Spatial Encoding and Referential Processing during Reading

Thierry Baccino¹ and Joel Pynte²
¹University of Nice Sophia-Antipolis, ²CREPCO-CNRS, Aix-en-Provence, France

The aim of this paper is to clarify the role played by referential factors in the development of a spatial code during reading. Specifically, it explores whether this spatial encoding is determined by referential events related to a change in narrative mode which affect the integration process. Participants read narrative texts consisting of two paragraphs in which the point of view either changed or remained the same. The display mode was also manipulated (spatialized versus nonspatialized presentation). The results of experiment 1 (reading task) indicated that readers take more time to read text containing a change in point of view. Using a new methodology to assess spatial memory, experiments 2 (visual-search pointing task) and 3 (memory-search pointing task) showed that subjects are faster and more accurate at locating text areas where such perspective shifts occurred. It is proposed that spatial encoding is a strategic process optimizing potentials by backtracking to important parts of a text in order to solve referential difficulties occurring later in the text.

Keywords: Reading, spatial encoding, referential events.

Introduction

The idea that a spatial encoding process is at work during reading was proposed quite some time ago in a number of studies showing that after reading readers are capable of stating where on a page (e. g., top left) the answer to a given question (rough location of a word or group of words) is located (Christie & Just, 1976; Rothkopf, 1971; Zeichmeister & McKillip, 1972; Zeichmeister, McKillip, Pasko, & Bespalec, 1975). Later studies based on an analysis of eye behavior furthered our understanding of this spatial encoding process by showing that it serves as a guide to backwards saccades, which are sometimes used to resolve linguistic difficulties. When a syntactic or referential difficulty is encountered in a sentence, the eye is capable of backtracking via a single large saccade to the exact area in the sentence where the information needed to resolve the ambiguity is found (Kennedy & Murray, 1987; Kennedy, 1991). Readers appear to mentally store the location of the disambiguating passage for later access if needed. In a recent paper, Baccino and Pynte (1994) extended such findings to text reading, showing a functional link between spatial coding and the discourse model. Readers were able to code for place words or expressions represented in the mental model; for example, they were able to retrieve precisely in a text the spatial location of anaphoric antecedents. This functional relation is still open to debate, however, and the question of which items in a text serve as input to this spatial-encoding process remains unanswered. Are all words in the text stored, or are some more likely to serve as spatial landmarks than others? The working hypothesis examined in this article is that if such landmarks do in fact exist, they should correspond to the locations in the text where a referential difficulty was encountered and where an inference or memory search took place in order to integrate the new

Thierry Baccino, PhD, is Lecturer in Cognitive Psychology, Co-Director of the Psychology Department, and Head of the Experimental Psychology Laboratory at the University of Nice Sophia-Antipolis. His main interests include psychology of reading, text comprehension, and reading ergonomics using eye-movement methodology.

Correspondence concerning this report should be addressed to Thierry Baccino, University of Nice Sophia-Antipolis, Laboratory of Experimental Psychology, 24, Av. des Diables Bleus, F-06357 Nice Cedex 4, France (tel. +33 4 92001204, fax +33 4 92001297, e-mail baccino@unice.fr).
information into the existing memory representation (for the notions of inference and memory search, see, for example, Kinston & Van Dijk, 1978, and Albrecht & O'Brien, 1993). The paper explores the role played by referential factors in the development of a spatial code during reading. Referential factors are manipulated here by means of a perspective shift, which seems to provide a mark of a topic change or new episode occurring in the text and, according to Gernsbacher's theory (1990), lead to an activation of a new Structure Building Framework. This is the mark made at the beginning of something different which can be spatially coded in order to be of potential value for reinspections.

Ordinarily, texts are written so as to facilitate the integration process. However, there are cases where some linguistic form or literary device, such as a change in narrative perspective (i.e., a change in point of view) disrupts the integration process (Black, Turner, & Bower, 1979). Although most narrations are written from the same perspective, an author may, for stylistic purposes, decide to change it during the narrative. For example, the author may first choose to restrict the narrative to the point of view of a given character, and then decide later to move away from that point of view. In such a case, we can assume that comprehension is more difficult for the reader, because of the lack of coherence between the previously read text and the new items to be processed (and the resulting need to assess the consistency of the change with respect to what precedes and modify the mental representation of the text accordingly). The Black, Turner, and Bower study (1979) provided supporting evidence for this idea by showing that it is easier to understand sentences in which a point of view is maintained throughout. Using a reading task, Millis (1995) offered recent evidence consistent with this latter position: Reading times on sentences that introduced a change in perspective were longer compared to sentences that did not.

