Mental Simulation of Spatial Perspective during Sentence Comprehension

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Abstract

We present an experiment, in which the Action-Sentence Compatibility Effect (ACE, Glenberg & Kaschak, 2002) was reversed when the perspective was changed by using first person pronouns as the agent or patient of the sentence. The results suggest that participants prefer to take the perspective of the first person protagonists – independent of their grammatical and semantic roles and the direction implicated by the action verb. We also discuss how mental simulations may work in sentences with only third person protagonists.

Keywords: Perspective taking; embodiment; situation models; ACE; sentence processing

Introduction

When processing language, comprehenders generate a mental model with an inherent perspective on the described situation (Zwaan, 2004). Our goal is to find out how linguistic units, such as the verb or grammatical markers, influence the mental simulation during language processing. According to the *embodied cognition* hypothesis, language comprehension amounts to the mental simulation of the action involved, i.e. the activation of perceptual schemata and motoric programs. Empirically, the embodiment hypothesis received support from a vast body of evidence from both behavioral and neurofunctional studies (e.g. Aziz-Zadeh, Wilson, Rizzolatti & Iacoboni, 2006; Pulvermüller, Härle & Hummel, 2001; Zwaan, Stanfield & Yaxley, 2002).

Glenberg and Kaschak (2002) reported the Action-Sentence Compatibility Effect (ACE): participants who had to respond to action-sentences, such as "You open the drawer", by performing an arm-movement either directed towards their own body or in the opposite direction showed increased response latencies whenever the required direction of the arm movement was incompatible with the direction of the movement inherent in the sentence (sentence direction). Hence planning and execution of an incompatible movement appear to be inhibited while compatible movements are facilitated (Glenberg & Robertson, 1999). Processing sentences describing directed actions thus trigger the execution of corresponding real actions.

To integrate the diversity of findings, Zwaan (2004) proposed the *Immersed Experiencer Framework*, which conceives language comprehension as situation simulation from the perspective of an observer who her/himself has a specific position in the situation model. According to this view, language comprehenders mentally simulate the reference situation as if they perceived a real-life situation (Zwaan, 2004). While doing so, they can follow the perspectives of protagonists in the story. Therefore it is easier to recall objects and events, if they are relevant for the protagonist than if they are not (Morrow, Bower & Greenspan, 1989). Perspective taking plays a crucial role in interpreting words (Black, Turner & Bower, 1979; Morrow & Clark, 1988; Pustejowsky, 1995; Sanford & Garrod, 1998) and texts (MacWhinney, 2008). In the sentence "The mouse approached the fence" the distance between agent and fence and the distance from which the situation is perceived by the observer (or simulated by the recipient) are both smaller than in the sentence "The tractor approached the fence" (Morrow & Clark, 1988). This difference indicates that different words suggest different perspectives. MacWhinney (2005) claims that discourse comprehension in general amounts to tracking multiple perspectives, a cognitive skill that has evolved from adaptations that supported the tracking of visual perspectives. Languages have evolved to provide perspective tracking devices, such as subjecthood in sentences (MacWhinney, 1987).

Applying this idea to the ACE, one might expect that there is a strong tendency to simulate the action from the sentence subject's perspective, which happens to coincide with the agent inherent in the verbs. Since the verb is the linguistic element in a sentence that encodes these actions and a single verb can also implicate directions and evoke action simulations (Black, Turner & Bower, 1979; Chen & Bargh, 1999; Tseng & Bergen, 2005), it seems obvious that the implicated spatial direction of its described action (verb direction) controls which sentence direction is simulated by the reader during language processing. However, language processing is more than just word processing. So it is important to understand the link between the processing of content words and grammatical constructions (Bergen & Wheeler, 2010). Thus, the question arises how verb direction can be set in relation to the sentence and its reader. When looking at the ACE we find shorter reaction times when the action performed by the participants is compatible with the action described in the sentence. Since usually the acting person in a sentence is the subject and the participant her/himself is also acting, it seems to be the easiest alternative to take the subject's perspective.

