*. Het concept *liefde* heeft meerdere metaforen in taal waarvan wordt aangenomen dat deze refereren naar bijbehorende conceptuele mappings. We onderzochten twee conceptuele mappings namelijk *liefde is warmte* en *liefde is nabijheid* waarvan wordt aangenomen dat ze gevormd zijn vanuit concrete ervaringen. (bv. Lakoff & Johnson, 1999). In Experiment 1 onderzochten we of *liefde* deels gerepresenteerd is door *warmte*, met de bijbehorende tweedeling *liefde is warm*, dat gereflecteerd wordt in zinnen als "Zij is warmhartig", en *geen liefde is koud*, dat gereflecteerd wordt in zinnen als "Hij gaf een ijskoude blik". Proefpersonen moesten beslissen of een woord positief gerelateerd was aan liefde (bv. *aantrekkelijk*, *lief*) of negatief gerelateerd was aan liefde (bv. *verachten*, *afwijzing*) terwijl ze met één arm op een koude en één arm op een warme kompres moest steunen. In de *liefde* decisie taak (*positief* of *negatief* gerelateerd aan *liefde*) zouden positieve liefde woorden *liefde* moeten activeren terwijl negatieve liefde woorden *geen liefde* zouden moeten activeren. De verschillende temperaturen van de twee kompressen waar proefpersonen hun armen op moesten laten steunen zou de oriëntaties *warm* en *koud* moeten activeren en koppelen aan de rechter- en linkerarm. Na afloop van de taak werden proefpersonen ondervraagd over het doel van het onderzoek. We verwachtten dat wanneer *warmte* een rol speelt in de mentale representatie van *liefde*, de temperatuur van de zakjes invloed zou hebben op de reacties van de verschillende handen op positieve en negatieve liefdeswoorden. Opvallend was dat we alleen een effect vonden voor proefpersonen die zich bewust waren van een mogelijk effect van temperatuur op positieve en negatieve liefdeswoorden. Proefpersonen die zich bewust waren van de link tussen temperatuur en liefde in de taak reageerden sneller op positieve liefdeswoorden met hun warme kant dan koude kant (*liefde is warm*), en sneller op negatieve liefdeswoorden met hun koude kant dan warme kant (*geen* *liefde is koud*). Voor mensen die zich niet bewust waren van het mogelijke effect van temperatuur op de taak, vonden we geen effect.

In Experiment 2 van Hoofdstuk 6 onderzochten we of *liefde* deels gerepresenteerd wordt door *nabijheid*, met de tweedeling *liefde is dichtbij* terug te vinden in zinnen als "Je kunt nooit tussen die twee komen" en *geen liefde is veraf* terug te vinden in zinnen als "Ik voel een afstand". Proefpersonen moesten beslissen of twee foto's van beroemde mensen een liefdes koppel waren (bv. Brad Pitt en Angelina Jolie) of niet (bv. Ozzy Osbourne en Prinses Maxima). De foto's werden gepresenteerd op drie verschillende afstanden (dichtbij, gemiddeld, veraf). In de *liefde* beslissing taak (*liefdeskoppel* of *geen liefdeskoppel*) zouden liefdeskoppels *liefde* moeten activeren, terwijl de niet-koppels *geen liefde* zouden moeten activeren. De verschillende afstanden tussen de foto's zouden het concept *nabijheid* moeten activeren met de *dichtbij-veraf* oriëntatie. Aan het einde van de taak werden proefpersonen ondervraagd over het doel van het onderzoek. Als *liefde* gerepresenteerd is door *nabijheid*, dan zou de afstand een verschillende invloed moeten hebben op de reacties van liefdes koppels versus niet-koppels. Van de 36 proefpersonen waren er maar 3 zich bewust van het mogelijke effect van de afstand van de plaatjes op de *liefdes* beslissing taak. Dit kleine aantal bemoeilijkte het om het effect van dit bewustzijn op de taak te onderzoeken. Bij de overige proefpersonen die zich niet bewust waren van het mogelijke effect van de afstand van de plaatjes op de *liefdes* beslissing taak vonden we geen interactie tussen afstand en status van koppel (*liefdeskoppel* versus *geen koppel*). Aangezien we in beide experimenten geen effect vonden voor de niet-bewuste proefpersonen, biedt Hoofdstuk 6 geen bewijs dat *liefde* deels gerepresenteerd is door *warmte* of *nabijheid*. Toch blijft het moeilijk om het nuleffect te interpreteren. Een alternatieve verklaring kan zijn dat het concept *liefde* complex is, meer is dan slechts de som van multipele metaforen, en dat *relaties* tussen verschillende concepten zoals *warmte* en *nabijheid* ook een belangrijke rol spelen.

