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ORIGINAL RESEARCH REPORT

Readers' Insensitivity to Tense Revealed: No Differences in Mental Simulation During Reading of Present and Past Tense Stories

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While the importance of mental simulation during literary reading has long been recognized, we know little about the factors that determine when, what, and how much readers mentally simulate. Here we investigate the influence of a specific text characteristic, namely verb tense (present vs. past), on mental simulation during literary reading. Verbs usually denote the actions and events that take place in narratives and hence it is hypothesized that verb tense will influence the amount of mental simulation elicited in readers. Although the present tense is traditionally considered to be more "vivid", this study is one of the first to experimentally assess this claim. We recorded eye-movements while subjects read stories in the past or present tense and collected data regarding self-reported levels of mental simulation, transportation and appreciation. We found no influence of tense on any of the offline measures. The eye-tracking data showed a slightly more complex pattern. Although we did not find a main effect of sensorimotor simulation content on reading times, we were able to link the degree to which subjects slowed down when reading simulation eliciting content to offline measures of attention and transportation, but this effect did not interact with the tense of the story. Unexpectedly, we found a main effect of tense on reading times per word, with past tense stories eliciting longer first fixation durations and gaze durations. However, we were unable to link this effect to any of the offline measures. In sum, this study suggests that tense does not play a substantial role in the process of mental simulation elicited by literary stories.

Keywords: mental simulation; story world absorption; verb tense; narratives; eye-tracking

Introduction

Readers, writers, and scholars alike have long recognized that mental images often accompany us while engaging in literary stories. When we read about the protagonist of a story, we might imagine his or her actions, perceptions, thoughts, or feelings. Similarly, mental images of the scenery in which a story takes place might arise, contributing to the creation of a so-called simulated story world. This process has been termed mental simulation and, according to some researchers, sits at the heart of the literary experience (Burke, 2011; Gerrig, 1993; Green & Brock, 2000; Green & Donahue, 2009; Mar & Oatley, 2008; Starr, 2013).

Not a lot is known, however, about the factors that determine when, what, and how much readers mentally simulate when they read a literary narrative. Previous research suggests that there are marked individual differences in mental simulation during (literary) reading. For example, frequent readers (Segal et al., 1997), people with a general tendency to form rich mental images (Long, Winograd & Bridge, 1989), and readers scoring higher on empathy measures (Hartung, Burke, Hagoort & Willems, 2016) report higher levels of mental simulation and immersion.

Moreover, an fMRI study by Nijhof and Willems (2015) suggests that readers do not only differ from each other with respect to *how much* mental simulation they experience while reading, but also with respect to *what* they simulate. Whereas some subjects in their study were mainly engaged in the simulation of thoughts and feelings, also called mentalizing, others responded more strongly to parts of the stories that allowed for the simulation of actions and scenery, also called sensorimotor simulation. Readers thus seem to differ from each other both quantitatively and qualitatively when it comes to mental simulation during reading (see also Hartung et al., 2017).

Next to individual differences between readers, text characteristics influence mental simulation during literary reading. Stylistic effects, like literal analogy and personification, lead to richer simulation (Long et al.,

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1989). Also, more basic linguistic choices such as the type of pronouns authors use to refer to the main protagonist of a story can affect mental simulation by influencing the reader's perspective on the events in the story. Readers identified more with the protagonist (Segal et al., 1997), felt more transported, and reported more mental imagery (Hartung et al., 2016) when first person pronouns ("I") were used to refer to the protagonist than third person pronouns ("he/she/it") (but see Hartung et al. (2017) for an absence of this effect).

As verbs usually refer to actions and events, it seems logical that verb characteristics might influence the mental simulation elicited in readers. One particularly well-studied case in this respect concerns the influence of grammatical aspect (e.g., perfective or imperfective) on mental simulation (e.g., Bergen & Wheeler, 2010; Madden & Ferretti, 2009; Madden & Therriault, 2009; Magliano & Schleich, 2000; Zwaan, 2008; Zwaan, Taylor, & de Boer, 2010). For example, Bergen and Wheeler (2010) found that the so-called action compatibility effect (ACE; Glenberg and Kaschak, 2002) was present for verbs described in imperfective aspect (e.g., He was walking) but not perfect aspect (e.g., He had walked). This suggests that grammatical aspect influences the simulation of action verbs (Bergen & Wheeler, 2010).

Similarly, some scholars have argued that the choice of verb tense (e.g., present vs. past tense) also influences the effect a story has on readers. Tense is a deictic mechanism that places events on a timeline, relative to the time of speaking (or writing; Comrie, 1985). According to traditional analyses (e.g., Fleischman, 1990; for an overview, see Schiffrin, 1981; for a critique, see Fludernik, 1991), the present tense, which has also been called the "historical present" in the context of literary stories, can make a narrative seem more "vivid" or "imaginable" (Sanders, 2010) as it allows events to be described as if they were happening at the moment of reading, for readers to witness as they occur. Similarly, it has been argued that the present tense marks the immediacy of what is described, bringing the events closer to the reader, creating a dramatical effect (Sanders, 2010). For example, such theories would suggest that the small discourse in example (2) is more vivid and exciting than the one in example (3), as the use of the present tense makes the first discourse seem as if the events were happening right in front of us, rather than being described as rounded off events that took place sometime in the past, as in example (3).

