



Brief article

Simulating an enactment effect: Pronouns guide action simulation during narrative comprehension

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ABSTRACT

Recent research has suggested that reading involves the mental simulation of events and actions described in a text. It is possible however that previous findings did not tap into processes engaged during natural reading but rather those triggered by task demands. The present study examined whether readers spontaneously mentally simulate the actions described in simple narratives by using a memory task that did not encourage the formation of mental images. During encoding, participants read event scenarios preceded by 'I', 'You', or 'He', and then 10 min (Experiment 1) or 3 days later (Experiment 2), we examined memory for action and descriptive elements of these scenarios. Given previous research demonstrating that readers simulate described actions preceded by 'You' from an actor's perspective, we predicted that such action statements would be better remembered than those preceded by 'He' or 'I' – a simulated enactment effect. Results of both experiments supported this prediction; readers had better memory for actions but not descriptive information (10 min and 3 days later) after reading statements preceded by 'You'. Results demonstrate that readers spontaneously mentally simulate actions during language comprehension and take different mental perspectives, even when doing so is not necessary to perform the task.

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1. Introduction

Language comprehension goes beyond an understanding of the text itself and involves the mental representation of described events, known as a situation model (Johnson-Laird, 1983; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). These multidimensional models contain information regarding characters, goals, locations, time, actions, objects, emotions, expectations, and causality (Ditman, Holcomb, & Kuperberg, 2008; Graesser, Gernsbacher, & Goldman, 2003; Magliano, Taylor, & Kim, 2005; Rapp &

Gerrig, 2006; Rapp, Klug, & Taylor, 2006; Rapp & Taylor, 2004; Zwaan, 1999; Zwaan, Langston, & Graesser, 1995; Zwaan, Radvansky, Hilliard, & Curiel, 1998). A growing body of work has also demonstrated that readers embody, or mentally simulate, described events and actions. For instance, readers are faster at identifying pictures that are congruent rather than incongruent with events described in a narrative (Fincher-Kiefer, 2001; Richardson, Spivey, Barsalou, & McRae, 2003; Stanfield & Zwaan, 2001; Yaxley & Zwaan, 2007; Zwaan, Stanfield, & Yaxley, 2002; Zwaan & Yaxley, 2003), and at making responses that are congruent rather than incongruent with implied motoric sequences (Glenberg & Kaschak, 2002; Tucker & Ellis, 2004). In addition, readers use linguistic cues to determine which character's perspective to take during these mental simulations (Black, Turner, & Bower, 1979; Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009; Brunyé & Taylor,

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2008; Ruby & Decety, 2001). Although these findings provide convincing evidence that readers are able to create vivid mental simulations of described events and actions, less clear is whether these simulations occur in the absence of experimental tasks that promote mental imagery (cf., Machery, 2007). The present experiments sought to address whether the mental simulations formed during reading occur spontaneously without the influence of task demands.

Most relevant to the present paper, Brunyé et al. (2009) recently employed a picture verification task to examine the qualitative perspectives characterizing mental simulations. In their study, readers read narratives containing simple action statements that were preceded either by a first-person pronoun (e.g., *I am slicing the tomato*), a second-person pronoun (e.g., *You are slicing the tomato*), or a third-person pronoun (e.g., *He is slicing the tomato*). Participants then saw a picture and indicated whether the action depicted in the picture matched the action described in the narrative. Pictures either depicted the action from an observer's perspective or an actor's perspective. Results demonstrated that readers appear to mentally simulate the performance of described actions from the actor's perspective when they are directly addressed as the performer (e.g., *You are slicing the tomato*), and otherwise simulate from an observer's perspective (e.g., *He is slicing the tomato*, or *I am slicing the tomato*; Brunyé et al., 2009).

Although the authors concluded that readers spontaneously use linguistic cues during language comprehension to guide mental simulations, it is possible that the results of Brunyé et al. (2009) were merely the result of the task itself rather than of mental simulations that occur naturally and spontaneously during reading. Specifically, exposing participants to action-related pictures following each trial may have promoted mental simulation during reading. Further, viewing these images from different perspectives may have promoted participants to adopt perspectives differentially as a function of pronominal cues. Thus, ideally to test mental simulations during language comprehension, one must choose a task that does not encourage participants to envision the described objects or events.