There are several methods available for manipulating the point of view, but perhaps the simplest way is to determine what pronouns are to be used in the text. Following the literary terminology (Brooks & Warren, 1943; Booth, 1961; Genette, 1972), which uses the term focus of narration to refer to the process of restricting a narrative to the point of view of one or more characters, we distinguished two types of point of view. The first person singular (I) is generally employed to describe an internal point of view; the narrator and the character are two different entities, and the author simply relates an action and makes the character act.

On another hand, it has also been shown that the ease with which the surface form of a text is retained depends on the difficulties encountered during reading. O'Brien and Myers (1985) and Cairns, Cowart, and Jablon (1981) showed that readers remember a narrative significantly better when they experience some difficulty as they read. Accordingly, readers are better at remembering passages preceding an unexpected word if that word was difficult (but not impossible) to integrate into the preceding context. O'Brien and Myers (1985) suggested that this improvement in memory for text is due to the additional processing carried out during the integration stage. In this article, it is assumed that this memorization process also involves the spatial location of the items involved in a change in point of view.

Experiment 1 aimed at determining whether a change in perspective generates an additional cognitive load for the reader. Experiments 2 and 3, in which subjects used the computer mouse to point to the text items where a perspective change took place, aimed at determining whether these items and/or their locations are stored in memory and thereby accessed more rapidly.

**Experiment 1 (Reading Task)**

The purpose of this experiment was to determine whether a change in narrative perspective requires the reader to furnish an additional cognitive effort in order to re-establish the coherence of the story, and whether a spatial representation of the text facilitates this process. It was assumed that this increased effort would lead to longer reading times in the areas in which the change occurred. If the reader's task is to relate the information being read to that preceding it, then maintaining the same point of view throughout a narrative should facilitate integration. In the opposing situation, a change in perspective should require the reader to modify his/her current mental representation of the text.

Two presentation modes (spatialized vs. nonspatialized) were compared. If it is true that a change in perspective triggers the memory storage of the spatial coordinates of certain words (those located in the area where the change took place), then this should have an impact on reading time, such that different reading patterns should be found for the two presentation modes (e.g., longer reading times after the change in perspec-
tive in the spatialized mode in order to compute spatial coordinates).

Method

Subjects. Forty-eight subjects from the University of Nice participated in the experiment. All were native speakers of French and were given course credit for participating.

Linguistic Materials. Twenty experimental French texts telling various stories, with or without titles, were presented to the subjects. All texts were seven lines long and contained two 44-word paragraphs. The first paragraph defined the general setting by giving a very vague description of the place or time of the main action, which was introduced at the beginning of the second paragraph. The last sentence of the first paragraph mentioned the character who would be the main actor in the narrative. The exact identity of this character was either stated in the title or specified in the first sentence of the second paragraph (see below).

1st paragraph
Le soleil luit vaguement sur les rochers. C'est une heure étrange, où les bruits ne se perçoivent que comme amortis par un voile opaque et les gens eux-mêmes ne semblent pas avoir de contour, ni de réalité. Un personnage se détache cependant du groupe. (The sun shone vaguely on the rocks. It was a strange hour, one where noises seemed to be muffled by an opaque screen, and even the people seemed to have neither shape nor reality. One person, however, stood out from the group.)

2nd paragraph
Tristement, je/il débarque du paquebot. Au milieu de gens pressés je descends sur le quai avec fièvre. Je n'aime pas les ports et pas davantage cette ville perchée sur la mer du Nord. (Sadly, I/he got off the ship. In the middle of the hurrying crowd I/he feverishly went down to the docks. I/he didn't like ports, no more than this town perched over the North Sea.)

This is an example of an experimental text (translation in italics). The two sentences in bold (test sentences) contain the reference to the character and the change in perspective, respectively.