However, it remains an open question whether the simulated perspective is dominated by the perspective of the action's subject, the topic of the sentence, whether it is verb-

driven (which would be the agent's perspective), or whether it is influenced by the whole situation model. In order to find out, we manipulated the grammatical and semantic roles of two interacting 3rd person protagonists in a previous study (Schwarzkopf, Müller, Weldle & Konieczny, 2008) instead of using pronouns as Glenberg and Kaschak (2002) did. While Bergen and Wheeler (2005) argued that motor processes are engaged in language comprehension even if the reader is not addressed in the sentences, we could not replicate the ACE with these materials. The assumption that the simulated direction is always the verb direction is also inconsistent with the findings of Glenberg and Kaschak (2002) in which the sentence direction seems to be reversed by directly addressing the reader by 2nd person pronouns. One possible explanation is that the simulated movement is not only implicated by the action verb, but by its relationship to the protagonists and their semantic or grammatical roles. Another question that remained unclear in their work is why 2nd person pronouns evoke a 1st person perspective taking and whether 1st person pronouns evoke a 1st or 2nd person perspective taking. 1st person perspective taking could be expected, because readers articulate the 1st person pronouns silently in inner speech (Abramson & Goldinger, 1997). 2nd person perspective taking (Reddy, 2008) could be expected, because when reading or hearing a 1st person personal pronoun in natural contexts the utterance usually comes from an interacting partner.

Experiment

The goal of this study is to investigate the perspectives that comprehenders take in their mental simulations of action sentences. More specifically, we want to know whether the ACE only reflects the direction implicated by the action verb, or whether the direction can be changed by other factors. Glenberg and Kaschak (2002) used the 2nd person singular pronoun *you* to establish the sentence direction: participants simulated the perspective of the 2nd person protagonists. They analysed their data only with regard to sentence type, but not to the grammatical roles of the pronouns. In our experiment we manipulate this factor systematically using the ACE-paradigm and varying the roles of protagonists in action sentences. The experimental setup is kept as close as possible to the original work by Glenberg and Kaschak (2002) but with German materials. In our target items, the pronoun perspective either coincides at the same time with the subject's, the topic's and the agent's perspective or with the object's and the patient's perspective.

Instead of 2nd person pronouns we use 1st person pronouns interacting with 3rd person protagonists. Our main interest concerns the question, whether 1st person pronouns evoke a 1st or 2nd person perspective taking. On the one hand they might lure readers into identifying with the 1st person protagonist and take over her/his perspective. Otherwise mentioning a protagonist with a 1st person pronoun could evoke a 2nd person perspective, which is usually taken during interactions with other persons.

We include sentences with two 3rd person protagonists in order to find out whether the (non-) effect of verb direction shown in Schwarzkopf et al. (2008) can be replicated.

Materials and design

Three types of sentences were constructed by varying the use of 1st person pronouns and 3rd person noun phrases: 3rd person subject and object (1), 1st person subject and 3rd person object (2), and 3rd person subject and 1st person object (3). This variation established the factor *sentence type* (or *perspective*) used in the experiment.

(1) 3rd/3rd person – sentences:
Der Zuschauer schiebt/zieht den Fußgänger.
The spectator pushes/pulls the pedestrian.
(2) 1st person agent – sentences:
Ich schiebe/ziehe den Fußgänger.
I push/pull the pedestrian.
(3) 1st person patient – sentences:
Der Zuschauer schiebt/zieht mich.
The spectator pushes/pulls me.

Half of the verbs denoted actions with an inherent movement directed towards the agent's body (e.g. *pull*), the other half directing away from it (e.g. *push*). Since we had no hypothesis about how the two verb directions themselves might affect response latency other than by interacting with the direction of the required response, data for the two verb-types were collapsed into a single factor level. The second experimental factor was established by varying the required response direction such that it was either *compatible* with the verb-inherent direction, or *incompatible*. In half of the trials the correct response to the target was in one direction, the other half in the other. Again, we were not interested in effect of arm movement direction in itself, but only in its interaction with verb direction. The experiment was hence built according to a 2×3 design with the factors *sentence type* and *compatibility* of response and verb direction.

