Tilburg University

Language matters

Tillman, Rick

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link to publication in Tilburg University Research Portal

Citation for published version (APA):
Tillman, R. (2016). *Language matters: The influence of language and language use on cognition*. [s.n.].

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 01. Nov. 2022

Language Matters:

The Influence of Language and Language Use on Cognition

Richard Tillman

Language Matters: The Influence of Language and Language Use on Cognition

Richard Newell Tillman
Ph.D. Thesis
Tilburg University

TiCC Ph.D. series no. 46

Print: CPI Wöhrmann print service
Cover design: George Oeser

© Richard N. Tillman
No part of this thesis may be reproduced, sorted in a retrieval system, or transmitted in any form, or by any means, without written permission of the author, or when appropriate, of the publishers of the publications.

Language Matters:
The Influence of Language and Language Use on Cognition

PROEFSCHRIFT

ter verkrijging van de graad van doctor

aan Tilburg University

op gezag van de rector magnificus,

prof.dr. E.H.L. Aarts,

in het openbaar te verdedigen ten overstaan

van een door het college voor promoties aangewezen commissie

in de aula van de Universiteit

op woensdag 30 juni 2016 om 10.15 uur

door

Richard Newell Tillman

geboren op 13 juli 1974 te Nashville, Verenigde Staten van Amerika

Promotores:

Prof. dr. M.M. Louwerse

Prof. dr. E.O. Postma

Overige leden van de promotiecommissie:

Prof. dr. A.M. Backus

Prof. dr. A.A. Maes

Prof. dr. G. Redeker

Acknowledgements

When I started my trajectory toward a Ph.D., I didn't know what to expect. I just knew that I had a deep passion for psychology and cognitive science, and I wanted to go as far as I could. If it were not for thoughtful, caring educators, supervisors, family, friends, and colleagues, I might have made it to this important milestone in my career, but it wouldn't have been as fruitful or interesting or fun.

I would like to first thank my dissertation supervisor; without his guidance I would not be the scientist I am today. We began working together while he was the director for the Institute for Intelligent Systems at the University of Memphis, while I was finishing my Master's Degree at a different university. I asked my then supervisor (who I will thank later in this section), how I should go about finding the right doctoral program. He told me that I should read as many articles as I can, and contact the authors of the ones that most interested me. With countless studies available, somehow I arrived at only one name: prof dr. Max Louwerse. If my current self could have said something to that past self, I would have said, "Self, you are crazy if you think you should only apply to one program and bank on this single person." I didn't know my Plan B, but thankfully I never needed one. In our initial conversation, I was so intrigued by his research, I didn't have time to be nervous. It was more exciting and interesting than I had imagined. I remember having the conversation, but I have no idea what we talked about. The next thing I knew, I was in Memphis exploring corpus linguistics and approaching psychological experiments in totally new ways. Within two years, Max decided to take a position at Tilburg University and invited me to accompany him and finish my degree in Tilburg. (He loves the story about how he sprung it on the people in his lab. If you ask him about it, you will see obvious delight in the panic he caused.) But through all his tons of work, he always found time to provide excellent mentoring for me. He may also delight in saying "Wrong!", but his guidance has made me a more thoughtful scientist. I have much appreciation for all that he's done for me.

Indeed, all my colleagues in the Tilburg Center for Cognition and Communication at Tilburg University are excellent researchers that I have the immense privilege to have gotten to know. It is a warm, collaborative environment where we share ideas and laughs, and above all, a strong desire to produce innovative research that helps society. I appreciate all the feedback for not only my research, but also how to be a better educator. I had a passion to teach starting at a very early age, but it is with the help of equally dedicated colleagues that are quick to give advice, or lend an ear, that I have been able to

improve how I approach teaching and student supervision. I give many thankulatories to my paranymphs Lieke van Maastricht and Hans Westerbeek, who have been exceptionally helpful during this process, as well as being awesome people to have in my life! All of us have been held together by our support team of Lauraine de Lima, Eva Verschoor, and for years prior to this one, Jacintha Buysse. If I individually named everyone in the department who has made this a most excellent time in my life, the printer would probably charge me extra! (I've at least assimilated into Dutch culture enough to know better than to let that happen.) So, everyone please know that my current self, and my 8-year-old self that wanted nothing more than to help people learn, thank you from the bottom of our hearts.

I would like to extend special appreciation to my thesis committee: prof. dr. Fons Maes, prof. dr. Eric Postma (co-supervisor), and prof. dr. Gisela Redeker. Their thoughts and comments have provided exceptional guidance in order to make this the best dissertation it could be. I hope I continue to help many students and people as you have helped me.

I attribute my start in graduate work to Dr. William Langston at Middle Tennessee State University in Murfreesboro, TN, USA. I am very glad he decided to take a chance on me, back <mumble> years ago. In addition to a lot of mentoring and fun times, he said two things that have stuck with me and helped in my research and resilience. The first was when I was preparing to leave the comfortable nest of my Master's program. He told me I'd do great things and bring pride to his lab. Of course, it's nice to be encouraged and I certainly appreciated that. The second, and maybe more powerful thing was, "Don't tell anybody you're interested in linguistic relativity. You're going to sound like a crazy person! When you get tenure, you can research anything you want." I know why he said it. This was several years before the beginnings of the real resurgence of linguistic relativity and it was even more controversial then than it is now. He wasn't wrong. Many programs likely would have frowned on it. But it helped to give me an even stronger drive to research the things that I think matter, and not give up on something I thought was worthwhile, just because it wasn't popular. That will have a lasting impact on me throughout my career, and he has my sincere thanks.

Of course there is life outside of the laboratory (so I hear). There have been so many people who have contributed to this thesis (at the very least, my happiness), through almost lifelong friendships. Sarah, Ivy, Kristin, Barbara, and Mel, you have seen me through most everything, and I love you all. And our newer, but no less dear friends, Frank, Martin, Michael & Tine have all been an important part of why I have enjoyed my time here, and felt connected to people even so far away from my known world.

I would like to also thank Tilburg International Club, as they have been a wonderful way to get connected to our temporary home and have a great social network. I appreciate all they do for their members. And also thanks to the people of Tilburg. (If you're thinking that's weird, remember that the Nobel Peace Prize was awarded to the entire EU in 2012. Perhaps what is really weird is that not everyone has written their acceptance speech yet!). Tilburg is a great city with warm folks, and has been an excellent place to call home over the last few years.

Hobson United Methodist Church and the Reverend Sonnye Dixon in Nashville, TN, USA has been a source of strength and support for me through all of the years of my graduate work (and before!). The importance that Hobson places on education, social justice, and helping others has instilled in me the belief that science is more than just increasing knowledge. It should be about improving lives, and I hope I continue to live up to that.

Family is of course important as well. However, if I listed everyone just in my immediate family, I'd also have to write an additional chapter. I love them all and appreciate them. I particularly want to say thank you to my sister Vickie for extra help and support especially over the last several years with graduate school things, general life things, and importantly bird things (PEEP!). My parents, Howard and Mary Tillman, are just so amazing and are there for not just me, but my half-dozen siblings, our spouses, their kids, their kids' kids, and so many people throughout the community. They are the greatest parents, and I hope to live up to the example of love, kindness, and generosity of spirit that they have set for me. I love them dearly! I also have been incredibly fortunate to have wonderful in-laws, Ernie and Geneva Oeser, that brought me into their family and have loved me like I had always been there. The feeling is certainly mutual. I am so fortunate to have them as parents-in-law, and I love [sic].

I save the best for last. Meeting my husband, George Oeser, has been the greatest thing to happen to me (present volume included). It is so incredible to have someone so loving, interesting, unique, talented, and singularly wonderful to share my life with. The whole of my life is enriched by knowing him, but in addition to sharing his digital art and photography talent with me for inspiration (and of course for designing the cover for this dissertation), it was George who insisted that I go to graduate school. It's very thoughtful, but he was probably just tired of me talking about it all the time. His encouragement and advice has been more valuable than he knows. He has read and listened to countless versions of the chapters in this dissertation, as well as challenging some of the ideas to make sure I was on the right track. I share this accomplishment, along with all others, with him.

Table of contents

Chapter 1
Introduction

Over the last few decades many studies in the cognitive sciences have assumed that language is a vessel through which a grounded (experiential) meaning is conveyed, and is merely an arbitrary tool from which no meaning can be extracted other than through references in the real or simulated world around us (Barsalou, 1999; Glenberg & Robertson, 2000; Zwaan & Yaxley, 2003). In fact, based on the number of studies, the cognitive sciences seem to have been dominated by a view that extracting meaning from language requires perceptual simulation of our experiences (Hauk, Johnsrude, & Pulvermüller, 2004; Pulvermüller, Hauk, Nikulin, & Ilmoniemi, 2005). Indeed, there has been overwhelming evidence to support the idea of embodied cognition in a wide variety of domains (Barsalou, 1999; 2003; 2007; 2010; Hauk, Johnsrude, & Pülvermüller, 2004; Glenberg, 1997; Glenberg & Kaschak, 2002; Glenberg & Robertson 1999; 2000; Kaschak & Glenberg 2000; Pecher & Zwaan, 2005; Pülvermüller, Hauk, Nikulin, & Ilmoniemi, 2005; Zwaan, 2004; Zwaan & Yaxley, 2003).

Symbolic Cognition

Before embodiment gained popularity in cognitive science, the prevailing view was more symbolic in nature. With the optimism following the cognitive revolution in the 1950s (see Miller, 2003 for an overview) and the enthusiasm about computers as a metaphor for the human brain (Turing, 1950), the account of what has been called "symbolic cognition" dominated cognitive science until the 1990s. Pylyshyn (1989), for instance, explains Turing's original theoretical machine, and real computers to follow, in terms of a *processor* and *memory*. The processor takes the symbolic expressions, which have meaning, and uses memory to read, and subsequently alter those expressions. In Pylyshyn's comparison between thought and computers, it seems to come down to symbolic representation. Pylyshyn's FINST (FINgers of inSTantiation) model indicates that early in the process of sensory processing, visual pointers are used to indicate where attention should be focused during multiple moving targets, in order to more effectively use finite resources during cognitive processing. In this view, these symbolically based pointers serve as indexes that bridge the world and mind.

Pylyshyn (1984) summarizes the classical view of cognitive architecture as holding three levels of processing: semantic, symbol, and physical, and that computers and the mind are similar in these respects. The semantic level refers to why people (or computers) reach a goal and how information is connected in a rational manner. The symbolic level contains semantic content using symbols to encode meaning. Finally, the physical level is the realization of the connections between the goals desired and the connection of the symbols. For an example, if someone wanted to enter a house, they would have a goal. Then they could use the symbols that are related to that goal, in this case a door and all the relevant functions that go along with it (e.g., there is a handle of some sort, how it swings open, etc.), and then the physical manifestation of the goal is realized through turning the handle and walking through it. Thus, realizing goals is related to a connection of symbols and then executing a logical action. This can further be represented in terms of words. For instance, we have memorized the word *dog* to represent what a dog is. We have also memorized other words that are associated with *dog* (e.g., *fur, barks*) along with their meaning, and are able to connect those arbitrary symbols (words) with other arbitrary symbols that already reside in our memory. In this situation, it is not necessary to recall all the instances of interacting with dogs, nor is it necessary to perceptually simulate interactions with dogs. The symbols (words) can act as good-enough representations and we can pet the nice doggie without too much of a fuss.

According to Collins and Quillian (1969), information is stored in hierarchical categories that are further subdivided into more specific subdivisions including features that broadly conform to each step. Then the retrieval from long term memory can be facilitated by using a syllogism, which is deducing logically using two or more propositions in order to form a conclusion. For example, when reading the sentence *Does a Black Labrador eat?*, a person would mentally go up the hierarchical chain that would contain the necessary information to arrive at a logical conclusion. Using the *dog* example, a basic hierarchical progression would be *animal* (eats, breathes) → *dog* (has fur, barks) → *Black Labrador* (is black, fetches well). A Black Labrador is a dog, a dog is an animal, an animal eats, therefore a Black Labrador eats. This is only a simplistic example, as we can encounter many novel situations related to dogs (not to mention countless other categories), and that in cognition the symbols associate and activate other relevant symbols.

While computational models are useful to represent the human mind, they may or may not be fully representative of the reality of how cognitive processing occurs in the human brain. This hierarchical process consecutively ascending over these levels at least seems cumbersome. One model that illustrates a mechanism on how this process can occur is parallel distributed processing (Rumelhart & McClelland, 1986). This model of memory encoding proposes that components of a concept are processed simultaneously, rather than consecutively as in older models, such as the Atkinson-Shiffrin (1968) multi-store model. In parallel distributed processing (PDP), the neurons act in parallel as simple encoders of the information components, then the storing of these pieces of information is also distributed throughout the neurons.

However, there are instances where this direct association that relies on strictly symbolic information does not apply. One salient example of an exception that arises is the issue of whether mental imagery can be used outside of directly experienced instances. Kosslyn, Thompson, and Ganis (2002) provided a thorough refutation of Pylyshyn’s claims about mental imagery. Most importantly, Kosslyn et al. regard *tacit knowledge* (e.g., riding a bicycle) as advocated by Pylyshyn (1981), as insufficient to fully explain mental imagery and no mechanism has been proposed as to how this transference can take place within a symbolic framework. This is just one example of how symbolic cognition cannot be the only explanation of how the mind not only meaningfully connects concepts with other concepts, but also how that knowledge is described, transferred to others, and utilized in novel situations. This leads to the question as to what approach can more fully represent cognition. The next section will focus on some of the most often cited theories and studies within the framework of embodied cognition.

Embodied Cognition

While symbolic cognition dominated from the 1950s onwards, embodied cognition emerged as a response to the mind-as-computer metaphor starting with Paivio's (1969) dual coding theory that postulates information is represented by both imagery and language in two distinct subsystems (although not explicitly stated as embodied cognition theory). The more codified form of embodied cognition began to flourish in the 1990s, and continues to have a strong presence in cognitive science. Although there are some varied accounts of what embodied cognition entails, the main thesis of embodied cognition is that our cognitive processing is related to our perceptual, or embodied, experiences (Barsalou, 1999; Glenberg 1997). For example, when we see the word *dog*, the embodied cognition approach states that we would activate all those sensory experiences that accompany *dog*: furry, four legs, wags its tail, barks, eats from a dish on the floor, etc. In this section, several well-known theoretical frameworks of embodiment, and their inclusion or exclusion of linguistic elements, will be described.

The perceptual symbol systems proposed by Barsalou (1999) states that when we experience something, our brains encode specific aspects of that experience that are related to sensorimotor perceptual symbols. This encoding can occur unconsciously, in terms of neural representation of the input, or consciously such as purposefully attending to one or more aspects of that experience. According to Barsalou, the six core properties that comprise the foundation of a conceptual system are: 1) there are neural representations in the sensorimotor areas of the brain; 2) perceptual symbols are schematic; 3) perceptual symbols are (multi)modal; 4) related symbols do not function independently in order to construct simulations; 5) perceptual symbols use an integrated system (frame) to construct simulations of a category; 6) and indexing is used for linking linguistic symbols to their perceptual referent. In this view, perceptual symbol systems refers to components or subsets of a referent that is stored in long-term memory and can be accessed in order to stand in for future referents that a person encounters. For instance, the conscious experience of an actual chair will automatically encode the features of that chair (e.g., back, seat, legs, general shape, function, etc.) in terms of perceptual symbols, as opposed to linguistic symbols that store the meaning of "chair." Barsalou also distinguishes that these encoded features are modal, in that they are specific to the modality of the encoded features (e.g., visual, motion, auditory). Essentially, the perceptual symbol systems is a major framework of embodied cognition that supposes that when we have experiences, we use sensorimotor information to encode those experiences and their related components.

Similar to Barsalou's (1999) perceptual symbols systems, the indexical hypothesis (Glenberg & Robertson, 1999; 2000) is another theoretical framework that connects the action based meaning of words to an embodied (i.e., grounded) meaning, however it is reached through three processes. First, an indexing process connects words or phrases to modal features of objects in the perceptual world, similar to Barsalou's (1999) perceptual symbol systems. Second, the objects have affordances (e.g., a teapot has a handle to allow, or afford, a person the means to hold it in order for it to function as it is should), however words do not have affordances, per se. In this hypothesis, the words are mere placeholders for the affordances that are extended by the objects themselves. The final process this framework uses is that relevant affordances are cognitively combined to produce a mental simulation of an object or motion. While perceptual symbol systems is similar to the indexical hypothesis in that both focus on the modal nature of these effects, the indexical hypothesis begins to show the impact of language. While this process is largely attributed to perceptual experiences, Kaschak and Glenberg (2000) as well as Goldberg (1995) include grammatical constructions as part of combining and attending to the correct agent and patient, as well as the temporal sequence. An instance of this grammatical inclusion is the fact than many Western languages use word order (e.g., Subject-Verb-Object) to often convey who is the subject, who is the indirect or direct object, and so forth. While this study does include a language component, it still centers on action-based meaning of words, and thus relates cognitive processing back to perceptual experiences.

Further development of the idea of language being grounded in action is established through the action-sentence compatibility effect (Glenberg & Kaschak, 2002). While not fully embracing linguistic features, this effect also incorporates the impact of grammar on this embodied approach. However, the indexical hypothesis states that language is not the source of understanding, but rather that understanding comes from perceptual experiences. In this framework, the direction of an action sentence has a direct effect on facilitation of sensibility judgments of those sentences while performing a motion that is either congruent or non-congruent. For example, the RT would become faster for reading the sentence *Open the drawer,* while rating sensibility with a button that is closer to the participant (i.e., in the direction of the action) rather than pressing a button that is farther away from the participant's resting location (conversely, *Close the drawer* would have a faster rating when pressing the farther away button). Glenberg and Kaschak's conclusion is that language is not the source of understanding, rather the understanding comes from actual action experienced with the body. It is interesting to note, however, that in a framework that is to explain everything in grounded terms, Glenberg and Kaschak also address how grammar can have a considerable impact on these mental simulations and combination of affordances. For instance, the position of the first of two objects in a sentence indicates that that is the indirect object, and therefore the subject is to transfer the (direct) object to that person. Therefore, as these embodied theories progress, they allow for more and more influence of language, however that is somehow going to be ultimately grounded in perceptual experience and situated simulation.

For further support of cognition being perceptually grounded, Zwaan and Yaxley (2003) examined judgments regarding semantic relatedness and iconicity, which is a relationship between linguistic signs and their referents, in this case a spatial relationship.

Participants saw experimental word pairs of objects that conventionally have a fixed vertical relationship, such as *attic-basement* or *nose-mouth*. These pairs were first vertically presented either in their iconic orientation (e.g., *nose-mouth*) or in their reverse iconic orientation (e.g., *mouth-nose*), and the participants made sensibility judgments. The results for the vertical presentation demonstrated that the iconic orientation facilitated RTs, indicating that people use perceptual information when cognitively processing object words. In a second experiment, Zwaan and Yaxley then presented these word pairs in a horizontal orientation, and found that the order in which the words are read does not have an effect. The conclusion drawn was that the spatial orientation of objects, as they are normally encountered in the perceptual world, is a driving force in how people cognitively process words and their spatially oriented (perceptual) relationships.

The immersed experiencer framework (Zwaan, 2004) further explains how this sequence occurs at a more specific level, particularly in what levels of language trigger such simulations. Along similar lines of previously mentioned embodied cognition theories, the immersed experiencer is another theoretical framework that builds on the idea that language activates perceptual experiences, and then simulates relevant aspects of that experience for cognitive processing. In the first level, *activation*, functional webs in encoding are activated by incoming words. This process is initially diffuse, spreading throughout overlapping functional webs of the experiential categories and features of the concept. The second stage of the immersed experiencer hypothesis is *construal*, which refers to a mental simulation that is reached by the integration of the functional webs that were first accessed or formed in the activation level. The diffuse characteristics of the initially activated webs become temporally and spatially articulated by a constraint-satisfaction mechanism. Similar to the indexical hypothesis (Glenberg & Robertson, 1999, 2000), there is a component of this process that uses grammar, such as word order or prepositions, in the final stage of *integration* in order to bring the relevant construct into focus for more efficient processing of these functional webs. Again, this stage is using linguistic information to facilitate processing, although this model seems to emphasize the simulation aspect, rather than the impact that language and its usage has on cognition.

Some embodiment research has extended to domains beyond objects and actions. Glenberg, Havas, and Rinck (2007) tested emotion simulation during a facial feedback task. In this study, participants either held a pen in their teeth (to simulate smiling) or in their lips (to simulate frowning) while reading pleasant or unpleasant sentences. Glenberg, et al. found that RTs were faster when the valence of the sentence and the facial posture were congruent. They concluded that emotional states can facilitate comprehension of sentences. The arguments used point to an evolutionary reasoning in that it is emotion that prepares the body to perform a certain action, such as push away those things that are to be avoided or pull pleasant things toward the perceiver. However, in this task it would seem that the embodied state preceded the sentence comprehension (it would be very difficult to have participants simulate the facial feedback task after each sentence without having many unintended effects). This is an important distinction to note here, because the theoretical frameworks presented above, such as the indexical hypothesis (Glenberg & Robertson, 1999, 2000), perceptual symbols systems (Barsalou, 1999), and the action-sentence compatibility effect (Glenberg & Kaschak, 2002), seem to indicate that the linguistic input (e.g., word or sentence) happens earlier in the cognitive process and that it activates the perceptual simulation. While it would be difficult to imagine that perceptual experiences and language would be in a vacuum in sentence comprehension, the order of tasks (i.e., embodied, then linguistic processing) seem to be tested in an opposite manner. In any case, the findings in Glenberg et al. (2007) seem to be logical and robust. However, many of these studies presented so far have been conducted in the laboratory that may be conducting these tasks in too much of an artificial way.

Going beyond indirect laboratory testing, these types of mental simulations of perceptual information have also been studied more directly through neuroimaging. Hauk, Johnsrude, and Pulvermüller (2004) challenged the previously held assumption that word meaning was localized to language areas, such as the left temporal lobe. Using event-related fMRI, Hauk et al. were able to demonstrate that not only do many expected language areas show activation during a passive reading task, but, also that the motor locations of specific body areas (face, arm, leg) in the brain would activate when reading about an action that corresponds with the body area, such as lick, pick, or kick. Pulvermüller, Hauk, Nikulin, and Ilmoniemi (2005) were able to affect processing also in the opposite direction using transcranial magnetic stimulation. Through magnetic stimulation of these same areas (face, arm leg) of the cortex that is associated with the movement of these body regions, language processing of related words (e.g., *lick*, *pick*, *kick*) was facilitated. While these two studies do not mention embodied cognition per se, both Hauk et al. (2004) and Pulvermüller et al. (2005) more directly support the link between language and grounded cognition, most notably the mental simulation aspect that is prevalent in many embodied cognition studies (Glenberg, 1999; Glenberg & Robertson, 2000; Glenberg & Kaschak, 2002; Barsalou, 2008). However, as briefly mentioned in Pulvermüller et al. (2005), these results indicate that there is an interaction between action and language systems calling into question the previously held notion that these two systems are independent of each other.

While there are many robust findings that support embodied cognition theories, what is common between many of these studies is that there is a linguistic component to the task, and in many cases the effects of grammar can be incorporated into the model. However, it seems that in these frameworks that language is assumed to merely be an arbitrary tool where grounded meaning is conveyed. This, therefore, leads to the question as to whether language has any influence on cognition, and, if so, in what situations would linguistic factors have equal or more influence than perceptually grounded factors.

Wilson (2002) indicated six of the main views for embodiment studies (see Table 1). While there is some overlap between the categories, it is important to include here some of the central goals of the previous embodiment literature. Four of Wilson's main views of embodied cognition regard the importance of the relationship between the mind and environment (Barsalou, 1999; Glenberg, Havas, & Rinck, 2007). Another of Wilson's six main goals refers to the action-oriented approach of many embodied cognition theories. This is not always necessarily the case such as in Barsalou's (1999) perceptual symbols system, where features of objects and how they are processed is central to his argument. However, many studies look at how we perceive action-based stimuli (Glenberg & Kaschak, 2002; Glenberg & Robertson, 1999; 2000). Finally, and perhaps intuitively, Wilson includes that bodily states are integral components of many embodied studies (Hauk, Johnsrude, & Pulvermüller, 2004). Of course, not all embodied cognition theories conform to all of these main goals. However, it is at least apparent that most of them do contain the components of a body-based state, such as perceptual experience or the interaction with the environment in arriving at a correct simulation or process. This leaves the essential question as to whether this view, in its myriad forms, is complete.

Table 2 shows the four main embodiment theories to be discussed within this dissertation as well as whether the theory specifically contains an element from Wilson's (2002) six main views of embodied cognition. While there are a few elements that may not be directly addressed in all of the theories (e.g., cognition is offloaded to the environment), they have components that they do share in abundance, such as cognition is situated and body-based, and that the environment is an integral part of perceptual simulation.

Table 1.

Six main views of Embodied Cognition (Wilson, 2002) and example studies discussed in this chapter.

Central divisions	Main points	Example studies*
Cognition is situated	Real world environment; task-relevant inputs and outputs	Barsalou, 1999; Glenberg & Kaschak, 2002; Glenberg & Robertson, 1999; Glenberg & Robertson, 2000; Zwaan, 2004
Cognition is time pressured	Must be analogous to real-time constraints	Barsalou, 1999; Zwaan, 2004
Cognitive work is off-loaded to the environment	Relevant details are stored "out in the world" rather than storing all of them mentally	Glenberg & Robertson, 1999; Glenberg & Robertson, 2000
The environment is part of the cognitive system	Cognition is spread over the mind-body-environment system	Barsalou, 1999; Glenberg & Kaschak, 2002; Glenberg & Robertson, 1999; Glenberg & Robertson, 2000; Zwaan, 2004
Cognition is for action	The mind guides action for situation-appropriate behavior	Glenberg & Kaschak, 2002; Glenberg & Robertson, 1999; Glenberg & Robertson, 2000; Zwaan, 2004
Offline cognition is body-based	Sensorimotor simulations are related to bodily states	Barsalou, 1999; Glenberg & Kaschak, 2002; Glenberg & Robertson, 1999; Glenberg & Robertson, 2000; Zwaan, 2004

*Note: The inclusion criterion was whether the component within the framework was explicitly stated in the study mentioned.

Table 2.

Embodied cognition theories to be discussed and inclusion for the categories in Wilson (2002).