The first sentence in the second paragraph was always comprised of an adverb, a personal pronoun, a verb, and a complement. This sentence was used to manipulate the perspective shift. The first person singular (I) is employed for an internal point of view (e.g., Sadly, I got off the ship), while the third person (he/she) indicates external point of views. In this experiment, the first paragraph was always written with an external point of view, whereas either external (personal pronoun he) or internal point of view (personal pronoun I) was used for the second paragraph. The first person thus introduced a change in perspective and a break in narrative coherence. The last sentence of the first paragraph and the first sentence of the second paragraph are referred to as test sentences. Each of 48 subjects read 20 narratives; the reading times of test sentences were used as dependent variable.

Procedure

After a learning phase on two practice texts, the subjects read 20 experimental texts displayed on the video monitor of an IBM-compatible 386 computer. The order of texts was randomized for each participant. The reading was done one segment at a time (a segment = a phrase), and the display was subject-controlled via a designated key on the keyboard (self-paced paradigm). Half of the texts contained a change in perspective (I), while the other half maintained the same perspective (he). All paragraphs had the same number of segments (21). We compared two presentation modes: In the nonspatialized mode, all segments were displayed in the middle of the screen; in the spatialized mode, each word occupied its own location (segments were displayed from left to right and from top to bottom), as in normal reading. The location of the words was shown in advance by a series of x's, each representing one character in the text (moving window technique). When the key was pressed, the next segment was displayed in words, and the preceding segment was changed back into x's. In half the cases, the title of the story (in the above example: Going Ashore) was displayed before the actual text reading began in order to promote the activation of a discourse schema. At the end of the reading phase, the subjects gave a written answer to a question about the content of the text.

Results and Discussion

The design of the analysis of variance was 2 (presentation mode) × 2 (change in perspective) × 2 (title). Presentation mode was a between-subject factor, and change in perspective and title were within-subject factors. Sepa-
Table 1
Mean segment reading time (in ms) for the two test sentences, by presentation mode and perspective.

<table>
<thead>
<tr>
<th>Last sentence in first paragraph</th>
<th>Seg1</th>
<th>Seg2</th>
<th>Seg3</th>
<th>Seg4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>One person</td>
<td>stood out</td>
<td>however</td>
<td>from the group</td>
</tr>
<tr>
<td>Spatial</td>
<td>945</td>
<td>828</td>
<td>737</td>
<td>1226</td>
</tr>
<tr>
<td>Nonspatial</td>
<td>893</td>
<td>797</td>
<td>754</td>
<td>883</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First sentence in second paragraph</th>
<th>Seg1</th>
<th>Seg2</th>
<th>Seg3</th>
<th>Seg4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Change (I)</td>
<td>Sadly</td>
<td>got off</td>
<td>the ship</td>
</tr>
<tr>
<td>Spatial</td>
<td>912</td>
<td>706</td>
<td>782</td>
<td>1157</td>
</tr>
<tr>
<td>No change (he)</td>
<td>905</td>
<td>646</td>
<td>669</td>
<td>1005</td>
</tr>
<tr>
<td>Nonspatial</td>
<td>Change (I)</td>
<td>873</td>
<td>687</td>
<td>703</td>
</tr>
<tr>
<td>No change (he)</td>
<td>827</td>
<td>618</td>
<td>617</td>
<td>1027</td>
</tr>
</tbody>
</table>

rate analyses of variance for each text segment were conducted using Subjects (F1) and Items (F2) as random effects.

No main effect of title and no interaction involving this factor were found. In agreement with the results obtained by Black, Turner, and Bower (1979), the analysis of the two test sentences (located on either side of the paragraph change) indicated that the effect of the perspective shift began on the personal pronoun (I) and was the strongest on the verb that followed (got off). The results are summarized in Table 1.

When the perspective changed and thereby disrupted the integration process by breaking narrative coherence, the segments that followed were read more slowly. This was particularly true for the pronoun and the verb [pronoun: l (696 ms) vs. he (632 ms), F1(1,46) = 4.188, p < .05; F2(1,16) = 5.136, p < .05; verb: l/got off (742 ms) vs. he/got off (643 ms), F1(1,46) = 22.341, p < .001; F2(1,16) = 4.122, p < .05]. The difference on the complement (the ship) was nonsignificant [F1(1,46) = 2.818 ns; F2(1,16) = 1.315 ns]. Further, an ANOVA using text segment as within-subject factor (4 segments of the 1st sentence in 2nd paragraph) showed a significant interaction between perspective change and text segment, F1(3,138) = 2.636, p < .05, F2(1,16) = 4.712, p < .05.