In a pretest, 87 transitive action verbs, each denoting an interaction between two protagonists, were rated with respect to their inherent movement direction towards or away from the agent's body. Similarly, 131 possible protagonists were rated with respect to commonness and how easy it is to take their perspective. The 96 protagonists and the 48 verbs that were rated best were selected for the target sentences of our study. 24 of the action verbs convey a concrete or abstract movement towards the agent's body; the other 24 express a movement away from the body.

From each of these 48 verbs three sentences were generated according to the factor *sentence type* as illustrated in (1)-(3). The resulting 132 items were distributed over three lists according to a latin square design, such that each sentence occurred in each list only in one version, and each condition occurred 16 times in each list.

144 fillers of various types were added to each list. 48 of them were meaningful, so that there were 96 meaningful and 96 meaningless items in each list (all target sentences

were meaningful). 48 of the meaningless fillers had the same sentence structure as the target sentences. The meaninglessness was established by impossible actions.

Hypotheses

If comprehenders simulate the agent's/subject's/topic's perspective, and the 1st person perspective does not influence the ACE at all, compatible responses should be faster than incompatible responses for all three sentence types. The same result is expected, if only verb direction is simulated. If the 1st person perspective contributes to the ACE, we expect that in sentences with 1st person subjects, latencies for compatible responses are smaller if verb and response directions are compatible, compared to the 3rd/3rd person sentences in which two 3rd person protagonists interact with each other. When the 1st person pronoun is in object position, its perspective differs from the subject's, topic's and agent's perspective. If all perspectives compete with each other, we expect elevated response latencies. If, however, the 1st person pronouns lure participants to adopt a 2nd person perspective, the 3rd/3rd person sentences should still show the ACE. The other sentences should either show no effect, if participants do not simulate the perspective of one of the protagonists, or there could be an effect for both sentence types, if the verb direction or the agent's/subject's/topic's perspective still directs the simulation regardless of the 2nd person pronoun.

Participants

Twenty-five students (10 female, 15 male) of the University of Freiburg voluntarily participated in the experiment. All participants were German native speakers, two grew up bilingually, one with English the other one with Italian as the second native language. The participant's age ranged between 23 and 36 years, the mean age was 26.5 years.

Procedure

Participants were instructed to read the sentences on a computer screen and to decide whether they were meaningful or not. They had to indicate their judgment by pressing one of two buttons as quickly as possible. We used a computer keyboard (see Figure 1) where all keys were removed except for three that were located in line, such that the middle button, the Z-key[1], was equally far from the other two buttons. The outer buttons were replaced by a 3x3 cm styrofoam top piece with the symbols '*' and 'o' to make them easier to press. The keyboard was turned by 90° so that the short side pointed towards the participant. Since the participant's index finger was placed on the Z-key during the presentation of the sentences, they had to stretch their arms away from their bodies to reach the o-button and had to move the arm towards their body to reach the *-button. The keyboard was placed to the right of the participants for right-handed, and to the left for left-handed participants.

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[1] Note that the Z-key is in the middle of the German keyboard on the position where the Y-key is on an English keyboard.

After half of the trials, the direction of the correct response was inverted, so that compatible and incompatible responses had to be given in both directions. Also, half of the participants started with the o-button and continued with the *-button for the meaningful-judgment, half of the participants vice versa. Furthermore, all target items were distributed to the lists in a way that each item was tested in both directions. Hence, any potential interaction of arm-movement direction that cannot be attributed to compatibility was eliminated.

Figure 1: Vertical three-button-keyboard

Participants were instructed in detail about the procedure of the experiment. Each trial started with a fixation cross in the center of the screen. Participants had to press the Z-button to start the sentence presentation and had to hold it down until the end of the trial. Sentences were presented in a stationary window word-by-word, using a rapid serial visual presentation (RSVP) paradigm implemented in DMDX (Forster & Forster, 2003). Each word was presented for 200 ms plus 28 ms for each character. At the end of each sentence - marked by "***" - participants were instructed to respond as quickly as possible by indicating whether the presented sentence was meaningful or not. In order to do so, they had to release the middle button and press either the button located closer to their body or the button further away from their body.