To this end, the present studies examined the resulting memory representations after participants read a set of action statements. Previous research has demonstrated that the richer the perceptual and motoric information contained within mental representations of described actions, the stronger the resulting memory traces (i.e., the enactment effect; Engelkamp, 1998; Nilsson, 2000; Nilsson & Cohen, 1988; Nyberg & Nilsson, 1995; Zimmer et al., 2001). Thus, as theories of embodied language comprehension posit that mental simulations overlap largely with those invoked during direct perception and action (cf. Barsalou, 2005; Barsalou, 2008; Fischer & Zwaan, 2008; Glenberg, 2007), then one would predict that performing first-person mental simulations of described events during reading (i.e., mentally simulating actions from an actor's perspective) would result in the development of situation models that are particularly amenable to memory retention; such a result would be analogous to an 'enactment effect' (e.g., Engelkamp, 1998). This should be especially true

relative to memories for actions that are mentally simulated from an observer's perspective (e.g., statements preceded by 'He' or 'I').

2. Experiment 1

Our first experiment examined whether recognition memory for object–action relationships would be better after participants read discourse scenarios that in a previous study (Brunyé et al., 2009) promoted mental simulations from an actor's, rather than an observer's, perspective. Participants read three-sentence scenarios in which a final sentence described an action that was either preceded by the pronoun 'You', 'He', or 'I'. Ten minutes later they completed a recognition test that probed for memory of actions. To isolate the effects of mental simulation from the potential effects of personalization (i.e., Moreno & Mayer, 2000), we also tested for memory of descriptive information about the character's age and occupation.² We predicted that participants would have better memory for actions after reading 'You' statements (i.e., *You are slicing the tomato*) relative to these same statements preceded by 'I' (i.e., *I am slicing the tomato*) or 'He' (i.e., *He is slicing the tomato*). This finding was expected because action statements preceded by 'You' have been found to be simulated from an actor's perspective whereas action statements preceded by 'He' or 'I' were simulated from an observer's perspective (i.e., Brunyé et al., 2009). We also expected that effects of pronominal perspective on action memory would occur above and beyond any effects on descriptive memory.

3. Method

3.1. Participants and design

Thirty-six native English speaking, right-handed Tufts University undergraduates (18 male; age $M = 19.11$) participated. We manipulated the pronoun preceding the action statement (Description Pronoun: I, You, He), and tested its influence on a yes/no recognition test.

3.2. Materials

3.2.1. Discourse scenarios

Twenty-four three-sentence discourse scenarios were adopted from earlier work (Brunyé et al., 2009; see Appendix A). The first sentence conveyed descriptive character information (e.g., *I am a 22-year old deli employee*), the second sentence restated the pronoun along with an occupation-appropriate goal (e.g., *I am making a vegetable wrap*), and the third sentence began with a temporal marker, reiterated the pronoun and ended with a verb/direct object action statement (e.g., *Right now I am slicing the tomato*).

3.2.2. Recognition test

A yes/no recognition test contained 32 trials of verb–object statements (e.g., *slicing the tomato*), 16 of which

² We thank reviewers Arthur M. Glenberg and Gabriel A. Radvansky for this suggestion.

Fig. 1. Experiment 1 mean sensitivity (d') and response times (s), and standard error, displayed by Description Pronoun (I, You, He).

planned comparisons revealed higher sensitivity during action statement recognition following the *You* pronoun relative to both the *I* pronoun, $t_1(35) = 3.64$, $p < .01$, $d = .61$, $t_2(23) = 3.0$, $p < .01$, $d = .60$, and the *He* pronoun, $t_1(35) = 2.45$, $p < .05$, $d = .41$, $t_2(23) = 2.15$, $p < .05$, $d = .44$ (*I* differed marginally from *He* in the subject, but not items, analysis, $t_1(35) = 1.78$, $p = .08$, $d = .30$, $t_2(23) = .40$, $p > .05$, $d = .08$). Participant gender did not modulate any of our effects (all F s < 1).