These data suggest that as soon as the perspective change arrived in the text, the readers had trouble linking the current information with their preexisting mental representations, and an additional cognitive effort (reflected by longer reading times) on the pronoun and the verb associated must take place in order to integrate the new point of view. The process appeared to spread out on the subsequent segments as noted by the total mean reading time for the second paragraph. The total mean reading time on that paragraph was found to be significantly longer after a change in perspective [888 ms vs 865 ms, F1(1,46) = 8.623, p < .01; F2(1,16) = 5.43, p < .05].

The text presentation mode was also found to affect reading time at the end of the first paragraph. Reading was slower on the last segment of this paragraph in the spatialized mode [from the group, 1226 ms vs 883 ms; F1(1,46) = 12.408, p < .001; F2(1,16) = 5.326, p < .05]

This suggests that in the spatialized mode, where the readers could visually locate paragraph changes and ends of sentences, they were able integrate information into memory as they would with a punctuation mark (Fayol & Abdi, 1988) or underlining (Gaonac’h & Passerault, 1990). It has indeed been shown that readers tend to defer integration until reaching the end of a line (Haberlandt & Graesser, 1989) by a kind of “wrap-up process,” though this process seems possible only if the text is represented spatially.

No interactive effect on reading time was found between presentation mode and perspective: It was not possible to show that certain spatial locations are stored in memory (in the spatialized mode). This does not mean, however, that memory storage did not take place. The lack of an interaction was probably due to the nature of the task itself (self-paced reading), which may not be sensitive enough in this respect. It seems indeed highly unlikely that spatial coordinates encoded online may affect reading times, since it is not the primary purpose of reading and spatial encoding of words has been shown to be effective only when text presentation allows it (Baccino, 1991). However, a task leading the subject to backtrack on the text would be more sensitive to spatial processing (see experiments 2 and 3).
Nevertheless, these results do confirm that a change in perspective (i.e., point of view) leads to a break in text coherence. But does the reader retain the spatial location of the break in the text or on the screen? In other words, are the points at which coherence is broken encoded spatially? If so, it should be easier for subjects to locate areas or expressions that mark a change in point of view. This hypothesis was tested in the next two experiments.

Experiment 2 (Visual-Search Pointing Task)

In order to deal with spatial processing, subjects in this experiment were asked to point with the cursor of the computer mouse to the noun located after the change in perspective (for example, ship). Pointing with the mouse is a prominently spatial task, since it requires grasping a system of coordinates inside of which the cursor must be moved (Baccino, 1991, 1994; Kennedy & Baccino, 1995). In a prior experiment using this task, we had showed that readers retain the spatial location of certain words in a text, for example, pronoun antecedents in anaphoric expressions (Baccino & Pynte, 1994) in order to retrieve their correspondent referents very efficiently. It is hypothesized here that spatial memory storage also occurs for words or expressions that correspond to a change in the narrative perspective, i.e., those that initiate a break in coherence. If so, readers should be faster at pointing to words where such breaks occur: Moreover, pointing should be facilitated by the presence of a spatial cue such as indentation, indicating a paragraph change. An indentation provides a spatial mark, which generally improves memory for expressions (Lorch & Lorch, 1996).

Method

Subjects. Forty right-handed subjects from the University of Nice participated in the experiment. All were native speakers of French. They were given course credit for their participation in the experiment.

Linguistic Materials. The experimental materials were the same as in experiment 1, but eight filler texts were created and sixteen experimental texts were used.

Procedure. As in experiment 1, half of the experimental texts had a change in perspective (I), while the other half retained the same perspective (he). The texts were right- and left-justified so as to neutralize any spatial effects of page format. The second paragraph either was or was not indented (see Figure 1). The occurrence of indented/nonindented paragraphs was counterbalanced across subjects, and the text presentation order was randomized.