When participants released the Z-key before the end of the sentence, presentation was stopped and participants were reminded to wait until the end of the sentence. No data were recorded for these trials. After accepting this notification by button press, they had to start the presentation of the next sentence by pressing the Z-key again. At the beginning of both parts of the experiment five training items were presented. After each training item, but not after experimental items, a feedback message was presented on the screen indicating the response the participant gave. When participants released the Z-key before the end of the sentence during training, the training run was extended. The whole experiment ran about 30 minutes.

Results

One of the participants rated less than 50% of the target sentences as meaningful and was excluded from analysis. Data of 24 participants were analyzed. 15% of the original data points were eliminated, because of technical errors or because they had been rated as not meaningful. Extreme

values in the remaining data were excluded separately for each condition. Thereby, we removed 4% of the data.

The data were submitted to a 2x3 analysis of variance (ANOVA) with the factors *compatibility* (compatible/incompatible) and *sentence type* ($3^{rd}/3^{rd}$ person / 1st person agent / 1st person patient). Separate analyses were conducted with participants (F1) and items (F2) as random variables. The dependent variable was the time between sentence offset and the time the Z-key was released. The main effect for sentence type was marginally significant only for items [$F1_{2;51,7} < 1$, *n.s.*; $F2_{2;117,1} = 2,44$, $p<0,1$]. The main effect for compatibility was not significant [$F1_{1;23,8} < 1$, *n.s.*; $F2_{1;67,9} < 1$, *n.s.*]. The interaction between compatibility and sentence type was highly significant for items [$F1_{2;51,5} = 1,16$, *n.s.*; $F2_{2;97,5} = 9.34$, $p<.001$]. There was a highly significant main effect for participants [$F1_{23;13,7} = 11,54$, $p< 0,001$], but not for items [$F2_{47;5,6} = 2.28$, *n.s.*].

In order to identify the origin of the interaction, each two of the three levels of the factor sentence type were analysed pairwise in a theoretical 2x2-design. When the analysis included level 1 ($3^{rd}/3^{rd}$ person) and level 2 (1st person agent), the interaction between sentence type and compatibility was not significant [$F1_{1;24,5} = 1.17$, *n.s.*; $F2_{1;46,7} < 1$, *n.s.*]. When the analysis included level 1 ($3^{rd}/3^{rd}$ person) and level 3 (1st person patient) the interaction was significant only for items [$F1_{1;25,0} < 1$, *n.s.*; $F2_{1;47,8} = 6.42$, $p<.05$]. When the analysis included level 2 (1st person agent) and level 3 (1st person patient) the interaction was marginally significant for participants and highly significant for items [$F1_{1;24,8} = 3,46$, $p< 0.1$; $F2_{1;48,9} = 26.42$, $p< .001$].
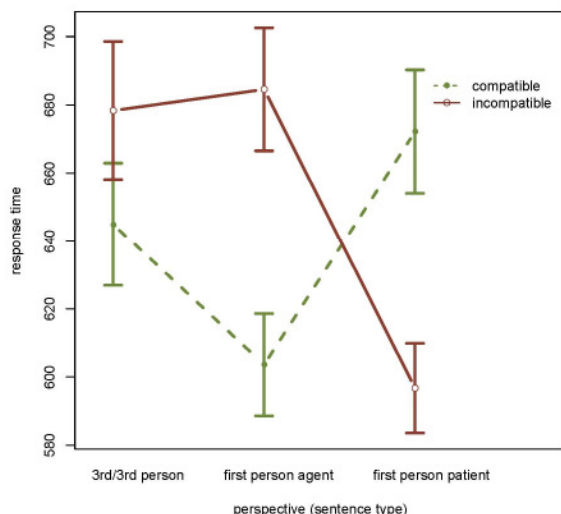

Figure 2: Mean reaction times depending on the factors sentence type and compatibility (error bars denote confidence intervals)

As illustrated in Figure 2, the $3^{rd}/3^{rd}$ person sentences did not show an ACE, while both 1st person sentence types did. However, the ACE was reversed for the two 1st person sentence types. There was no compatibility effect in the $3^{rd}/3^{rd}$ person sentences [$F1_{1;27,5} < 1$, *n.s.*; $F2_{1;51,2} = 1.66$, *n.s.*]. The compatibility effect in the 1st person agent sentences is marginally significant for participants and highly significant for items [$F1_{1;28,9} = 3,22$, $p<.1$; $F2_{1;54,3} = 9.94$, $p<.01$]. Participants were significantly faster when the verb direction was compatible with the movement direction. There was a significant compatibility effect in the 1st person patient sentences, however only by items [$F1_{1;35,6} < 1$, *n.s.*; $F2_{1;52,4} = 13,56$, $p<.01$]. Participants were significantly slower when the verb direction was compatible with the movement direction.