(2) Fee opens the door and steps into the closet. In a few steps, I am near her. I push the door shut and turn the lock.

(3) Fee opened the door and stepped into the closet. In a few steps, I was near her. I pushed the door shut and turned the lock.[1]

There are relatively few studies that have experimentally assessed how mental simulation elicited by literary stories is influenced by verb tense. Segal et al. (1997) found weak indications of an effect of tense on reading experience, specifically relating to the experience of plot structure: present tense stories elicited more plot awareness in readers, but readers were more understanding of the intentions of story characters in past tense stories. However, some caution is warranted in interpreting these results as the effects of different stories and the additional manipulation of gender and person were so large that a clear effect of tense might have been obscured.

Nevertheless, Macrae (2016) did find an effect of tense using short English stories. In this study, a different measure of simulation was used. Subjects read a story and were interrupted five times during reading. Subjects then selected a picture that most closely resembled what they visualized while reading, through the use of an interactive interface. Macrae found that subjects chose a picture with the main protagonist's point of view significantly more often when the story was written in the present tense than when it was written in the past tense. This suggests that readers were more transported into the present tense stories.

More indirect evidence for possible effects of tense on mental simulation comes from studies assessing the influence of tense on mental models in a more general sense. For example, it has been found that information associated with the main character of a short description in the present tense is recognized faster than the same information in the past tense, suggesting that information described in the present tense is somehow more activated or available in readers' situation models (Carreiras, Carriedo, Alonso & Fernández, 1997).

Similarly, the present tense has also been associated with a more concrete mindset, whereas the past tense has been associated with more abstract thinking. Carrera, Muñoz, Caballero, Fernández, Aguilar, and Albarracín (2012) found that situations were perceived as less probable, and social targets were seen as less familiar when they were described in the past tense, compared to the present tense. Moreover, when subjects were instructed to write a narrative using either the present or past tense, stories in the past tense contained more abstract language.

To sum up, there is direct and indirect evidence from various fields of research suggesting a relationship between verb tense and mental simulation, with the present tense eliciting stronger, and more concrete simulations than the past tense. Most of these studies seem to support the claim that the present tense is more vivid and elicits more mental simulation in readers, but more research, using real literary stories, is needed to find direct support for this hypothesis.

The main aim of the present study is to investigate the influence of the verb tense of literary narratives on the mental simulation elicited in readers. In this study, mental simulation will refer to the implicit simulation of actions and perceptions in the readers' mind, or, following Barsalou (1999), to the implicit mental "enactment of the perceptual or motor […] experiences" of the characters in the story, also called sensorimotor simulation. Evidence suggests that mental simulation can be distinguished conceptually and neurally from the more explicit imagery that occurs when one deliberately generates visual images in the mind in the absence of direct sensory input (Jacobs & Willems, 2017; Willems, Toni, Hagoort & Casasanto, 2010).

We measured readers' responses to four different stories in original and manipulated present and past tense versions. We used an adapted version of the Dutch Story World Absorption Scale and especially its mental imagery subscale (SWAS; Kuijpers, Hakemulder, Tan, & Doicaru, 2014) to measure self-reported levels of mental simulation. Besides questionnaires, we also explored the option of using an online measure of mental simulation. Consequently, we measured subjects' eye-movements during reading to see whether mental simulation elicited by stories is reflected by reading times. Our initial hypothesis was that mental simulation takes time, and might therefore show up in the eye-tracking data as increased reading times for passages that elicit simulation. Simulation-eliciting passages were pre-scored in our materials, yielding a 'sensorimotor score' per word (cf. Mak & Willems, submitted; Nijhof & Willems, 2015; Van den Hoven et al., 2017).

In line with earlier research outlined above, we hypothesized that stories in the present tense would elicit more mental simulation and would thus lead to higher scores on the mental imagery subscale of the SWAS compared to the past tense stories and would increase reading times for simulation-eliciting passages. Hence, we expected a main effect of tense on the offline measures of mental simulation, and an interaction effect of tense and sensorimotor score per word for the eye-tracking measures.

Method

Subjects

Based on a power analysis for mixed effects models by Brysbaert and Stevens (2018), 43 native speakers of Dutch were recruited from the subject pool of Radboud University Nijmegen and participated in the experiment in exchange for course credit or 15 euro. Subjects with dyslexia and/or contact lenses were excluded from participation. After the exclusion of data from three subjects (see Results) the final dataset included 40 subjects (32 women, 7 men, 1 other) aged between 18 and 46 (M = 22.89, SD = 5.07). Ethical approval was obtained from the institutional review board.

Materials

Four short stories (743–2016 words) were selected from Dutch literature (see **Table 1**). All stories have been published in books or literary magazines. Two of these stories (A and B) were originally written in the present tense and used a first-person perspective, whereas the other two (C and D) were originally written in the past tense and used a third-person perspective (C) or first-person perspective (D). An alternative version of each story was created using the opposite tense, by changing the tense of the verbs and, if necessary, tense sensitive connectives such as "als" ("when"). This manipulation lead to a total of eight stimuli: two present tense stories that were originally written in the present tense (A and B in the present tense), two present tense stories that were originally written in the past tense (C and D in the present tense), two past tense stories that were originally written in the past tense (C and D in the past tense), and two past tense stories that were originally written in the present tense (A and B in the past tense). On average, 11.6% of the words in a story were changed in the alternative versions (see **Table 2**). Due to copyright reasons, stimuli are only available (in Dutch) upon request.