The subjects were seated facing a VGA graphic screen controlled by an IBM-compatible 386 computer equipped with a mouse. The procedure involved two phases: a reading phase with a self-paced paradigm and a pointing phase with the mouse (for more details see also Baccino & Kennedy, 1995). In the reading phase, subjects used the left button on the mouse to display the texts, segment by segment. Each time the button was pressed, the next segment appeared and the preceding segment was replaced by a series of x’s (moving window technique). The computer recorded segment reading time in milliseconds. At the end of the reading phase, a box with a “+” on it appeared at the bottom of the screen. This mark was used to initiate the starting point of the mouse trajectory and to display the stimulus by clicking on it (starting a clock in the same time). The stimulus was the phrase containing the change in perspective (personal pronoun + verb: I/he got off...); as soon as it appeared in the box, the subject task was to point as quickly as possible to the target word (the complement of the verb phrase: ship) and then click the mouse button once the target reached; at this point, the entire text was visible. The click on the target word produced a signal tone from the computer stopping the chronometer and allowed the...
Table 2
Mean segment reading time (in ms) for the two test sentences, by paragraph format and perspective.

<table>
<thead>
<tr>
<th>Last segment in first paragraph</th>
<th>Seg1</th>
<th>Seg2</th>
<th>Seg3</th>
<th>Seg4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>One person</td>
<td>stood out</td>
<td>however</td>
<td>from the group</td>
</tr>
<tr>
<td>Indent</td>
<td>951</td>
<td>843</td>
<td>793</td>
<td>1468</td>
</tr>
<tr>
<td>Nonindent</td>
<td>970</td>
<td>834</td>
<td>770</td>
<td>1266</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First sentence in second paragraph</th>
<th>Seg1</th>
<th>Seg2</th>
<th>Seg3</th>
<th>Seg4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>Change (I)</td>
<td>Sadly</td>
<td>got off</td>
<td>the ship</td>
</tr>
<tr>
<td>Indent</td>
<td>972</td>
<td>698</td>
<td>748</td>
<td>1155</td>
</tr>
<tr>
<td>No change (he)</td>
<td>917</td>
<td>658</td>
<td>702</td>
<td>1124</td>
</tr>
<tr>
<td>Nonindent</td>
<td>838</td>
<td>728</td>
<td>787</td>
<td>1059</td>
</tr>
<tr>
<td>No change (he)</td>
<td>896</td>
<td>705</td>
<td>725</td>
<td>1022</td>
</tr>
</tbody>
</table>

The trend of results shown in Table 2 was similar to those obtained in the first experiment, except that no significant effects of perspective shift occurred on the pronoun (F1(1,38) = 1,372 ns) but only on the verb (F1(1,38) = 4.376, p < .05; F2(1,12) = 5.312, p < .05). Verbs were read longer when there was a perspective shift, suggesting that integrative operations had taken place. There were no effects on the complement and no interactions involving indentation and perspective shift (all F < 1).

Results and Discussion

The analysis design was 2 (paragraph format) x 2 (perspective) x 2 (paragraph presentation order). The paragraph format and the perspective were within-subject factors; the paragraph presentation order was a between-subject factor. We should note here that contrary to the experiment 1, every text was spatialized and the texts differed visually only according to the presence or absence of an indentation mark arriving at the first sentence of the second paragraph. ANOVAS were performed for participants (F1) and for items (F2).

Reading Phase. Table 2 shows the means for reading times on test sentences. Separate analyses of variance for each text segment showed very similar results to those obtained on spatialized condition in experiment 1. However, the last segment of the first paragraph (from the group) was read more slowly when there was a spatial mark (indentation) informing the reader of the division of the narrative into two physically separate paragraphs (1468 ms vs. 1266 ms, F1(1,38) = 4.329, p < .05; F2(1,12) = 3.276 ns). A kind of wrap-up process seems to take place, the presence of a spatial mark being the signal for the reader to integrate previously-read information. Since the text was left and right justified, indentation played an important role here for the structure of text, there being no other spatial marks (such line endings or boxes, etc.).

The next trial to appear. For the filler texts, the stimulus was of the same form (pronoun + verb) but the location of the target words was random. After two practice trials, each reader processed the experimental and fillers texts.