	Cognition is situated	Cognition is time-pressured	Offload cognition to environment	Environment is part of the cognitive system	Cognition is for action	Off-line cognition is body-based
Perceptual Symbols Systems (Barsalou, 1999)	✓	✓		✓		✓
Indexical Hypothesis (Glenberg & Robertson, 1999)	✓		✓	✓	✓	✓
Action-Sentence Compatibility Effect (Glenberg & Kaschak, 2002)	✓			✓	✓	✓
Immersed Experiencer (Zwaan, 2004)	✓	✓		✓		✓

Another way to illustrate the embodied cognition view is that when we think of a concept or a word, we activate the connections to those referents in the real-world. This is evident in the presence of the environmental interaction within the six points by Wilson

(2002). Indeed, if the central theme of embodiment hinges on the real-world experiences of the perceiver, then this relationship is logical. However, much of the embodied cognition literature either ignores the impact of linguistic components, or relegates them to a status of arbitrary placeholders that activate simulation of perceptual experiences. For instance, one of the more influential embodied cognition theories is the perceptual symbols systems (Barsalou, 1999), which posits that linguistic symbols are merely referents that are linked to perceptual experiences and that the symbols, meaning words and phrases, do not function independently in order to process an object. What this viewpoint does not take into account is that the words themselves can be more than arbitrary referents, but can also contain perceptual information within the words by which the linguistic components can account for as much, if not more, of processing given certain circumstances (Louwerse, 2007; 2008, 2011).

Wilson (2002) also emphasizes action within embodied cognition, although this is not explicitly addressed in Barsalou's (1999) perceptual symbols system, or Zwaan's (2004) immersed experiencer. As an example to illustrate a situation in which action is integral to cognition, an often-cited embodiment hypothesis is the action-sentence compatibility effect (Glenberg & Kaschak, 2002). In this view, Glenberg and Kaschak found faster RTs for sentences that were congruent with direction of motion (e.g., *Open the drawer* would elicit faster reactions if the button was placed closer to participants, which mimics the action, rather than farther away. The same effect was found in the opposite direction for *Close the drawer*). Glenberg and Kaschak maintain that these faster

RTs are attributed to grounded bodily actions. However, somewhat counterintuitively regarding their strong standpoint that all things are grounded, do acknowledge that grammar, particularly word order of direct and indirect objects, can impact how we perceive an event. While the compatibility of action directions between sentences and their perceptual states can be attributed to considerably impacting cognition, there needs to be room for the impact of language usage. Thus, if word order can affect this process, then there is reason to question whether many more facets of language can impact how we think and perceive.

While there is robust evidence to support perceptual simulation, there are two theoretical frameworks, symbol interdependency and linguistic relativity, that have received more attention recently by showing evidence that language itself can have an impact on cognition. It is important to extend our view of cognition beyond the current trend of embodiment to include an approach that includes linguistic factors more than mere placeholders, but rather as important and influential components of how we think and perceive.

The aim of the studies presented in the subsequent chapters is to investigate whether our statistical relationship with language and its usage can affect cognition, instead of grounding all information in perceptual experiences. The research presented will examine how our statistical relationship with language or grammatical constructions can affect our perceptions. The remainder of this chapter will address possibilities for a more balanced approach that allows for both language and perceptual processing. The final portion of the introductory chapter will describe the research questions that will be the focus of each chapter, and how the studies contained within this dissertation will address those questions.

Combining Symbolic and Embodied Approaches

As seen in previous sections, robust evidence for both the symbolic and embodied approaches to cognition has been found in numerous studies spanning several decades. However, neither approach can fully account for the richness and complexity that the other approach can contain. Therefore, a combination of both approaches seems to be the likely candidate to more fully represent the underpinnings of cognition.

Paivio's (1969) dual-coding theory was one of the seminal works that demonstrated that both visual images (ostensibly embodied) and language information are used in order to represent a concept. Somewhat along the same lines as more recent embodied cognition theories (e.g., Glenberg & Robertson, 1999; Kaschak & Glenberg, 2000; Barsalou, 2008), Paivio postulated that images are linked to associated experiences. Paivio went a step further and states that images are indeed symbols, however, those symbols are assumed to represent a perceptual concept. Through earlier studies (Paivio, 1965; Lambert & Paivio, 1956), Paivio used paired-associate learning of sequences of familiar and differentiated stimulus items and participants were to link the item using perceptual imaging and other linguistic features, such as rhyming, in order to recall the correct stimulus. Although Paivio found that imagery was able to produce a stronger effect on remembering, language could still be an effective alternative. This language facilitation is particularly evident in response to stimuli when they were low in imageability, such as abstract nouns (Paivio, Smythe, & Yuille, 1968). Because the language aspect continued to not perform as well as imagery in Paivio et al. (1968), Paivio and Yuille (1967) further investigated the verbal contribution to remembering and found that both imagery and verbal mediators produced better learning than mere repetition. In summary, while Paivio and others have found that imagery can greatly benefit remembering, language can be on par with those benefits, at least with certain tasks and stimuli.

Although much of Barsalou's work focuses solely on situated cognition (e.g., Barsalou, 2003; 2007; 2010; Solomon & Barsalou, 2004), the language and situated simulation (LASS) theory also incorporates linguistic processing as a part of cognition (Barsalou, 2008). The first stage of the LASS theory is linguistic processing. This initial stage of conceptual processing is immediately activated when a word is perceived, and categorization occurs according to its form (i.e., modality). After word recognition, associated words are also activated (e.g., *dog* will activate associated words such as *furry*, *tail*, and *bark*). This immediate and quick processing comes at a price, however. According to the LASS framework, the linguistic associations are superficial and this stage does not allow for deep processing of information, but is nonetheless effective in facilitating accurate performances in cognitive tasks. As the linguistic processing progresses, the situated simulation system also activates associated simulations. While perhaps not as rapid as the linguistic processing, it is still a relatively quick procedure in the LASS framework, even though the simulations may not necessarily dominate in the cognitive process, due to the efficiency of other systems such as linguistic features. This brings the progression of processes to the third component of the LASS framework where language and situation simulation integrate in the stage of mixtures. At this stage, both processes are assumed to engage, although the conditions of the task will influence which system is more dominant in a given situation and moment. The final component of LASS is the reliance on statistical occurrences in order to come to the most efficient response according to the processing in the earlier systems of language and situated simulation. When the system is linguistic, co-occurrences of words can often greatly influence how language was processed in the fast and early stage, and in the simulated situation phase the statistical frequency of experiences can also have a large impact. Thus, the LASS framework still emphasizes situated simulation and is hierarchical similar to other embodiment theories (Barsalou, 1999; Glenberg & Robertson, 1999;2000). However it is more inclusive when it comes to language processing and the statistical nature of our language and perceptual experiences than much of the purely embodied cognition theories.

Also, due to the shortcomings and incompletion of using solely the symbolic or embodied cognition model, Mahon and Caramazza (2008) propose a middle-ground: grounding by interaction. In their interpretation, however, there is a much more stringent distance between embodied cognition and “disembodied” cognition (meaning support for other symbolic factors). Following a general interpretation of an embodied cognition hypothesis, processing a concept and sensorimotor activation is essentially the same event, as opposed to the more hierarchical progressions of the dual coding theory (Paivio, 1969) and the LASS framework (Barsalou, 2003). According to Mahon and Caramazza, these processes are intertwined, as many embodied cognition studies strongly connect perceptual experiences and motor activation to cognitive processing. However, a main aspect of Mahon and Caramazza's argument that embodied cognition is vastly incomplete in that embodied cognition does not fully account for abstract concepts (e.g., *justice*, *beauty, freedom*), as there is not a direct manner in which these concepts can be perceptually simulated. This hindrance is also present in studies that show a weaker lexical decision performance for verbs as compared to nouns (Neininger & Pulvermüller, 2003). Further arguments are presented that show that in order for the motor system to be as quickly and automatically activated and as purported in previous embodied cognition studies, there would have to be further evidence provided that distinguishes among several possibilities on how that system is activated, such as direct activation of the motor system without connections to an abstract concept, or vice versa. In their more balanced view, Mahon and Caramazza (2008) suggest grounding by interaction, where "sensory and motor information colors conceptual processing, enriches it, and provides it with a relational context" (p. 68). In this case, there is a complimentary enhancement of processing where both the symbolic and perceptual activation are consequential and work in concert with one another in order to provide richer comprehension. Mahon and

Caramazza have obviously brought attention to some major deficiencies in embodied cognition theories that can be mediated by a model that is more inclusive of symbolic representation.

Another framework that incorporates linguistic and perceptual processing is the symbol interdependency hypothesis (Louwerse, 2007). This hypothesis states that conceptual processing can be explained by *both* embodied and symbolic mechanisms, although it focuses on different aspects than Mahon and Caramazza (2008). There are three components of the Symbol Interdependency Hypothesis. First, perceptual information is encoded in language. This aspect differentiates the symbol interdependency hypothesis from the previous "hybrid" approaches by assuming that many of the benefits previously found to support embodiment theory is actually already encoded in the language itself. By using language analysis tools, such as latent semantic analysis, language can be used to predict semantic relationships, as well as temporal and spatial relationships (Louwerse, Cai, Hu, Ventura, & Jeuniaux, 2006). Therefore, the facilitated activations that have previously been ultimately attributed to perceptual simulation can be attributed to language itself, at least in a significant number of cases.

Second, language users rely on language statistics and perceptual simulation during cognitive processes. Zwaan and Yaxley (2003) found that iconic orientation does facilitate judgment (e.g., when a participant sees *basement* over *attic* rather than the reverse orientation). However, it was more recently found that the order of word co-occurrences can also facilitate this judgment (Louwerse & Jeuniaux, 2008). Louwerse and Jeuniaux used the same paradigm as Zwaan and Yaxley (2003), with using iconic and reverse-iconic relationships with word pairs. In one experiment, it was again found that iconicity facilitated judgment. However, this facilitation was also found for the words that occurred more frequently together (i.e., as determined by Latent Semantic Analysis). This demonstrated that language use can also impact cognition, alongside embodied cognition. In a second experiment, the materials and procedure were similar, however the instructions differed in that participants were instructed to make a lexical judgment. For the second experiment, there was again a significant effect of iconicity and semantic relationship. In a third experiment, the same items were presented horizontally and half of the participants were instructed to make a semantic judgment and the other half were instructed to make a lexical judgment. Support was found for semantic relatedness, however not for iconicity. These findings were explained in terms of depth of processing. Semantic relatedness requires deeper processing than a lexical judgment. Therefore, the situation, such as whether quick or deep processing is more necessary, can influence which kind of processing takes place.

Finally, the dominance of either the embodied or symbolic system is dependent on the type of task and stimulus. The symbol interdependency hypothesis posits that there is an interdependence between the (presumably amodal) linguistic symbols, as well as the perceptual references that those symbols represent. Furthermore, it has also been shown that there are situations that can influence whether more symbolic or more perceptual cognition will be used. Louwerse and Jeuniaux (2008; 2010) were able to demonstrate that symbolic cognition will dominate in the early stages of cognition; whereas when deeper cognition is necessary or more time is available, perceptual cognition will be more utilized. The participant relied on whichever system that was most efficient. The evaluation of an unusual orientation facilitated turning to another system, statistical linguistic frequencies, that was more efficient to process distance judgments. In summary, grounded cognition has been supported in many domains, but certainly not in all circumstances.

In short, language can be used as a shortcut to more efficiently process cognition in some situations. We use the symbolic system to garner a fuzzy, good-enough representation that can facilitate cognition. This system still accounts for the perceptual approach, when more thorough processing is required. Therefore, the Symbol Interdependency Hypothesis takes into account previous embodied cognition findings, however it also provides for a fuller approach when pinpointing how language processing occurs. Now that it has been demonstrated that language itself can influence cognition beyond perceptual experiences, it is necessary to test this possibility further by showing the impact of language systems.

Going Beyond Embodiment

As discussed in the previous section, there have been robust findings in supporting an embodied cognition account. Strong evidence has also been put forth that demonstrates that there are many instances where language does more than convey a more grounded meaning, and that language itself can have an effect on how people view the world. There are several frameworks that account for the impact of language including Paivio's (1969) dual-coding theory, and the language and situated simulation (LASS) theory (Barsalou, 2003), as well as advocating for a more balanced approach through grounding by interaction (Mahon & Caramazza, 2008), and symbol interdependency (Louwerse, 2007).

The studies contained in this dissertation progress from a task that is embodied, such as pairing emotions with a facial feedback task (Strack, Martin, & Stepper, 1988) through more specifically linguistically based tasks such as grammatical words that cannot by definition be embodied. In order to more fully examine the impact of language, a cross-linguistic approach is also needed in order to explore whether language systems themselves have an impact on cognition. In the final chapters of this dissertation, linguistic relativity (Whorf, 1956; Lucy, 1997; Boroditsky, 2001; Wolff, Jeon, & Yu, 2009) will be discussed in order to more fully address the impact of a language's grammatical conventions. In linguistic relativity, it is held that the structure of a language (such as Spanish or German) can affect our cognition. For example, it has been found that the grammatical gender of nouns can influence how an object is perceived, even though the categories were previously deemed arbitrary (Boroditsky, Schmidt, & Phillips, 2003).

While these studies that include language as effectors in cognition are different approaches, they do demonstrate that language can have a significant impact on how we conceptualize our world. In the following section, linguistic relativity will be described, as well as studies that allow for a broader approach that includes the impact of language will be discussed.

Linguistic relativity

It has now been demonstrated that alongside perceptual simulation, language is indeed an important influence in cognitive processing. However, many of these studies are only in English. The question that then remains is whether these principles apply across different languages. The reason this is an essential question is that languages often have different grammars and word associations. Therefore, it is necessary to examine the impact of the system of a language itself, such as differing word patterns or grammatical conventions. This will be investigated through the framework of linguistic relativity.

The strong view of linguistic relativity (also known as the Sapir-Whorf hypothesis or linguistic determinism) that was long ago rejected by lack of evidence (cf. Gumperz & Levinson, 1996), posits that our thoughts are *determined* by the language that we speak. For instance, if there is a concept that is not represented in a person's native language, they will not be able to fully comprehend that concept. The most well-known example of this is Whorf (1956) reporting that there are far more words for snow in "Eskimo" languages (Eskimo is now considered a crude conglomeration of native North American native languages centered in the cold weather north), because of the increased experience with snow. However, we now know this is not the case (Pinker, 1994). Not only are there not as many "Eskimo" words for snow as reported by Whorf, more importantly people can learn more than one language later in life, and can have a full representation of knowledge within another realm of language.

So we are left with a subtler possibility: that language has a relativistic effect, where one's native language can *influence* thought (Boroditsky, 2001; Wolff, Jeon, & Yu, 2009). For example, some languages have grammatical gender for nouns (e.g., (*apple*) *manzana* is feminine in Spanish, while (*apple*) *Apfel* is masculine in German). It has been assumed that there is no reason an apple would be feminine or masculine, so therefore the grammatical gender of inanimate objects is arbitrary. However, there is the possibility that seeing gender associated with people (i.e., *women* is a feminine word) can influence how people conceptualize and categorize objects. This can be accomplished in a variety of ways, such as analyzing the frequencies of words with a grammatical gender in languages that have opposite genders. Therefore, as we go through life encountering countless examples of categorization and co-occurrences within our language(s), the linguistic relativistic view would hold that language use indeed can influence how people conceptualize an object or its descriptors.

Research Questions and Overview of Chapters

Due to the contradictions between previous studies regarding how perceptual or symbolic cognition is, the aim of this dissertation is to investigate whether language and its usage in domains such as emotion and spatial orientation can affect cognition, instead of grounding all information in perceptual experiences. Specifically, the research presented here will address how language statistics (linguistic co-occurrences) or grammatical constructions can affect how we perceive the world. And if there is an effect, in what instances do linguistic factors or perceptual factors dominate? The remainder of the introductory chapter will be devoted to specific research questions that will be addressed, the organization of the chapters, and how each chapter will address the accompanying research questions.

RQ1: Does the influence of language occur even when a perceptual task is used?
RQ2: Can language statistics explain reaction time (RT) to emotion words?

Chapter 2 examines whether comprehension of emotion words can be explained by an embodied cognition account, a language statistics account, or a combination of both approaches. Since embodied cognition theorists hold that we simulate grounded experiences, embodied cognition should dominate in the realm of emotion word judgments, particularly when a specifically embodied task, such as the facial feedback paradigm, is used (Strack, Martin, & Stepper, 1988). First a corpus linguistic study was conducted to investigate whether emotion word co-occurrences are more frequent when they regard similar emotions as opposed to when they regard divergent emotions, specifically happy, sad, and angry emotions. Then, these linguistic frequency findings were applied to an experiment in which same- and different-emotion pairs of sentences were read by participants, comparing results produced using a facial feedback task (to further influence an embodied reaction) to those found without inducing embodiment.

RQ3: Can spatial judgments be predicted by language statistics?

The aim of Chapter 3 is to explore the domain of spatial location judgments, through using both traditional psychological experiments and corpus linguistic studies, and to determine whether we use language statistics for these judgments. Previous studies have shown that language statistics play a role in geographical estimates, however those studies used primarily perceptual tasks. This chapter investigates whether language frequencies are also used in a linguistic-based task by examining spatial judgments on a large scale using the relative locations of cities and their co-occurrence frequencies. In Chapter 4, this phenomenon will be examined on a smaller scale, human body parts, which would particularly be assumed to be facilitated by embodiment. This chapter will compare adult human and children body part location judgments and corpus linguistic data, and end with a multidimensional scaling (MDS) analysis that will demonstrate how location information can be correctly spatially oriented by using just text.

RQ4: Do effects of embodied cognition still hold when words cannot be perceptually simulated?

Chapter 5 revisits whether language can affect cognition, using a feature of language that cannot, by nature, fit into the embodied cognition paradigm. Many studies, including those presented in this dissertation, have used words that can easily be represented by concepts that are perceptual in nature, such as nouns or adjectives. Chapter 5 will investigate whether the effects of language statistics hold for grammatical words (i.e., prepositions) that cannot be perceptually simulated. This chapter will also include more general situations in which one system, perceptual or symbolic, will tend to dominate.

RQ5: Does grammar and the language that we use affect our perceptions?

Linguistic relativity, the idea that language itself can affect cognition, is explored by means of two studies in Chapters 6 and 7. First, a corpus linguistic study was conducted investigating effects of grammatical gender for nouns and adjectives that accompany them in Spanish and German. Previous studies regarding linguistic relativity have been limited by laboratory experimentation that can be artificial. Chapter 6 will use linguistic co-occurrences in order to show relativistic patterns found in these two languages. Along the same line as presented in Chapter 2, the purpose of Chapter 6 is to determine whether words similar in concept are more often found in the company of the same type of words (e.g., nouns that are grammatically feminine are more often accompanied by adjectives with a semantically feminine meaning). Chapter 7 will be based on a study that also examines the effects of grammar on cognition. In this chapter, an experiment conducted with Spanish-speaking and English-speaking participants reveals that the manner in which accidental actions are depicted can affect how speakers of that language will attribute responsibility, providing further evidence in support of linguistic relativity and the idea that language use can affect how we perceive the world.

General conclusions about a more inclusive approach to cognition, as well as some suggestions for future research, will be presented in Chapter 8.

Chapter 2
Language and Emotion

This chapter is based on:

Tillman, R., & Louwerse, M. M. (under review). Emotions in language statistics and embodied cognition.

Tillman, R., Hutchinson, S., & Louwerse, M. (2013). Verifying properties from different emotions produces switching costs: Evidence for coarse-grained language statistics and fine-grained perceptual simulation. *Proceedings of the 35th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

Theories of embodied cognition claim that cognition is fundamentally based in perceptual experiences, so that words only become meaningful through mentally reenacting perceptual experiences (Barsalou, 1999; Pecher & Zwaan, 2005). Various experimental studies have demonstrated evidence favoring an embodied cognition account (Barsalou, 1999; Glenberg & Kaschak, 2002; Pecher & Zwaan, 2005). For instance, Glenberg and Kaschak (2002) proposed the action-sentence compatibility effect whereby language processing is facilitated when a congruent response motion is used to respond to sentences describing motion away from or towards the body. That is, sentences describing motion away from the body (e.g., *close a drawer*) were processed faster when response motions were also moving away from the body, and vice versa.

Pecher, Zeelenberg, & Barsalou (2003) found that when participants read a sentence like *apples can be tart* followed by the sentence *apples can be sweet* (describing the same gustatory modality), RTs were faster when there was no shift in modality between the sentences (e.g., *apples can be tart* followed by *radios can be loud*). The reason for the processing costs in shifting modalities Pecher et al. give is the shift in perceptual simulations. These results and findings similar to these demonstrate that linguistic processing is facilitated through perceptual-motor information (see Leventhal, 1982 for an overview).

The evidence for embodied cognition is not limited to modalities. Strack et al. (1988) showed that when participants were instructed to smile, cartoons were perceived as more humorous than when subjects were not smiling, suggesting that embodied states can affect both judgments. Mouilso, Glenberg, Havas, and Lindeman (2007) showed that sentences describing emotions yield an embodied activation of these emotions. They asked people to read happy or angry content (e.g., *You shout at the pushy telemarketer who had the nerve to call during dinner*) while participants pushed or pulled a lever. They found that for angry sentences the participants were faster to respond when the emotion was angry and the action was pushing the lever (presumably, away from their bodies), and for happy sentences the action was faster for pulling the lever (again, presumably bringing the emotion closer).

In previous studies, an exclusive embodied or perceptual interpretation of experimental findings has been cautioned against. For instance, with regards to modality shifts being explained by perceptual simulations, Louwerse and Connell (2011) found that the modality of a word can be predicted on the basis of linguistic frequencies of the word. For example, after reading *lemons can be sour,* there will be a faster judgment response to *coffee can be bitter* than *radios can be loud*. Further, experimental findings that had been explained by perceptual simulations, could also be explained by language statistics. It was also previously shown that findings can also be modulated by the type of task utilized (Louwerse & Jeuniaux, 2010). These and other findings (Louwerse, Hutchinson, Tillman, & Recchia, 2014; Louwerse, 2008) have been explained in terms of the Symbol Interdependency Hypothesis, which proposes that conceptual processing can be explained by both symbolic and embodied mechanisms, because language encodes sensorimotor information, such that language users can utilize these cues in cognitive processes (Louwerse, 2011).

Evidence in favor of the Symbol Interdependency Hypothesis (Louwerse, 2000) primarily comes from conceptual knowledge with descriptive language describing what we see, hear, touch, smell, and taste. Through this framework whether the comprehension of emotions expressed in language can also be explained by language statistics or need to be explained exclusively by an embodied cognition account (Havas, et al., 2007; Mouilso et al., 2007).

In a corpus study, it was tested whether emotions can be extracted from language statistics. Two experiments next tested whether the statistical linguistic frequencies explained emotions better than embodied cognition ratings. In the first experiment, a semantic judgment task was used, but potentially favoring a language statistics account. In the second experiment, a facial feedback paradigm was added, thereby favoring an embodied cognition account.

Corpus Linguistic Study

The purpose of the corpus linguistic study was to determine whether different emotions (happiness, sadness, anger) can be predicted from linguistic frequencies. The first order co-occurrences in the English language of the stimuli in Shaver, Schwartz, Kirson and O'Connor (1987) were calculated. These words were divided into primary emotions of six categories: *love, joy, surprise, anger, sadness,* and *fear* and added adjectives derived from these emotions (e.g., *happy* for *happiness*), totaling 252 emotion words.

The first order-co-occurrence frequency of the emotion words was computed using the Web 1T 5-gram corpus (Brants & Franz, 2006). This corpus consists of 1 trillion word tokens (13,588,391 word types) from 95,119,665,584 sentences. The frequency of co-occurrences of the word pairs was computed for bigrams (emotion_word1 emotion_word2), trigrams (emotion_word1 any_word emotion_word2), 4-grams (emotion_word1 any_word1 any_word2 emotion_word2) and 5-grams (emotion_word1 any_word1 any_word2 any_word3 emotion_word2).

The 252 x 252 = 63504 combinations minus the 252 same pair emotion words (e.g., *happy-happy*) were next categorized in no-shift and shift categories. For instance, the word pair *grief-sadness* was categorized as no-shift, whereas *grief-happiness* was marked as shift. The log frequency of the word pairs was used as a dependent variable, and the shift vs. no-shift categories were used as an independent variable. If emotions can be estimated from language statistics, same-emotion words should have a higher log frequency than different-emotion words. The log frequency of the co-occurrences indeed significantly differed between same-emotion and different-emotion word combinations, $F(1, 7038) = 275.05$, $p < .001$, with same-emotion pairs being more frequent than different-emotion pairs ($M = 6.40$, $SD = 1.78$ and $M = 5.71$, $SD = 1.54$ respectively). These findings provide evidence suggesting that, like modality shifts (Louwerse &

Connell, 2011), emotion shifts are encoded in language. Next, the aim was to determine whether language users rely on language statistics in their interpretation of emotions.

Experiment 1

Experiment 1a was similar to Pecher et al. (2003), except that here sentences were used that expressed similar and different emotions, rather than modalities. Moreover, rather than only including perceptual simulation as a factor in the analysis, language statistics (i.e., co-occurrences for the words) was included, in order to measure the effect of the two factors on cognitive processing. A two-sentence paradigm was employed, in which Sentence 1 was to prime Sentence 2, where fixation crosses separated the pairs.

Method

Participants. Thirty-three undergraduate students at the University of Memphis participated for Psychology course credit.

Materials. Sixty emotion sentences were created, following the method described in Pecher et al. (2003) with each sentence in the format *X can be Y*. There were three experimental types of emotions depicted in the sentences: angry, happy, and sad. For example, sentences included *birthdays can be happy*, and *insults can be devastating*. See Appendix A.

Procedure. Participants were seated in front of a computer screen. Five practice items preceded the experimental phase to ensure participants understood the task. Participants saw sentences one at a time in the center of the screen and then were asked to respond to the question *Is the characteristic true of the items it described?* Participants pressed designated yes (e.g. *birthdays can be happy*) or no (e.g. *failure can be blissful*) keys on the keyboard, while RTs were recorded.

Results and Discussion

Incorrect responses (e.g., a yes answer to the question *insults can be happy*) and RT outliers, defined as 2.5 SD above the mean per subject per item, were removed from the analysis. This affected less than 3.6% of the data.

