**Computer Games versus Maps before Reading Stories: Priming Readers’ Spatial Situation Models**

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**ABSTRACT**

The current study investigated how computer games and maps compare as preparation for readers to comprehend and retain spatial relations in text narratives. Readers create situation models of five dimensions: spatial, temporal, causal, goal, and protagonist (Zwaan, Langston, & Graesser 1995). Of these five, readers mentally model the spatial dimension least well (Rinck, 2005). Studying maps before reading improves retention of general details from non-narrative readings (Kulhavy & Stock, 1996). The current study investigated how playing interactive computer games compared with studying a computer-based map as a preparation for reading a narrative. The dependent variables were: 1) evidence of monitoring spatial relations while reading stories, and 2) comprehension and retention of spatial relations in stories. Evidence of monitoring of the spatial relations was measured by average times, in milliseconds, for reading individual sentences with changes in protagonist location. Comprehension and retention of spatial relations in stories were measured by multiple-choice posttests of spatial relations in the stories. Eighty 11-year-olds participated in all three experimental conditions: 1) studying a map with sound and animations but no interaction, 2) playing an interactive computer game, and 3) completing a filler task. Each condition was followed by reading a narrative and then taking a spatial posttest. In terms of multiple-choice posttests, map condition had the highest average number correct, closely followed by the computer game. Filler task condition was a distant third. No between-condition differences were found for the reading times on sentences with changes in protagonist location. Results suggest that maps may be superior to computers games as preparation for spatial reading.

**Keywords**  
Reading comprehension, Situation models, Computer games, Maps, Spatial

**Introduction**

Video games have become ubiquitous in contemporary adolescent culture. Perhaps unaware that they are doing so, children playing video games are learning skills that can be transferred into practical learning situations. For example, computer-game play can improve spatial skills such as spatial orientation, mental rotation, and spatial visualization (Larish & Andersen, 1995; Okagaki & Frensch, 1994; Greenfield, 1994); develop attention- dividing strategies (Greenfield, deWinstanley, Kilpatrick, & Kaye, 1994); improve spatial integration skills (Greenfield, 1993); and improve understanding of iconic languages (Greenfield, Camaioni et al., 1994). While building spatial visualization can aid gamers in computer-game play, those skills may also aid students in improving reading comprehension.

Comprehension of a text is not only parsing of words and sentences, but is also constructing a situation model of the story (Zwaan, Radvansky, Hilliard, & Curiel 1998). Reading is quite complex; readers must create and update the situation model along five dimensions: temporal, spatial, protagonist, causal, and intentional (Zwann et al., 1995). The spatial dimension is typically hardest for readers (Hakala, 1999; O’Brien & Albrecht, 1992). Yet spatial understanding is crucial to a host of disciplines (Casey, Nuttall, Pezaris, & Benbow, 1995; Humphreys, Lubinski, & Yao, 1993; Pribyl & Bodner, 1987). Evaluating the relative strengths of priming activities designed to stimulate the creation of the situation model prior to reading is an important area for empirical study as it can inform design of multimedia materials for education.

Readers who study a map prior to reading have better retention of material than readers who study the map after reading (Kulhavy & Stock, 1996). This may be the result of priming the spatial dimension of the reader’s situation model prior to reading. For example, icons on the map activate both visuospatial and semantic networks that facilitate comprehension of spatial sentences in the text. It could be that some of the hand-eye activities of computer-game interaction (if they involve maps or other visuospatial stimuli) might initiate an even greater priming of the readers’ spatial situation models, as computer-game interaction involves both visual and kinesthetic encoding.
Understanding how readers create spatial mental models is essential for instructional designers. It is also an important design factor for new interactive book technologies, such as the interactive map-book (patent pending), which combines hardcopy books with paper-based computer games (via pen-top computers such as LeapFrog’s FlyPen and microdot paper) in such a way that readers must complete the paper-based computer games to read further (Smith, 2008). The purpose of this study is to explore to what extent adding interactivity to the reading experience will improve the reader’s ability to form their spatial situation models.