In a pre-test, five independent judges (aged 19–25, M = 22.60, SD = 1.96) who were naive to the purpose of the study, underlined the words, phrases, sentences or paragraphs of the four stories that, according to them, were

Table 1: Descriptive information for the four original stimuli stories used in the experiment.

Story title	Author	Year of publication	Original tense	Word count
A: *Het is muis* (It's mouse)	Sanneke van Hassel	2012	Present tense	2016
B: *Hoe de wolven dansen* (How the wolves dance)	Jordi Lammers	2017	Present tense	1176
C: *De invaller* (The substitute)	René Appel	2003	Past tense	743
D: *Ze is overal* (She is everywhere)	Ed van Eeden	2015	Past tense	1074

Table 2: Descriptive statistics for the pre-test stimuli and results. Independent judges (N = 5) scored the words of the four original stimuli stories for the presence or absence of sensorimotor simulation.

Story	Amount of words changed in manipulated versions	%	Amount of words underlined in original versions *M* (*SD*)	%	Fleiss's kappa	*p*-value
A	251	12.45	687.20 (157.17)	34.09	.41	< .001
B	140	11.91	428.80 (97.47)	36.46	.44	< .001
C	81	10.90	324.80 (74.24)	43.72	.54	< .001
D	119	11.08	342.40 (61.60)	31.88	.61	< .001

sensory descriptions (i.e., descriptions of the observable characteristics of people, things or spaces) and/or motor descriptions (i.e., descriptions of concrete actions of people or things). To avoid idiosyncratic differences in the underlining between the two versions of each story, only the original versions were underlined. A sum score (0–5) was calculated for every word based on the number of judges that thought a word to elicit sensorimotor simulation. This score was then, transferred on a word-by-word basis to the manipulated versions of the stories and was used as a measure of sensorimotor simulation per word in the analysis of the eye-tracking data.

The descriptive statistics for the results of the pre-test can be found in **Table 2**. Fleiss's kappa showed that the inter-rater reliability was moderate for all stories (range: .41–.61) and significantly differed from 0 (all p-values < .001), which would indicate no agreement between the raters at all.

To measure mental simulation offline we used the Dutch Story World Absorption Scale (SWAS, Kuijpers et al., 2014) which includes a mental imagery subscale. The original subscales of the SWAS were augmented with eight questions (see **Table 3**), partially based on Mak & Willems (submitted) and items originally designed by Kuijpers et al. (2014), that were added to the emotional engagement scale (n = 1) and the mental imagery scale (n = 7). In the latter case, these questions were intended to enrich the mental imagery subscale to also include non-visual modalities and as such represent the broader concept of mental simulation.

In addition, a questionnaire was created to measure story appreciation partially based on Hartung et al.

Table 3: Overview of the items (newly added items in italics) and reliability (Cronbach's alpha) per subscale of the SWAS questionnaire (Kuijpers et al., 2014).

Attention (α = .90)
When I was reading the story I was focused on what happened in the story.
I felt absorbed in the story.
The story gripped me in such a way that I could close myself off for things that were happening around me.
While I was reading I forgot the time.
I was reading in such a concentrated matter that I had forgotten the world around me.
Emotional engagement (α = .87)
I felt sympathy for the main character.
I felt for what happened in the story.
I felt how the main character was feeling.
I felt connected to the main character in the story.
I feel like I really got to know the characters in the story.
When I read the story I could imagine what it must be like to be in the shoes of the main character.
Mental imagery/mental simulation (α = .89)
I could see the events in the story through the eyes of the main character.
When I was reading the story I had an image of the main character in mind.
When I was reading I could see the events in the story being played like a movie in my head.
When I was reading the story I could see the situations happening in the story being played out before my eyes.
The situations in the story were described in an evocative way.
While reading I felt like I experienced the same bodily sensations as the main character.
When I was reading the story I could see the acts that the characters performed being played out before my eyes.
I had a clear image in my mind of the characters in the story.
I could imagine what the world in which the story took place looked like.
While reading I could hear the sounds that were described in the story in my head.
Transportation (α = .87)
When I was reading the story it sometimes seemed as if I were in the story world too.
The world of the story sometimes felt closer to me than the world around me.
When reading the story there were moments in which I felt that the story world overlapped with my own world.
Because all of my attention went into the story, I sometimes felt as if I could not exist separate from the story.
When I was finished with reading the story it felt like I had taken a trip to the world of the story.

(2017), Knoop, Wagner, Jacobsen and Menninghaus (2016) and Kuijpers et al. (2014). Subjects answered nine questions relating to how much they liked the story. The questionnaire also contained twelve 7-point Likert scales with adjectives describing different qualities of the stories such as 'beautiful' and 'interesting'. However, we decided to not use these adjective scales in the analysis as we did not have clear predictions about the relationship between tense and appreciation, and the first nine questions form a more intuitive measure of appreciation. Next, we asked subjects several questions about their reading habits. We also used the Author Recognition Test (ART; Koopman, 2015) as an implicit measure of print exposure. Finally, we created three multiple-choice questions per story (four response options per question) to measure basic comprehension. Subjects scoring below chance on these questions (i.e., less than two correct answers) were excluded on a story-by-story basis.