Similar concepts are usually found in near proximity of one another, therefore the perceptual simulation factor was operationalized as the Euclidean distance ($d_{xy} = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$) of six point Likert-type scale ratings of the nouns and adjectives on the emotions *happy*, *sad* and *angry*. Forty participants were recruited through the online crowd sourcing website Mechanical Turk and were asked to rate 60 nouns and adjectives for their levels of happy, sad, and angry (Appendix A). The language statistics factor was operationalized as in Study 1 taking the log frequency of noun pairs (*birthdays – insults*) and adjective pairs (*happy – devastating*) of first-order co-occurrences of all the possible combinations of the nouns and adjectives using the Web 1T 5-gram corpus (Brants & Franz, 2006).

We also examined the corpus data in order to discover whether the shift vs. no-shift pattern was found in the text for nouns, adjectives, and a combination of both nouns and adjectives used in the corpus linguistic experiment.

As in the corpus study, the log frequency of the co-occurrences of combinations of nouns and adjectives was higher for same-emotion pairs than different-emotion pairs, $F(1, 7078) = 212.76$, $p < .001$ ($M = 2.08$, $SE = .04$ versus $M = 1.11$, $SE = .054$). This pattern was also found when only noun pairs were compared, $F(1, 3479) = 148.11$, $p < .001$, ($M = 4.29$, $SE = .08$ and $M = 2.60$, $SE = .11$) and when adjectives were compared, $F(1, 3598) = 279.17$, $p < .001$ ($M = 2.53$, $SE = .05$ and $M = 1.00$, $SE = .07$).

A mixed-effect analysis was conducted on RTs with language statistics and perceptual simulation as the fixed factors and participants and items as random factors (Baayen, Davidson, & Bates, 2008). The model was fitted using the restricted maximum likelihood estimation (REML) for the continuous variable (RT). F-test denominator degrees of freedom were estimated using the Kenward-Roger's degrees of freedom adjustment to reduce the chances of Type I error (Littell, Stroup, & Freund, 2002).

The language statistics factor significantly predicted RTs for both nouns, $F(1,515.36) = 6.24$, $p = .01$, and adjectives, $F(1,600.57) = 6.24$, $p < .001$ such that higher frequencies yielded faster RTs. The perceptual simulation factor neither predicted noun RTs, $F(1,509.77) = .734$, $p = .39$, nor adjective RTs, $F(1,801.16) = 3.01$, $p = .08$, even though higher rating did yield faster RTs. This demonstrates that participants relied on statistical linguistic frequencies to aid judgments for emotional sentences for both nouns and adjectives.

However, asking participants whether the characteristic described in the sentence is true might bias a language statistics account at the expense of an embodied cognition account as one can argue that no emotions are activated when reading a sentence describing emotions. Even though that argument would go against an embodied cognition account (after all, even perceptual simulations are activated when reading about an eagle high in the nest; Zwaan, Stanfield, & Yaxley, 2002), an experiment in which participants are asked to explicitly embody emotions might be desirable. The question still remains whether language statistics will reign supreme while processing sentences with emotional content when participants were explicitly asked to embody an emotion. Study 2 investigates this addition of an embodied task to the paradigm of Study 1.

Experiment 2

Experiment 2 used the facial feedback hypothesis (Strack, et al., 1988) in order to instill emotions (frowning or smiling) in participants. Because the previous experiment was fully linguistic in nature, the facial feedback task was used in order to introduce an embodied component to the experiment.

Method

Participants. Twenty-six undergraduate students at the University of Memphis participated for Psychology course credit.

Materials. The same materials were used as in Experiment 1.

Procedure. The procedure was the same as that used in Experiment 1, with one important addition. Participants were also randomly assigned to one of two facial feedback conditions. In one condition, the participants held a pen in their lips (N = 15) to simulate frowning; in the other, the participants held a pen in their teeth (N = 11) to simulate smiling.

Results and Discussion

Incorrect responses (e.g., a yes answer to the question *insults can be happy*) and RT outliers, defined as 2.5 SD above the mean per subject per item, were removed from the analysis. This affected less than 3.04% of the data.

We first examined the effects of the facial feedback task on the paradigm in order to demonstrate an effect on perceptual ratings as previously shown in embodied cognition literature (e.g., Strack, Martin, & Stepper, 1988). First, shifts or no shifts within each sentence were examined. For Sentence 1, there was no main effect for the perceptual distance of the adjectives ($F(1,281.610) = .079$, $p = .78$). However, there was a significant main effect of the perceptual distance ratings for nouns ($F(1,346.122) = 5.00$, $p = .026$, which indicates that for this task, the participants were more likely to consider physical distance of noun concepts rather than adjectives. This finding is intuitive given that nouns have a definitive physical property, while adjectives do not. There was a significant interaction between the facial feedback condition and the perceptual distance rating for the concept nouns, $F(1,348.443) = 4.35$, $p = .038$. There was no significant interaction found between the facial feedback condition and the perceptual distance for adjectives, $F(1,250.884) = 0.06$, $p = .80$. For Sentence 2, the target sentence, there was a main effect of perceptual rating of adjective, $F(1,271.368) = 4.26$, $p = .04$, and no main effect of perceptual rating for the concept noun, $F(1,345.583) = .20$, $p = .66$. There was also no significant interaction between the facial feedback condition and the perceptual distance rating for the concept nouns, $F(1,347.625) = 1.76$, $p = .19$, however the interaction was significant between the facial feedback condition and the perceptual distance rating for the adjectives, $F(1,243.326) = 4.67$, $p = .03$. The effects of the shift of emotion (e.g., happy to sad) from concept noun to adjective is not surprising, given that emotions are more often represented by adjectives (Mohammed & Turney, 2010) and the purpose of Sentence 1 was to prime Sentence 2. In sum, this analysis determined that smiling or frowning was related to the effect on the perceptual ratings, suggesting that perceptual simulation influences cognition, depending on the embodiment of the emotion in the experiment. While this phenomenon can be explained in terms of the effect of the cognitive task (see Louwerse & Jeuniaux, 2010), however, this did not take the linguistic factors into account.

For the frowning induced condition across Sentence 1 and Sentence 2, language statistics was again a significant factor for predicting RTs for both nouns, $F(1,848.871) = 6.22$, $p = .013$, and adjectives, $F(1,837.193) = 9.65$, $p = .002$. Perceptual simulation was neither significant for nouns, $F(1,880.796) = 1.83$, $p = .18$, nor for adjectives, $F(1,880.066) = 1.11$, $p = .292$.

For the smiling condition across Sentence 1 and Sentence 2, language statistics also significantly predicted RTs for both nouns, $F(1,651.886) = 9.79$, $p = .002$, and adjectives, $F(1,651.849) = 21.26$, $p < .001$. But for the perceptual simulation factor this was not found for nouns, $F(1,648.144) = .541$, $p = .46$, but it was found for adjectives, $F(1,649.740) = 5.06$, $p = .025$). The emergence of significant results for the perceptual factor for adjectives, at least in the case of the smiling condition, can be attributed to the stronger link between adjectives and emotions rather than nouns and emotions, although this was not the case for the frowning condition.

These findings suggest that the cognitive task modulates the effect of language statistics and perceptual simulation factors, even though language statistics seems to dominate in explaining cognitive processing of emotion sentences.

Discussion

The current chapter investigated whether the processing of emotion sentences is affected by language statistics or perceptual simulation by comparing same-emotion and different-emotion sentences. In two experiments, it was found that language statistics explained RTs across sentences, for only nouns, and only adjectives, while perceptual factors did not explain RTs, with the exception of adjectives in the smiling facial feedback condition. Furthermore, two corpus linguistic studies demonstrated that language statistics not only explained RTs, but also emotion shifts.

Previous studies have found that two sentences that elicit a modality shift produce cognitive switching costs, compared to sentences that describe the same modality (Pecher et al., 2003). This finding has been reported as evidence for an embodied cognition account, because the increased RTs are an indication that comprehenders perceptually simulate the sentences. However, Louwerse and Connell (2011) concluded that language statistics serves as a coarse-grained system that serves as a shallow heuristic. Perceptual simulation, on the other hand, serves deeper conceptual processing. The idea that language encodes perceptual information and that these linguistic cues can be used by language users in shallow comprehension tasks, such as quick RTs used in this experiment, is predicted by the Symbol Interdependency Hypothesis (Louwerse, 2007; Louwerse & Connell, 2011). Language statistics explained emotion shifts. On the other hand, assuming that a perceptual simulation system is responsible for RT differences that were obtained in the two experiments, the perceptual system did not explain the differences in general emotion shifts. These results provide further evidence for the theory that conceptual processing can be explained by both symbolic and embodied cognition accounts.

Chapter 3

Language and Geographical Estimates

This chapter is based on:

Tillman, R., Hutchinson, S., Jordan, S., & Louwerse, M. (2013). Geographical estimates are explained by perceptual simulation and language statistics. *Proceedings of the 35th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

The aim of this dissertation is to demonstrate how language use can influence cognition, and whether a more inclusive approach should be used in the investigation, rather than either symbolic or embodied cognition. In the previous chapter regarding emotions, it was demonstrated that while perceptual simulations (Barsalou, 1999; Pecher & Zwaan, 2005) can explain processing of emotion words, it was also shown that language statistics can explain processing time equally well. In the previous corpus linguistic studies and psychological experiments with emotions, perceptual simulations were given every opportunity to dominate as a facial feedback task was given in order to directly prime embodied reactions to emotional stimuli. However, as this was a unique domain, it would be assumed that emotional testing can be more susceptible to evoking a visceral reaction, as well as being on a small (personal) scale. Because these findings should also include a larger, more external domain, this chapter will investigate spatial judgments on a much larger scale: spatial proximity judgments of geographical locations of U.S. Cities. The position in this dissertation is not to discount embodied cognition, rather than to examine in which conditions perceptual simulation or language statistics produce more effective results.

Judgment can be deep and precise, as with perceptual simulation, or quick and shallow, as with symbolic representation. For instance, humans can make geographical estimates on the basis of their perceptual experiences from locomotion and stationary viewing, from static pictorial representations, such as diagrams, paintings and photos, provided on a map, and they can acquire information via dynamic pictorial representations, including animations, and videos (Freundschuh & Mercer, 1995). The importance of a perceptual simulation system has been strongly advocated by accounts of embodied cognition (Barsalou, 1999; Barsalou, 2008; Glenberg & Kaschak, 2002; Pecher & Zwaan, 2005; Semin & Smith, 2008). According to Barsalou, Solomon, and Wu (1999), perceptual states are transferred into memory and function symbolically, rather than through arbitrary representation such as language. As an example, overwhelming evidence in favor of an embodied cognition account has accumulated, showing that processing within modalities is faster than having to map across modalities, and suggesting that modality switching comes at a price (e.g., Marques, 2006; Pecher, Zeelenberg, & Barsalou, 2003; Spence, Nicholls, & Driver, 2001). Furthermore, language comprehension seems to be influenced by action representations primed in experimental tasks (e.g., Glenberg & Kaschak, 2002; Kaschak et al., 2005; Klatzky, Pellegrino, McCloskey, & Doherty, 1989; Zwaan, Stanfield, & Yaxley, 2002), and visual representations get activated during language comprehension (see also Boroditsky, 2000; Fincher-Kiefer, 2001; Matlock, Ramscar, & Boroditsky, 2005).

One particular study nicely illustrates the embodied cognition account. Zwaan and Yaxley (2003) presented iconic word pairs either as they occur in the real world, such as *attic* over *basement*, or the reverse-iconic orientation, such as *basement* over *attic*. They found significant differences between the iconic and reverse-iconic configurations of these word pairs. They concluded that the explanation for the iconicity effect was that words activate their perceptual representations (*attics* presented above *basements* are processed faster than *basements* above *attics*, because of their iconic relationship in the real world).

Louwerse (2008) questioned whether the Zwaan and Yaxley (2003) finding should be solely attributed to perceptual simulation. Statistical linguistic frequencies, the co-occurrence of words in a given frame, showed that items that are normally high in space preceded items that are normally low in space more frequently than vice versa, suggesting that language encodes spatial information (e.g., we say *up* and *down*, *top* and *bottom*, *knees* and *toes*, rather than *down* and *up*, *bottom* and *top* and *toes* and *knees*). Moreover, statistical linguistic frequencies explained RTs better than the perceptual factor. These findings demonstrate that there is a complementary linguistic explanation to a perceptual simulation explanation.

Louwerse and Jeuniaux (2010) showed that the extent to which cognitive processes can be explained by perceptual simulation or language statistics (frequency of word co-occurrence) depends on a variety of factors, including the nature of the stimulus (e.g., words versus pictures) and the cognitive task (e.g., shallow or deep cognitive task). In Louwerse and Jeuniaux (2010), participants saw either pictures or words in their natural orientation (e.g., ceiling above floor), or in their reverse orientation (e.g., floor above ceiling). Statistical linguistic frequencies were better able to explain RTs than perceptual ratings when the word pairs were used, with the reverse result when picture pairs were used. Similarly, when participants were asked to make a judgment whether items were similar, the effect for perceptual ratings on RTs was larger than that for statistical linguistic frequencies, with the opposite result for a semantic judgment task. Importantly, effects for both language statistics and perceptual simulation were found for both stimulus types and both cognitive tasks, however, their relative dominance was modified by task and stimulus.

These findings have been captured through the Symbol Interdependency Hypothesis, which proposed that conceptual processing can be explained by both symbol and embodied mechanisms (Louwerse, 2007; 2008; 2011). When we encounter a word, a rough meaning is elicited by using the linguistic, that is symbolic, neighbors. This is accomplished by using language statistics, where words that often appear together are related in important ways that can facilitate initial cognitive processing. In order to fully ground the word, we can mentally simulate the features of the word in order to process the word in a deeper way. Human beings can use the fuzzy sense of words by a linguistic (symbolic) short-cut when processing language as it occurs. In addition, language is encoded with spatial information. The Symbol Interdependency Hypothesis is composed of three components. First, language encodes perceptual information. Second, during cognitive processes users of language rely on language statistics and perceptual simulation. Finally, the dominance of either language statistics or perceptual simulation is dependent on the type of task and stimulus.

Geographical locations

Do the three claims of the Symbol Interdependence Hypothesis also hold for spatial cognition within geographical representations? Using newspapers such as the New York Times and the Wall Street Journal Louwerse and Zwaan (2009) were able to estimate the longitude and latitude of the largest cities in the US computationally, based on the idea that “cities that are located together are debated together.” That is, by computing the n x n frequencies of the co-occurrence of city names in the newspapers, a two-dimensional multidimensional scaling analysis yielded correlations with the longitude and latitude of the cities. The Louwerse and Zwaan (2009) findings are not limited to the English language. Louwerse, Hutchinson, and Cai (2012) found similar results using Arabic for predicting cities in the Middle East, and Chinese for predicting cities in China. It is interesting to note the presence of this effect was found for three languages each with different writing directions (English- left to right, Arabic- right to left, and Chinese, at least historically- top to bottom). This shows, at the least, that it is possible to map out cities in different locations, within different writing systems, by using the frequency of co-occurrences of city names within a large corpus.

Language has been shown to encode geographical information. The question is whether this also means that humans use these encodings. Louwerse and Zwaan (2009) stated that between 16% and 35% of the latitude and longitude variance in human location estimates can be attributed to linguistic coding. These percentages were found by using a bidimensional regression analysis correlating human and computational longitude and latitude estimates (using a large newspaper corpus). However, it is unclear whether

84% and 65% and of the latitude and longitude variance in human location estimates can be attributed to spatial information. Moreover, given that language encodes spatial information, it is difficult to disentangle linguistic and perceptual processes. It could be argued that proximity can explain estimation bias when determining distance between two locations (Tobler, 1970). However, Friedman, Kirkman, & Brown (2002) tested this hypothesis by comparing latitude estimates by participants in Canada and Texas. Their findings did not support the proximity hypothesis, while participants in Texas exhibited greater bias in their estimates of Mexican locations than the participants from Canada. The explanations proposed by Friedman et al. included cognitively based beliefs, geopolitically based beliefs, and socio-culturally based beliefs. It was also argued by Brown (2002) that seeding effects can affect real-world judgments, such as proximity and size estimation of two cities. However, many of the experiments contained in Brown (2002) were designed for numerical estimates such as population, or how many square kilometers are in a given country. While they were robust and interesting effects, they do not necessarily apply here, because the tasks in the present study utilize the distance between two cities, not estimations of numbers about those locations.

Louwerse and Benesh (2012) investigated to what extent geographical estimates could come from language statistics and from perceptual simulations by comparing readers who had read Tolkien's Lord of the Rings trilogy and The Hobbit with participants who studied a map and had never seen the text. As in Louwerse and Zwaan (2009), computational estimates of co-occurrence of the location of the cities in Middle

Earth were determined. Participants were asked to draw the location of the cities on a piece of paper. Again, computational estimates of co-occurrence for cities mentioned in the text correlated with the longitude and latitude of cities in Middle Earth. Interestingly, estimates from those who studied a map correlated with the actual geographical location in Middle Earth more than the estimates from those who had read the text did. On the other hand, estimates from those who had read the text correlated more with the computational estimates of co-occurrence than the estimates from those who studied a map did. These results support the claims made by the Symbol Interdependency Hypothesis: 1) Language (Lord of the Rings) encodes geographical (Middle Earth) information; 2) Those who read Lord of the Rings and those who studied the map relied both on language statistics and perceptual simulation in their estimates; 3) the relative dominance of language statistics and perceptual simulation factors is modified by whether participants read the text or studied the map.

Importantly, human estimates in Louwerse and Zwaan (2009) and Louwerse and Benesh (2012) were derived from an experimental setting in which participants were asked to draw the location of cities on a piece of paper, which is a perceptual task. Given that the cognitive task determines the effect of language statistics and perceptual simulations (Louwerse & Jeuniaux, 2010), the estimates how much of human geographical estimates come from language statistics and come from perceptual simulations are likely to be biased. Chapter 4 will focus on an experiment in which participants were not asked to draw a map (a perceptual task) but to estimate geographical distances from words (a task that better justifies linguistic processing).

Experiment

In a between-subjects design, participants viewed city pairs in the United States in either a horizontal or vertical orientation. These city pairs randomly appeared in either their natural orientation (i.e., a more northern city was presented above a second city, or a more western city was presented to the left of a second city), or the opposite of their natural orientation. In this iconic orientation, the prediction was that participants would rely on perceptual information. Conversely, when the location of the city pairs was reversed (i.e., reverse-iconic), the prediction was that participants would rely on language statistics.

Methods

Participants. Ninety-three undergraduate native English speakers at the University of Memphis (67 females) participated for extra credit in a Psychology course. Forty-five participants were randomly assigned to the vertical presentation condition and forty-eight participants were randomly assigned to the horizontal presentation condition.

Materials. The experiment contained 50 of the largest cities in the United States using the U.S. Census data from 2000 and were presented in 2,450 name pairs.

Procedure. In two presentation conditions (horizontal or vertical), subjects were presented with city pairs in their iconic configuration and their reverse iconic configuration. Participants were randomly assigned to view either the vertical or horizontal configuration. To reduce order effects, participants were counterbalanced across four groups per condition.

The city pairs were presented on a 1280x1024 computer screen. Participants were asked whether the named United States cities were closely located. The vagueness of the question intentionally left open the question of closeness for the participant to decide. A more specific question would have added a number of constraints that would influence the judgment in unintended ways. The center of the screen was positioned at eye level. Each trial began with the presentation of a fixation cross for 300ms. The participants would select their choice (yes or no) by designated buttons on a keyboard then a fixation cross would appear on the screen for the next trial.

Results

Outliers were defined as response times (RTs) that were 2.5 SD above the mean per subject per condition and were removed from the analysis. This affected less than 5% of the data.

The perceptual factor was operationalized as the differences in latitude or longitude of the cities. Language statistics was operationalized as the log frequency of a – b (e.g., for North – South: New York – Miami; for East – West: Los Angeles – Boston), or b – a (e.g., for North – South: Miami – New York; for West – East: Boston – Los Angeles) order of word pairs using the large Web 1T 5-gram corpus (Brants & Franz, 2006). This corpus consists of 1 trillion word tokens (13,588,391 word types) from 95,119,665,584 sentences. Using the log frequency of the co-occurrence of word pairs enables linear regressions to be performed comparing frequencies with other types of data, because raw frequencies of those co-occurrences are extremely skewed (Gries, 2010).

A mixed-effect regression analysis was conducted on RTs with linguistic frequency and the perceptual factor as fixed factors and participants and items as random factors (Baayen, Davidson, & Bates, 2008). The model was fitted using the restricted maximum likelihood estimation (REML) for the continuous variable (RT). *F*-test denominator degrees of freedom were estimated using the Kenward-Roger's degrees of freedom adjustment to reduce the chances of Type I error (Littell, Stroup, & Freund, 2002). Participants and items were treated as random factors in the analysis.

Note that the strength of a model association is represented as a weighted ratio of the F statistic. R^2 and F used in ordinary regression analysis are closely related, since where k is the number of model parameters and N is the number of cases, such that F has (k, N - k - 1) df. See also Pedhazur (1997, p. 105) and Louwerse and Jeuniaux (2010). See Figure 3.1.

$$F = \frac{\frac{R^2}{k}}{\frac{1 - R^2}{N - k - 1}}$$

Figure 3.1. Weighted ratio of the *F* statistic.

The perceptual factor explained RTs in the iconic pairs, $F(1,964.821) = 17.7$, $p < .001$, with larger distances yielding lower RTs. The linguistic factor, however, did not explain RTs for the iconic word pairs, $F(1,960.549) = 0.45$, $p = .50$.

For the reverse iconic configuration the perceptual factor also explained RTs, $F(1,984.502) = 8.382$, $p = .004$, except that the effect was considerably smaller. Importantly, for these reverse-iconic word pairs a significant effect on RTs was obtained for the linguistic factor, $F(1,970.543) = 6.18$, $p = .013$, with higher frequencies yielding lower RTs. Figure 2 gives an estimate of effect sizes, which are calculated by differences between groups as opposed to within the two original groups. See Figure 3.2.

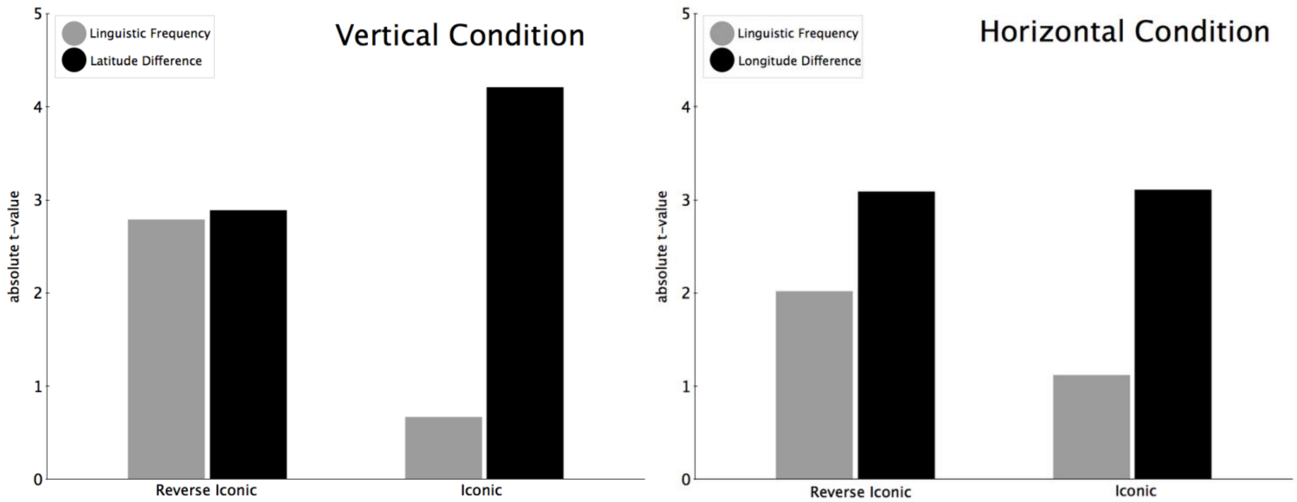

Figure 3.2. Absolute t-values of the linguistic frequencies and coordinate differences in reverse-iconic and iconic orientation in the vertically and horizontally positioned city names.

Discussion

The goal of the study in this chapter was to determine to what extent humans rely on language statistics and on perceptual simulation in spatial cognition. Previous work has found that language encodes geographical information, so much so that by computing the rates of co-occurrence of city names in the text, multidimensional scaling techniques allow for estimating the relative longitude and latitude of cities. Experiments have shown that humans rely on perceptual simulation, for instance, a perceptually grounded memory of the text. However, there is also evidence humans rely on language statistics, similar to those obtained from computational estimates. Because the existing literature used human estimates from map drawings, the current paper investigated to what extent linguistic and perceptual factors would affect cognitive processes in a more linguistic task.

When city pairs were presented to participants in their iconic order, their distance best explained RTs. The larger the distance, the larger the RTs were. No effect was obtained for language statistics in the iconic order. For the reverse-iconic order, the perceptual factor again explained RTs, but language statistics did so as well. This suggests that when the task or the stimulus invites for perceptual simulation, humans rely on perceptual simulation. When perceptual simulation is harder, other heuristics, such as language statistics are used. This finding lies fully in line with the results obtained by Louwerse and Jeuniaux (2010) showing that linguistic and perceptual factors dominate in conceptual processing when they are relevant.

Further research should investigate the weaker effects for the horizontal condition compared to those for the vertical condition. Barsalou (2008) argues that locating objects on a left/right axis is more difficult possibly due to the symmetry of the body and less salient cues to differentiate those objects. This weaker effect might be explained by embodiment and/or linguistic factors. When reporting two spatially related words in English, such as up-down or left-right, the top or the left most word is most often reported first. There is the possibility that there are less instances of the left-right phenomenon found in language. Future study of the nature of this phenomenon could illuminate why this weaker effect has been found. In the past, it has been shown that the linguistic system is used more often when quick decisions are made, and the perceptual system is used when slower decisions are made (Louwerse & Connell, 2011). However, more specific investigation is recommended in the future as to the exact mechanisms of these speed differences and to what degree they affect decisions.

The findings reported in this chapter are in line with the Symbol Interdependency Hypothesis (Louwerse, 2007), which claims that cognitive processes rely both on language statistics and perceptual simulation. Because language encodes spatial information, including geographical information, language users can utilize these cues in their comprehension process. Geographical judgments then rely on both a shallow heuristic, called the linguistic system, and a fine-grained and more precise perceptual simulation system. In summary, when examining cognition, both a symbolic and perceptual approach can be used depending on the cognitive goals of the situation, rather than an either/or approach.