Literature review

One of the fundamental abilities that education attempts to impart to students is the ability to read, and yet many children leave the school systems with only a basic level of reading (Biancarosa & Snow, 2004; Strommen & Mates, 2004). Apparently in the United States, reading instruction does not result in students’ acquisition of high-level comprehension (Biancarosa & Snow, 2004; RAND Education, 2005). According to Leonhardt (1998), “The sophisticated skills demanded by high-level academic or professional work—the ability to understand multiple plots or complex issues, a sensitivity to tone, the expertise to know immediately what is crucial to a text and what can be skimmed—can be acquired only through years of avid reading” (p. 29). The ability to read skillfully remains important in the digital age. Although multimedia abounds on the Internet, much of the information available in the digital age is still textual. Krashen (1993) argues that while free voluntary reading (FVR) is not sufficient for higher-level reading skills, developing these skills without FVR is impossible. Krashen also suggests that when children get “hooked on books” that “they acquire, involuntarily . . . nearly all of the . . . language skills many people are so concerned about” (p. 124). Unfortunately, the steady decline in reading among adolescents (National Endowment for the Arts, 2007) combined with the decline of reading comprehension has resulted in a culture of students who never become “hooked on books” (Krashen, 1993, p. 124) and are losing the ability to understand what they have read.

According to the most empirically supported theoretical model, readers process text at three levels: the surface code, textbase, and situation model (van Dijk & Kintsch, 1983; Graesser, Mills & Zwaan, 1997). The surface code is the verbatim wording of the text. The textbase is the propositional structure of the text. The situation model is the “cognitive representation of the events, actions, persons, and in general the situation, [i.e., what] a text is about” (van Dijk & Kintsch, 1983, p. 11–12). Zwaan, Langston, and Graesser (1995) proposed the event-indexing model, the currently accepted theoretical model of how readers create and update an internal mental model from a text narrative. This event-indexing model suggests that as people comprehend a text narrative, they relate successive events in the story to their internal situation model comprised of five dimensions: spatial (where events occur), temporal (when events occur), causal (how events cause changes in the flow of the story), protagonist (the main character), and intention (character goals). When events in the story suggest discontinuities in these dimensions, such as a change of location, a flash forward or back in time, entrance or exit of a character, etc., the reader updates the state of their internal situation model of the story. Of the five dimensions of the situation model, the spatial dimension is the least well formed. Hakala (1999) performed experiments using both naming and reading times that demonstrated readers had access to spatial information when instructed to focus on spatial details, but not when asked to read for comprehension. O’Brien and Albrecht (1992) showed that subjects were not aware of contradictions in statements about spatial information unless they were instructed to read from the perspective of the protagonist. Wilson, Rinck, McNamara, Bower, & Morrow (1993) performed a series of experiments that indicated that subjects were aware of the physical layout of a narrative only in a general way, even if the subjects learned the physical layout before reading the narrative.

Given the importance of situation models for learning from a text, enhancements to text presentation that potentially improve situation models (and comprehension) are important. In the case of the spatial situation model, this may be particularly true in subject areas that rely on spatial abilities, such as geometry (Battista, 1990), other higher forms of mathematics (Battista, 1990), chemistry (Pribyl & Bodner, 1987), and academic areas that use maps such as geography, social studies, and history.

A number of enhancements provided to learners, prior to reading expository texts, provide preparation for learning. Advance organizers, which provide learners with a contextual overview or “advance introduction of relevant subsuming concepts” (Ausubel, 1960, p. 267), improve retention (Ausubel, 1960). However, theoretical explanations for this effect vary. Ausubel (1960) suggested that advance organizers help learners build hierarchical cognitive structures surrounding the content. Mayer (1979) suggested that advance organizers help learners assimilate new
knowledge with relevant prior knowledge. Alternatively, advance organizers may be part of an orientation phase to student learning, gaining the student’s attention and providing them with an agenda to internalize, a precursor to effective learning within the zone of proximal development (Haenen, 2001; Vygotsky, 1987). Visual representations, or graphic organizers, may be quicker to absorb and thus better for learning than text-based advance organizers (Robinson & Kiewra, 1995).