Data recording and stimulus presentation

To record eye-movement data, we used a monocular desktop-mounted EyeLink1000plus eye-tracking system that recorded at a sampling rate of 1000 Hz. To minimize head movements, subjects placed their head in a head stabilizer with a chin rest. Eye-movements were measured for the subject's dominant eye except in five cases when it was impossible to track this eye, for example due to reflections of glasses. The interest areas for the eye-tracking data were created automatically by SR Research Experiment Builder software by defining each word as an area of interest, with borders centered between adjacent words, leaving no space between two subsequent areas of interest.

The stories were presented with the use of SR Research Experiment Builder software and divided into 12–20 sections that resembled their original paragraphs as much as possible. On average, a section contained 96 words (*SD* = 26, range: 32–150). Text was presented as black letters on a white background, set in Times New Roman, 16 pts with margins of 100 pixels on each side.

Procedure

Before the experiment started, subjects signed an informed consent form. The experiment itself took place in a sound-proof booth with a desk on which the screen for stimulus presentation and the eye-tracking device were positioned. Each subject read all four stories in a randomized order across subjects, with each story appearing in a different version, counterbalanced over participants. As such, each subject read (in a random order) one story in the original present tense, one in the manipulated present tense, one in the original past tense and one in the manipulated past tense. Each story began with the instruction to read normally followed by the calibration and validation of the eye-tracker. Subjects were informed in advance that there would be questions about their reading experience after every story. During reading, each section started with a fixation cross (1000 ms) marking the position of the first word. A drift correction of the eye-tracker was performed after every four sections.

After each story, subjects left the experimental booth to fill in the SWAS and appreciation questionnaires (see **Table 5**) on paper. After the final story, subjects filled in the basic comprehension check questions for all four stories, the reading habits questionnaire, and the Author Recognition Test. As a final question subjects were asked what they thought the experiment was about. The experiment took between 60 and 90 minutes to complete, depending on the reading speed of the subjects.

Data analysis

Data exclusion. Data of three subjects were excluded from all analyses because of abnormal reading behavior due to sleepiness (n = 1) or technical malfunctioning (n = 2). Data for one story read by a subject who scored below chance level on the basic comprehension questions for that story was removed from all analyses.

Pre-processing of eye-tracking data. The eye-tracking data was pre-processed using SR Research Eyelink Data Viewer. If fixations diverged too much from the lines of the text, i.e., consistently falling into the interest areas of the next line, a manual drift correction was performed by shifting either all fixations or, in a few extreme cases, the upper or bottom half of the fixations on the page, on the vertical axis. This was done for approximately 19% of the screens. If manual alignment was not possible, individual screens were excluded and treated as missing data by replacing the values with NaN's. In total, 11 screens from five different subjects (< 1% of the total) were rejected based on this criterion. All fixations before a first fixation on any area of interest on the first line of each section were removed to avoid regression artifacts for potential future analyses of regressions. On average, this led to the removal of less than one fixation per subject, per story. Finally, data for the first word on every page (except for the first page, where the first word was the title of the story) was removed from all analyses and treated as missing data to avoid a spill-over effect from the fixation cross that appeared before every new page.

After pre-processing, an area of interest report was generated including the two relevant fixation time measures per word: first fixation duration (i.e., the duration of the first fixation on an area of interest) and gaze duration (i.e., the summation of all the fixations on an area of interest during the first run of reading; see also Van den Hoven et al., 2017). To clean up the data, for all areas of interest first fixation durations and gaze durations < 50 ms or > 1200 ms were replaced by NaN's for all analyses (for a similar approach, see Luke & Henderson, 2016). For first fixation duration, this led to the rejection of on average (per subject) 14.65 or 0.5% of the areas of interest (for which data was available, i.e., excl. NaN's) over all stories (min. = 0, max. = 33). For gaze duration, on average 13.88 or 0.5% of the areas of interest (for which data was available, i.e., excl. NaN's) were rejected per subject over all stories (min. = 0, max. = 29).

Statistical analyses. All statistical analyses were performed in R, implemented in RStudio (version 0.99.486; R Core Team, 2015). For analyses with linear mixed models we made use of the *lme4* package (Bates, Maechler, Bolker & Walker, 2015). Models for the questionnaire data were created by simultaneously adding fixed effects of tense, ART scores and reading habit scores, and random intercepts for subject and story. Separate models for the two eye-tracking measures, first fixation duration and gaze duration, were created by simultaneously adding fixed effects of tense and sensorimotor score, as well as page number, word length and the log transformed lemma frequency of each word (taken from Keuleers, Brysbaert & New, 2010). The latter two were included to improve model fit, based on earlier findings that word length and frequency influence reading times (Juhasz & Rayner, 2003; Rayner & Duffy, 1986). The variables sensorimotor score, word length and log transformed lemma frequency were centered to improve model fit. In addition, both models included random intercepts for story and subject, and by-subject random slopes for sensorimotor score. In all cases, parameters were estimated using maximum likelihood.

To test for statistical significance of effects, Likelihood Ratio Tests were used comparing the models described above to models in which the fixed effect of interest was removed. As there are no clear published guidelines for calculating effect sizes for linear mixed models, we follow Nakagawa and Schielzeth (2013) and report the marginal and conditional R^2 for each full model, that were obtained with the *MuMIn* package (Bartoń, 2018).