Chapter 4

Language and Body Part Location Estimates

This chapter is based on:

Tillman, R., Datla, V., Hutchinson, S., & Louwerse, M. (2012). From head to toe: Embodiment through statistical linguistic frequencies. *Proceedings of the 34th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

The previous chapter presented evidence supporting the idea that people use linguistic or perceptual information to process relative spatial orientation. But the question remains whether corpus linguistic findings (i.e., linguistic co-occurrences) correlate with actual human responses. In Chapter 4, a direct comparison will be made between corpus linguistic findings and findings of human participants using names of body parts. Furthermore, the scope of spatial orientation in Chapter 3 was quite large in using geographical locations, therefore it would be beneficial to see whether using linguistic and perceptual information is also present in a smaller scope using human body parts locations.

As previously presented, several embodied cognition studies have shown a relation between the meaning of words and their spatial configuration when presented on the screen. For instance, when words for concepts in the air, such as birds and insects, are presented in the upper half of a screen, participants respond faster than when the same words are presented in the bottom of the screen, with a reverse effect for words referring to concepts on land or in the ocean (Šetić & Domijan, 2007; Pecher, Van Dantzig, Boot, Zanolie, & Huber, 2010). Similarly, when word pairs such as attic and basement are presented vertically, one above the other, iconic pairs are processed faster than reverse iconic pairs, presumably because comprehenders perceptually simulate the position of these concepts (Zwaan & Yaxley, 2003).

Other studies have demonstrated that the vertical configuration of words on the screen and the meaning of those words can be extended to concepts we literally embody, such as body parts. For instance, understanding parts of our body is directly linked to the spatial representation of the human body, and that representation contains veridical information about the relative distance between body parts (Smeets et al., 2009; Struiksma, Noordzij, & Postma, 2011; Van Elk & Blanke, 2011). When participants were presented with combinations of concepts that represent body parts, such as head-neck, processing time was considerably faster when the embodied distance of those concepts was small, compared to concepts for which the distance is large, such as head-toe. Studies like these yet again show that embodiment explains cognition.

However, the question can be raised as to what extent the relation between body semantics and spatial body representations can only be explained by an embodied cognition account. This is an important question, particularly if other accounts are complementary to the embodied cognition account.

Again, the Symbol Interdependency Hypothesis argues that language comprehension is both perceptual and linguistic in nature (Louwerse, 2008, 2011; Louwerse & Connell, 2011; Louwerse & Jeuniaux, 2010). That is, language comprehension is linguistic through statistical interdependencies between linguistic units and is perceptual through the references linguistic units make to perceptual representations. The Symbol Interdependency Hypothesis thereby makes an important prediction: language has evolved to become a communicative shortcut for language users and it encodes relations in the world. Accordingly, it is hypothesized that the findings attributed to an embodied cognition account can also be explained through statistical linguistic frequencies.

A number of studies have shown that language indeed encodes perceptual information. Louwerse, Cai, Hu, Ventura, and Jeuniaux (2006) and Louwerse and Zwaan (2009) aimed to determine if language encodes geographical information by comparing city latitude/longitude with how often those cities appeared in a corpus. Louwerse, Hutchinson, and Cai and (2012) demonstrated that these predictions are not limited to English, but can also be found in Chinese (predicting cities in China) and Arabic (predicting cities in the Middle East). Louwerse and Benesh (2012) also demonstrated through using The Lord of the Rings trilogy the longitude and latitude for cities in the fictional Middle Earth can be predicted. The physical distance between cities was accurately estimated based upon statistical linguistic frequencies of city names, thus suggesting that language does encode (perceptual) geographical information.

The encoding of perceptual information in language goes well beyond geography. Louwerse and Connell (2011) have shown that the modality of a word (e.g., *sour*, *soft*, *loud*) can be predicted on the basis of statistical linguistic frequencies. That is, computational estimates on the modality of a word were less precise (visual/tactile, olfactory/taste, auditory) but equally as accurate as human estimates on the modality of words. In addition to geographical predictions and modality predictions, Louwerse (2008) investigated whether iconicity of words can be predicted. Analogous to binomials such as *top and bottom*, *high and low*, and *up and down,* this study found that the iconic order of concepts such as *flower-stem* could indeed be predicted by simply looking at the order of the words.

It is relevant here to address the question whether these statistical linguistic cues are in fact used by comprehenders. Louwerse (2008) tested whether word pairs like *flower-stem*, presented vertically, yielded faster response times because participants were perceptually simulating the word pairs, or because of the word order (a linguistic factor). The findings demonstrated that the frequency of word pairs such as *flower-stem* (a perceptually realistic order) is significantly higher than word pairs *stem-flower* (a perceptually unrealistic order), and that linguistic frequencies explained response times at least as well as perceptual ratings.

The effect of perceptual and linguistic factors on cognitive processes is modulated by stimulus, cognitive task, and by duration of processing. Louwerse and Jeuniaux (2010) showed that linguistic factors best explained semantic judgments of word pairs, whereas perceptual factors best explained iconicity judgments of picture pairs. Furthermore, they concluded that linguistic factors dominated when participants were involved in shallow cognitive processes, and that perceptual factors dominated in deeper cognitive tasks. Louwerse and Connell (2011) extended these findings, showing that faster response times were best explained by linguistic factors, and slower response times were best explained by perceptual factors. These findings suggest that the relative employment of linguistic or perceptual representations changed as a function of the task, duration of the task, or stimulus.

In the study for this portion of the chapter, the question whether embodied information (i.e., information about the distance between body parts) is also encoded in language is examined. To test for this possibility, a computational linguistic study was conducted in which the co-occurrences of body part names were calculated and then compared to the statistical linguistic frequencies with the existing experimental data. It was hypothesized that body parts that are perceptually close together are placed in similar linguistic contexts, thereby allowing for accurate computational estimates on the position of the body part.

Comparing human and corpus data

In previous research, Jacobowitz (1973) explored the development of language by comparing body part similarity ratings of five-year-old children, and adults. The 15 body parts used were: Arm, body, cheek, ear, elbow, face, finger, foot, head, hand, knee, leg, mouth, palm, and toe. Jacobowitz conducted four replicated multi-dimensional scaling analyses (RMDS), which simultaneously analyzed multiple matrices. The dimensional scaling illustrated that the five-year-olds grouped the head items, arm items, and leg items more similarly than body parts in the other two of the three categories (see Figure 4.1.B). The adults, on the other hand, grouped head terms together, but the other extremities were grouped by function (e.g., arm and leg (limbs) were more similar, finger and toe (digits) were more similar, etc.) (see Figure 4.1.A). Jacobowitz found that the similarity ratings for body parts were hierarchical for both the children and adults.

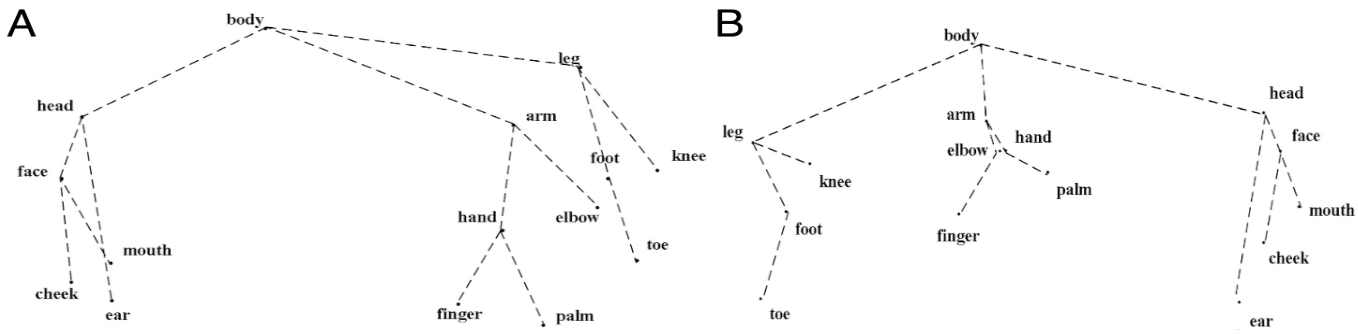

Figure 4.1. Body part similarity ratings of adults (A) and children (B) (Jacobowitz, 1973).

In the study for the present chapter, Jacobowitz's (1973) data was compared with findings from statistical linguistic frequencies. The frequencies of first-order co-occurrences in the Web 1T 5-gram corpus (Brants & Franz, 2006) were calculated. This corpus consists of one trillion word tokens (13,588,391 word types) from 95,119,665,584 sentences. The volume of the corpus allows for an extensive analysis of patterns in the English language. The frequency of co-occurrences of the 15 words was computed in bigrams, trigrams, 4-grams and 5-grams. For instance, the frequency of the words {head, toe} was determined by considering these words next to one another {head, toe}, with one word in between{head w1 toe}, with two {head w1 w2 toe} or with three intervening words {head w1 w2 w3 toe}. This method is identical to the one used in Louwerse (2008), Louwerse and Jeuniaux (2010), and Louwerse and Connell (2011).

Results

The result of these computations was a 15 x 15 matrix of raw frequencies of co-occurrences, from which log frequencies were obtained. This matrix was submitted to an MDS analysis using the ALSCAL algorithm (see Young, Takane, & Lewyckyj, 1978). For purposes of mapping the relative location of body parts, it is insufficient to simply obtain the co-occurrence frequencies in the Google corpus. The frequencies must be converted to x and y coordinates, and then a mathematical analysis performed to find the relative spatial location of the body parts. Multidimensional scaling (MDS) is a series of mathematical operations that can illuminate patterns within data that may not be immediately recognizable with standard numerical output (Kruskal, & Wish, 1977; Blake, Schulze, & Hughes, 2003). MDS has been utilized to not only analyze similarity, but also to provide a graphical representation of those similarities. A Euclidean distance measure transformed the semantic similarities into dissimilarities, such that the higher the value, the longer the distance. Default MDS criteria were used with an S-stress convergence of .001, a minimum stress value of .005, and a maximum of 30 iterations. The fitting on a two-dimensional scale was moderate, with a Stress value = .21 and an R^2 = .86.

To do justice to the geometry of the 2D variables in Jacobowitz (1973), bidimensional regression analyses were used to compare the participants' estimates with the actual coordinates of the body parts. Tobler (1994) and Friedman and Kohler (2003) introduced bidimensional regressions in order to compute the mapping of any two planes under consideration. Whereas in a unidimensional regression each data point is shifted by intercept and slope, each actual and predicted value of the dependent variable are presented by a point in space, whereby vectors represent intercept and slope.

A bidimensional regression yielded a significant correlation between the frequency estimates and Jacobowitz's (1973) loadings on a two-dimensional plane for both the adult study, $r = .66$, $p < .01$, $n = 15$, and the child study, $r = .63$, $p = .01$, $n = 15$. To ascertain that these findings could not be attributed to accidental pairings of coordinates, a Monte Carlo simulation was conducted, randomly sampling each dataset 1000 times. The findings solidified the results, with no bidimensional relation between the statistical linguistic frequencies and Jacobowitz's (1973) adult data, average $r = .23$ ($SD = .12$), $n = 15$ or child data, average $r = .24$ ($SD = .12$) , $n = 15$. These findings suggest that statistical linguistic frequencies can explain data obtained from human participants.

In addition to the comparison between Jacobowitz's (1973) two-dimensional fitting, a one-dimensional solution, using the first dimension of the MDS solution, was compared with the actual location of the body part terms. The correlation between the location of the body parts and the computational estimates was again high, $r = .6$, $p < .001$, $n = 15$. The linear fitting between the computational estimates and the actual position is presented in Figure 4.2.

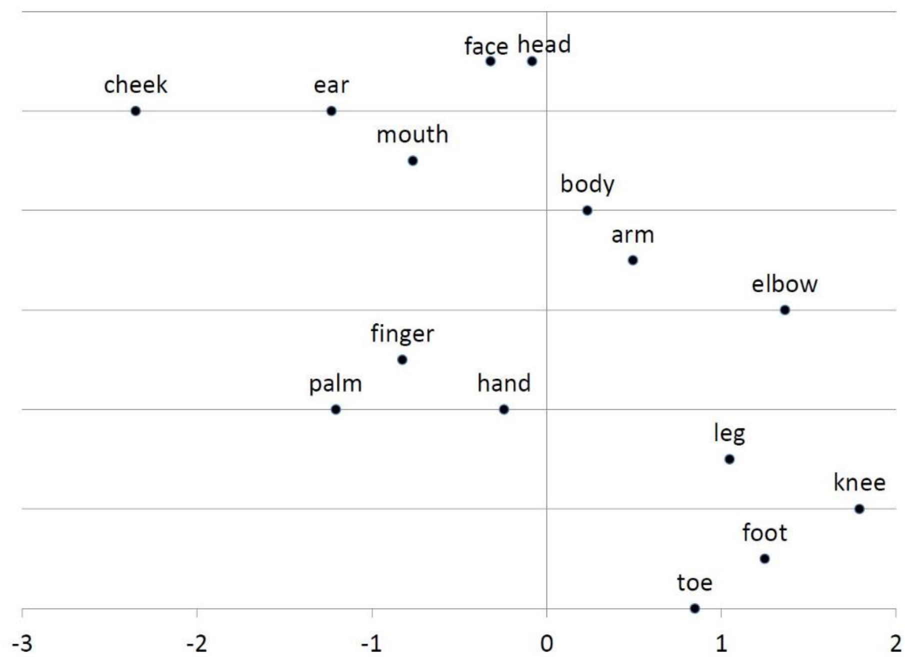

Figure 4.2. Multidimensional Scaling of 15 body parts from Jacobowitz (1973).

Distance ratings

Van Elk and Blanke (2011) established that there is a relationship for spatial position of body parts as well as the relative distance between them for native French speakers (see Table 4.1.). In Experiment 1, 38 body parts were assigned to nine categories dependent upon the distance from each other on the body (e.g., forehead/toe = 9; forehead/eye = 1). The words were then presented vertically in a congruent or incongruent spatial position (forehead/toe; toe/forehead). Subjects demonstrated increased RTs for larger distances, while position congruency did not seem to have an effect. Experiment 2 consisted of an iconicity judgment also using relative distance and congruency. However, in this experiment the words were not in the center of the screen as in Experiment 1, but arranged in varying distances from each other. There were significant main effects, as well as an interaction, for the error rates. The RTs revealed there were main effects of congruency and distance, but no interaction was found.

We computed the log frequency of all combinations of the English body part words and compared the data with the Van Elk and Blanke (2011) distance data. Because the algorithm functions best with single words in a 2-5 gram window, all words that require two words in English (*under arm*, *ring finger*, *index finger,* and *middle finger*) were removed. Moreover, no frequencies were found for *instep* and *pinkie* combinations, therefore these words were removed from the analysis.

The correlation of the 32 x 32 word pair frequencies and the distances was significant, $r = .35$, $p < .001$, $n = 1024$, with higher frequencies yielding lower physical distances. This finding suggests that embodiment is encoded in language, such that the relative location of body parts can be estimated using statistical linguistic frequencies.

Next, analyses similar to the first study were conducted, whereby the raw frequency comparisons were not used, but instead entered the n x n matrix in an MDS algorithm and used the loadings of the body parts names as a comparison. To do justice to the one-dimensional plane Van Elk and Blanke (2011) used, the MDS solution was restricted to a one-dimensional solution. The fitting was moderate, $Stress = .47$, $R^2 = .50$. When the loadings of the 32 body parts were compared with their physical distances, a strong correlation was found, $r = -.76$, $p < .001$, $n = 32$.

Table 4.1. Body part positions and factor loadings (Van Elk & Blanke, 2011).

Word	Position	Loading	Word	Position	Loading	Word	Position	Loading
hair	1	0.79	back	3	-1.15	palm	6	1.05
eye	1	1.01	shoulder	3	-0.42	thigh	7	-0.83
ear	1	1.13	chest	3	0.31	leg	7	-0.56
forehead	1	1.35	elbow	4	-0.81	knee	8	-0.95
eyebrow	1	2.09	wrist	5	-0.82	calf	8	-0.88
neck	2	-0.14	forearm	5	-0.75	ankle	9	-1.36
throat	2	0.91	butt	5	-0.58	shin	9	-1.24
chin	2	0.92	thumb	5	0.13	heel	9	-1.09
nose	2	1.24	stomach	5	0.86	foot	10	-0.9
lip	2	1.35	hand	6	-0.89	toe	10	-0.61
cheek	2	1.56	hip	6	-0.7	palm	6	1.05

To determine whether these findings could in any way be attributed to accidental pairings of variables, a Monte Carlo simulation was again conducted, whereby correlations of the 1000 randomizations of the data were computed. The average correlation did not come close to the correlation obtained for the actual data, average r = .15, p = .41, n = 1000. As before, the position of the body parts and their corresponding words were plotted (Figure 4.3).

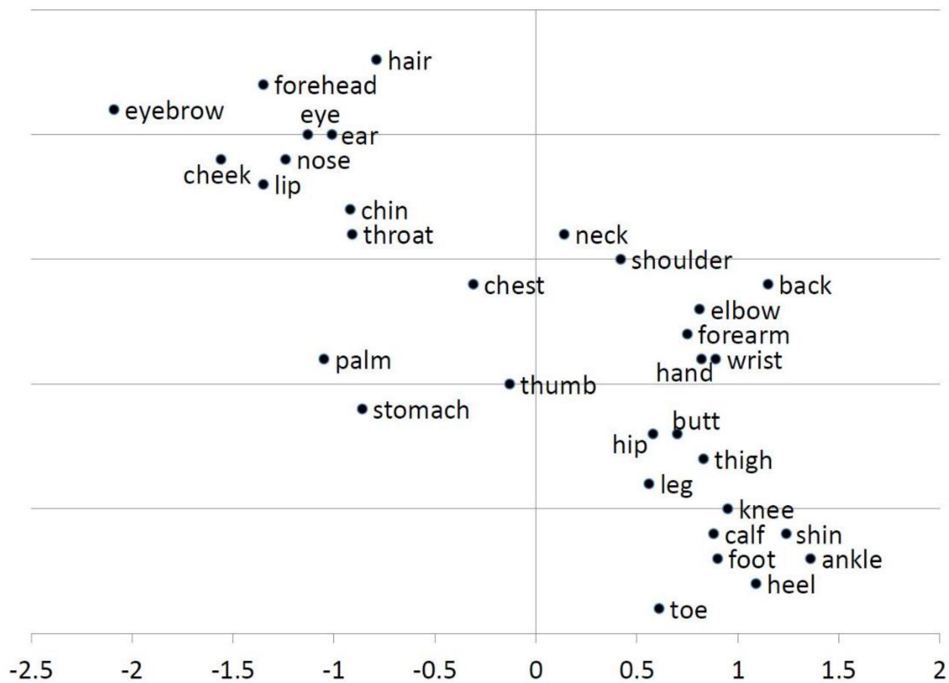

Figure 4.3. Multidimensional Scaling of 32 body parts (Van Elk & Blanke, 2011).

Discussion

Recent literature has shown that perceptual information, such as geographical locations, modalities, and iconicity, is encoded in language. The study in the current chapter extended these findings by addressing the question whether language encodes (literally) embodied information: whether statistical linguistic frequencies can explain the relative location of different parts of the body. Results from two computational studies showed that such frequencies indeed can estimate the relative location of body parts. First, it was demonstrated that computationally derived values can explain human similarity estimates of body-parts. In the second study in the chapter, it was also found that word frequencies can estimate physical distances between body parts. Both of these studies support the claim that language encodes body information.

The present study addressed one portion of the ongoing debate whether perception can be more than simply embodied. The impressive correlation between the human perceptual ratings and the Google *N*-Gram corpus ratings demonstrate that co-occurrence frequencies can compare to actual human ratings. One possible limitation of this study is the use of colloquial or metaphorical phrases within a given corpus, such as *hand-to-mouth*, *putting your foot in your mouth*, etc. Humans may or may not process these co-occurrences when rating similarity. Therefore, part of speech and usage could be controlled for in future analyses using linguistic co-occurrence data.

A next step in validating these results would be to obtain more current human body part similarity ratings. Perhaps human perception has changed in the last few decades due to the increase in television watching, internet usage, or other societal factors. The next projected step is to compare possible differences using a more specified list that also contains relative distance ratings with the 32 body part similarity ratings used by van Elk and Blanke (2011). Van Elk and Blanke contradicted previous findings by Zwaan & Yaxley (2003) and Louwerse and Jeuniaux (2010) that demonstrated a congruity effect (i.e., direction of the body part presentation) and did not find a congruity effect for the body part ratings used in their study. However, van Elk and Blanke did find that the relative distance of the compared body parts did produce a significant effect. The larger the distance between the two body parts (*eye/foot* vs. *eye/mouth*), the more the error rates and RTs increased. This difference is in accord with the mental scanning hypothesis (Kossyln et al., 1978) where larger distances can take longer to scan rather than shorter distances. A logical next experiment to conduct should compare similarity judgments for these body parts across three languages (English, Dutch, and French). Perhaps replication of the English list, in addition to the other languages, will show a congruency effect as found in the studies by Zwaan and Yaxley and Louwerse and Jeunieaux. Van Elk and Blanke stated that perhaps their lack of congruency effect could have resulted from not knowing whether participants were using 1st or 3rd person perspective. The increasing improvement of technology and access to vast amounts of text will improve the future endeavors of finding the importance of linguistic patterns.

The conclusion is that language inherently contains body part information, such that experimental results can be approximated computationally. This is in line with previous research that has demonstrated that language encodes geographical information (Louwerse & Zwaan, 2009), and that it also encodes modality specific information (Louwerse & Connell, 2011), spatial information (Louwerse, 2008), and social relations (Hutchinson, Datla, & Louwerse, 2012). The study in this chapter adds to existing findings and suggests that cognition is indeed both embodied and symbolic.

Chapter 5

Grammatical Words and Cognition

This Chapter is based on:

Tillman, R., Hutchinson, S., & Louwerse, M. M. (2015). How sharp is Occam's razor? Language statistics in cognitive processing. *Proceedings of the 34th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

As previously discussed, a large body of literature has accumulated that argues that language processing is fundamentally embodied (Barsalou, 1999; 2008; Glenberg, 1997; Semin & Smith, 2008). That is, words only gain meaning through their referents to objects or persons in the outside world or in the perceptual experiences of the comprehender. Consequently, when understanding a word, comprehenders are actually mentally reenacting all prior physical and perceptual experiences with the referent (Barsalou, 1999; Barsalou, Santos, Simmons, & Wilson, 2008; Glenberg, 1997). Experimental evidence supports this embodied cognition account with words being processed faster when relationships to their real world locations, features, and attributes are emphasized. For example, sentences describing objects are processed faster when a primed image of the word matches the orientation described in the sentence (Stanfield & Zwaan, 2001). Similarly, facilitative processing effects were found when words were presented when words presented in a vertical configuration matched their expected locations (e.g., *attic* above *basement*; Zwaan & Yaxley, 2003). Similarly, when words referring to flying animals were presented at the top of the screen, they were processed faster than when they were presented at the bottom of the screen (Pecher, van Dantzig, Boot, Zanolie, & Huber, 2010; Šetić & Domijan, 2007). The same pattern holds true for up/down metaphors (Meier & Robinson, 2001; Schubert, 2005). Neurological evidence also shows support for such an embodied cognition account, with participants activating the same neural mechanisms for language processing that are active when actually experiencing or performing the sentence described (Hauk, Johnsrude, & Pulvermüller, 2004; Tettamanti et al., 2004). Findings like these have led many to emphasize the necessity of embodied cognition during language processing. Indeed, sensorimotor activation has been found to contribute to language processing in a number of studies (Rizzolatti & Craighero, 2004). Strong accounts like these suggest that language processing *is* mental simulation of sensory and motor systems.

The embodied cognition account is a response to what has been described as a symbolic account that dominated the cognitive sciences in the 1970s and 1980s. Symbolic accounts suggest that meaning is derived from abstract relationships that words share with other words (Fodor, 1975) which can be found using statistical linguistic frequencies. In essence, within this framework language processing is not strictly embodied in nature and does not necessarily share a direct relation to biomechanical states. Instead, meaning can also be derived from a linguistic context where the co-occurrence frequencies of words contribute to language meaning. These linguistic connections are (also) relied upon during language processing.

More recently, the argument has been made that rather than pitching cognitive processes as either embodied *or* symbolic, cognitive processes are likely to be symbolic *and* embodied. For instance, the Symbol Interdependency Hypothesis proposed that language processing can be explained by both symbolic and embodied mechanisms, because language encodes perceptual information (Louwerse, 2007; 2008; 2010; Louwerse & Jeuniaux, 2010). When we encounter a word, we create good-enough representations using language statistics and perceptually simulate its physical and somatosensory features depending on the time course of processing, the cognitive task, the nature of the stimuli and individual differences (Louwerse & Connell, 2011; Louwerse & Hutchinson, 2012; Louwerse & Jeuniaux, 2010). For instance, Louwerse and Jeuniaux (2010) asked participants to process concept pairs such as *monitor* - *keyboard* placed in a vertical configuration, one above the other. An embodied cognition account would argue that these concept pairs are processed by perceptually simulating that monitors are placed higher than keyboards. However, linguistic frequencies also show word pairs *monitor* - *keyboard* to be more frequent than *keyboard* - *monitor*, which suggests that language encodes perceptual information (Louwerse, 2008). Louwerse and Jeuniaux (2010) found that subjects rely on linguistic versus perceptual information depending on cognitive task and stimulus. When a concept was presented as a word, linguistic frequencies better explained response times, but when concepts were presented as pictures, perceptual information was the better explanation. Similarly, when participants performed a semantic judgment task linguistic frequencies best explained response times, but when participants performed a perceptual simulation task, perceptual information better explained response times than linguistic frequencies did. Louwerse and Connell (2010) extended these findings to demonstrate that linguistic information is relatively more important during early processing whereas perceptual information becomes relatively more important later. In other words, we rely on linguistic information when quickly processing language but perceptual information is used during more deliberate language processing (Louwerse & Hutchinson, 2012).

However, given that language encodes perceptual information, and given the evidence that language processing seems to rely on both language statistics and perceptual simulation, the question needs to be raised how a language statistics account relates to a perceptual simulation account. The dominant view suggests that language might encode perceptual simulation, but there is no role for language statistics in cognitive processing. Perceptual simulation is quick (Hauk, Shtyrov, & Pulvermüller, 2008) and complete (Glenberg, 1997) leaving little to no room for processing effects that could be attributed to language statistics. In this scenario statistical linguistic information does not play a role during processing (Van Dantzig, Pecher, Zeelenberg, & Barsalou, 2008).