However, for highly spatial reading, the subject of the current investigation, maps are a more commonplace visual reading enhancement that has been used traditionally for narrative non-fiction as well as for narrative fiction. Kulhavy proposed the co-joint retention theory based on the idea that the text and map are processed by different memory systems, semantic and visuospatial, and that the image of the map, stored in long-term memory, can be searched with relatively low overhead. Thus, the map with text supplies two types of cues, semantic and visuospatial, for recall of propositions from the text (Verdi & Kulhavy, 2002). Kulhavy’s theory also predicts that the ordering of the map-text presentation influences effectiveness. The superiority of map before text (versus text before map) ordering has been demonstrated experimentally (Kulhavy & Stock 1996; Verdi & Johnson, 1997). However, the informational texts used in these experiments were not true narratives, since the sentences could be reordered in virtually any way without loss of meaning. The current research focuses more on true narratives and the spatial dimension of readers’ situation models.

Another body of research suggests that spatial skills may be improved by interactivity. Larish and Andersen (1995) used a pilot-copilot experimental setup in a flight simulator to demonstrate that interactivity improved sensitivity to changes in spatial orientation. Other researchers have shown that interactivity improved recognition of objects (Harman, Humphrey, & Goodale, 1999), driving awareness (Gugerty, 1997), learning anatomy (Garg, Norman, & Sperotable, 2002), polygonal puzzle solving (Smith, 2001), and spatial priming (Smith & Olkun, 2005). Interactive computer games such as Tetris can improve mental rotation and spatial visualization skills (Okagaki & Frensch, 1994).

There is also evidence that reading concrete sentences involves resonant activation of motor systems and, conversely, that manual manipulations can tap into this motor resonance to facilitate language processing (Fischer & Zwaan, 2008). Hand positions and small hand interactions can prime syntactic parsing during reading (Zwaan, & Taylor, 2006). People holding their fingers open, as if to grasp a small object, judged the sensibility (versus “nonsensicality”) of word pairs such as “squeeze-tomato” or “squeeze-milk” more quickly than did people not holding their fingers open (Klatzky, Pelligrino, & McCloskey, 1989).

In an “action-sentence compatibility effect,” subjects answering yes or no questions about whether short sentences made sense (“open the drawer” versus “boil the air”) responded faster when the direction of finger movement on the “yes” or “no” buttons (either towards or away from their body) was consistent with the direction of the movement in the sentences, either towards or away (“Andy delivered the pizza to you/You delivered the pizza to Andy”) (Glenberg & Kashak, 2002). The same action-sentence compatibility effect also worked with relatively more abstract sentences (“Liz told you the story/You told Liz the story”). These results support the indexical hypothesis, consistent with situation model theory, that words and phrases are indexed to perceptual symbols, based on brain states similar to the perception of the referenced objects.

Given that maps before text improve recall of propositions (Kulhavy, Stock, Peterson, Pridemore, & Klein, 1992), that interactive computer games can improve spatial skills (Okagaki & Frensch, 1994), and that motor processes and reading are interconnected (Fischer & Zwaan, 2008), it is logical to ask how playing computer games and studying maps (both before reading a text narrative) compare in terms of priming readers’ spatial situation models and subsequent retention of spatial details from stories. To begin this investigation it is necessary to define what is meant by a game. The Educational Games Commons of Penn State University (2007) provides a thorough review of the literature on the definition of a game. The authors adopt their definition of a game as a voluntary rule-based activity that motivates the player to achieve a goal state via conflict.

The authors hypothesize that either playing a computer game or viewing a static map before reading a text narrative will improve spatial comprehension compared to reading a text with no visuospatial assistance. Given the power of interactivity to motivate, as well as an affordance (Gibson, 1979), the authors also hypothesize that computer games may be more effective in boosting situation models than static maps. However, unlike static maps, computer games
involve more overhead for players to learn the structure of the game and involve more challenging design factors that potentially mediate their effectiveness for improving readers’ situation models.