Results

Manipulation check

To assess if the manipulation of tense was not perceived as strange language use, paired *t*-tests were run on two questions from the appreciation questionnaire: *I found the language use in the story artificial* and *The story reads easily*. In both cases there was no significant difference between the original, $M = 3.28$ ($SD = 1.38$) and $M = 5.06$ ($SD = 1.67$), respectively, and manipulated, $M = 3.15$ ($SD = 1.28$) and $M = 5.13$ ($SD = 1.42$), respectively, versions of the stories, $t(78) = 0.67$, $p = .51$; $t(78) = –0.36$, $p = .72$.

SWAS

For each subscale of the SWAS questionnaire, an average score per subject was first calculated. Reliability of all subscales was high (Cronbach's alpha > .87; see **Table 3**).

Linear mixed models were fitted to the data for each subscale separately to test for an effect of tense. No main effect of tense was found for the main subscale of interest, mental imagery, $\beta = –0.02$, $SE = 0.11$, $t = –0.17$, $\chi^2(1) = 0.03$, $p = .87$, $R^2_m = 0.04$, $R^2_c = 0.59$, nor for any of the other subscales: attention, $\beta = –0.11$, $SE = 0.17$, $t = –0.70$, $\chi^2(1) = 0.47$, $p = .49$, $R^2_m = 0.14$, $R^2_c = 0.33$, emotional engagement, $\beta = –0.14$, $SE = 0.16$, $t = –0.88$, $\chi^2(1) = 0.76$, $p = .38$, $R^2_m = 0.06$, $R^2_c = 0.33$, and transportation, $\beta = –0.01$, $SE = 0.14$, $t = –0.05$, $\chi^2(1) = 0.002$, $p = .96$, $R^2_m = 0.13$, $R^2_c = 0.52$. The results for the SWAS are also summarized in **Table 4**. In sum, there was no evidence for an effect of tense on self-reported measures of mental simulation or other aspects of story world absorption.

Appreciation

An appreciation scale that was reliable enough to use in the main analysis ($\alpha = .92$) was created by averaging the eight questions from the appreciation questionnaire, as displayed in **Table 5**.

A Likelihood Ratio Test comparing the models with and without tense revealed no main effect of tense, $\beta = –0.10$, $SE = 0.18$, $t = –0.52$, $\chi^2(1) = 0.27$, $p = .60$, $R^2_m = 0.02$, $R^2_c = 0.18$, as was suggested by the small difference in means for the present tense, $M = 4.80$ ($SD = 1.28$), and the past tense, $M = 4.71$ ($SD = 1.27$), stories. In sum, there was no evidence for an effect of tense on story appreciation.

Eye-tracking data

First of all, we analyzed whether mental simulation was reflected in reading times by testing for the main effect of sensorimotor score on the two measures of reading time. Although the descriptives in **Figures 1** and **2** below seem to suggest that subjects slowed down when reading words that received a high score for sensorimotor simulation content, there was no significant main effect of sensorimotor score on either first fixation duration, $\beta = 0.19$, $SE = 0.18$, $t = 1.08$, $\chi^2(1) = 1.13$, $p = .29$, $R^2_m = 0.006$, $R^2_c = 0.07$, or gaze duration, $\beta = 0.23$, $SE = 0.23$, $t = 1.00$, $\chi^2(1) = .97$, $p = .32$, $R^2_m = 0.03$, $R^2_c = 0.08$.

To test for the predicted interaction effect of tense and sensorimotor score on the two measures of reading time, we added the interaction term to the full. Likelihood Ratio Tests showed that the interaction effect was not significant for first fixation duration, $\beta = 0.18$, $SE = 0.28$, $t = 0.64$, $\chi^2(1) = 0.41$, $p = .52$, $R^2_m = 0.006$, $R^2_c = 0.07$, or

Table 5: The appreciation scale derived from the appreciation questionnaire.

Appreciation (α = .92)
How much did you like the story?
I was constantly curious to find out how the story would end.
I enjoyed reading this story.
I would like to read this story again.
I found the story to be well written.
I did not want the story to end.
I would recommend this story to someone else.
This story reads easily.

Table 4: By condition means (SD) for the four subscales of the SWAS.

	Attention	Emotional engagement	Mental imagery	Transportation
Present tense	4.83 (1.22)	3.91 (1.16)	4.55 (1.05)	3.78 (1.30)
Past tense	4.71 (1.35)	3.76 (1.34)	4.53 (1.04)	3.77 (1.24)