Despite studies demonstrating evidence for a language statistics account complementary to a perceptual simulation account (Louwerse, 2008; Louwerse &

Jeuniaux, 2010), this option cannot be ruled out, because the evidence for language statistics is also evidence for perceptual simulation (but see Louwerse, Hutchinson, Tillman, & Recchia, 2014). To solve this problem it is necessary to examine word combinations that are easy to explain according to a language statistics account, but are difficult to explain using an embodied cognition account. For instance, *eagle* can be perceptually simulated (e.g., a creature flying in the sky), but for abstract words such as *anything* such perceptual simulation is considerably harder, if not impossible.

Such abstract words provide the litmus test on whether a language statistics account should at least be considered in cognition experiments. If processing of abstract words, such as grammatical items, can be explained by a language statistics account, but not by a perceptual simulation account, but processing of concrete words, such as lexical items, can be explained by both a language statistics account as well as a perceptual simulation account, Occam's razor would dictate that embodied cognition experiments should at least include language statistics as a covariate. An experiment was conducted that included stimuli that are fundamentally non-perceptual, namely grammatical items, such as *the*, *a*, and *ought*. If language indeed encodes perceptual information, and effects for statistical linguistic frequencies (Louwerse, 2008; Louwerse & Connell, 2011; Louwerse & Jeuniaux, 2010) cannot simply be attributed to perceptual simulation, then grammatical items should be able to be explained through linguistic frequencies despite their lack of perceptual information. On the other hand, if language instead must always refer to perceptual experiences to gain meaning, then linguistic frequencies should be unable to explain RTs to grammatical items because such items lack perceptual referents.

It was predicted that processing times for perceptual lexical words would be explained by language statistics, and that the same would be true for non-perceptual grammatical items, following the principle of parsimony.

Methods

In a response time (RT) experiment participants were presented with pairs of grammatical words (*several* – *both*) and pairs of lexical words (*blouse* – *socks*). Items were vertically presented following Zwaan and Yaxley (2003).

Participants

One hundred and one undergraduate native English speakers at the University of Memphis participated for extra credit in a Psychology course.

Materials

The experiment consisted of 20 pairs of grammatical words (see Appendix B). Grammatical words were matched on syntactic category (i.e., auxiliary, conjunction, determiner, preposition, pronoun, and quantifier). Because grammatical items of different categories tend to occur in particular sequences (Finch and Chater, 1992), this was to avoid a grammatical effect (e.g., *of the* vs. *the of*). Same part-of-speech word pairs with the greatest difference in frequency of a-b versus b-a orders were selected for inclusion in the experiment. The more frequent order of the grammatical items (i.e., *a-b*) was represented as similar to the iconic relationship of the lexical items. See Appendix B.

To verify these grammatical items were not experienced through perceptual simulation, but rather through linguistic experience perceptual ratings were obtained for each word, by using imagability, concreteness, and meaningfulness scores. The MRC Psycholinguistic database (Coltheart, 1981) provides information on different linguistic properties of words, including properties like imagability, concreteness, and meaningfulness on a scale of 100-700 for each property (Gilhooly & Logie, 1980; Paivio, Yuille, & Madigan, 1968; Toglia & Battig, 1978). Grammatical items included in this experiment scored low on imagability ratings, $M = 272.21$ $SD = 67.53$, concreteness ratings, $M = 288.43$, $SD = 69.36$, and meaningfulness ratings, $M = 339.12$, $SD = 88.51$.

An additional 60 lexical items were included in order to reduce the likelihood of participants' developing expectations about the experiment and to demonstrate the applicability of perceptual simulation during language processing. Lexical items consisted of 40 semantically related and 20 semantically unrelated word pairs extracted from previous research (Louwerse, 2008; Louwerse & Jeuniaux, 2010; Zwaan & Yaxley, 2003). As the task was to determine semantic relatedness, lexical words included pairs with high (cos = .55) versus low (cos = .21) semantic association as determined by Latent Semantic Analysis (Landauer, McNamara, Dennis, & Kintsch, 2007). In addition to semantically related pairs, half of those pairs also shared an iconic relationship whereby pairs were presented vertically on the screen in the same order they would appear in the world (i.e., *sky* appears above *ground*). Likewise, the other half of pairs appeared with a reverse-iconic relationship in an order opposite of that which would be expected in the world (i.e., *ground* appears above *sky*). These lexical pairs were included in order to replicate embodiment effects of prior research (Louwerse, 2008; Louwerse & Jeuniaux, 2010; Zwaan & Yaxley, 2003), as meaningful lexical items share a perceptual relation. All items were counterbalanced such that all participants saw all word pairs, but no participant saw the same word pair in both orders.

Procedure

Subjects were presented with grammatical items in the same manner that Zwaan & Yaxley (2003) presented subjects with meaningful stimuli. Participants were asked to judge the semantic relatedness of word pairs presented on an

800x600 computer screen. Words were presented one above another in a vertical configuration.

Upon presentation of a word pair, participants were asked to indicate whether the word pair was related in meaning by pressing designated and counterbalanced *yes* or *no* keys. Subjects were not instructed as to whether grammatical item pairs should be considered semantically related. All word pairs were randomly ordered for each participant to negate any order effects and each trial was separated by a '+' fixation symbol.

Results

Twenty-two participants were removed from the analysis because >30% of their answers were 'incorrect', as it is difficult to justify why grammatical items should or should not be judged as semantically related. After all, grammatical items in this experiment were low on concreteness, imagability, and meaningfulness, but at the same time were potentially statistically, conceptually, or even grammatically related. All remaining responses to grammatical items were judged to be correct responses.

All error trials for lexical items were removed. Outliers were identified as those correct responses greater than 2.5 standard deviations from the mean per subject per item. Outlier removal resulted in a loss of 3.12% of the data. Mean RT or lexical items was 1,922ms (*SD* = 1,186) and the mean RT for grammatical items was 1,873ms (*SD* = 1,147).

As in previous studies (Louwerse, 2008; 2011), the bigram linguistic frequencies were operationalized as the log frequency of a-b (e.g., *a-the*) or b-a (e.g., *the-a*) order of word pairs. The order frequency of all word pairs within 3-5 word grams was obtained using the large Web 1T 5-gram corpus (Brants & Franz, 2006).

Lexical Items

In order to determine initially whether participants performed the task as expected, the first analysis was the effect of semantic relatedness as measured by LSA. Indeed, semantically related lexical items were processed faster when they were related than when they were unrelated, $F(1, 5351) = 6.65$, $p < .01$.

However, the primary objective with using lexical items was to demonstrate that iconic presentation of lexical pairs would be processed faster than those presented in a reverse iconic orientation. Such findings would lend support to an embodied cognition account. To check for an iconicity effect (Louwerse, 2008), a mixed models analysis was conducted on those filler pairs sharing an iconic relationship. Orientation (either iconic orientation or reverse iconic orientation) and statistical linguistic frequencies were again operationalized as fixed factors and participants and items as random factors (Baayen, Davidson, & Bates, 2008). The model was fitted using the restricted maximum likelihood estimation (REML) for the continuous variable (RT). F-test denominator degrees of freedom were estimated using the Kenward-Roger's degrees of freedom adjustment to reduce the chances of Type I error (Littell, Stroup, & Freund, 2002). Orientation was marginally significant, $F(1, 705) = 3.40$, $p = .06$, with those pairs in an iconic orientation being processed faster than those pairs in a reverse iconic orientation. These findings suggest that an embodied cognition account could explain response times such that when items are in an expected iconic orientation, they are processed faster than when they are in an unexpected iconic orientation. These findings for lexical items indicate that subjects rely on perceptual information when processing these words.

Importantly, statistical linguistic frequencies also explained RTs to lexical items, $F(1, 795) = 5.63$, $p = .02$, with higher frequencies yielding lower RTs. These findings replicate previous embodied cognition research (Louwerse, 2008; Louwerse & Jeuniaux, 2010), indicating that subjects are relying on both perceptual and linguistic information during language processing. No interactions were found. See Figure 5.1.

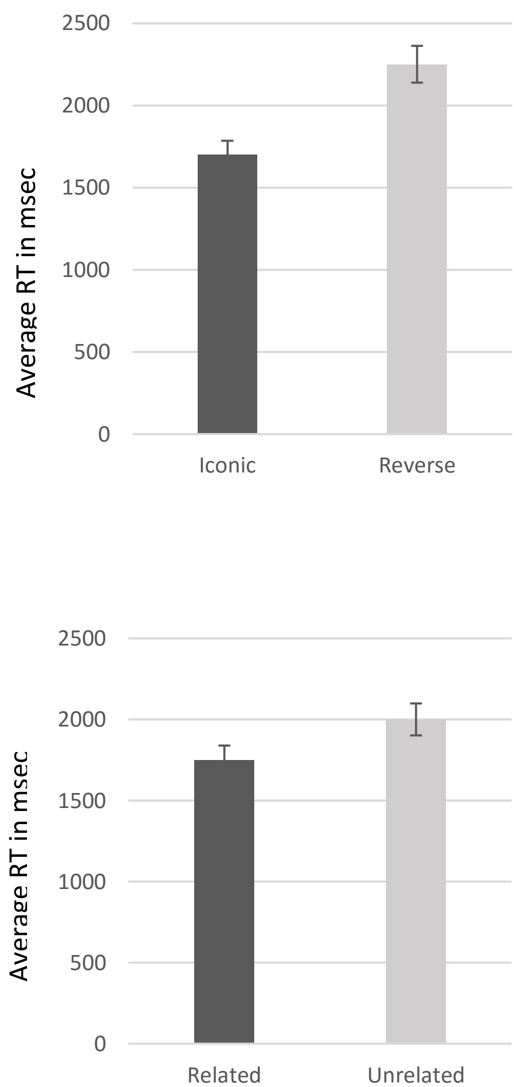

Figure 5.1. Average RTs for iconic and reverse-iconic positions, and related and unrelated pairs.

Differences in RTs due to iconic and reverse-iconic word pairs can be accounted for by language in that, in the Web 1T 5-gram corpus (Brants & Franz, 2006), iconic word pairs are more frequent than reverse iconic word pairs (Louwerse, 2008). These findings indicate that these iconic (and reverse-iconic) relations are indeed encoded in language, such that iconic relations are more frequent, and easier to process.

Grammatical Items

The language statistics findings for the lexical items, however, might in fact have to be attributed to perceptual simulation, because language encodes perceptual information. The question is whether a statistical linguistic frequency effect can be found for word pairs that cannot be perceptually simulated.

In order to isolate and examine the effects of very frequent co-occurrences, a mixed-effect regression analysis was conducted on RTs to grammatical items with the bigram frequency as a fixed factor and participants and items as random factors (Baayen et al., 2008). For these non-perceptual grammatical words, the statistical linguistic frequencies again explained RTs, $F(1, 1528) = 5.69$, $p = .02$, with ordered pairs with higher frequencies yielding lower RTs. In other words, the frequency of two grammatical words in a given (frequent) order was processed faster than the same two words in the reverse order. These findings demonstrate that statistical linguistic frequencies can account for RTs that cannot be explained by embodied perceptual account alone. See Figure 5.3.

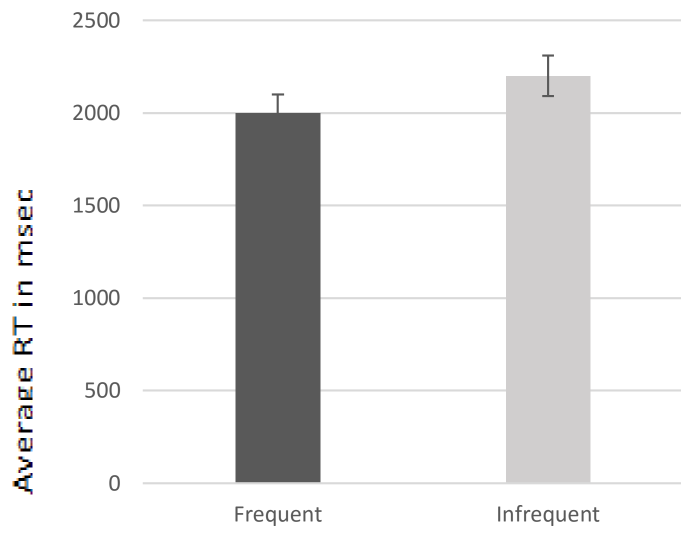

Figure 5.3. Average RTs for frequent and infrequent co-occurrences.

Discussion

In this chapter, the objective was to address the claim that because language encodes perceptual simulation, evidence for language statistics might actually just be evidence for perceptual simulation. In one experiment, participants were asked to make semantic judgments about word pairs presented vertically on a screen. Both perceptual word pairs (*sky* – *ground*) and non-perceptual (*a* – *the*) grammatical word pairs were included. By including items that are devoid of perceptual information (grammatical words) it was possible to determine that, in fact, language statistics are not simply further evidence supporting perceptual information, as language statistics explain RTs to grammatical word pairs alone, just as these same language statistics explain RTs to iconic and reverse iconic word pairs that are grounded in the perceptual context around them. Results showed the pattern of an iconicity effect (i.e., iconic items were processed faster than reverse-iconic items). Statistical linguistic frequencies explained RTs as well, with higher frequencies yielding lower RTs. Importantly, the same effect was obtained for those words pairs for which a perceptual explanation does not exist: grammatical words.

The findings of the current experiment support the Symbol Interdependency Hypothesis which states that language encodes perceptual information, such as their usual orientation or position, and that statistical linguistic frequencies explain language processing. In other words, linguistic information, such as statistical frequency, does not only refer back to those relevant encoded perceptual experiences, but in some cases is the driving factor in and of itself for how we encode language. Grammatical items provide evidence for linguistic processing that is distinct and distinguishable from perceptual simulation. At the same time, as meaningful stimuli are explained by both perceptual and linguistic factors, it seems likely that language statistics cannot account for these findings alone either. Rather, to explain language processing, both language statistics and perceptual simulation work together.

Chapter 6

Linguistic Relativity I: Grammatical Gender

This chapter is based on:

Tillman R., & Louwerse, M. M., (under review). Gender Equality in German and Spanish: Language Statistics Demonstrate Linguistic Relativism.

Evidence for the impact of language on cognition has been presented in the previous chapters. However, many of these studies have been in English. The logical question, therefore, is whether this is also true for other languages. The current chapter will explore the effects of grammatical gender within the framework of linguistic relativity (Whorf, 1956; Boroditsky, Fuhrman, & McCormick, 2010).

Regarding linguistic relativity, Pinker (1994) states, "But it is wrong, all wrong" (p. 57). Pinker's view on linguistic relativity, the theory that language structure affects the way humans conceptualize the world, summarizes decades of skepticism in linguistic and cognitive sciences. In the late 1930s Whorf (1956) proposed what now is known as the Sapir-Whorf hypothesis or the hypothesis of linguistic relativity. The strong version of this hypothesis states that a person's native language *determines* thought. A weaker version of the principle states that the use of linguistic categories influences thought and certain kinds of non-linguistic behavior (Davies & Corbett, 1997). For example, Whorf (1956) described the differences of the depiction of mass nouns between "Standard Average European" [language speakers] (SAE) and Hopi speakers. In English mass nouns such as *water, butter,* or *sand* do not usually use articles (e.g., *a*, *the*) and often need a qualifier (e.g., *a glass of water, a stick of butter, a grain of sand*) in order to show individuation (although Whorf uses an overgeneralization of unindividuated entities, see Wisniewski, Clancy, and Tillman, 2005, for a more precise categorization of multiple entities). According to Whorf, Hopi speakers do not have a distinctive grammatical category for mass nouns and do not need the qualifier (e.g., *a water*, *a butter*, *a sand*).

Linguistic relativity has been largely ignored in the cognitive sciences over the last few decades, but has recently received a new impetus. For instance, differences between languages and the conceptualizations in their native speakers have been found for spatial conceptualization of time (Boroditsky, Fuhrman, & McCormick, 2010), with Mandarin speakers referring to time more vertically, compared with English speakers who refer to time more horizontally. Object naming for Italian-English bilinguals has provided further support for linguistic relativity with bilingual participants Kousta, Vinson, & Vigliocco (2008). Kousta et al. (2008) demonstrated that speakers relied on the structure of the language at hand, rather than being solely limited to the structure of their first language. They found that when participants were asked to name animals in Italian, a language with grammatical gender, semantic substitution errors (e.g., *eye* when *ear* is intended) increased compared to naming animals in English, a language with no (obvious) grammatical gender system. Further effects of the impact of grammatical gender have also been shown across two languages that both have grammatical gender (Vigliocco, Vinson, Paganelli, & Dworzynski, 2005). Vigliocco et al.

examined two language groups: German (a language with three grammatical gender categories), and Italian (a language with two grammatical gender categories) and found that grammatical gender of animals more influenced object naming of animals rather than artifacts. They postulated that the mechanisms behind this phenomenon are due to the fact that children bootstrap meanings of words from those with similar properties (e.g., phonological, syntactic, etc.). In the case of grammatical gender, especially words that depict animate objects, meaning can be connected to grammatical properties that then affect how we view those objects (Boroditsky & Schmidt, 2000). Because grammatical gender of nouns is considered largely an arbitrary phenomenon (Corbett, 1991), this is a research area that is a good domain for research regarding linguistic relativity, because of its impact on semantic gender differences (Ibrahim, 1973).

Grammatical gender categories are present in numerous languages, with some languages distinguishing between masculine and feminine (e.g., Spanish,) and others distinguishing between masculine, feminine, and neuter (e.g., German). The origin of these gender categories is not clear. On the one hand, one could argue grammatical gender is determined by semantic differences (*woman* is feminine in both Spanish and German), but gender is not unequivocally determined by meaning; a Spanish *apple* being feminine (*la manzana*), but a German *apple* being masculine (*der Apfel*). Similarly, the Spanish *sun* is masculine (*el sol*), but the German *sun* is feminine (*die Sonne*). Given that grammatical gender across languages seems at least to some extent arbitrary, speakers of different languages with opposing grammatical genders for nouns might view adjectives differently.

Several studies have indeed shown a facilitative cognitive effect when grammatical gender is congruent to person gender in a given situation (Italian: Belacchi, & Cubelli, 2012; German: Bendera, Bellera, & Klauera, 2011). For instance, Ramos and Roberson (2011) found that speakers of Portuguese were more likely to assign a male or female voice to a noun that corresponded to its grammatical gender. Sera, et al. (2002) compared speakers of French, German, Spanish, and English for their assignment of male or female voices to inanimate objects, and found that speakers of French, German and Spanish were systematically affected by grammatical gender. In a similar vein, Boroditsky and Schmidt (2000) examined the effects of grammatical gender on cognition for German and Spanish speakers who also spoke English. Participants learned pairs of 24 objects paired with male or female proper names, whereby the grammatical gender of the objects were opposite in Spanish and German (e.g., masculine *el sol* vs. feminine *die Sonne*). While the entire experiment was conducted in English, native speakers of the individual languages with grammatical gender nevertheless had higher memory scores for objects that were presented with the gender that corresponds to their grammatical gender, as opposed to those that were not.

Vigliocco, Vinson, Paganelli, and Dworzynski (2005) proposed two hypotheses on the impact of grammatical gender on cognitive processing, the sex-and-gender hypothesis and the similarity-and-gender hypothesis. The sex-and-gender hypothesis predicts that there is an association of grammatical gender of a noun and the male-like or female-like qualities of that noun. The grounding of referents could explain words that have an intrinsic gender (e.g., *waiter* or *waitress*). However, gender-neutral words such as *apple* and *sun* are not easily explained by the sex-and-gender hypothesis. The similarity-and-gender hypothesis, on the other hand, predicts that associations between grammatical gender and person gender are derived from co-occurrences in similar linguistic contexts. This hypothesis predicts that the presence and strength of the effect of grammatical gender on cognition (e.g., in a memory task) will differ across languages as well as the categories within a given language (e.g., an animal or an artifact).

In previous work, it was demonstrated that language statistics explain conceptual processing (Louwerse, Hutchinson, Tillman, & Recchia, 2015). This was framed in what is called the Symbol Interdependency Hypothesis, which states that language users rely on statistical linguistic shortcuts when assigning meaning to language. Importantly, in the current study participants were not asked to respond to Spanish or German masculine and feminine words (cf. Boroditsky and Schmidt, 2000; Boroditsky, Fuhrman, & McCormick, 2010). Instead, the language system at large was investigated by conducting a corpus linguistic study, examining those object nouns and their grammatical gender used in previous research (Boroditsky and Schmidt, 2000; Konishi, 1993) as well as the co-occurrences of these nouns with adjectives that had a predominantly masculine and feminine meaning. Following the similarity-and-gender hypothesis, it was predicted that *der Berg* (transl. *mountain*; $masc_{gram.}$ in German) co-occurs with an adjective such as *konkurrenzfähig* (transl. *competitive*; $masc_{sem}$ adjective) in German more frequently than with *schön* (transl. *pretty*; fem_{sem} adjective) in German, whereas *la manzana* (transl. *apple*; $fem_{gram.}$ in Spanish) is predicted to co-occur more frequently with *hermoso(a)* (transl. *beautiful*; fem_{sem} adjective) in Spanish than with *fuerte* (transl. *strong*; $masc_{sem}$ adjective) in Spanish.

Given that we do not have a straightforward explanation why the meaning of *apple* is more feminine in German than in Spanish (and vice versa for *sun*), the similarity-and-gender hypothesis (Vigliocco et al., 2005) was tested. The nouns between the two languages are the same except for their grammatical gender, so their co-occurrences with specific adjectives can be explained by linguistic relativity.

Corpus Linguistic Study

Nouns for English and Spanish were counterbalanced so that $feminine_{gramm}$ nouns in Spanish were matched with $masculine_{gramm}$ nouns in German and vice versa in order to avoid co-occurrences to be driven by the semantics rather than the grammatical gender of the noun (e.g., *father, mother, woman*, etc.). Nouns (*N* = 67) were taken from Boroditsky and Schmidt (2000) and Konishi (1993) (see Appendix C). Adjectives that differed in more masculine and feminine meaning were selected using Crawford, Leynes, Mayhorn, and Bink's (2004) human ratings of gender stereotypicality of 600 words. Words in Crawford et al. were judged on a 5-point Likert scale from 1 (*definitely feminine*) to 5 (*definitely masculine*), including in a three tiered classification of feminine (means ranging from 1-2.49), neuter (2.5-3.49), and masculine (3.5-5) adjectives. Only those adjectives with the highest masculine (*N* = 33) and feminine (*N* = 38) ratings (see Appendix C) were selected, and both nouns and adjectives were translated into Spanish and German and verified with a native speaker.

The co-occurrence frequencies of the adjective and noun pairs in German and Spanish were computed using the Web 1T 5-gram, 10 European Languages corpus (Brants & Franz, 2009). This corpus covers 1-5 grams and their frequency counts for ten European languages, including German and Spanish, totaling 1,306,807,412,486 word tokens from 150,727,365,731 sentences.

Because of grammatical agreement, adjective endings in both Spanish and German can differ due to gender of the noun they modify. For instance, in Spanish *un mundo hermoso* (transl. *a beautiful world*; masculine$_{\text{gram}}$) vs. *una silla hermosa* (transl. *a beautiful chair*; $\text{feminine}_{\text{gram}}$). Similarly, in German, adjectives can take different forms based on their case: *Ich spiele Fußball mit dem großen Ball* (transl. *I play soccer with the big ball;* dative) vs. *Der Fußball ist groß* (transl. *The soccer ball is big;* nominative). To address the morphological inflections, we took all possible suffixes for both languages into account. For example, for the German *schön* (transl. *pretty, nice*), all grammatical forms related to the lemma were included: *schön, schöne, schönen, schöner, schönes,* and *schönem*.

Results

The 46512 adjective-noun combinations in German and the 38649 adjective-noun combinations in Spanish yielded 95% null frequencies, which can be explained by the grammatical gender combinations (e.g., *großem Blume* is ungrammatical and therefore yields null frequencies). Therefore, we aggregated the noun-adjective combinations for each lemma type of adjective (e.g., *agresivo, agresiva, agresivos, agresivas*), and noun (e.g., *mundo, mundos*). The aggregated scores were then subjected to a chi-squared test for independence.

Spanish

For Spanish token bigrams, the percentage of the feminine gender nouns significantly differed by gender adjective, $\chi^2(1) = 37.94$, $p < .01$, however they were in the opposite direction as was hypothesized with more feminine nouns paired with masculine adjectives. The percentage of the masculine gender nouns also significantly differed by gender adjective in the expected direction, $\chi^2(1) = 44.03$, $p < .01$. For Spanish type bigrams, the percentage of the feminine gender nouns again significantly differed by gender adjective, $\chi^2(1) = 5.44$, $p < .01$, and again they were in the opposite direction as expected. The percentage of the masculine gender nouns also significantly differed by gender adjective in the expected direction, $\chi^2(1) = 6.64$, $p < .01$. See Table 1.

Table 1. Aggregated Spanish tokens and types for feminine and masculine nouns and adjectives.

	Token		Type	
	$Fem_{gram.}$ Nouns	$Masc_{gram.}$ Nouns	$Fem_{gram.}$ Nouns	$Mas_{gram.}$ Nouns
Fem_{sem} Adj.	1165.86	1018.2	221	190
$Masc_{sem}$ Adj.	1626.14	1487.99	296	268

German

For German token bigrams, the percentage of the feminine gender nouns significantly differed by gender adjective, $\chi^2(1) = 17.31$, $p < .01$, similar to the Spanish token nouns, they were in the opposite direction as expected with more feminine nouns paired with masculine adjectives. The percentage of the masculine gender nouns also significantly differed by gender adjective in the expected direction, $\chi^2(1) = 81.16$, $p < .01$. For German type bigrams, the percentage of the feminine gender nouns significantly differed by gender adjective, $\chi^2(1) = 2.87$, $p < .01$, and again they were in the opposite direction as expected. The percentage of the masculine gender nouns also significantly differed by gender adjective in the expected direction, $\chi^2(1) = 13.28$, $p < .01$. See Table 2.

Table 2. Aggregated German tokens and types for feminine and masculine nouns and adjectives.

	Token		Type	
	$\text{Fem}_{\text{gram.}}$ Nouns	$\text{Masc}_{\text{gram.}}$ Nouns	$\text{Fem}_{\text{gram.}}$ Nouns	$\text{Mas}_{\text{gram.}}$ Nouns
Fem_{sem} Adj.	548.15	657.36	107	135
Masc_{sem} Adj.	761.04	1207.56	145	234

Even though most adjectives can be used with most nouns, and certainly with nouns whose meanings are the same across languages but whose grammatical genders differ, we can expect considerable noise in the data. It is therefore noteworthy that the current findings show the expected patterns for masculine nouns and adjectives according to the linguistic relativity hypothesis, namely that these matching pairs were more frequent when the meaning of gender of the adjectives matched the grammatical gender of the nouns than when there was a mismatch.