4.2. Response times

Response time results mirrored those of sensitivity, with action recognition items showing a main effect of Description Pronoun, $F_1(2, 70) = 5.04$, $p < .01$, $\eta^2 = .13$, $F_2(2, 46) = 4.42$, $p < .05$, $\eta^2 = .16$; this effect was not found for descriptive items, $F_1(2, 70) = .59$, $p > .05$, $\eta^2 = .02$, $F_2(2, 46) = .40$, $p > .05$, $\eta^2 = .02$. As depicted in Fig. 1, planned comparisons revealed faster response times during action statement recognition following the *You* pronoun relative to the *I* pronoun, $t_1(35) = 3.09$, $p < .01$, $d = .51$, $t_2(23) = 3.23$, $p < .01$, $d = .66$, and marginally to the *He* pronoun, $t_1(35) = 1.98$, $p = .06$, $d = .33$, $t_2(23) = 2.06$, $p = .051$, $d = .42$ (*I* did not differ from *He*, $t_1(35) = 1.18$, $p > .05$, $d = .20$, $t_2(23) = .68$, $p > .05$, $d = .14$). As with sensitivity analyses, gender did not modulate any of our effects (all F s < 1).

4.3. Covariate analyses

Though there was no significant effect of Description Pronoun when examining sensitivity and response times to descriptive items, results generally patterned similarly to those of action items (see Table 1). To further confirm that the effect of Description Pronoun on action recognition could not be accounted for by variation due to personalization, we conducted two additional analyses. First, we re-evaluated the effect of Description Pronoun on action item sensitivity by including variation in descriptive item sensitivity as a covariate ($You - ((I + He)/2)$) in a one-way repeated measures ANCOVA; the effect of Description Pronoun on action item sensitivity persisted, $F(2, 68) = 6.91$, $p < .01$, $\eta^2 = .17$. The second analysis examined response times to action items while using variation in descriptive item response times as a covariate ($You - ((I + He)/2)$); as with sensitivity, the effect persisted, $F(2, 68) = 5.27$, $p < .01$, $\eta^2 = .13$.

4.4. False alarms: verbs versus nouns

False alarm rates varied as a function of Description Pronoun and Old Word (noun or verb), as confirmed by an interaction in a 3×2 ANOVA, $F_1(2, 70) = 3.41$, $p < .05$, $\eta^2 = .04$, $F_2(2, 46) = 4.09$, $p < .05$, $\eta^2 = .04$. Follow-up comparisons demonstrated that trials pairing an old verb with a new noun elicited higher false alarm rates relative to a new verb with an old noun; this was only true following the *You* pronoun, $t_1(35) = 2.71$, $p < .01$, $d = .45$, $t_2(23) = 2.41$, $p < .05$, $d = .49$ (all other p 's > .10).

5. Discussion

Our first experiment found better retention, in the form of higher sensitivity and faster response times, when action statements were preceded by “You”. Critically, these results were only found when examining memory for actions rather than descriptive information, and were observed using a task that did not encourage participants to mentally simulate described actions. We propose that the rich mental simulations performed when readers are addressed as an actor rather than observer encode perceptual and motor information that is imparted by verb–noun relationships.

In addition, readers appear to produce particularly low false alarm rates when they read “You” statements and then view recognition trials coupling a new (previously unstudied) verb with an old (previously studied) noun. For instance, participants showed high performance when disconfirming sentences about chopping (rather than slicing) a tomato, relative to disconfirming sentences about slicing an onion (rather than a tomato), but only after initially reading about these actions from the “You” perspective. This result suggests that final memory forms resulting from first-person mental simulations of described events contain relatively rich action-related information. These findings lend strong support for the notion that mental representations built during reading store strong and lasting traces of described and inferred motor movements (Borghi, Glenberg, & Kaschak, 2004; Glenberg, 2007; Glenberg, Brown, & Levin, 2007; Glenberg & Kaschak, 2002; Glenberg et al., 2008; Nilsson et al., 2000; Taylor, Lev Ari, & Zwaan, 2008; Zwaan & Taylor, 2006).

6. Experiment 2

Our second experiment examined whether the above results would persist over a 3-day retention interval.