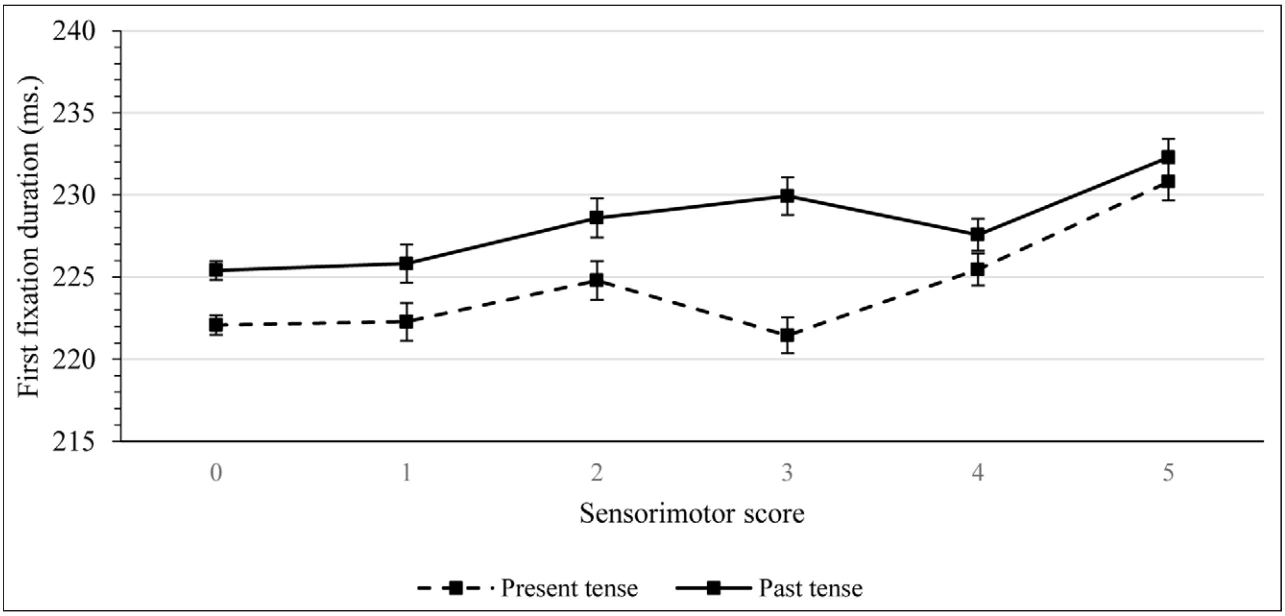

Figure 1: The effect of sensorimotor score and tense on first fixation duration. Error bars denote standard error.

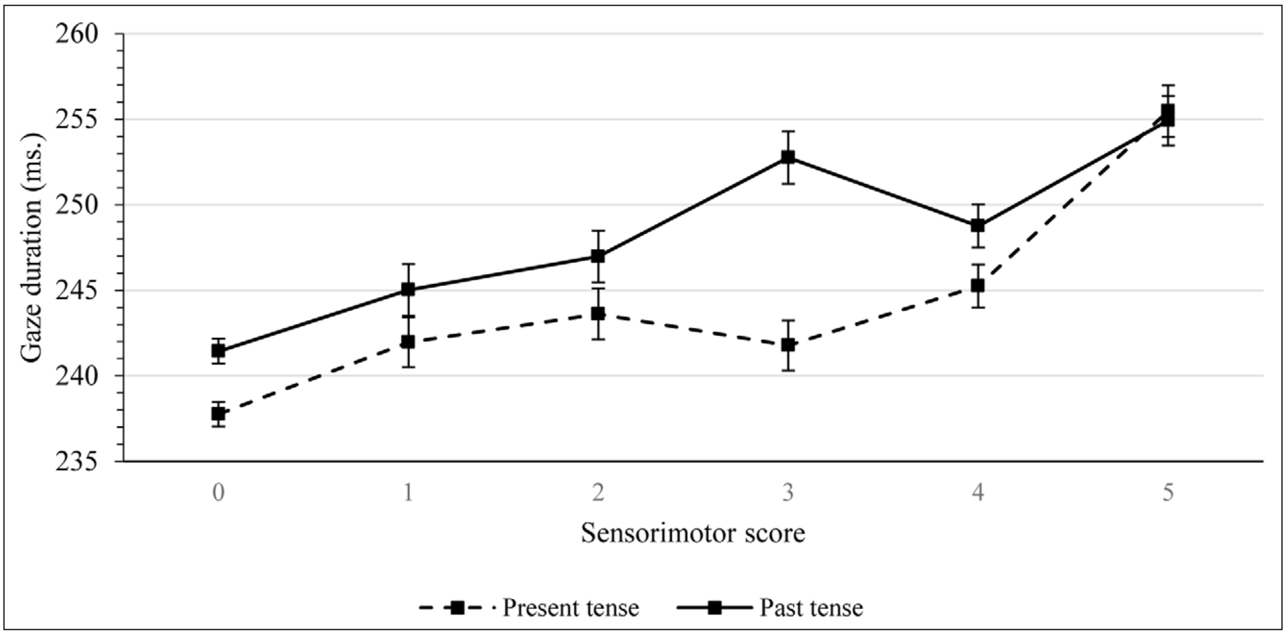

Figure 2: The effect of sensorimotor score and tense on gaze duration. Error bars denote standard error.

gaze duration, β = 0.14, *SE* = 0.35, *t* = 0.39, $\chi^2(1) = 0.15$, $p = .70$, $R^2_m = 0.03$, $R^2_c = 0.08$.

There was a significant main effect of tense on first fixation duration, β = –2.10, *SE* = 0.53, *t* = –3.96, $\chi^2(1) = 15.67$, $p < .0001$, $R^2_m = 0.006$, $R^2_c = 0.07$, and gaze duration, β = –2.10, *SE* = 0.65, *t* = –3.21, $\chi^2(1) = 10.30$, $p = .001$, $R^2_m = 0.03$, $R^2_c = 0.08$, such that reading times were higher in the past tense condition, $M_{\text{first fixation duration}} = 227.43$ (*SD* = 90.98) and $M_{\text{gaze duration}} = 246.36$ (*SD* = 116.41), than in the present tense condition, $M_{\text{first fixation duration}} = 223.83$ (*SD* = 90.25) and $M_{\text{gaze duration}} = 242.44$ (*SD* = 115.45), as is also displayed in **Figures 1** and **2** above.