Moreover, these results support the similarity-and-gender hypothesis from Vigliocco et al. (2005), that associations between grammatical gender and person gender are derived from similar linguistic contexts as well as the linguistic relativity hypothesis showing that grammatical gender in nouns affects meaning gender in adjectives.

Discussion

The study in this chapter investigated whether previous linguistic relativity experimental findings can be replicated using corpus linguistic methods. Using Spanish and German translations of the nouns from two existing experimental studies, we tested the frequency of types and tokens of grammatically gendered nouns and adjectives that were rated for gender. Masculine adjectives whose gender matched the grammatical gender of the noun yielded higher frequencies than mismatching combinations, in German and Spanish. While significant, the opposite configuration was the case for grammatically feminine nouns and adjectives. The consistency for both types and tokens of masculine nouns accompanying the matched gender for the adjectives in both German and Spanish does show that corpus linguistics can at least in a significant way demonstrate similar context occurring more often when examining grammatical nouns and rated adjectives. The reason for the matching to not occur in every instance could be related to the words used. In Boroditsky and Schmidt (2000) and Konishi (1993), participants were able to view all items and respond accordingly. However, the nature of corpus linguistics includes many null frequencies, which could diminish the effect of linguistic relativity. Specifically, masculine nouns outnumbered feminine nouns in German, and the opposite occurred for the Spanish nouns. We attempted to compensate for this effect by using the expected means in the chi-squared analysis, and for this set of words the results were consistent. For future research, expanding the word lists and using a variety of languages is highly recommended.

According to the original linguistic relativity hypothesis, grammatical properties of the language influences habitual patterns of thoughts of the speaker. Experimental findings supporting linguistic relativity might leave the question open whether language users rely on culture or language. It is unlikely that these effects are due to culture, as it can be assumed that the German and Spanish culture are relatively similar. However, to rule this out, evidence for linguistic relativity hypothesis should come from language itself.

One of the benefits of using corpus-based linguistics is that it can better reflect actual text usage, compared to findings within a constructed experiment that can be removed from how people actually use words. The patterns found in this study can illuminate the categorization of adjectives associated with grammatical gender for Spanish and German. In combination with previous findings that show grammatical gender can have an effect on categorization, the present findings show that the link between grammatical gender and gender-like qualities extend to general language usage outside the laboratory.

Now that we have demonstrated a consistent effect, this leads to the question as to what is the nature of a facilitation effect for grammatical gender. One important function of grammatical gender is classification. Sera et al. (2002) reported that language can affect classification of objects in terms of concepts that they link to males and females. This brings the focus back to the use of corpus linguistics and the effects of statistical linguistic frequencies. If people come in contact with many instances of feminine words associating with actual females, and in turn also see numerous instances of those words with neutral, but grammatically female nouns, the connections will be made due to the statistical regularities of this pattern within language. This actually bridges the two opposing hypotheses put forth by Vigliocco, Vinson, Paganelli, and Dworzynski (2005), the sex-and-gender hypothesis where the concepts of gender are grounded, and the similarity-and-gender hypothesis where the associations between grammatical gender and person gender are established due to linguistic contexts. In other words, the effects of grammatical gender stems from both the grounding of gender-like qualities with those associated with actual gender, as well as similar linguistic contexts.

The findings reported here extend our previous work that found that frequencies of concepts of a matching spatial configurations (e.g., *attic – basement*) yielded higher frequencies mismatching configurations. The current paper demonstrates that language statistical results are not limited to lexical items, but extend to grammatical items. Whereas other have demonstrated that language users are more likely to generate masculine or feminine adjectives matching the grammatical gender of the noun, we have shown here that these patterns are encoded in language.

Chapter 7

Linguistic Relativity II: Attribution of Responsibility

This chapter is based on:

Tillman, R., Langston, W., & Louwerse, M. (2013). Attribution of responsibility by Spanish and English speakers: How native language affects our social judgments. *Revista Signos*, *46*(83), 408-422.

When an official states *a mistake was made,* his or her responsibility for the error seems limited. However, when *an official made a mistake,* he or she will likely be held fully accountable for the error. Subtle differences in the linguistic structure of the sentence could have important ramifications on the psychological consequences of the sentence. Perhaps it is therefore no surprise that U.S. presidents commonly state that *mistakes were made* rather than use the agentive wording that *we made a mistake*. Presidents Reagan, H. W. Bush, Clinton, G. W. Bush, and Obama have used this non-agentive phrase in at least one of their speeches to perhaps shift responsibility away from themselves or their administrations (Peters, 2010). Chapter 7 will demonstrate that the grammatical structure of a person's native language can impact how they interpret attribution of responsibility. This will be accomplished by comparing English, a language that has more active voice constructions for assigning responsibility, and Spanish, a language that uses more passive voice constructions.

The idea that linguistic structures affect the way we interpret a sentence is not surprising when we consider the variation of linguistic expressions in a language. The effect can become more interesting when the structures of different languages might affect the interpretation of an utterance. This idea is reminiscent of the Sapir-Whorf hypothesis, or the principle of linguistic relativity, that states that the structure of language affects our cognitive conceptualization of the world around us (Carroll, 1956). Recently, evidence has been reported supporting this idea. Fuhrman and Boroditsky (2010), found that speakers of Hebrew or English more often perceived temporal events in the direction that was congruent with the writing direction used by the participant. In another study, Boroditsky (2001) provided evidence that native language has also been shown to affect thought by demonstrating that speakers of Mandarin can view time in a vertical or horizontal dimension while speakers of English more easily interpret time along a horizontal dimension. These types of differences have also been found comparing word ordering effects in Spanish and German (Popović & Ney, 2006), and contextual effects in German (Telljohann, Hinrichs, & Kübler, 2004).

Similarly, there are studies that have examined the effect language can have on how an agent is perceived. Wolff, Jeon, and Yu (2009) found that Korean does not allow for an object to be an agent (e.g., a *key* cannot *open a door* on its own power), while it is acceptable to say an object is the agent in Chinese and English (*a key opened the door*). This study illustrates that how a person perceives a causal agent can also be linked to how their language depicts causal agents. Wolff and Ventura (2009) found that Russian speakers are more inclined to use internally generated forces for causal verbs, whereas English speakers consider both internally and externally generated forces.

Burger (1981) found that it is the perceiver's specific role in a potential accident that determines the attribution of blame. These findings are also in accord with Shaver (1970). According to Burger, the differences found can be attributed to the similarity between the participant and the person in question (e.g., car owner) and the situation. This meta-analysis, at the least, has shown that different situations and motivations can impact how someone assigns responsibility. It is possible that the construction of a particular language can impact the attribution of responsibility due to how it depicts a situation.

Judgments of responsibility have shown to be affected by agentive wording (Fausey & Boroditsky, 2010). Fausey and Boroditsky used two descriptions of the televised "wardrobe malfunction" of the 2004 Superbowl half-time show during which Janet Jackson's breast was exposed during a dance with Justin Timberlake. The only difference between the two experimental conditions was that one used agentive language and the other did not. The agentive version stated *... he unfastened the snap and tore a part of the bodice. He slid the cover….* The non-agentive version stated *... a snap unfastened, and a part of the bodice tore. The cover slid…* After reading the account of the event, participants who read the agentive version were not only more likely to assign blame to Mr. Timberlake; they also assigned 53% more financial liability in the agentive condition compared to the non-agentive condition (i.e., Federal

Communications Commission violation fees). Therefore, wording alone can affect how someone perceives a potentially accidental act.

The current chapter investigates whether different languages affect how people attribute responsibility in Spanish and English. Much of the present design follows Walster (1966), who tested the amount of responsibility assigned according to severity of the outcome and whether a person other than the agent was affected. Walster used four recorded scenarios of an event in which a car was involved in an accident. The scenarios all began with the same information, but ended with different information. The outcomes were: (1) the car owner suffered no real damage; (2) the car hit a big tree at the bottom of a hill and was totaled; (3) someone else could have been affected, but there were no severe consequences; and (4) a child was slightly injured, and a man was severely injured. Walster found that if an outcome of an accidental event was more severe, the participants not only were more punitive in their assessment of the individual that owned the car, but also assigned more responsibility. The assignment of responsibility was also higher for when the event affected people other than the agent.

As with Walster (1966), the study presented in this chapter used a scenario describing an accident and made minor changes in each condition to examine whether there were differences found between those conditions. The participants read a brief scenario involving a family, a shopkeeper, and a vase that was broken and answered questions assessing the level of blame they assigned. Groups within each language group were further divided by the level of agentive wording used in the scenario. Spanish was chosen to compare with English, because of the difference of grammatical construction of accidental acts for the two languages. When an accident is described in Spanish, such as someone breaks a vase, the verb is conjugated in the third person and the literal translation would be something akin to “The vase broke on him.” Whereas when the act was purposeful, the verb is conjugated to match the agent and the translation would be the same as either case in English, “He broke the vase.” The difference between the study in this chapter and the study by Walster (1966) is that the agentive wording was manipulated, rather than the severity of the outcome. Following the linguistic relativity principle, it was hypothesized that the native language of a speaker would affect the attribution of blame, such that levels of responsibility would be assigned differently due to the participant’s native language, specifically when using non-agentive wording.

The agentive conditions were predicted to elicit higher overall ratings for guilt for the main character in the story (and lower for the shop owner) by both Spanish- and English-speakers, since he was referred to directly by name. However, it was also predicted that the non-agentive conditions would elicit higher guilt ratings for the main character by the Spanish-speakers than the English-speakers due to the grammatical construction of using non-agentive language when referring to an accidental act in Spanish.

EXPERIMENT

A rating experiment was conducted with native speakers of English and Spanish judging the attribution of blame based on an agentive and a non-agentive sentence following a story they read. The purpose of the study was to investigate whether native language or agentive wording would have more of an impact on attribution of responsibility using Spanish- and English-speaking participants.

Methods

Participants. Eighty-five participants (about half female) were recruited from the Nashville, TN, area in the United States. Participants ranged in age from young adults to elderly. Because of the specific language backgrounds of the speakers, traditional subject pools could not be used and churches were an ideal way of reaching two different language groups that were both similarly heterogeneous.

Materials. Following Walster (1966) and Fausey and Boroditsky (2010), a single scenario was used for each language group. The materials were translated into Spanish by the first author, and independently verified by three native Spanish-speakers. Participants read a printed copy in their native language of a short vignette about a small claims court case in which a shop owner claims that a man owes him $1000 for a broken vase. The four vignettes were identical except for the target sentence, which was changed according to the agentive condition (*Martin broke a vase; A vase was broken by Martin; A vase was broken; A vase broke*). The vignettes and questions can be found in Appendix D and Appendix E, respectively.

Procedure. Participants were asked to read a brief scenario and answer questions regarding different aspects of who was responsible and other factors that could impact their judgment. The questions that followed the vignettes were on a scale of 1 (Completely Disagree) to 7 (Completely Agree). Questions were also designed to have an attribution that was either internal (e.g., the main character in the scenario should have left his bags at the register) or external (e.g., the shop owner was responsible for the vase breaking). The questions where created such that all characters in the scenario could be held responsible for breaking the vase.

Native Spanish (n = 45) or native English speakers (n = 40) were randomly assigned to one of four conditions: 1) agentive: the main character in the scenario broke the vase; 2) somewhat agentive: the vase was broken by the main character in the scenario; 3) somewhat non-agentive: the vase was broken; 4) non-agentive: the vase broke. The experiments thus used a 2 (language) x 4 (agentive) mixed factorial design. There were approximately 10 participants per group. The two independent variables, language and agentive wording, were treated as between-subjects factors.

Results

The ratings of the 17 questions provide an overview of attribution of blame. In the analysis, the aim was to distinguish between internal (personal) and external (situational) attributions of blame (Wallace & Hinsz, 2009; Sosis, 1974). For example, a question that asked if the main character broke the vase would be considered an internal attribution for the main character, while the question that asked if the aisles were too close together would be an external attribution. In order to determine how participants viewed internal and external attributions of the current scenario, a multidimensional scaling

(MDS) was conducted using the ALSCAL algorithm (Kruskal & Wish, 1977) for the ratings of the English speakers and the Spanish speakers. The Euclidian distance between the ratings of the questions was then calculated per language group with a maximum of 30 iterations, and a stress convergence = .001. The fitting of the data for the English and Spanish speakers was good (Stress = .32, R^2 =.63 and Stress = .25, R^2 = .74, respectively). Figure 1a and 1b show the clustering of the questions for the English (1a) and the Spanish speakers (1b). As both figures show, the mapping of the questions between the two language groups is very similar with a bidimensional regression yielding a significant correlation, $r = .53$, $p < .03$, $n = 17$.

The two characters that best represented the internal and external attribution dimension (x-axis in the graph) were selected: the main character and the shopkeeper. In order to assess if there are differences of blame between English- and Spanish-speaking participants, as well as the four types of agentive wording, a two-way analysis of variance (ANOVA) was conducted to assess level of responsibility for the main character in the scenario presented where a vase was broken. With respect to how much participants held the main character in the scenario responsible, language (Spanish $M = 4.56$, $SD = 2.41$, or English $M = 4.74$, $SD = 1.39$) did not significantly affect blame, $F(1, 112) = 1.92$, $MSE = 3.72$, $p = .17$. Agentive wording across the four conditions (*M* = 4.64, *SD* = 1.99) also did not significantly affect the extent to which the main character in the scenario was blamed, $F(3, 112) = 0.72$, $MSE = 3.72$, $p = .54$. Finally, there was no interaction between language and agentive wording, $F(1, 112) = 0.32$, $MSE = 3.72$, $p = .81$. This suggests that neither language nor agentive wording had an effect on responsibility, when looking at only the central figure in the presented scenario. Perhaps this finding is not surprising as it seems reasonable that the central figure in the story, when referenced by name, would intuitively be assigned more responsibility, regardless of the language (cf. Fausey and Boroditsky, 2010).

More of interest to the relativity hypothesis is not the absolute attribution of blame (e.g., is the main character guilty), but the relative attribution of blame (e.g., is the main character more or less responsible than other characters). To address this question, the attribution of blame to the main character was compared with the attribution of blame to his opponent (the shop owner). Accidents are usually depicted in Spanish by using the non-agentive construction (e.g., lit. *The vase broke on him*). This construction is often called “no fault se” (Herschberger, Navey-Davis, & Borrás A., 2011; Lafford & Salaberry, 2003), where the Spanish word *se* is used to reflect that an accident occurred, by using the reflexive *se*. Therefore, there may be a difference between the two language groups when using agentive versus non-agentive wording. A two-way ANOVA was conducted comparing responsibility ratings for the main character in the scenario with those for the owner of the shop in the agentive and non-agentive conditions in English and Spanish. In both of these conditions, the responsibility ratings for the main character were significantly higher than the owner of the shop in the agentive condition in both Spanish and English and lower for the owner of the shop, $F(1,24) = 16.13$, $p < .001$ (Figure 1a).

However, when using non-agentive wording, there was a reversal for Spanish- and English-speakers indicating the responsibility assigned for the main character rose for Spanish-speakers in the non-agentive condition, $F(1,18) = 21.32$, $p < .001$ (Figure 1b). This suggests that the Spanish speaking participants rated responsibility for the main character higher because of an assumption that can arise from using the convention of non-agentive language when depicting an accident (Herschberger, Navey-Davis, Borrás A., 2011; Lafford & Salaberry, 2003). In Spanish, the culpability is implied, because one would not think that vases are capable of breaking themselves and the person is a mere bystander. In short, how accidents are depicted in Spanish affect how speakers of that language interpret blame.

Discussion

The focus of Chapter 7 was to determine whether a person's native language influenced how they assigned responsibility. Participants read a scenario in which an accident occurred for which responsibility could be attributed to different individuals. In two conditions of the experiment the scenario was the same, but one version was in English, the other in Spanish. In addition, four versions of the Spanish text and the English text were created, in which participants saw either an agentive version, or a non-agentive version. Findings demonstrated that there was no difference between the responsibility ratings for two individuals who could be blamed for the accident. However, the participants in the non-agentive condition showed a significant difference between Spanish- and English-speakers. Further analysis using multidimensional scaling also demonstrated a language difference for how participants grouped external and internal attributions. The current findings are in line with previous research that demonstrates a link between native language and perception of an event (e.g., Fausey and Boroditsky, 2010; Wolff, Jeon, & Yu (2009); Boroditsky, 2001). Fausey and Boroditsky demonstrated how agentive wording can affect not only who is responsible for an event, but also how much punitive damage should be assigned. This is an important finding in and of itself, but the exploration of how speakers of different languages are affected by agentive language is also important.

The main findings regarding the effect of language supported the hypotheses of language being the factor that will impact attribution of responsibility, but the results of analyses for the internal and external attributions were only marginally significant for agentive wording. There are a number of explanations for the lack of effect of language in this instance. First, the linguistic relativity principle predicts a subtle effect of language. Various studies have dismissed a strong version of the Sapir-Whorf hypothesis, but have defended a weaker version (Gentner & Goldin-Meadow, 2003), confirming subtle effects of language on thought. Secondly, off-line responses were recorded. That is, results might have been stronger with more fine-grained measures that would prevent the participant from making deliberate decisions after carefully weighing the options. Finally, and perhaps most importantly, the findings reported so far are based on the internal and external attributions that were predetermined. It is possible that with the addition of more scenarios and questions that can detect subtle effect sizes, this type of research could begin to reveal the nature of assignment of responsibility for speakers of different languages and agentive wording.

In conclusion, two interesting findings emerged from the data. First, Spanish and English speakers attributed responsibility differently, particularly when the participants saw non-agentive wording. This indicates that Spanish and English speakers react differently depending on wording used. Second, internal and external factors were used in the deliberation of who was ultimately responsible for the vase breaking; this was also dependent on the language group. The difference between internal and external factors begins to demonstrate that speakers of different languages can view responsibility in different ways.

Chapter 8

Conclusions & Future Research

The current debate within cognitive science as to how we extract meaning from language has explored many domains. The aim of this dissertation was to investigate whether an account that focuses on language and language use can affect cognition should be considered in addition to accounts that focus on grounding in perceptual experiences. Through corpus linguistics and psychological experiments, the effects of language statistics and grammatical constructions were explored in the domains of emotion, grammatical gender, attribution of responsibility, spatial orientation, and grammatical words.

Chapter Summaries and Answers to the Research Questions

In Chapter 1, following a review of a symbolic approach to cognition, an embodied approach to cognition and a merging of the two complementary approaches, five research questions were proposed in order to investigate whether that language usage can affect cognition in ways that are related to statistical regularities in language. These questions were answered in six chapters.

RQ1: Does the influence of language occur even when a perceptual task is used?

In Chapter 2, a shift vs. no-shift in emotions was first explored using computational linguistic analysis and the large English language Google Corpus (Brans & Franz, 2006). Using 252 emotion words (Shaver, Schwartz, Kirson, &

O'Connor, 1987), it was found that similar emotions such as *adorable* and *cheerful* significantly occurred more often than non-similar emotions such as *adorable* and *disappointing*. This pattern held for pairs of adjective-adjective, noun-noun, and adjective-noun. This shift effect was then tested using human participants comparing effects of perceptual factors (Euclidean distance) supported by embodied cognition, and language statistics factors (the log frequency of word pairs). The language statistic factor significantly predicted reaction times (RTs) for both nouns, adjectives, and a combination of nouns and adjectives, while the perceptual factor did not. This indicates that people do rely on language usage (i.e., linguistic co-occurrences), and do not necessarily ground all language in order to facilitate processing. The findings in this chapter support previous conclusions by Louwerse and Connell (2011) in that language statistics can serve as a shallow heuristic, allowing for more rapid processing, while perceptual information can aid deeper processing. So while there has been much evidence put forward supporting embodied cognition, the study within Chapter 2 provides further evidence that grounding is not always necessary, and we indeed sometimes rely on symbolic information.

RQ2: Can language statistics explain reaction time (RT) to emotion words?

The findings in Chapter 2, however, might have been biased towards language, because the task was a language-based task. Therefore, a perceptual task designed to elicit embodied responses, the facial feedback paradigm (Strack et al., 1988), was used again during the same judgment task. For both induced smiles and frowns, language statistics again was a significant predictor of RTs for nouns and adjectives. The perceptual factor did predict RTs for adjectives for the target sentence, but that stands to reason because emotions are more often represented by adjectives (Mohammed & Turney, 2010).

In summary, both a corpus linguistic analysis and psychological RT experiments demonstrated that language statistics indeed play a role in how similar and different emotions are processed, and that we rely on those language statistics. Along lines of previous work (Louwerse & Connell, 2011; Louwerse & Jeuniaux, 2010), it has been demonstrated that it is possible to use statistical linguistic frequencies to explain participants' RT, and in particular with emotion language stimuli.

RQ3: Can spatial judgments be predicted by language statistics?

As found in Chapter 2, language statistics did explain reaction times to emotion words within a shift paradigm, even when using a perceptually-based task. In Chapter 3, these effects were also investigated in the domain of spatial orientation judgments. This chapter focused on RTs when making close/distance judgments of pairs of the 50 most populous US cities. Using a similar paradigm as Chapter 2, perceptual and linguistic factors were predetermined. The perceptual factor was operationalized as the differences in longitude and latitude between the cities, and the language statistics factor was operationalized as the log frequency of a – b (iconic configuration where the northern or western city was presented first) or b – a (reverse-iconic configuration where the southern or eastern city was presented first). In this study, the perceptual factor predicted RTs for both the iconic and reverse-iconic configuration, although in the latter configuration the effect was smaller. The language statistics factor did not predict RTs in the iconic direction, however they did so in the reverse-iconic direction. The findings for the reverse-iconic direction demonstrate that when necessitated by the task, the linguistic factors will emerge as the dominant factor over the perceptual factor.

In Chapter 4, this phenomenon was then applied to a smaller spatial frame: the body. Again, co-occurrence frequencies of a short list and a long list of common body part names were calculated using a large corpus. These frequencies were then converted to x-y coordinates and were submitted to multidimensional scaling (MDS) to map their relative location. The MDS revealed that the relative locations showed two important features. First, the fittings of the body part name coordinates were moderate to good, and showed relative positions in the locations how they would actually occur. Second, and more importantly for the purposes of this chapter, there were strong correlations between the factor loadings and experimental data obtained by Van Elk and Blanke (2011). These two studies together support the idea that not only can we use language statistics to predict RT, but that corpus data and psychological data can be significantly comparable in many respects, particularly with spatial orientation in both a small (body parts) and large (U.S. cities) scale.

RQ4: Do effects of embodied cognition still hold when words cannot be perceptually simulated?

In Chapter 5, participants were asked to make semantic judgments about vertically presented word pairs that were either perceptual or non-perceptual (grammatical words such as prepositions and auxiliary verbs). By using items that could not be perceptually simulated, it was found that language statistics are not just a way to further support for perceptual information. In this study, language statistics explained RTs to grammatical word pairs, just as these same language statistics explain RTs to iconic and reverse iconic word pairs that are grounded.

Chapter 5 demonstrates that linguistic information, such as statistical frequency, does not simply refer to encoded perceptual experiences, but in some cases can be the main factor that influences how we encode language. However, since meaningful stimuli can be explained by both perceptual and linguistic factors in other situations, the fact is that language statistics cannot solely account for these findings in all instances. Moreover, the study in Chapter 5 demonstrates that language statistics are not merely support for embodied cognition. If we ground everything, then higher frequencies of grammatical word pairs should not be able to yield lower RTs.

Following the other studies presented in this dissertation, the conclusion is that perceptual and linguistic factors work in concert, but it is indeed possible in some situations that language usage and patterns can influence cognition.

RQ5: Does grammar and the language that we use affect our perceptions?

The purpose of Chapter 6 and Chapter 7 was to further establish evidence to support the idea that language and language use can affect cognition. By using the linguistic relativity hypothesis, it was demonstrated that language structure alone can affect differences between groups beyond perceptual simulation.

In Chapter 6, corpus linguistic data from Spanish and German was used in order to investigate whether masculine and feminine grammatical gender of nouns would affect the adjectives (rated for gender) that were used to describe those nouns. It was found that the noun-adjective combinations that were matched in masculine gender significantly outnumbered the combinations that were of mismatched gender. Furthermore, this study was able to demonstrate that many of the patterns of linguistic relativity that were only found in the laboratory, could be extended to real-world texts.

Then in Chapter 7, the grammatical construction of accidental acts in Spanish and English were compared to investigate whether wording differences could affect attribution of responsibility in the respective languages. It was found that non-agentive wording could elicit different responsibility attributions in the two languages, and that internal (e.g., the person was usually careful) and external (e.g., the environment was poorly designed) factors also contributed to differences in responses. These two chapters were able to provide further evidence for linguistic relativity, as well as demonstrate that language, and its usage, can indeed significantly influence cognition. As shown in the earlier chapters, we use statistical linguistic frequencies (i.e., co-occurrences) to facilitate cognition. Therefore, it stands to reason that larger patterns in language, such as grammatical constructions, also facilitate cognition. One of the mechanisms behind this facilitative effect can be due to classification (Sera et al., 2002). When we encounter numerous associations in language, that may not be explicit, we will tend to associate the concepts in the real world.

The chapters in this dissertation were assembled in order to demonstrate that language itself can have an impact on cognition, beyond conveying grounded meaning. Linguistic co-occurrences were shown to reveal that we indeed use language statistics in cognitive processing, such as geographical ordering information or similar emotions. This effect of language was still present, even when a task to elicit embodied responses was used. Previously, a multitude of studies have provided evidence for an embodied cognition approach (Barsalou, 2008; Glenberg & Kaschak, 2002; Pecher & Zwaan, 2005), as well as studies that have argued for symbolic cognition (Fodor, 1975; Pylyshyn, 1981). The studies presented in this dissertation, however, show a more balanced approach that provides a more accurate representation of how we use *both* language and grounded information in conceptual processing. These findings were further supported by showing that the grammatical constructions in other languages, through linguistic relativity, can also have an effect on cognition. In summary, neither language statistical information nor grounded perceptual information should be ignored when examining factors that influence our thought, or rather both language statistics and perceptual simulations explain cognitive processes.