**Research question**

The current study investigated the following research question, which revolved around the impact of computer-style interaction on readers’ spatial situation models as they read text narratives. How do playing an interactive computer game, viewing a static map (with animations and audio added), doing a non-related activity compare as preparation for reading a text narrative in terms of the reader’s comprehension and retention of spatial relations in a story?

**Independent variables**

The main independent variable was the presence or absence of computer-game play interaction as preparation for reading text narratives. The three values of the independent variable investigated were interaction with map, no interaction with map, and no map as preparation for reading a story.

**Dependent variables**

A spatial discontinuity in a text narrative is defined as when “the incoming event occurs in a spatial setting that is different from the prior event” (Graesser, Millis, & Zwaan, 1997, p. 179). This change of spatial setting may be signaled by a transitional phrase, such as “We moved to the living room,” or may be implicit through naming or describing a new location in the context of describing an event. As long as the before and after locations are discretely different, they may be adjacent, close, or distant. The change in spatial setting may be via character movement or change in narrator focus (“Meanwhile back at the ranch . . .”). Current authors operationally assume that any change to another spatial location referred to by a short location noun phrase, for example, dining room or living room, is a change of location in a spatial discontinuity sentence.

Typically, readers not comprehending the spatial relations in a story are not expending the extra cognitive effort needed to monitor the spatial situation in a story (Rinck, 2005). All other things being equal, readers monitoring spatial situations in a narrative will expend more cognitive effort, and thus time, reading spatial discontinuity sentences than readers not monitoring the spatial situations (Zwaan, Langston, & Graesser, 1995). One dependent variable, time reading spatial discontinuity sentences, is operationally defined as the average time a reader spends reading sentences containing spatial discontinuities.

If readers monitor the spatial situation in a story, they should, after reading, have better retention of the spatial relations in the story. The second dependent variable, retention, is operationally defined as the persistence in memory of visuospatial or verbal information, facts, behavior, or experiences after an interval has elapsed in which there has been no related performance, practice, or reinforcement. Retention will be operationally measured through recognition, when a person is presented with the correct answer as one choice of available answers on a multiple-choice test.

**Method/data sources**

**Participants**

Eighty-three fifth-grade students (average age 11.5), 43 males and 40 females, participated in the study. The participants attended an average-sized public elementary school in Florida. The school had a diverse enrollment, comprised of nearly 20% minority students. Additionally, 20% of the students were considered economically disadvantaged.
Materials

Three text narratives were developed by the lead author and were calibrated so that each story was comparable with the other stories in terms of length (average of 1,123 words), complexity of the spatial settings, numbers of objects, number of characters, and movements of characters. In each story, a protagonist was faced with a suspenseful situation that required moving around a limited spatial area of five rooms, described in detail as the setting of the story (see Figure 1).

![Figure 1. The maps of the three stories used in the posttests](image)

Protagonist movement from one room to another was described in sentences of 20 syllables each. This was done because one of the dependent variables was time spent reading spatial discontinuity sentences, and a major factor in time spent reading any sentence is the number of syllables. As mentioned earlier, readers monitoring the spatial situation tend to take longer reading spatial discontinuity sentences, as they need time not only to read the sentence, but also to update their spatial model of the story.

Before reading, the participants were exposed to one of three separate conditions: a) computer game, b) map with animations and sound, but no interactions, or c) non-related filler activity. It was intended that the computer game and map conditions would foster the mental modeling of the space subsequently described in the story.

The maps were designed using a graphic software application, and the described animations and interactions were added with The Games Factory, a game-development authoring system (http://www.clickteam.com/eng/tgf2.php). Before viewing the map, participants were told they would view a map. The map itself was labeled “map,” which encouraged a map-viewing mindset that changes how people visually process a graphic (Kealy & Webb, 1995).