In Hoofdstuk 7 werden alle bevindingen op een rijtje gezet, de problemen en onbeantwoorde vragen kritisch besproken, suggesties voor toekomstig onderzoek gegeven en een algemene conclusie aan onze bevindingen verbonden. De kritische geluiden die we hebben laten horen gingen over het ontbreken van een duidelijk model voor de werking van conceptuele mapping en het mechanisme dat abstracte concepten van concrete concepten moet onderscheiden. Conceptuele mapping moet op de juiste manier gecoördineerd worden zodat eigenschappen van een concreet concept niet onjuist worden toegeschreven aan een abstract concept (bv. *geld* kan op een bank worden gestort maar *tijd* niet). Een skeletachtige mentale representatie van een abstract concept onafhankelijk van concrete concepten zou conceptuele mapping op de juiste manier moeten kunnen coördineren (bv. Lakoff, 1993), alsook een grens kunnen trekken tussen twee concepten (bv. *tijd* en *geld* zijn twee verschillende dingen). Het is van belang dat toekomstige onderzoeken zich focussen op fundamentele vraagstukken. Fundamentele vraagstukken waar nog een antwoord op moet gevonden worden zijn o.a., wat deze skeletachtige mentale representaties van abstracte concepten inhouden, hoe deze gevormd worden en hoe het skelet van abstracte concepten op de juiste manier conceptuele mappings kan begeleiden en beperkingen kan opleggen.

In deze dissertatie verschaften we bewijs dat metaforen niet alleen voor poëtische genieën of verhalenvertellers weggelegd zijn, maar voor alle mensen die een taal begrijpen. Evenmin zijn metaforen slechts een linguïstisch fenomeen, maar eerder een onderdeel van ons denken. Door metaforisch gebruik van concrete concepten kunnen mensen over abstracte concepten op een concrete manier nadenken. Bovendien lijkt dit te impliceren dat het perceptuele, sensorische en motorische systeem niet alleen betrokken zijn bij de mentale representatie van concrete concepten maar ook bij de mentale representatie van abstracte concepten. Nochtans blijven veel vragen onbeantwoord over het proces van conceptuele mapping en de mentale representatie van abstracte concepten. De studies in de huidige dissertatie moeten worden gezien als een eerste stap van een lange weg met als doel de mentale representaties van abstracte concepten te ontrafelen. Ter conclusie kan worden gesteld dat metaforisch denken onvermijdelijk is wanneer abstracte concepten ons levenspad doorkruisen.

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Curriculum Vitae

CurriculumVitae

Inge Boot was born in Vlaardingen on February 19th, 1982. She completed secondary education in 2000 at the Stedelijk Gymnasium Schiedam. She started studying psychology at the Leiden University directly after secondary school and graduated with honours in experimental cognitive psychology with a graduation course in neuropsychology in 2004. After working for one and a half year as a junior researcher at the Erasmus University Rotterdam, she started working as a PhD student at the Erasmus University Rotterdam in 2006 to investigate the role of concrete metaphors in the mental representation of abstract concept. In addition to performing research , she was involved in a number of educational tasks. She taught a number of practical courses such as the e-prime software course and supervised several tutorial groups and students with writing their bachelor thesis.

In September 2010 she starts working as a PostDoc at the Amsterdam School of Communication Research (ASCoR) that is part of the University of Amsterdam in the project that concerns the impact of sexual media content on adolescent sexuality.

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