Perspectives for Future Research

To some readers, the viewpoint in this dissertation and the collection of articles may seem like a refutation of embodied cognition. It is far from it. There is no doubt that embodiment has been shown to have a robust effect, and the associated theories and studies have greatly impacted how we view cognition (see Louwerse et al., 2015 for an overview). For instance, many components of Barsalou's (1999) perceptual symbol systems framework have been shown in empirical studies as well, such as there are neural representations of perceptual referents shown in fMRI analysis (Hauk et al., 2004), or transcranial magnetic stimulation (Pulvermüller et al., 2005) regarding processing of an action (*pick*, *kick*, *lick*). And the action-sentence compatibility effect (Glenberg & Kaschak, 2002) where congruence between a sentence direction and actual motion direction facilitates processing seems equally robust.

Instead, the purpose here is to demonstrate that there need not be a one-exclusive-theory-fits-all approach to language processing and cognition. Particularly, there should be room to include the impact of the reliance on statistical frequencies in language. The symbol interdependency hypothesis (Louwerse, 2007; 2008) acknowledges that both symbolic and perceptual information can both be used, but which system dominates is often related to task and/or situational demands. Specifically, when quick or shallow processing is needed, we will rely on symbolic (i.e., linguistic) information, while when deeper processing is necessary, or there is ample time, then we will often use perceptual information. This is a reasonable conclusion, not only because data within this dissertation and previous studies have demonstrated evidence for support of this view, but also it is a logical connection. We use language as a shortcut as a matter of course. If we had to say *that thing that has fur, wags its tail, barks, eats expensive food, greets me when I come home, etc. etc.* every time we wanted to refer to a dog, then we would spend all our time describing things, rather than having one familiar term. This is also applicable to some of the evidence that has shown support for embodied cognition. If we have time to mentally simulate an action, and it is the most efficacious way to process a sentence, then we will do that. On the other hand, if we can more efficiently process a stimulus in a symbolic way, then why would we use up cognitive resources in simulating all the perceptual information that accompanies *dog*. For example, we've seen *dog* much more frequently with *pet, animal,* and *cat* than *strawberry, radio,* and *coin*. So it is intuitive that we can rely on this information when making a quick sensibility judgment on a pair of words. It is this statistical regularity, meaning innumerable exposures in language and perceptual information that is at the heart of how we use both systems.

The idea that we rely on statistical regularities in language, also leads to a reasoned conclusion regarding linguistic relativity. If, for instance, your language has a certain grammatical and syntactical way of describing an accident, and you've encountered thousands (perhaps hundreds of thousands) of instances in which this pattern is indicative of a likely outcome, then it stands to reason that you will rely on this information and use it in an effective manner. Furthermore, if your language has a grammatical category of feminine words, even though it may seem arbitrary, if feminine adjectives more often accompany feminine nouns, then it is also reasonable to assume that you will use that information.

While there is now sufficient evidence to support that at least in some domains language and its usage can affect cognition, there are possibilities for future exploration of the extent of these effects. In Chapter 2, similar emotions occurring together were predictors of reaction times. However, this was using a paradigm containing three basic emotion categories of happy, sad, and angry. Given the uncertainty within the emotion research community as to which emotions belong in a category, it would be of further interest to explore more nuanced emotions such as where does surprise and fear fall within the emotion continuum, and how language statistics can perhaps illuminate underlying patterns regarding these more elusive emotions. Moreover, are there some emotion words that have a weaker effect in the shift paradigm? It would be useful to not only advance emotion research in general, but also to find a more definitive distinction between emotion categories when using linguistic tasks.

There is also ample opportunity to extend the work on effects of grammatical gender on cognition. The current study and previous studies have found evidence for an effect, however there are many ways that the work here can be extended. The languages studied should be expanded to languages with different categories (i.e., grammatical gender beyond a masculine/feminine paradigm) such as animate-inanimate (e.g., Basque, Ojibwe), non-human-human (e.g., Polish, Tamil), and common-neuter (e.g., Danish, Dutch). Perhaps, there are further cognitive effects that arise from categorical distinctions that are different from gender-linked categories. Furthermore, the area of grammatical constructions, such as attribution of responsibility in Spanish, is ripe for exploration of how patterns in our language can affect how we perceive the world. These patterns can lie deeper than semantic meaning of words, such as abstract concepts, emotional engagement, and memory and attention.

References

Akhutina, T., Kurgansky, A., Polinksky, M., & Bates, E. (1999). Processing of grammatical gender in a three-gender system: Experimental evidence from Russian. *Journal of Psycholinguistic Research*, *28*, 695-713.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence, J. T. Spence (Eds.), *The psychology of learning and motivation (Volume 2)* (pp. 89-195). New York, NY: Academic Press.

Baayen, R. H., Davidson, D., & Bates, D. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*, 390-412.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*, 577–660.

Barsalou, L. W. (2003). Situated simulation in the human conceptual system. *Language and Cognitive Processes, 18*, 513-562.

Barsalou, L. W. (2005). Abstraction as dynamic interpretation in perceptual symbol systems. In L. Gershkoff-Stowe, D. Rakison (Eds.), *Building object categories*, Carnegie Symposium Series (pp. 389-431). Mahwah, NJ: Erlbaum.

Barsalou, L. W. (2007). Grounding symbolic operations in the brain's modal systems. In G. R. Semin, E. R. Smith (Eds.), *Embodied Grounding: Social* *cognitive, affective, and neuroscientific Approaches* (pp. 9-42). New York: Cambridge University Press.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*, 617-645.

Barsalou, L. W. (2010), Grounded Cognition: Past, Present, and Future. *TopiCS in Cognitive Science, 2*, 716–724.

Barsalou, L. W., Santos, A., Simmons, W. K., & Wilson, C. D. (2008). Language and simulation in conceptual processing. In M. De Vega, A. M. Glenberg & A. C. Graesser (Eds.), *Symbols, embodiment, and meaning* (pp. 245–283). Oxford, England: Oxford University Press.

Barsalou, L.W., Solomon, K.O., & Wu, L.L. (1999). Perceptual simulation in conceptual tasks. In M.K. Hiraga, C. Sinha, & S. Wilcox (Eds.), *Cultural, typological, and psychological perspectives in cognitive linguistics: The proceedings of the 4th conference of the International Cognitive Linguistics Association,* Vol. 3 (209-228). Amsterdam: John Benjamins.

Belacchi, C., & Cubelli, R. (2012). Implicit knowledge of grammatical gender in preschool children. *Journal of Psycholinguistic Research*, *41*, 295-310.

Bendera, A., Bellera, S., & Klauera, C. (2011). Grammatical gender in German: A case for linguistic relativity? *The Quarterly Journal of Experimental Psychology*, *64*, 1821-1835.

Blake, B., Schulze, S., & Hughes, J. (2003). *Perceptual mapping by multidimensional scaling: A step by step primer*. Research Reports in Consumer Behavior. Cleveland, OH: Cleveland State University.

Boroditsky, L. (2000). Metaphoric structuring: Understanding time through spatial metaphors. *Cognition, 75*, 1-28.

Boroditsky, L. (2001). Does language shape thought? English and Mandarin speakers' conceptions of time. *Cognitive Psychology, 43*, 1-22.

Boroditsky, L., Fuhrman, O., & McCormick, K. (2010). Do English and Mandarin speakers think about time differently? *Cognition, 118*, 123-129.

Boroditsky, L., Schmidt, L., & Phillips, W. (2003). Sex, syntax, and semantics. In D. Gentner, & S. Goldin-Meadow (Eds.), *Language in mind: Advances in the study of language and thought* (pp. 61-80). Cambridge, MA: MIT Press.

Boroditsky, L., & Schmidt, L. (2000). Sex, syntax, and Semantics. In R. Alterman and David Kirsh (Eds.), *Proceedings of the 22nd Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

Brants, T., & Franz, A. (2006). *Web 1T 5-gram version 1*. Philadelphia: Linguistic Data Consortium.

Brown, N. R. (2002). Real-world estimation: Estimation modes and seeding effects. *Psychology of Learning and Motivation, 41*, 321-359.

Burger, J. M. (1981). Motivational biases in the attribution of responsibility for an accident: A meta-analysis of the defensive-attribution hypothesis. *Psychological Bulletin, 90*, 496-512.

Carroll, J. B. (1956). *Language, thought and reality: Selected writings of Benjamin Lee Whorf*. Cambridge, MA: MIT Press.

Casasanto, D. (2008). Who's afraid of the Big Bad Whorf? Cross-linguistic differences in temporal language and thought. *Language Learning*, *58,* 63-79.

Clarke, M. A., Losoff, A., McCracken, M. D., & Still, J. A. (1981). Gender perception in Arabic and English. *Language Learning*, *31*, 159–169.

Collins, A. M., Quillian, M. R. (1969). Retrieval time from semantic memory. *Journal of Verbal Learning and Verbal Behavior*, *8*, 240–247.

Coltheart, M. (1981). The MRC psycholinguistic database. *The Quarterly Journal of Experimental Psychology*, *33*, 497-505.

Crawford, J.T., Leynes, P.A., Mayhorn, C.B., & Bink, M.L., (2004). Champagne, beer, or coffee? A corpus of gender-related and neutral words. *Behavior Research Methods, Instruments and Computers, 36,* 444-458.

Estes, Z., Verges. M,, & Barsalou, L.W. (2008). Head up, foot down: object words orient attention to the objects' typical location. *Psychological Science, 19,* 93-97.

Fausey, C. & Boroditsky, L. (2010). Subtle linguistic cues influence perceived blame and financial liability. *Psychonomic Bulletin & Review*, *17*, 644-650.

Finch, S., & Chater, N. (1992). Bootstrapping syntactic categories using statistical methods. In W. Daelemans, & D. Powers (Eds.), *Proceedings of the 1st SHOE workshop* (pp. 229-236). Tilburg, Netherlands.

Fincher-Kiefer, R., (2001). Perceptual components of situation models. *Memory & Cognition*, *29*, 336-343.

Fodor, J. (1975). *The Language of Thought.* New York, NY: Crowell.

Friedman, A. & Kohler, B. (2003). Bidimensional regression: A method for assessing the configural similarity of cognitive maps and other two-dimensional data. *Psychological Methods*, *8*, 468-491.

Freundschuh, S. M., & Mercer, D. (1995). Spatial cognitive representations of story worlds acquired from maps and narrative. *Geographical Systems*, *2*, 217-233.

Friedman, A., Kirkman, D. D., & Brown, N. (2002). Spatial location judgments: A cross-national comparison of estimation bias in subjective North American geography. *Psychonomic Bulletin & Review*, *9*, 615-623.

Fuhrman, O. & Boroditsky, L. (2010). Cross-cultural differences in mental representations of time: Evidence from an implicit non-linguistic task. *Cognitive Science*, *34*, 1430-1451.

Gentner, D. & Goldin-Meadow, S. (Eds.) (2003). *Language in mind: Advances in the study of language and thought*. Cambridge, MA: MIT Press.

Gilhooly, K. J., & Logie, R. H. (1980). Age-of-acquisition, imagery, concreteness, familiarity, and ambiguity measures for 1,944 words. *Behavior Research Methods, 12*, 395–427.

Glenberg, A. (1997). What memory is for. *Behavior and Brain Sciences, 20*, 1-55.

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin & Review, 9*, 558-565.

Glenberg, A. M., & Robertson, D. A. (1999). Indexical understanding of instructions. *Discourse Processes, 28,* 1-26.

Glenberg, A. M., & Robertson, D. A. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of Memory & Language*, *43*, 379-401.

Goldberg, A. E. (1995). *Constructions: A construction grammar approach to argument structure.* Chicago: University of Chicago Press.

Goldstone, R., & Barsalou, L. (1998). Reuniting perception and conception. *Cognition*, *65*, 231-262.

Gries, S. Th. (2010). Useful statistics for corpus linguistics. In Sánchez, A. & Almela, M. (Eds.), *A mosaic of corpus linguistics: Selected approache*s (pp. 269-291). Frankfurt am Main: Peter Lang.

Hauk, O., Johnsrude, I., & Pulvermüller, F. (2004). Somatotopic representation of action words in human motor and premotor cortex. *Neuron, 41,* 301–307.

Havas, D. A., Glenberg, A. M., & Rinck, M. (2007). Emotion simulation during language comprehension. *Psychonomic Bulletin and Review, 14*, 436-441.

Herschberger, R., Navey-Davis, S., & Borrás A.G. (2011). *Viajes: Introducción el Español.* Boston, MA: Heinle.

Hutchinson, S., Datla, V., & Louwerse, M. M. (2012). Social networks are encoded in language. *Proceedings of the 34th Annual Conference of the Cognitive Science Society*. Austin, TX: Cognitive Science Society.

Ibrahim, M. H. (1973). *Grammatical gender: Its origin and development*. The Hague, Netherlands: Mouton.

Jacobowitz, D. (1973). *Development of semantic structures*. Unpublished dissertation. University of North Carolina- Chapel Hill, NC.

Kaschak, M., Madden, C., Therriault, D., Yaxley, R., Aveyard, M., Blanchard, A., & Zwaan, R. (2005). Perception of motion affects language processing. *Cognition, 94*, B79-89.

Kaschak, M., & Glenberg, A. M. (2000). Constructing meaning: The role of affordances and grammatical constructions in sentence comprehension. *Journal of Memory & Language, 43*, 508-529.

Klatzky, R. L., Pellegrino, J. W., McCloskey, B. P., & Doherty, S. (1989). Can you squeeze a tomato? The role of motor representations in semantic sensibility judgments. *Journal of Memory and Language, 28*, 56–77.

Konishi, T. (1993). The semantics of grammatical gender: A cross-cultural study. *Journal of Psycholinguistic Research, 22*, 519-534.

Kosslyn, S. M., Thompson, W. L., & Ganis, G. (2002). Mental imagery doesn't work like that. *Behavioral and Brain Sciences, 25*, 198-200.

Kousta, S., Vinson, D., Vigliocco, G. (2008) Investigating linguistic relativity through bilingualism: The case of grammatical gender. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*, 843-858.

Kruskal, J. & Wish, M. (1978). *Multidimensional scaling*. Beverly Hills, CA: Sage Publications.

Lafford, B. & Salaberry, R. (Eds.) (2003). *Spanish second language acquisition: The state of the science.* Washington, DC: Georgetown Press.

Lakoff, G. & Johnson, M. (1999) *Philosophy in the flesh*. New York: Basic Books.

Lambert, W. E., and Paivio, A. (1956). The influence of noun-adjective order on learning. *Canadian Journal of Psychology, 10*, 9-12.

Landauer, T., & Dumais, S. (1997). A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction, and representation of knowledge. *Psychological Review, 104*, 211-240.

Landauer, T., McNamara, D., Dennis, S., & Kintsch, W. (2007). LSA and meaning: In theory and application. *Handbook of latent semantic analysis*. Mahwah, NJ: Lawrence Erlbaum Associates.

Littell, R. C., Stroup, W. W., & Freund, R. J. (2002). *SAS for Linear Models*, 4th Edition. Cary, NC: SAS Publishing.

Louwerse, M. M. (2007). Symbolic embodied representations: A case for symbol interdependency. In T. Landauer, D. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of latent semantic analysis*. Mahwan, NJ: Erlbaum.

Louwerse, M. M. (2008). Embodied representations are encoded in language. *Psychonomic Bulletin and Review, 15,* 838-844.

Louwerse, M. M. (2011). Symbol interdependency in symbolic and embodied cognition. *TopiCS in Cognitive Science, 3*, 273-302.

Louwerse, M. M. & Benesh, N. (2012). Representing spatial structure through maps and language: Lord of the Rings encodes the spatial structure of Middle Earth. *Cognitive Science*, *36*, 1556-1569.

Louwerse, M. M., Cai, Z., Hu, X., Ventura, M., & Jeuniaux, P. (2006). Cognitively inspired natural language based knowledge representations: Further explorations of Latent Semantic Analysis. *International Journal of Artificial Intelligence Tools, 15*, 1021-1039.

Louwerse, M. M., Hutchinson, S., & Cai, Z., (2012). The Chinese route argument: Predicting the longitude and latitude of cities in China and the Middle East using statistical linguistic frequencies. In N. Miyake, D. Peebles, & R. P. Cooper (Eds.), *Proceedings of the 34th Annual Conference of the Cognitive Science Society* (pp. 695-700). Austin, TX: Cognitive Science Society.

Louwerse, M. M., and Connell, L. (2011). A taste of words: linguistic context and perceptual simulation predict the modality of words. *Cognitive Science, 35,* 381-398.

Louwerse, M. M., Hutchinson, S., Tillman, R., & Recchia, G (2015). Effect Size Matters: The Role of Language Statistics and Perceptual Simulation in Conceptual Processing. *Language, Cognition, and Neuroscience, 30,* 430-447.

Louwerse, M. & Jeuniaux, P. (2008). Language comprehension is both embodied and symbolic. In M. de Vega, A. Glenberg, & C. Graesser (Eds.). *Symbols, embodiment, and meaning* (pp. 309-326). Oxford University Press: New York, NY.

Louwerse, M. M., & Jeuniaux, P. (2010). The linguistic and embodied nature of conceptual processing. *Cognition, 114,* 96–104.

Louwerse, M. & Zwaan, R., (2009). Language encodes geographical information. *Cognitive Science, 33*, 51-73.

Lucy, J. (1997). Linguistic Relativity. *Annual Review of Anthropology*, *26*, 291-312.

Mahon, B.Z., & Carramazza, A. (2008). A critical look at the embodied cognition hypothesis and a new proposal for grounding conceptual content. *The Journal of Physiology – Paris*, *102*, 59-70.

Marques, J. (2006). Specialization and semantic organization: Evidence for multiple semantics linked to sensory modalities. *Memory & Cognition, 34,* 60-67.

Matlock, T., Ramscar, M., & Boroditsky, L. (2005). The experiential link between spatial and temporal language. *Cognitive Science*, *29*, 655-664.

McCloskey, B., Klatzky, R. L., & Pellegrino, J. (1992). On rubbing your stomach while tapping your fingers: Interference between motor planning and semantic judgments. *Journal of Experimental Psychology: Human Perception and Performance, 18*, 948-961.

Meier, B. P., & Robinson, M. D. (2001). Why the sunny side is up: Automatic inferences about stimulus valence based on vertical position. *Psychological Science, 15*, 243–247.

Meteyard, L., Bahrami, B., & Vigliocco, G. (2007). Motion detection and motion verbs: Language affects low-level visual perception. *Psychological Science, 18,* 1007-1013.

Miller, G. A. (2003). The cognitive revolution: A historical perspective. *Trends in Cognitive Science, 7*, 141-144.

Mohammad, S.M., and Turney, P.D. (2010), Emotions evoked by common words and phrases: Using Mechanical Turk to create an emotion lexicon. In *Proceedings of the NAACL HLT 2010 Workshop on Computational Approaches to Analysis and Generation of Emotion in Text*. Assoc. for Computational Linguistics (pp. 26-34). Stroudsburg, PA, USA.

Mouilso, E., Glenberg, A. M., Havas, D. A., & Lindeman, L. M. (2007). Differences in action tendencies distinguish anger and sadness after comprehension of emotional sentences. In D. S. McNamara & J. G. Trafton (Eds.), *Proceedings of the 29th Annual Cognitive Science Society* (pp. 1325-1330). Austin, TX: Cognitive Science Society.

Neininger, B., & Pulvermüller, F. (2003). Word-category specific deficits after lesions in the right hemisphere. *Neuropsychologica, 41*, 53-70.

Paivio, A. (1965). Abstractness, imagery, and meaningfulness in paired-associate learning. *Journal of Verbal Learning and Verbal Behavior, 4,* 32-38.

Paivio, A. (1969). Mental Imagery in associative learning and memory. *Psychological Review, 76*, 241-263.

Paivio, A. (1986). *Mental representations: A dual coding approach.* Oxford, England: Oxford University Press.

Paivio, A., Smythe, P. E., & Yuille, J. C. (1968). Imagery versus meaningfulness of nouns in paired associate learning. *Canadian Journal of Psychology, 22,* 427-441.

Paivio, A., & Yuille, J. C. (1967). Latency of imaginal and verbal mediators as a function of stimulus and response concreteness-imagery. *Journal of Experimental Psychology, 75,* 540-544.

Paivio, A., Yuille, J. C., & Madigan, S. A. (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. *Journal of Experimental Psychology, 76*, 1-25.

Pecher, D., Van Dantzig, S., Boot, I., Zanolie, K., & Huber, D. E. (2010). Congruency between word position and meaning is caused by task induced spatial attention. *Frontiers in Cognition, 1*, 1-8.

Pecher, D., Zeelenberg, R., & Barsalou, L.W. (2003). Verifying different-modality properties for concepts produces switching costs. *Psychological Science, 14*, 119-124.

Pecher, D., & Zwaan, R. A. (2005). Introduction to Grounding Cognition: The Role of Perception and Action in Memory, Language, and Thinking. In D. Pecher & R. A. Zwaan (Eds.), *The Grounding of Cognition: The role of perception and action in memory, language, and thinking* (pp. 1-7). Cambridge, MA: Cambridge University Press.

Pedhazur, E. J. (1997). *Multiple regression in behavioral research*. Fort Worth, TX: Harcourt Brace.

Peters, G. (n.d.). *American presidency project*. Retrieved October 11, 2010, from http://www.presidency.ucsb.edu/

Pinker, S. (1994). *The Language instinct*. New York, USA: William Morrow and company, Inc.

Popović, M., & Ney, H. (2006). POS-based word reordering for statistical machine translation. In *5th International Conference on Language Resources and Evaluation (LREC),* 1278-1283, Genoa, Italy.

Pulvermüller, F., Hauk, O., Nikulin, V.V. & Ilmoniemi, R.J. (2005). Functional links between motor and language systems. *European Journal of Neuroscience*, *21*, 793-797.

Pylyshyn, Z. (1989). The role of location indexes in spatial perception: A sketch of the FINST spatial-index model. *Cognition, 32*, 65-97.

Pylyshyn, Z. (1984). *Computation and cognition: Towards a foundation for cognitive science*. Cambridge, MA: MIT Press.

Pylyshyn, Z. W. (1981). The imagery debate: Analogue media versus tacit knowledge. *Psychological Review, 87*, 16-45.

Ramos, S. D. & Roberson, D. (2011). What constrains grammatical gender effects on semantic judgments? Evidence from Portuguese. *Journal of Cognitive Psychology, 23*, 102-111.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience*, *27*, 169–192.

Rumelhart, D. E., McClelland, J. L., & the PDP Research Group. (1986). *Parallel distributed processing: Explorations in the microstructure of cognition. Volumes I & II.* Cambridge, MA: MIT Press.

Schubert, T. W. (2005). Your highness: Vertical positions as perceptual symbols of power. *Journal of Personality and Social Psychology, 89*, 1–21.

Semin, G. & Smith, E. (Eds.) (2008). *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches*. New York: Cambridge University Press.

Šetić, M., & Domijan, D. (2007). The influence of vertical spatial orientation on property verification. *Language and Cognitive Processes*, *22*, 297-312.

Shaver, K.G. (1970). Defensive attribution: Effects of severity and relevance on the responsibility assigned for an accident. *Journal of Personality and Social Psychology*, *14*, 101-113.

Smeets, M., Klugkist, I., van Rooden, S., Anema, H., & Postma, A. (2009). Mental body distance comparison: a tool for assessing clinical disturbances in visual body image. *Acta Psychologica, 32*, 157-165.

Solomon, K., & Barsalou, L. (2004). Perceptual simulation in property verification. *Memory and Cognition, 32*, 244-259.

Sosis, R. (1974). Internal-external control and the perception of responsibility of another for an accident. *Journal of Personality and Social Psychology, 30*, 393-399.

Spence, C., Nicholls, M., & Driver, J. (2001). The cost of expecting events in the wrong sensory modality. *Perception & Psychophysics, 63*, 330–336.

Stanfield, R., & Zwaan, R. A. (2001). The effect of implied orientation derived from verbal context on picture recognition. *Psychological Science, 12*, 153-156.

Stein, T., & Sterzer, P. (2012). Not just another face in the crowd: Detecting emotional schematic faces during continuous flash suppression. *Emotion, 12*, 988-996.

Strack, F., Martin, L. & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobtrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology, 54*, 768-777.

Struiksma, M., Noordzij, M., & Postma, A. (2011). Reference frame acceptability in haptics differs for the blind and sighted in the horizontal but not in the vertical plane. *Perception, 40*, 725-738.

Telljohann, H., Hinrichs, E. W., & Kübler, S. (2004). The TüBa-D/Z Treebank – Annotating German with a context-free backbone. In *Proceedings of the 4th International Conference on Language Resources and Evaluation (LREC)*, Lisbon, Portugal.

Tillman, R., Hutchinson, S., Jordan, S., & Louwerse, M. (2013). Geographical estimates are explained by perceptual simulation and language statistics. In M. Knauff, M. Pauen, N. Sebanz, & I. Wachsmuth (Eds.) *Proceedings of the 35th Annual Conference of the Cognitive Science Society* (pp. 3557-3562). Austin, TX: The Cognitive Science Society.

Tobler, W. (1994). Bidimensional regression. *Geographical Analysis, 26*, 186–212.

Tobler, W. (1970). A computer movie simulating urban growth in the Detroit region. *Economic Geography Supplement, 46*, 234–240.

Toglia, M. P., & Battig, W. F. (1978). *Handbook of semantic word norms*. Hillsdale, NJ: Lawrence Erlbaum.

Turing, A.M. (1950). Computing machinery and intelligence. *Mind, 59*, 433-460.

Van Dantzig, S., Pecher, D., Zeelenberg, R., & Barsalou, L. W. (2008). Perceptual processing affects conceptual processing. *Cognitive Science*, *32*, 579-590.

Van Elk, M. & Blanke, O. (2011). The relation between body semantics and spatial body representations. *Acta Psychologica, 138,* 347-358.

Vigliocco, G., Lauer, M, Damain, M. F., & Levelt, W. J. M. (2002). Semantic and syntactic forces in noun phrase production. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 46-58.

Vigliocco, G., Vinson, D. P., Paganelli, F., & Dworzynski, K. (2005). Grammatical gender effects on cognition: Implication for learning and language use. *Journal of Experimental Psychology: General*, *134,* 501-520.

Wallace, D. & Hinsz, V. (2009). Group members as actors and observers in attributions of responsibility for group performance. *Small Group Research 40,* 52-71.

Walster, E. (1966). Assignment of responsibility for an accident. *Journal of Personality and Social Psychology, 3,* 73-79.