The computer games used in the treatment were created with a game-authoring system, The Games Factory. Each game displayed a full-screen map of the location described in the associated story. Screenshots of the three games are included below in Figure 2. The player controlled an animated virtual character that started in the middle of the map. The player was tasked with retrieving objects from each of the five rooms in a particular order and in a limited amount of time, receiving points based on their performance. Each room’s function was identified by one or more icons, for example, table and chairs identified the snack room. The object to be retrieved in each room was visible only when the onscreen character was in that room. Therefore, to retrieve a particular object, participants had to deduce, by the room’s icons, which room to go to. For example, a drink might be found in the snack room, identified by its table and chairs. To acknowledge a correct move, a short audio sounded when an object was retrieved. If the objects were retrieved out of order, an appropriate sound played and the participant was required to restart the game. There were two levels to complete in 90 seconds, each level having a unique set of items. The activity qualifies as a game under the working definition of a game, voluntary rule-based activity that motivates the player to achieve a goal state via conflict (Educational Games Commons of Penn State University, 2007), because the activity has rules, a goal state, and sets up conflict (time, order, obstacles). The computers games also had design features such as challenge, performance feedback, and fantasy, which players found motivating (Malone, 1981). Before playing, participants were notified that they would play a computer game, establishing a mindset of playing a computer game.

In the map treatment, the game was replicated as closely as possible, omitting only the game-play interaction of moving the character around the space, retrieving objects, etc. The identical graphic appeared on the participants’ screen, and periodically throughout 90 seconds, the same objects from the game appeared in the same rooms as in the game, and the same sound played simultaneously. The objects and sounds appeared and played in the same order of
the task list in the game. A short amount of time, 90 seconds, was used to minimize boredom while viewing the static map. It was necessary to mirror that time in the game treatment to control that variable.

![Figure 2. Screenshots from the three computer games](image)

The elementary school provided the use of its computer lab where the participants took part in the experiment. The interactive games, maps, stories (which were read sentence by sentence on the computer), and the posttests were all hosted on web pages. Data from these are sent to a database on the server.

**Procedure**

Participants took part in three experiments during a 45-minute session in a school lab. Each experiment consisted of receiving a treatment, reading a story, and then taking a posttest of multiple-choice questions about locations of events and locations of objects in the stories. Figure 3 shows a time line for each experiment.

![Figure 3. Experiment timeline](image)

During each experiment, participants received one of three types of treatments: playing an interactive computer game based on a map of the story setting, such as an interactive map (IM), before reading a text; viewing a static map (SM) with animation and sound before reading a text; or engaging in an unrelated filler task with no visual map before reading a text, or no map (NM). The study employed a within-subject design over three experiments. All participants received all three experimental treatments and read the same three text narratives.

The participants were randomly assigned to one of three groups, and the groups received the treatments as per the schedule shown in Table 1. The experiment was counterbalanced in terms of treatment condition, narrative, and the order of reading the narratives to minimize the effect of order and having taken previous posttests. Groups receiving the no map (NM) treatment were given a filler task (viewing a series of cartoons) before reading the text. Participants were given 90 seconds to play the computer game, 90 seconds to view the map, and 90 seconds to view the cartoons.

<table>
<thead>
<tr>
<th>Table 1. Group treatment schedule</th>
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<tr>
<td><strong>Session 1</strong></td>
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<td>Group 1</td>
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<td>Group 2</td>
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<td>Group 3</td>
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The posttest consisted of ten multiple-choice spatial questions related to the locations of characters and events in the story setting. Each multiple-choice question had five possible answers, and included a map of the story setting.
without the room names. The following is a typical posttest question, which was accompanied by the leftmost map in Figure 1:

“At the end of the zoo keeper story, which room was Rolf in? A) north-west B) north-east C) center D) south-west E) south-east”

Each participant received all three treatments over the course of three experiments during one 45-minute class period. The investigators also closely observed all participants during the course of the experiment, taking notes about any behavior that might affect the experiment. Close to the end of the 45-minute session, participants took part in a focus group where they discussed relative effectiveness of the three treatment conditions and other aspects of the experimental design.

Results

Significant between-condition differences were found for the multiple-choice posttest of retention of the spatial relations in the story. However, no between-condition differences were found for the reading times on the spatial discontinuity sentences.