7. Method

7.1. Participants and design

Thirty-six native English speaking, right-handed Tufts University undergraduates (18 male; age $M = 18.83$) participated for monetary compensation. The design matched that of Experiment 1.

7.2. Materials and procedure

The materials and procedure matched those of Experiment 1 with the exception of the retention interval between study and test, which was extended to 3 days.

8. Results

Table 1 details sensitivity, response times, and false alarm rates.

8.1. Sensitivity (d')

For action recognition items, a single-factor 3 (Description Pronoun: I, You, He) repeated-measures ANOVA revealed a main effect, $F_1(2, 70) = 4.75$, $p < .05$, $\eta^2 = .12$, $F_2(2, 46) = 3.48$, $p < .05$, $\eta^2 = .13$; this effect was not found for descriptive items, $F_1(2, 70) = .91$, $p > .05$, $\eta^2 = .03$, $F_2(2, 46) = .67$, $p > .05$, $\eta^2 = .03$. Planned comparisons revealed higher sensitivity during action statement recognition following the *You* pronoun relative to both the *I* pronoun, $t_1(35) = 3.37$, $p < .01$, $d = .56$, $t_2(23) = 2.58$, $p < .05$, $d = .53$, and the *He* pronoun, $t_1(35) = 2.2$, $p < .05$, $d = .37$, $t_2(23) = 2.13$, $p < .05$, $d = .43$ (*I* did not differ from *He*, $t_1(35) = .42$, $p > .05$, $d = .07$, $t_2(23) = .13$, $p > .05$, $d = .03$). Participant gender did not modulate any of our effects (all F s < 1).

8.2. Response times

Response time results mirrored those of sensitivity, with action recognition items showing a main effect of Description Pronoun, $F_1(2, 70) = 5.23$, $p < .01$, $\eta^2 = .14$ (marginally for $F_2(2, 46) = 2.91$, $p < .10$, $\eta^2 = .11$); this effect was not found for descriptive items, $F_1(2, 70) = .19$, $p > .05$, $\eta^2 < .01$, $F_2(2, 46) = .01$, $p > .05$, $\eta^2 < .01$. Planned comparisons revealed faster response times during action statement recognition following the *You* pronoun relative to both the *I* pronoun, $t_1(35) = 2.98$, $p < .01$, $d = .50$, $t_2(23) = 2.92$, $p < .01$, $d = .60$, and the *He* pronoun, $t_1(35) = 3.26$, $p < .01$, $d = .54$, t_2 marginal, $p = .06$ (*I* did not differ from *He*, $t_1(35) = .93$, $p > .05$, $d = .15$, $t_2(23) = .74$, $p > .05$, $d = .13$). As with sensitivity analyses, gender did not modulate any of our effects (all F s < 1).

8.3. Covariate analyses

As in Experiment 1, the effect of Description Pronoun could not be accounted for by any variation due to personalization; after covarying out differences in descriptive item sensitivity and response times in two ANCOVAs, respectively, the effect of Description Pronoun persisted for both sensitivity, $F(2, 68) = 4.82$, $p < .05$, $\eta^2 = .12$, and response times, $F(2, 68) = 5.40$, $p < .01$, $\eta^2 = .14$.

8.4. False alarms: verbs versus nouns

False alarm rates showed a Description Pronoun \times Old Word interaction, $F_1(2, 70) = 3.54$, $p < .05$, $\eta^2 = .04$ (F_2 non-sig, $p > .05$). As in Experiment 1, false alarm rates to trials containing an old noun (with new verb) versus an old verb (with new noun) only differed following the use of the *You* pronoun, $t(35) = 3.05$, $p < .01$, $d = .51$, $t_2(23) = 2.75$, $p < .05$, $d = .56$ (all other p 's $> .10$).

9. Discussion

The present results replicated Experiment 1, demonstrating that readers mentally simulated action statements from different perspectives even when the task did not encourage such simulation. Specifically, results showed

better retention of action, but not descriptive, information when participants were directly addressed as an actor during reading; these effects persisted over a 3-day interval.