Discussion

The results indicate that the simulated action direction is clearly dependent on the perspective that is induced by the 1st person pronoun. The hypothesis that participants prefer to take the perspective of the 1st person protagonists regardless of their grammatical or semantic roles within the sentence was confirmed by the interaction between sentence types (2) and (3). When the 1st person pronoun is in patient/object position, it clearly overrides the agent's/subject's/topic's perspective as well as a potential simulation of the verb direction, and participants adopt the patient's/object's perspective.

The lack of an ACE during the processing of sentences with two interacting 3rd person protagonists ($3^{rd}/3^{rd}$ person) suggests that verb-inherent perspective alone might not be sufficient to trigger an effective simulation. However, if a perspective is induced by indexical pronouns, clear compatibility effects arise. These effects interact with sentence perspective, i.e. whether the 1st person protagonist is the agent or patient of the action, and seem to be independent of the direction implicated by the action verb.

We did not find evidence in any of the conditions that the verb direction itself or the perspective of the agent, the subject or the topic of the sentence is simulated by language comprehenders. For sentence type (1) no evidence for simulation could be shown at all whereas the pronoun directed perspective taking in sentence types (2) and (3).

General Discussion

Our results confirm that participants also adopt the 1st person protagonist's perspective if the protagonist is in patient/object position. Interestingly, this is compatible with the finding of Glenberg and Kaschak (2002) with 2nd person personal pronouns. Our results show that 1st and 2nd person (indexical) personal pronouns seem to work similar: they draw the comprehender into their perspective. This supports the results of Brunyé, Ditman, Mahoney, Augustyn and Taylor (2009). They also tested perspective taking preferences during language processing, but pre-activated the visual modality and thereby visual simulation by using a sentence-picture matching task. The pictures and correspondingly the perspectives are predetermined in their paradigm. With our paradigm we show that the same perspective taking processes take place even if only the language system is involved in the task and no image

processing or -matching is required. This indicates that the effects are task-independent.

Our results suggest that the sentence direction is defined not only by the verb direction but also by the verb's relationship to the protagonists. While the general direction may still be encoded by the verb, personal pronouns seem to define the location of the comprehender within the space of her/his situation model. Instead of rigidly taking over the agent's perspective, she/he seems to be drawn into the perspective of a 1st or 2nd person protagonist – regardless of whether or not the protagonist is the agent of the action. The identification with different protagonists in different grammatical roles changes the perspective on the spatial direction of the action verb and therefore also changes the activated motion direction. This confirms the idea that content words encode *what* – whereas grammatical constructions modulate *how* it is mentally simulated (Bergen & Wheeler, 2010).

Our results show that 1st person pronouns do not evoke the taking of a 2nd, but – same as 2nd person pronouns – of a 1st person perspective within the situation model. This is an interesting finding, because in directed speech comprehenders generally are addressed only by 2nd person pronouns. 1st person pronouns are in a way ambiguous: they describe the speaker's perspective and although in our study participants are not speakers but comprehenders they seem to simulate the speaker's perspective. Another explanation includes the reader's use of inner speech (Abramson & Goldinger, 1997): the 1st person pronouns are silently articulated as they are in directed speech and therefore evoke a 1st person perspective taking. In this case it should be more difficult to simulate a 1st person perspective with 2nd person pronouns, because the perspective has to be switched by the comprehender. Both accounts predict that the 2nd person's perspective will be taken, if a 2nd person interacts with a 3rd person. But if the 2nd person is the only protagonist in the sentence, the personal pronoun may not trigger perspective taking, because it is – and this is in contrast to sentences with only one 3rd person protagonist – not obvious for the comprehender that she/he isn't in an interactional context with the producer of the sentence. The weakness of Glenberg and Kaschak's (2002) results with imperative sentences supports this explanation.