Whorf, B. L. (1956). *Language, thought, and reality: Selected writings.* Cambridge, MA: Technology Press of Massachusetts Institute of Technology.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin and Review, 9*, 625-636.

Wolff, P., Jeon, G. & Yu, L. (2009). Causers in English, Korean, and Chinese and the individuation of events. *Language and Cognition, 1-2,* 165-194.

Wolff, P. & Ventura, T. (2009). When Russians learn English: How the semantics of causation may change. *Bilingualism: Language and Cognition*, *12*, 153-176.

Young, F., Takane, Y., & Lewyckyj, R. (1978). ALSCAL: A nonmetric multidimensional scaling program with several different options. *Behavioral Research Methods and Instrumentation, 10*, 451-453.

Zajonc, R. B., Murphy, S. T., & Inglehart, M. (1989). Feeling and facial efference: Implications for the vascular theory of emotion. *Psychological Review, 96*, 395-416.

Zwaan R. A. (2004). The immersed experiencer: toward an embodied theory of language comprehension. In B. H. Ross, (Ed.) *The Psychology of Language and Motivation, 44*. New York, NY: Academic Press.

Zwaan R., Madden C., & Whitten S. (2000) The presence of an event in the narrated situation affects its activation. *Memory and Cognition*, *28*, 1022-28

Zwaan, R., Stanfield, R., & Yaxley, R. (2002). Language comprehenders mentally represent the shapes of objects. *Psychological Science, 13,* 168-171.

Zwaan, R., & Yaxley, R. (2003). Spatial Iconicity Affects Semantic Relatedness Judgments. *Psychonomic Bulletin and Review*, *10*, 954-8.

Appendices

Appendix A.

Chapter 2 Concepts and adjectives used in the construction *X* can be *Y* for Experiments 1 and 2.

Concept	Adjective	Concept	Adjective
selfishness	annoying	failure	disappointing
gossip	appalling	rejection	disheartening
waiting	bothersome	poverty	dismal
hatred	disgusting	heartbreak	mournful
nagging	enraging	cheating	acrimonious
dishonesty	frustrating	bullies	irksome
inconsideration	galling	accomplishments	blissful
resentment	grating	holidays	pleasant
violence	harsh	racism	discouraging
bitterness	hostile	catastrophes	tragic
arguments	irritating	animals	adorable
traffic	maddening	friends	cheerful
profanity	offensive	food	delicious
hostility	virulent	love	delightful
tickets	exasperating	music	enchanting
loss	damaging	money	favorable
disappreciation	trying	weddings	happy
laughter	amusing	relaxation	soothing
family	comforting	dreams	wishful
vacations	exciting	jokes	funny
success	exhilarating	abuse	heartbreaking
kindness	gratifying	insults	wearing
babies	joyful	rudeness	hurtful
sunshine	pleasurable	hopelessness	grim
gifts	thrilling	pain	miserable
cruelty	sickening	separation	lonely
mistreatment	nauseating	diseases	sad
hardwork	exhausting	bills	infuriating
loneliness	depressing	rain	gloomy
funerals	devastating	surgery	painful

Appendix B.

Chapter 5 Critical and Grammatical items.

Table 1. Log frequencies of critical items (grammatical).

Word pair	Order 1	Order 2
by – at	18.28	16.22
everything–anything	11.57	13.89
his – her	16.65	14.80
me – it	16.27	17.16
more – enough	13.55	11.95
my – a	16.60	16.71
need – dare	7.78	6.82
no – any	15.56	13.45
of – in	20.17	20.49
ought – could	6.85	8.02
per – for	15.57	15.01
several – both	10.68	9.59
shall – had	10.64	9.09
some – most	15.23	12.26
the – our	17.65	17.29
what – this	17.51	16.06
with – to	18.86	19.64
would - should	12.29	11.80
you – we	16.18	17.75
your – an	15.53	16.50

Table 2. Lexical filler items.

aisle	chocolate	grass	ram
ant	Circle	hall	rib
bank	clarinet	ham	river
bar	clover	helmet	road
basket	coal	herb	roof
bath	coat	horn	scissors
bike	couch	insect	shirt
blade	cow	jet	slope
blossom	cream	lamb	snake
blouse	crocodile	limb	socks
bolt	crow	lunch	spinach
bone	dancer	milk	stair
bowl	desk	money	surf
bush	doctor	monkey	sword
butterfly	drum	moth	tail
button	duck	nail	toad
cable	eagle	nest	tooth
cake	electricity	owl	train
calf	elephant	palace	triangle
camera	engine	paper	trout
canoe	fish	pen	veil
car	flag	pencil	walnut
carrot	flute	porch	walrus
cent	frog	priest	weed
chair	fruit	prince	wine
cheese	gown	queen	zipper
chicken		rain	

Appendix C.

Nouns used for the corpus linguistic experiment in Chapter 6.

English Noun	Spanish Noun	German Noun
air[K]	aire (m)	Luft (f)
army[K]	ejército (m)	Armee (f)
bridge[K]	puente (m)	Brücke (f)
brush[B,K]	cepillo (m)	Bürste (f)
cat[B]	gato (m)	Katze (f)
clock/watch[B,K]	reloj (m)	Uhr (f)
corner[K]	rincón (m)	Ecke (f)
desert[K]	desierto (m)	Wüste (f)
drum[B]	tambor (m)	Trommel (f)
fork[B]	tenedor (m)	Gabel (f)
garage[K]	garaje (m)	Garage (f)
love[K]	amor (m)	Liebe (f)
necklace[K]	collar (m)	Halskette (f)
newspaper[K]	periódico (m)	Zeitung (f)
number[K]	número (m)	Zahl (f)
pan[K]	sartén (m)	Pfanne (f)
record(disc)[K]	disco (m)	Schallplatte (f)
shoulder[K]	hombro (m)	Schulter (f)
snail[B]	caracol (m)	Schnecke (f)
stamp[K]	sello (m)	Briefmarke (f)

sun[B,K]	sol (m)	Sonne (f)
tablecloth[K]	manteles (m)	Tischdecke (f)
toilet[B]	inodoro (m)	Toilette (f)
trip[K]	viaje (m)	Reise (f)
world[K]	mundo (m)	Welt (f)
apple[B,K]	manzana (f)	Apfel (m)
arrow[B]	flecha (f)	Pfeil (m)
ball[K]	pelota (f)	Ball (m)
beach[K]	playa (f)	Strand (m)
beard[K]	barba (f)	Bart (m)
boot[B,K]	bota (f)	Stiefel (m)
broom[B,K]	escoba (f)	Besen (m)
butterfly[K]	mariposa (f)	Schmetterling (m)
carpet[K]	alfombra (f)	Teppich (m)
chair[K]	silla (f)	Stuhl (m)
curtain[K]	cortina (f)	Vorhang (m)
frog[B]	rana (f)	Frosch (m)
head[K]	cabeza (f)	Kopf (m)
key[K]	llave (f)	Schlüssel (m)
letter[K]	carta (f)	Brief (m)
moon[B,K]	luna (f)	Mond (m)
mountain[K]	montaña (f)	Berg (m)
mouth[K]	boca (f)	Mund (m)
pocket[K]	tasche (f)	Bolsillo (m)

pot[K]	olla (f)	Topf (m)
pumpkin[B]	calabaza (f)	Kürbis (m)
rain[K]	lluvia (f)	Regen (m)
skirt[K]	falda (f)	Rock (m)
spoon[B]	cuchara (f)	Löffel (m)
star[B,K]	estrella (f)	Stern (m)
stone[K]	piedra (f)	Stein (m)
store[K]	tienda (f)	Laden (m)
table[K]	mesa (f)	Tisch (m)
thirst[K]	sed (f)	Durst (m)
tire[K]	llanta (f)	Reifen (m)
toaster[B]	tostadora (f)	Toaster (m)
trash[K]	basura (f)	Abfall (m)
war[K]	guerra (f)	Krieg (m)
whale[B]	ballena (f)	Wal (m)

Note: Superscript indicates the study that previously used the nouns: Boroditsky & Schmidt (2000), Konishi (1993), or both.

Adjectives used for the corpus linguistic experiment in Chapter 6.

Adjective English	Adjective Spanish	Adjective German
Masculine		
aggressive	agresivo	aggressiv
angry	enojado	wütend
athletic	atlético	athletisch
blue	azul	blau
competitive	competitivo	konkurrenzfähig
destructive	destructivo	destruktiv
dominant	dominante	dominant
forceful	enérgico	kraftvoll
handsome	guapo	stattlich
hostile	hostil	feindlich
muscular	muscular	muskulös
powerful	potente	mächtig
reckless	temerario	leichtsinnig
rough	áspero	rau
strong	fuerte	stark
tall	alto	groß
tough	duro	hart
violent	violent	heftig
vulgar	vulgar	vulgär
Feminine		
beautiful	hermoso	schön
cosmetic	cosmético	kosmetisch
emotional	emocional	emotional
flirtatious	coqueto	kokett
gentle	suave	sanft
innocent	inocente	unschuldig
maternal	materno	mütterlich
nagging	persistente	nagend

petite	chiquito	zierlich
pink	rosado	rosa
pregnant	embarazado	schwanger
romantic	romántico	romantisch
sensitive	sensible	empfindliche
sentimental	sentimental	sentimental
skinny	flaco	dünn
sweet	dulce	süß
sympathetic	simpatico	sympathisch
virginal	virginal	jungfräulich
voluptuous	voluptuosa	wollüstig

Note: The table above lists only the adjectives in grammatical masculine and singular.

Appendix D.

Scenario for attribution of responsibility in English and Spanish used in Chapter 7.

English

In a small claims court, a shop owner claims that Martin T. broke a vase and owes him $1000.

Martin took his wife and two children ages 6 and 9, to a large resort town for vacation. After a long day at an amusement park, they went shopping and he bought many things for his family and friends back home. Martin was carrying many large bags full of all the things he purchased. In one gift shop, his children were exhausted from the full day and were being restless. While carrying all his purchases and trying to calm his children, [Martin broke a vase; A vase was broken by Martin; A vase was broken; A vase broke]. The price of the vase was $1000.

Español

En una corte de reclamos menores, de los reclamos dueño de la tienda que Martín T. rompió un florero y le debe $1000. Martín lleva a su esposa y a sus dos hijos de 6 y 9 de vacaciones a un gran complejo turístico. Después de un largo día en un parque de diversiones, se fueron de compras y el compró muchas cosas para su familia y sus amigos cuando les regresaron a casa. Martín cargaba muchas bolsas grandes llenas de las cosas que compró. En una tienda de regalos, sus hijos estaban exhaustos de todo el día y estaban inquietos. Mientras cargaba todas sus compras, y el trataba de calmar a sus hijos, [Martín quebró un florero; un florero fue quebrado por Martín; un florero fue quebrado; se le quebró un florero].

El valor del florero fue de $1000.

Appendix E.

Questions to Assess Responsibility in Chapter 7.

[Provided in native language of participant]

For the following questions, please circle the number that best states your response.

(Provided after each question)

1	2	3	4	5	6	7
Completely Disagree	Strongly Disagree	Tend to Disagree	Neutral	Tend to Agree	Strongly Agree	Completely Agree

1. Martin was responsible for the vase breaking.

2. The shop owner was responsible for the vase breaking.

3. The children were responsible for the vase breaking.

4. The wife was responsible for the vase breaking.

5. No one was responsible for the vase breaking.

6. Martin was usually very careful in stores. He was careful on the day the vase was broken.[*]

7. Another customer in the store said Martin was being careful, but the aisles were too close together for the situation. Martin was being careful in the aisles.[*]

8. Martin was buying gifts for people other than himself, but this does not affect how responsible he was for the vase.

9. Martin's wife was equally responsible as Martin. †

10. Martin's children were usually well behaved.

11. Martin should have left his bags at the register.*

12. The shop owner was truthful when he said the vase was worth $1000.

13. Martin could have done something with his children before entering the shop to make his children less restless.*

14. The owner of the store should have anticipated tired and restless children and designed the shop accordingly. †

15. Martin's wife was not as responsible as Martin.†

16. If Martin and his family went to the gift shop before the trip to the amusement park, Martin would have the same level of responsibility for the vase breaking.

17. Martin cares for his family deeply.

Note: * denotes questions originally determined to be used for the internally attributed combined score; † denotes questions originally determined to be used for the externally attributed combined score

Summary

For the past two decades, the cognitive sciences have been dominated by a view that our cognition lies in perceptual simulation of our physical, worldly experiences. Indeed, there has been overwhelming evidence to support the idea of this perceptual grounding, known as embodied cognition, in a wide variety of domains. However, it's less clear whether perceptual simulation occurs in every situation and every domain. While there is robust evidence to support perceptual simulation, there are two theoretical frameworks, symbol interdependency and linguistic relativity, that have also shown evidence that language itself can have an impact on cognition.

The first framework is the Symbol Interdependency Hypothesis which states that conceptual processing can be explained by *both* embodied and symbolic mechanisms. There are three components of the Symbol Interdependency Hypothesis. First, perceptual information is encoded in language. Second, language users rely on language statistics and perceptual simulation during cognitive processes. Finally, the dominance of either system is dependent on the type of task and stimulus. In short, we use language as a shortcut for a rough meaning, so we use the symbolic system to garner a fuzzy, good-enough representation that can facilitate cognition. Whereas, it still accounts for the perceptual approach when more thorough processing is required. Therefore, the Symbol Interdependency Hypothesis takes into account previous embodied cognition findings, however provides for a fuller approach when pinpointing how language processing occurs.

The second framework is linguistic relativity, often referred to as the Sapir-Whorf hypothesis. The strong view of linguistic relativity, long ago rejected by the lack of evidence, posits that our thoughts are *determined* by the language that we speak. However, in recent years, there has been increasing evidence to support a weaker view that holds the position that language *influences* our cognition. The findings show evidence of linguistic relativity, in the domains of attribution of responsibility and grammatical gender.

Through using these two linguistic-based frameworks, the aim of this dissertation is to highlight some of the many domains in which language is not necessarily always arbitrary, and that we can find patterns in large bodies of text that parallel how humans think and make judgments.

Author Publications

Tillman, R., & Louwerse, M. M. (under review). Emotions in language statistics and embodied cognition.

Tillman R., & Louwerse, M. M., (under review). Gender equality in German and Spanish: Language statistics demonstrate linguistic relativism.

Hong, T., He, X., **Tillman, R.** (under review). The vertical and horizontal spatial-temporal conceptual metaphor representation of Chinese temporal words.

Bernabeu, P, & **Tillman, R.** (in press). More refined typology and design in linguistic relativity: The case of motion event encoding. *Dutch Journal of Applied Linguistics.*

Tillman, R., Hutchinson, S., & Louwerse, M. M. (2015). How Sharp is Occam's Razor? Language Statistics in Cognitive Processing. In D. Noelle, R. Dale, A. Warlaumont, J. Yoshimi, T. Matlock, C. Jennings, & P. Maglio, *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 2399-2404). Austin, TX: Cognitive Science Society.

Louwerse, M. M., Raisig, S., **Tillman, R.**, & Hutchinson, S. (2015). Time after time in words: Chronology through language statistics. In D. Noelle, R. Dale, A. Warlaumont, J. Yoshimi, T. Matlock, C. Jennings, & P. Maglio, *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 1428-1433). Austin, TX: Cognitive Science Society.

Louwerse, M. M., Hutchinson, S., Tillman, R., & Recchia, G (2015). Effect Size Matters: The Role of Language Statistics and Perceptual Simulation in Conceptual Processing. *Language, Cognition, and Neuroscience*, *30,* 430-447.

Hutchinson, S., **Tillman, R.**, & Louwerse, M. (2014). Quick linguistic representations and precise perceptual representations: Language statistics and perceptual simulations under time constraints. In P. Bello, M. Guarani, M. McShane, & B. Scassellati, *Proceedings of the 36th Annual Conference of the Cognitive Science Society* (pp. 2399-2404). Austin, TX: Cognitive Science Society.

Tillman, R., Hutchinson, S., & Louwerse, M. (2013). Verifying properties from different emotions produces switching costs: Evidence for coarse-grained language statistics and fine-grained perceptual simulation. In M. Knauff, M. Pauen, N. Sebanz, & I Washsmuth (Eds.) *Proceedings of the 35th Annual Conference of the Cognitive Science Society* (pp. 3551-3556). Austin, TX: Cognitive Science Society.

Tillman, R., Hutchinson, S., Jordan, S., & Louwerse, M. (2013). Geographical Estimates are Explained by Perceptual Simulation and Language Statistics. In M. Knauff, M. Pauen, N. Sebanz, & I Washsmuth (Eds.) *Proceedings of the 35th Annual Conference of the Cognitive Science Society* (pp. 3557-3562). Austin, TX: Cognitive Science Society.

Tillman, R., Langston, W., & Louwerse, M. (2013). Attribution of responsibility by Spanish and English speakers: How native language affects our social judgments. *Revista Signos, 46*(83), 408-422.

Tillman, R., Datla, V., Hutchinson, S., & Louwerse, M. (2012). From head to toe: Embodiment through statistical linguistic frequencies. In N. Miyake, D. Peebles, & R. P Cooper (Eds.), *Proceedings of the 34th Annual Conference of the Cognitive Science Society* (pp. 2434-2439). Austin, TX: Cognitive Science Society.

Wisniewski, E.J., Clancy, E.J., and **Tillman, R.** (2005). On Different Types of Categories. In Ahn, W., Goldstone, R.L., Love, B.C., & Markman, A.B., Wolff, P. (Eds.), *Categorization inside and outside the laboratory* (pp. 103-126). Washington, DC: American Psychological Association.

TiCC Ph. D. Series

1. Pashiera Barkhuysen. *Audiovisual Prosody in Interaction.* Promotores: M.G.J. Swerts, E.J. Krahmer. Tilburg, 3 October 2008.
2. Ben Torben-Nielsen. *Dendritic Morphology: Function Shapes Structure*. Promotores: H.J. van den Herik, E.O. Postma. Co-promotor: K.P. Tuyls. Tilburg, 3 December 2008.
3. Hans Stol. *A Framework for Evidence-based Policy Making Using IT.* Promotor: H.J. van den Herik. Tilburg, 21 January 2009.
4. Jeroen Geertzen. *Dialogue Act Recognition and Prediction.* Promotor: H. Bunt. Co-promotor: J.M.B. Terken. Tilburg, 11 February 2009.
5. Sander Canisius. *Structured Prediction for Natural Language Processing.* Promotores: A.P.J. van den Bosch, W. Daelemans. Tilburg, 13 February 2009.
6. Fritz Reul. *New Architectures in Computer Chess.* Promotor: H.J. van den Herik. Co-promotor: J.W.H.M. Uiterwijk. Tilburg, 17 June 2009.
7. Laurens van der Maaten. *Feature Extraction from Visual Data.* Promotores: E.O. Postma, H.J. van den Herik. Co-promotor: A.G. Lange. Tilburg, 23 June 2009 (cum laude).
8. Stephan Raaijmakers. *Multinomial Language Learning.* Promotores: W. Daelemans, A.P.J. van den Bosch. Tilburg, 1 December 2009.
9. Igor Berezhnoy. *Digital Analysis of Paintings.* Promotores: E.O. Postma, H.J. van den Herik. Tilburg, 7 December 2009.
10. Toine Bogers. *Recommender Systems for Social Bookmarking.* Promotor: A.P.J. van den Bosch. Tilburg, 8 December 2009.
11. Sander Bakkes. *Rapid Adaptation of Video Game AI.* Promotor: H.J. van den Herik. Co-promotor: P. Spronck. Tilburg, 3 March 2010.

12. Maria Mos. *Complex Lexical Items.* Promotor: A.P.J. van den Bosch. Co-promotores: A. Vermeer, A. Backus. Tilburg, 12 May 2010 (in collaboration with the Department of Language and Culture Studies).
13. Marieke van Erp. *Accessing Natural History. Discoveries in data cleaning, structuring, and retrieval*. Promotor: A.P.J. van den Bosch. Co-promotor: P.K. Lendvai. Tilburg, 30 June 2010.
14. Edwin Commandeur. *Implicit Causality and Implicit Consequentiality in Language Comprehension*. Promotores: L.G.M. Noordman, W. Vonk. Co-promotor: R. Cozijn. Tilburg, 30 June 2010.
15. Bart Bogaert. *Cloud Content Contention*. Promotores: H.J. van den Herik, E.O. Postma. Tilburg, 30 March 2011.
16. Xiaoyu Mao. *Airport under Control.* Promotores: H.J. van den Herik, E.O. Postma. Co-promotores: N. Roos, A. Salden. Tilburg, 25 May 2011.
17. Olga Petukhova. *Multidimensional Dialogue Modelling*. Promotor: H. Bunt. Tilburg, 1 September 2011.
18. Lisette Mol. *Language in the Hands.* Promotores: E.J. Krahmer, A.A. Maes, M.G.J. Swerts. Tilburg, 7 November 2011 (cum laude).
19. Herman Stehouwer. *Statistical Language Models for Alternative Sequence Selection*. Promotores: A.P.J. van den Bosch, H.J. van den Herik. Co-promotor: M.M. van Zaanen. Tilburg, 7 December 2011.
20. Terry Kakeeto-Aelen. *Relationship Marketing for SMEs in Uganda*. Promotores: J. Chr. van Dalen, H.J. van den Herik. Co-promotor: B.A. Van de Walle. Tilburg, 1 February 2012.
21. Suleman Shahid. *Fun & Face: Exploring non-verbal expressions of emotion during playful interactions*. Promotores: E.J. Krahmer, M.G.J. Swerts. Tilburg, 25 May 2012.

22. Thijs Vis. *Intelligence, Politie en Veiligheidsdienst: Verenigbare Grootheden?* Promotores: T.A. de Roos, H.J. van den Herik, A.C.M. Spapens. Tilburg, 6 June 2012 (in collaboration with the Tilburg School of Law).
23. Nancy Pascall. *Engendering Technology Empowering Women.* Promotores: H.J. van den Herik, M. Diocaretz. Tilburg, 19 November 2012.
24. Agus Gunawan. *Information Access for SMEs in Indonesia*. Promotor: H.J. van den Herik. Co-promotores: M. Wahdan, B.A. Van de Walle. Tilburg, 19 December 2012.
25. Giel van Lankveld. *Quantifying Individual Player Differences.* Promotores: H.J. van den Herik, A.R. Arntz. Co-promotor: P. Spronck. Tilburg, 27 February 2013.
26. Sander Wubben. *Text-to-text Generation Using Monolingual Machine Translation.* Promotores: E.J. Krahmer, A.P.J. van den Bosch, H. Bunt. Tilburg, 5 June 2013.
27. Jeroen Janssens. *Outlier Selection and One-Class Classification*. Promotores: E.O. Postma, H.J. van den Herik. Tilburg, 11 June 2013.
28. Martijn Balsters. *Expression and Perception of Emotions: The Case of Depression, Sadness and Fear*. Promotores: E.J. Krahmer, M.G.J. Swerts, A.J.J.M. Vingerhoets. Tilburg, 25 June 2013.
29. Lisanne van Weelden. *Metaphor in Good Shape.* Promotor: A.A. Maes. Co-promotor: J. Schilperoord. Tilburg, 28 June 2013.
30. Ruud Koolen. *"Need I say More? On Overspecification in Definite Reference."* Promotores: E.J. Krahmer, M.G.J. Swerts. Tilburg, 20 September 2013.

31. J. Douglas Mastin. *Exploring Infant Engagement. Language Socialization and Vocabulary. Development: A Study of Rural and Urban Communities in Mozambique.* Promotor: A.A. Maes. Co-promotor: P.A. Vogt. Tilburg, 11 October 2013.
32. Philip C. Jackson. Jr. *Toward Human-Level Artificial Intelligence – Representation and Computation of Meaning in Natural Language.* Promotores: H.C. Bunt, W.P.M. Daelemans. Tilburg, 22 April 2014.
33. Jorrig Vogels. *Referential choices in language production: The Role of Accessibility.* Promotores: A.A. Maes, E.J. Krahmer. Tilburg, 23 April 2014.
34. Peter de Kock. *Anticipating Criminal Behaviour.* Promotores: H.J. van den Herik, J.C. Scholtes. Co-promotor: P. Spronck. Tilburg, 10 September 2014.
35. Constantijn Kaland. *Prosodic marking of semantic contrasts: do speakers adapt to addressees?* Promotores: M.G.J. Swerts, E.J. Krahmer. Tilburg, 1 October 2014.
36. Jasmina Marić. *Web Communities, Immigration and Social Capital.* Promotor: H.J. van den Herik. Co-promotores: R. Cozijn, M. Spotti. Tilburg, 18 November 2014.
37. Pauline Meesters. *Intelligent Blauw*. Promotores: H.J. van den Herik, T.A. de Roos. Tilburg, 1 December 2014.
38. Mandy Visser. *Better use your head. How people learn to signal emotions in social contexts.* Promotores: M.G.J. Swerts, E.J. Krahmer. Tilburg, 10 June 2015.
39. Sterling Hutchinson. How symbolic and embodied representations work in concert. Promotores: M.M. Louwerse, E.O. Postma. Tilburg, 30 June 2015.

40. Marieke Hoetjes. *Talking hands. Reference in speech, gesture and sign.* Promotores: E.J. Krahmer, M.G.J. Swerts. Tilburg, 7 October 2015
41. Elisabeth Lubinga. *Stop HIV. Start talking? The effects of rhetorical figures in health messages on conversations among South African adolescents*. Promotores: A.A. Maes, C.J.M. Jansen. Tilburg, 16 October 2015.
42. Janet Bagorogoza. *Knowledge Management and High Performance. The Uganda Financial Institutions Models for HPO*. Promotores: H.J. van den Herik, B. van der Walle, Tilburg, 24 November 2015.
43. Hans Westerbeek. *Visual realism: Exploring effects on memory, language production, comprehension, and preference.* Promotores: A.A. Maes, M.G.J. Swerts. Co-promotor: M.A.A. van Amelsvoort. Tilburg, 10 Februari 2016.
44. Matje van de Camp. *A link to the Past: Constructing Historical Social Networks from Unstructured Data.* Promotores: A.P.J. van den Bosch, E.O. Postma. Tilburg, 2 Maart 2016.
45. Annemarie Quispel. *Data for all: How designers and laymen use and evaluate information visualizations.* Promotor: A.A. Maes. Co-promotor: J. Schilperoord. Tilburg, 15 Juni 2016.
46. Rick Tillman. *Language matters: The influence of language and language use on cognition.* Promotores: M.M. Louwerse, E.O. Postma. Tilburg, 30 Juni 2016.