The average times for reading spatial discontinuity sentences by the three conditions are shown in Table 2. There were no significant differences between the conditions. A one-way within-subjects (repeated measures) ANOVA comparing average times reading spatial discontinuity sentences revealed no significant differences between the treatment conditions, $F(2, 70) = .129$, $p < .879$. Contrary to investigator expectations, participants in the computer-game condition read the spatial discontinuity sentences the fastest, followed by those in the map condition and then in the control condition. However, these differences were not significant.

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
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<tbody>
<tr>
<td>Computer Game</td>
<td>4839</td>
<td>2073</td>
<td>80</td>
</tr>
<tr>
<td>Control</td>
<td>4988</td>
<td>2714</td>
<td>80</td>
</tr>
<tr>
<td>Map</td>
<td>4918</td>
<td>2184</td>
<td>80</td>
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Table 3 shows the fraction correct on the posttest across all three sessions. Note that with five possible answers to each multiple-choice question, the fraction correct for both computer game and map treatment are well above what would be expected from random guessing. The map condition had the highest average number correct, followed by the computer game, then by the control condition. All of these differences were significant.

<table>
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<th>Treatment Condition</th>
<th>Mean</th>
<th>Std. Deviation</th>
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<tbody>
<tr>
<td>Computer game</td>
<td>.380</td>
<td>.245</td>
<td>80</td>
</tr>
<tr>
<td>Control</td>
<td>.263</td>
<td>.2</td>
<td>80</td>
</tr>
<tr>
<td>Map</td>
<td>.471</td>
<td>.268</td>
<td>80</td>
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</table>

A one-way within-subject (repeated measures) ANOVA comparing effects of treatments (computer game then read; map then read; and filler task then read) on multiple-choice, spatial posttest revealed significant differences, $F(2, 79) = 19.7$, $p < 0.0001$. Based on the pair-wise hypotheses, that is, that computer games would be superior to control condition, that maps would be superior to control condition, and that computer games would be superior to map condition, some pair-wise a priori comparisons were made. An a priori comparison between the map condition and the control condition (dependent-samples paired $t$-test) was significant, $t(1, 79) = 6.4, p < 0.0001$ (two-tailed), $d = .9$. A similar comparison between the computer-game condition and the control condition was also significant, $t(1, 80) = 3.9, p < 0.0001$ (two-tailed), $d = .5$. A third comparison between the computer-game and map conditions was also significant, $t(1, 79) = 2.3, p < 0.023$ (two-tailed), $d = .3$.

Despite counter-balancing of conditions across the three sessions, investigators wanted to further eliminate possible effects that the posttests might have on participants reading behaviors in subsequent sessions. In other words, the posttest in the first session probably influenced how participants read the stories in the second and third sessions. To
provide an analysis without the effects of prior posttests, investigators analyzed the first session results by themselves. The times for reading the spatial discontinuity sentences again produced no significant differences. However, the first session results for the multiple-choice spatial posttest did produce significant differences. Table 4 shows the fraction correct on the posttest for session one. A one-way between groups ANOVA for the fraction correct on the first session multiple-choice spatial posttest was significant, $F(2, 79) = 7.28, p < 0.001$. An a priori comparison between the map condition and the control condition, for the first session one multiple-choice posttest, (independent-sample t-test) was also significant, $t(1, 53) = 3.66, p < 0.001$ (two-tailed), $d = 1.0$. A similar comparison (of session one multiple-choice posttests) between the computer-game condition and the control condition was also significant, $t(1, 52) = 2.62, p < 0.01$ (two-tailed), $d = .7$. However, the third comparison between the computer-game and map conditions, for session one multiple-choice posttest, was not significant, $t(1, 53) = 1.46, p < 0.15$. So for the first session multiple-choice posttests, the map group did significantly better than the control group, the computer-game group did significantly better than the control group, but there was no significant difference between the map group and the computer-game group. These results from the first session are largely consistent with results across all three sessions, suggesting that the effect of posttests on reading behaviors in subsequent sessions was negligible.