Future research has to show, whether 1st and 2nd person pronouns still evoke a 1st person perspective taking if comprehenders do not read but listen to sentences – this is probably closer to a real-life interaction, because the voice articulating the stimuli obviously belongs to another person. Another possibility to test if these results can be generalized and participants usually take the 1st person perspective when reading 1st or 2nd person pronouns is to present written stimuli within an interactional context, e.g. in a letter.

Other studies have shown that usually many aspects of a 3rd person protagonist's perspective are simulated automatically (Bergen & Wheeler, 2005; Bower, 2000; Horton & Rapp, 2003; Morrow, Bower & Greenspan, 1989; Rinck & Trabasso & Suh, 1993; Zwaan, 1996). One study

even documented slower reaction times if the direction of action verbs does not correspond with the perspective from which the protagonist perceives the movement (Black, Turner & Bower, 1979). It is therefore somewhat surprising that our sentences with two interacting 3rd person protagonists did not evoke an ACE in the present study. We expected to replicate the ACE in the 3rd/3rd person sentences with 3rd person agents and patients, because in these sentences nothing prevented participants from simply simulating the verb direction. Additionally one of the two protagonists was the sentence topic, the subject and the agent at the same time. However, we did not find an ACE. This non-effect is an accurate replication of the non-effect reported by Schwarzkopf et al. (2008). As other studies found comparable results with other paradigms (e.g. Brunyé et al., 2009) we'll discuss why there eventually may be no effect.

If there is actually no effect, it seems that participants may not simulate any protagonist's perspective, if there are two interacting 3rd person protagonists. It remains unclear, why that could be the case and how this finding should influence our understanding of the role of embodiment in language processing. The contextual factors definitively seem to play a more important role for embodied simulations than expected. We can assume that the tested sentences were well-understood by the participants, because at least their meaningfulness was rated correctly - but if they are not perceptually simulated, the results seem to suggest that mental simulation is not a necessary condition for language comprehension. Is the ACE a fragile effect? Is it just a special case calling for a better interpretation? May it not be possible to show the embodied character of language comprehension in all kinds of sentences? Further work will be required to clarify these issues.

On the other hand, the measuring of action simulation could simply be sensitive to the method. In this case the ACE paradigm could only evoke the effect using a 'perspectivation', e.g. via an interaction between personal pronoun perspective and the verb (or agent's) perspective. In most of the studies mentioned above, in which 3rd person perspective taking was shown, there was just one 3rd person protagonist used in the target items, mostly interacting with a non-animated object – only two studies used sentences with two interacting 3rd person protagonists (Black, Turner & Bower, 1979; Horton & Rapp, 2003). In both of them, one protagonist was described in detail at the beginning of a story, while the other one just dropped by at one point to interact with the first protagonist within the existing reference situation. In this context our results may suggest that during the construction of a situation model, the protagonist's perspective is only simulated if not more than one protagonist appears or if one specific perspective is suggested. In order to suggest a perspective to the reader, 1st or 2nd person pronouns can be used or the perspective of one of the protagonists can be described in detail.

Another possible interpretation of the replicated non-effect is that the reference situation is simulated from a

perspective that was not investigated in this study. Possibly, the reference situation is simulated from a by-standing perspective, from which the interaction of the protagonists in the reference situation can be observed. This observer perspective would not evoke a movement towards or away from the body but a movement from the left to the right or vice versa (Maas & Russo, 2003). If such a horizontal arm-movement is pre-activated, the simulation contains not only a model of the action, but also a spatial discourse model. This question remains to be addressed in further research.

Acknowledgments

References

Abramson, M., & Goldinger, S. D. (1997). What the reader's eye tells the mind's ear: Silent reading activates inner speech. *Perception & Psychophysics, 59(7),* 1059-1068.

Aziz-Zadeh, L., Wilson, S., Rizzolatti, G., & Iacoboni, M. (2006). Congruent Embodied Representations for Visually Presented Actions and Linguistic Phrases Describing Actions. *Current Biology, 16(18),* 1818-1823.