In sum, we did not find the expected interaction effect of tense and sensorimotor score, nor a main effect of sensorimotor score, but there was a significant main effect of tense, with past tense stories eliciting slower reading.

Combining offline and online measures

Although we did not find a general effect of sensorimotor score on reading times, we wanted to explore whether the degree to which individual subjects' reading times were influenced by sensorimotor score could be linked to any of our offline measures. We ran a linear mixed model on the gaze duration data with fixed effects of tense, sensorimotor score, page number, lemma frequency and word length, random intercepts for story and subject and, crucially, by-subject random slopes for sensorimotor score. This resulted in one coefficient for the effect of sensorimotor score per subject. We extracted these coefficients as an individual measure of the degree to which subjects slowed down when encountering more simulating words (more positive score meaning more slowing down). We then reran linear mixed models with the four subscales of the SWAS and the appreciation questionnaire as dependent variables, with fixed effects of the coefficients, ART and reading habit scores, and random intercepts for subject and story to see whether this slowing down affected any of our offline measures of reading experience.

Likelihood Ratio Tests showed that there was a significant effect of the sensorimotor coefficients on the attention subscale, $\beta = 0.44$, $SE = 0.20$, $t = 2.18$, $\chi^2(1) = 4.50$, $p = 0.03$, $R^2_m = 0.18$, $R^2_c = 0.32$, and the transportation subscale, $\beta = 0.56$, $SE = 0.24$, $t = 2.34$, $\chi^2(1) = 5.14$, $p = 0.02$, $R^2_m = 0.19$, $R^2_c = 0.52$, with subjects who slowed down more when encountering simulating words, reporting higher levels of attention and transportation. There was no effect of the sensorimotor coefficients on the main subscale of interest, mental imagery, $\beta = 0.36$, $SE = 0.23$, $t = 1.61$, $\chi^2(1) = 2.51$, $p = 0.11$, $R^2_m = 0.08$, $R^2_c = 0.59$, the emotional engagement subscale, $\beta = 0.10$, $SE = 0.20$, $t = 0.50$, $\chi^2(1) = 0.25$, $p = 0.62$, $R^2_m = 0.06$, $R^2_c = 0.32$, or appreciation, $\beta = -0.04$, $SE = 0.21$, $t = -0.21$, $\chi^2(1) = 0.04$, $p = 0.83$, $R^2_m = 0.02$, $R^2_c = 0.18$. A similar analysis on the first fixation duration data showed the same pattern.

Hence, despite the fact that we found no main effect of sensorimotor score on reading times, the degree to which subjects slowed down on an individual basis when reading simulation eliciting content was related to attention and transportation, with subjects who slowed down more when reading such passages reporting more attention and transportation.

We used a similar approach to further explore the unexpected main effect of tense, which indicated that readers in general slowed down when reading past tense stories. Specifically, we wondered whether the degree to which subjects slowed down in the past tense stories, could predict the degree to which people reported to experience mental simulation and how much they liked the story.

To explore this idea, we ran a linear mixed model on the gaze duration data with fixed effects of tense, sensorimotor score, page number, word length and lemma frequency, random intercepts for subject and story, and, crucially, by-subject random slopes for the effect of tense. This resulted in one coefficient for the effect of tense on gaze duration, per subject. We used the coefficients of these random slopes as individual measures of the degree to which subjects slowed down in the past tense stories or not (more negative scores meaning more slowing down). We then reran the linear mixed models on the four subscales of the SWAS and the appreciation questionnaire with fixed effects of the coefficients, ART and reading habit scores, and random intercepts for subject and story.

Likelihood Ratio Tests indicated that there was no significant effect of the tense coefficients on the main subscale of interest, mental imagery, $\beta = 0.01$, $SE = 0.02$, $t = 0.71$, $\chi^2(1) = 0.50$, $p = .48$, $R^2_m = 0.05$, $R^2_c = 0.59$, or any of the other SWAS subscales: attention, $\beta = -0.01$, $SE = 0.02$, $t = -0.68$, $\chi^2(1) = 0.45$, $p = .50$, $R^2_m = 0.15$, $R^2_c = 0.32$, emotional engagement, $\beta = -0.003$, $SE = 0.02$, $t = -0.19$, $\chi^2(1) = 0.03$, $p = .85$, $R^2_m = 0.06$, $R^2_c = 0.32$, and transportation, $\beta = -0.004$, $SE = 0.02$, $t = -0.18$, $\chi^2(1) = 0.03$, $p = 0.86$, $R^2_m = 0.13$, $R^2_c = 0.52$. Nor was there a significant effect on appreciation, $\beta = -0.002$, $SE = 0.02$, $t = -0.12$, $\chi^2(1) = 0.02$, $p = .90$, $R^2_m = 0.02$, $R^2_c = 0.18$. A similar analysis on the first fixation duration data showed no significant effects either. Hence, the degree to which readers slowed down in the past tense stories could not be linked to our offline measures of mental simulation and appreciation.

Discussion

The current study aimed to test the hypothesis that stories written in the present tense are more "vivid" than stories written in the past tense. Specifically, we addressed the question whether literary stories in the present tense elicit more mental simulation in readers than stories in the past tense, by measuring on- and offline responses.