<table>
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<tr>
<th>Treatment condition</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer game</td>
<td>.374</td>
<td>.218</td>
<td>27</td>
</tr>
<tr>
<td>Control</td>
<td>.230</td>
<td>.186</td>
<td>27</td>
</tr>
<tr>
<td>Map</td>
<td>.479</td>
<td>.306</td>
<td>28</td>
</tr>
</tbody>
</table>

Investigator observations during the experiment revealed that for the computer-game treatment, the time limit of 90 seconds provided insufficient time for some participants to both learn the game and then play it. In the judgment of the investigators, more time than 90 seconds was needed to obtain a full effect from playing the computer game. The participant comments during the focus group confirmed that the time was too short for the computer-game play. Nevertheless, participants expressed much more eagerness to play the computer games than to view the maps.

**Discussion**

There were two main outcomes for this experiment. First, there were no between-condition differences for times reading the spatial discontinuity sentences. Second, there were significant between-condition differences for the multiple-choice posttest on spatial relations from the story. The map condition had the highest average number correct, followed by computer-game condition. The filler condition was a distant third.

Despite no significant between-condition differences on the times for reading spatial discontinuity sentences, there were significant differences in the multiple-choice posttest, suggesting between-condition differences in retention of spatial details in the story. Based on the prevalent views from research, one might have expected readers in the game and map conditions to take longer reading spatial discontinuity sentences because, in addition to reading, they were expending cognitive effort to update their spatial situation models, while readers in the text-only condition might not monitor the spatial situation, and might therefore not spend time updating a spatial mental model. However, the sense of urgency created by the 90-second time limits for playing/viewing games/maps may have caused readers in the map and computer-game conditions to update their spatial situation models quickly. This seems plausible considering the instantaneous decisions computer-game players often make. Further, in mental rotation tests, time pressure is a prerequisite to encourage people to actually visualize shapes rotating (Lohman, 1979). Without time limits, some subjects may employ analytic strategies that circumvent the intent of the test designers to make people mentally rotate (Hegarty, 2009; Lohman, 1979). So, in the current study, the time pressure in the map and computer-game conditions may actually have encouraged subjects to visualize the story setting. On the other hand, the 90-second time limit for both learning and playing the computer game may have favored the map condition, which, in contrast to the computer game, did not require time to figure out the structure of the game.

Retention of spatial details from the story was significantly greater for both the computer-game and map conditions than for the control condition (medium to large effect sizes), yet the map condition was generally better than the computer-game condition (except in session one). This finding is consistent with the map and (non-narrative expositional) text experiments of Kulhavy and Stock (1996). However, investigators observed during the experiment,
and fifth graders commented during the focus group, that 90 seconds was not enough time to learn the computer game and then complete the level, indicating that imposed time limits on game play affected the ability of the participants to effectively engage in the interaction. Further, the sounds and animations included in the map condition offered visual interactions to the participants, who were engaged with the graphic without having to learn the rules of a game. These visual interactions set the map condition apart from traditional static maps, which fail to offer incentives for viewing. In the final analysis, the current results suggest that both maps and computer games can be used to improve spatial understanding of a text narrative. However, with a limited amount of time to learn a game and short narratives (approximately 1,000 words), maps, with their lower overhead, may be superior to computer games in priming readers for spatial understanding of a narrative.

In terms of implications for practice, for computer-based reading of short narratives, both maps and computer games may be effective preparation for comprehending and retaining spatial relations in text. The animation and sound added to the static maps in the current study might help students view maps longer. Computers games, although more appealing, require more design and more overhead for students to learn the game play.

Further research

Since the current study sought to isolate interaction as a variable, the “map” condition was unlike a traditional map in that it included sound and animation. A good follow-up study would be to compare a more traditional-style map, with no sound and animation, to a computer game, to observe the effects of each format on readers’ situation models. Further, the projected follow-up study will have participants learn a similar computer warm-up game prior to the experiment proper, so that no time is spent learning the computer game during the experiment. Longer time limits could be used to minimize any sense of urgency that might potentially carry over into reading the story. Alternatively, a similar experiment with no time limits might reveal the implicit effects of maps and computer games on reading.

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