Bergen, B., & Wheeler, K. (2005). Sentence understanding engages motor processes. *Proceedings of the Twenty-Seventh Annual Conference of the Cognitive Science Society* (pp. 238-243). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bergen, B., & Wheeler, K. (2010). Grammatical aspect and mental simulation. *Brain & Language 112,* 150-158.

Black, J. B., Turner, T. J., & Bower, G. H. (1979). Point of view in narrative comprehension, memory, and production. *Journal of verbal learning and behaviour, 18,* 187–198.

Brunyé, T. T., Ditman, T., Mahoney, C. R., Augustyn, J. S., & Taylor, H. A. (2009). When You and I Share Perspectives: Pronouns Modulate Perspective Taking During Narrative Comprehension. *Psychological Science 14(4),* 27-32.

Chen, M., & Bargh, J. A. (1999). Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus. *Personality and social psychology bulletin, 25,* 215–224.

Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers, 35(1),*116–124.

Glenberg, A., & Kaschak, M. (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),* 1-26.

Horton, W., & Rapp, D. N. (2003). Out of sight, out of mind: Occlusion and the accessibility of information in narrative comprehension. *Psychonomic Bulletin & Review, 10(1),* 104–110.

Maas, A., & Russo, A. (2003). Directional Bias in the Mental Representation of Spatial Events: Nature or Culture? *Psychological Science 14(4),* 296-301.

MacWhinney, B. (1987). Toward a psycholinguistically plausible parser. In S. Thomason (Ed.), *Proceedings of the Eastern States Conference on Linguistics* (pp. 1-8). Columbus, Ohio: Ohio State University.

MacWhinney, B. (2005). Language evolution and human development. In B. Ellis & D. Bjorklund (Eds.), *Origins of the social mind*. New York: Guilford.

MacWhinney, B. (2008). How mental models encode embodied linguistic perspectives. In R. Klatzky, B. MacWhinney & M. Behrmann (Eds.), *Embodiment, Ego-space, and Action*. Lawrence Erlbaum.

Morrow, D. G., Bower, G. H., & Greenspan, S. L. (1989). Updating situation models during narrative comprehension. *Journal of Memory and Language, 28,* 292–312.

Morrow, D. G., & Clark, H. H. (1988). Interpreting words in spatial descriptions. *Language and Cognitive Processes, 3,* 275–291.

Pulvermüller, F., Härle, M., & Hummel, F. (2001). Walking or talking?: Behavioral and neurophysiological correlates of action verb processing. *Brain and Language, 78,* 143–168.

Pustejowsky, J. (1995). *The generative lexicon.* Cambridge, MA: MIT Press.

Reddy, V. (2008). *How infants know minds.* Cambridge: Harvard University Press.

Rinck, M., & Bower, G. H. (2000). Temporal and spatial distance in situation models. *Memory & Cognition, 28(8),* 1310–1320.

Schwarzkopf, S., Müller, D., Weldle, H., & Konieczny, L. (2008). Grammatical person controls perspective taking in embodied simulation semantics. *Proceedings of the Architectures and Mechanisms for Language Processing (AMLaP) Conference* (p. 144), Cambridge, UK.

Trabasso, T., & Suh, S. (1993). Understanding text: Achieving explanatory coherence through on-line inferences and mental operations in working memory. *Discourse Processes, 16,* 3–34.

Tseng, M. J., & Bergen, B. K. (2005). Lexical processing drives motor simulation. *Proceedings of the Twenty-Seventh Annual Conference of the Cognitive Science Society* (pp. 2206-2211). Hillsdale, NJ: Lawrence Erlbaum Associates.

Zwaan, R. A. (1996). Processing narrative time shifts. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 1196–1207.

Zwaan, R. A., Stanfield, R. A., & Yaxley, R. H. (2002). Do language comprehenders routinely represent the shapes of objects? *Psychological Science, 13,* 168-171.

Zwaan, R. A. (2004). The immersed experiencer: Toward an embodied theory of language comprehension. *Psychology of Learning and Motivation: Advances in Research and Theory, 44,* 35-62.