Contrary to our expectations, we found no effect of tense on any of our offline measures. Readers did not report increased levels of mental simulation, general transportation or appreciation after reading present tense stories compared to reading past tense stories. Eye-tracking data showed a slightly more complex pattern. First of all, we did not find a significant main effect of sensorimotor score on reading times. Hence, in general, we were unable to match reading time behavior to mental simulation. Second, and contrary to our expectations we also found no significant interaction between sensorimotor score and tense. However, we were able to link the degree to which subjects slowed down when reading simulation eliciting content to offline measures of attention and transportation, showing that those readers who slowed down more when they read simulation eliciting content, reported more attention and transportation afterwards.

We found that in general subjects read more slowly in past tense stories. This finding is not only surprising because no effect of tense was found for the offline measures, the direction of the effect also contradicts our predictions, as we expected increased reading times in the present tense stories as an indication of increased mental simulation. In an explorative analysis, we were unable to match the degree to which subjects slowed down in past tense stories to any of the offline measures of mental simulation and appreciation, and we refrain from functionally interpreting these increased reading times as signs of increased mental simulation, transportation or appreciation.

In sum, this study provides evidence against the "present more vivid" hypothesis. Stories in the present tense do not elicit more mental simulation than stories in the past tense. This result is not only at odds with earlier claims from the field of literary studies, but also with two previous studies showing an effect of tense on simulation (Macrae, 2016) and mental models (Carreiras et al., 1997). This discrepancy might be explained by the materials used in these studies. Carreiras and colleagues (1997) used short descriptions containing five sentences written in either the past or present tense and found that subjects recognized information from the present tense description faster, suggesting that information read in the present tense is somehow represented in a richer or more salient fashion in the mental model. In the Macrae (2016) study the stimuli were also relatively short (approx. 250 words) and had been manipulated to allow for maximum experimental control: possible alienating effects were deleted, and the stories mostly focused on scenic descriptions and the main protagonist's movement through a landscape. It might be argued that tense plays a different role in such short, decontextualized linguistic stimuli. The meaning or characteristics of a specific tense might be simplified and enlarged, with the past tense clearly representing a rounded off event or process, and the present representing an ongoing, relevant event or process. Literary stories, however, are characterized by contextualized, rich and stylistic language use. In such stories, other textual characteristics such as perspective (e.g., Hartung et al. 2016) or the presence of metaphors (e.g., Bergen, 2005) are at play and might also influence mental simulation. Although the design of our experiment rules out the possibility that these textual characteristics acted as confounding factors, the meaning of tenses might be more subtle and thus backgrounded in the light of the complexity of these other textual characteristics, explaining why readers were found to be insensitive to tense in this study.

A limitation of our study is that our analysis is solely focused on sensorimotor simulation. It is possible that tense influences reading times of other aspects of reader experience such as mentalizing (e.g., Jacobs, 2015; Jacobs & Willems, 2017; Nijhof and Willems, 2015). Moreover, sensory and motor simulation might be reflected differently in eye-tracking data (see Mak & Willems, submitted). Distinguishing between these different kinds of simulation that occur during reading might thus be an interesting direction for future research (see Mak & Willem, submitted, for this approach). However, it should be noted that we did not observe an effect of tense in any of the story world absorption subscales. A more viable explanation for the fact that we did not find an effect of tense is that readers employ a default processing strategy as far as mental simulation is concerned. Hartung and colleagues (2017) similarly found that perspective-taking during mental simulation depended more on individual preferences than on the pronouns used in stories to refer to the main protagonist.

In this respect, future research might benefit from taking individual differences between readers into account, such as vividness of imagery (Marks, 1995), need for cognition (Cacioppo & Petty, 1982) or need for affect (Maio & Esses, 2001). Here, we only took general reading habits and print exposure into account, but perhaps a more fine-tuned measure of readings habits could tap into the difference between readers who are more familiar with past tense stories through exposure to popular fiction, and readers who are also familiar with present tense, which is used more frequently in literary stories.

To conclude, this study found no evidence that tense (present vs. past) plays a substantial role in the mental simulation elicited by literary stories. This does not mean that authors cannot use tense as one of the many factors that can contribute to a good story. However, the relationship between the tense of a story on the one hand and mental simulation, transportation and appreciation on the other hand might not be as clear cut as we expected.

Data Accessibility Statements

The pre-registration, materials, subject data and analysis scripts of all experiments can be found on the Open Science Framework (osf.io/qynhu). The final project deviated from the pre-registration in the following respects: hypothesis 3 and 4 were disregarded as their predictions were confounded with an effect of story. The findings for hypothesis 5 will be discussed elsewhere. The proposed Bayesian analysis has been reported in the unpublished master thesis of the first author. We decided to report linear mixed models here as they are more suitable and precise for analyzing eye-tracking data. This also allowed us to use sensorimotor scores per words as a continuous variable (0–5), rather than a binary variable (0 vs. 1).

Notes

[1] Excerpt taken from stimulus story A ('Het is muis') by Sanneke van Hassel (2012).

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Competing Interests

The authors have no competing interests to declare.

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- Contributed to conception and design: LE, RW, AE
- Contributed to acquisition of data: LE
- Contributed to analysis of data: LE, RW
- Contributed to interpretation of data: LE, RW, AE
- Drafted and/or revised the article: LE, RW, AE
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