10. General discussion

Recent research has demonstrated that language comprehension activates internal modal simulations that allow readers to fully understand the perceptual and motor characteristics of described events (Barsalou, 2008; Fischer & Zwaan, 2008; Glenberg, 1997; Glenberg, 2007), although the extent to which this occurs without task demands has been unclear (cf., Machery, 2007). This process has often been described as automatic and tacit, and involving the reactivation of (at least) the visual and motor characteristics of experience. In addition, recent work suggests that these mental simulations can take on very different qualitative perspectives as a function of linguistic cues (Borghi et al., 2004; Brunyé et al., 2009; Ruby & Decety, 2001). The present results support these previous findings and, importantly, suggest that the internalization of described objects and actions (via the pronoun 'You') occurs in the absence of a task that encourages visualization, providing evidence that these mental simulations occur spontaneously and naturally.

Our false alarm data suggest that memories for imagined actions are particularly strengthened by a persisting action representation, analogous to results found when examining the enactment effect (i.e., Einstein & Hunt, 1980; Engelkamp, Mohr, & Zimmer, 1991). Indeed verbs appear to lead to a more reliable memory trace, as readers seem to remember the described actions but not necessarily the referenced object/patient. Addressing readers as the performers of actions rather than as passive observers may hold promise for increasing student retention (see also Bender & Levin, 1976; Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004). Moreover, our results suggest that the mental simulations resulting from directly addressing readers as performers of actions may account for some earlier effects attributed to personalization alone (i.e., referring directly to a reader; Moreno & Mayer, 2000).

Some work shows that rich mental simulations can prepare readers for action (Bergen, Lindsay, Matlock, & Narayanan, 2007; Glenberg & Kaschak, 2002), and help them build clear and unambiguous memory representations of described actions and scenes (Bergen & Chang, 2005; Horton & Rapp, 2003; Zwaan, 1999). It also seems to be the case that readers can achieve greater retention as a function of increased reader engagement and binding of words to objects and actions (Glenberg & Robertson, 2000; Glenberg et al., 2004); in our case greater engagement during action comprehension was triggered by linguistic cues. These results extend recent theoretical accounts of linguistic focus during text comprehension (i.e., Taylor & Zwaan, 2008), demonstrating that whereas action information can be communicated by a verb alone, motor resonance is often derived from larger units of text that guide and constrain mental simulations (Bergen et al., 2007; Taylor et al., 2008; Zwaan, Taylor, & de Boer,

in press). In this case, readers use pronominal reference to inform the perspectives characterizing mental simulations.

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Appendix A

Scenarios	Recognition test items
<i>I am/You are/He is</i> a 30-year old deli employee	Slicing the tomato (old verb/old noun)
<i>I am/You are/He is</i> making a vegetarian wrap	Chopping the tomato (new verb/old noun)
Right now, <i>I am/You are/He is</i> slicing the tomato	Slicing the onion (old verb/new noun) 30-Year old deli employee (old descriptive) 30-Year old lawyer (new descriptive)
<i>I am/You are/He is</i> a 36-year old bartender	Cracking the coconut (old verb/old noun)
<i>I am/You are/He is</i> making a pina colada from scratch	Shredding the coconut (new verb/old noun)
Right now, <i>I am/You are/He is</i> cracking the coconut	Cracking the pineapple (old verb/new noun) 36-Year old bartender (old descriptive) 36-Year old police officer (new descriptive)
<i>I am/You are/He is</i> a 37-year old food critic	Cutting the steak (old verb/old noun)
<i>I am/You are/He is</i> testing out the food at a new eatery	Salting the steak (new verb/old noun)
Right now, <i>I am/You are/He is</i> cutting the steak	Cutting the chicken (old verb/new noun) 37-Year old food critic (old descriptive) 37-Year old fire fighter (new descriptive)
<i>I am/You are/He is</i> a 35-year old postal worker	Taping the package (old verb/old noun)
<i>I am/You are/He is</i> preparing a small shipment to Hawaii	Stamping the package (new verb/old noun)
Right now, <i>I am/You are/He is</i> taping the package	Taping the envelope (old verb/new noun) 35-Year old postal worker (old descriptive) 35-Year old mechanic (new descriptive)

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