Pointing Phase. We should recall here that the subject must point as soon as possible the mouse cursor to the target word during which the trajectory is recorded (x and y coordinates) every 5 ms. Once the trajectory has been recorded, temporal and spatial analyses may be performed (see Baccino & Kennedy, 1995). For the purpose of analysis, the trajectory of the cursor was broken down into two zones (see Figure 1), corresponding to (i) the motor programming phase and the reaction time (RT), (ii) the visually guided phase and positioning time (when the cursor is crossing the empty screen and the text area), hereafter called the starting zone and the trajectory zone, respectively. Schematically, the division of the trajectory into zones followed psychophysiological arguments, indicating that the RT was mainly dependent on cognitive processes (such as word identification) during which preparatory motor processes took place and the positioning time corresponded to perceptual processes (such as spatial processing) guiding the hand movement by visual feedback control (Hay, 1987). Each zone was analyzed for both temporal variables (pointing time) and spatial variables (dispersion of the trajectory) (described in Baccino, 1991; Baccino & Kennedy,
Table 3
Mean pointing time (in ms) in the mouse trajectory zones, by paragraph format and perspective.

<table>
<thead>
<tr>
<th></th>
<th>Starting zone</th>
<th>Trajectory zone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change / No change</td>
<td>2055 / 1988</td>
<td>4868 / 5093</td>
<td>6923 / 7081</td>
</tr>
<tr>
<td>No indentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change / No change</td>
<td>2042 / 1971</td>
<td>4517 / 4965</td>
<td>6559 / 6936</td>
</tr>
</tbody>
</table>

Table 4
Mean dispersion (in square pixels) in the mouse trajectory zones, by paragraph format and perspective.

<table>
<thead>
<tr>
<th></th>
<th>Starting zone</th>
<th>Trajectory zone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change / No change</td>
<td>657 / 788</td>
<td>17966 / 20776</td>
<td>18623 / 21564</td>
</tr>
<tr>
<td>No indentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change / No change</td>
<td>149 / 157</td>
<td>15663 / 19126</td>
<td>15812 / 19283</td>
</tr>
</tbody>
</table>

1995). Trajectory dispersion was defined as the area between a hypothetical straight line from the initial point of departure of the mouse to the target word and the trajectory itself.

Pointing Time. The overall pointing times (time between when the stimulus was displayed and the target word was clicked) across zones are given in Table 3. There was a significant interaction between perspective shift and zones \([F(1,39) = 5.628, p < .025; F(1,12) = 4.667, p < .05]\). Planned comparisons of that interaction revealed that pointing times were faster for perspective shift only when the cursor was in action (trajectory zone), i.e., when it crossed the screen and text area \([F(1,39) = 4.004, p < .05; F(1,12) = 5.316, p < .05]\). No effects of perspective shift were observed on starting zone \((F < 1)\), and there was no main effect of indentation in all zones \((F < 1)\). There was no interaction involving this factor with perspective shift.

Pointing Dispersion. The pointing dispersion defines the measure of the area between the trajectory of the mouse and the straight line connecting the stimulus to the target and is representative of the subjects’ hesitation in locating the target. Dispersion was calculated for each zone separately, and the straight line is only calculated from the initial launch. Since almost no movement existed during the starting zone, the measure is mostly relevant to the trajectory zone, and no cumulative effect appeared. The total amount of dispersion in the pointing was smaller when the narrative contained a change in perspective \([F(1,38) = 7.665, p < .01; F(1,12) = 4.86, p < .05]\). The mean dispersion by zones is given in Table 4.

As with pointing time, differences in dispersion occurred especially when the cursor entered the text zone. Dispersion was significantly smaller with a perspective shift than no shift \([F(1,38) = 6.651, p < .025; F(1,12) = 4.568, p < .05]\). This result is consistent with the above temporal data and points out the subjects’ hesitation in locating the target when no perspective shift occurred to prevent or reduce any spatial coding during the reading phase. No interaction was found for the dispersion variable between the paragraph format and the perspective.

These overall results suggest that a change in perspective causes the reader to memorize the location or expression where the change occurred (e.g., I got off the ship). This is done during the reading phase, as shown by the increasing reading times spent on perspective shift expressions. During the pointing phase, a predominantly spatial task, readers must retrieve and localize target words (ship) in the text, and they use their spatial memory to perform the task, i.e., they point faster on target words associated with a perspective shift. In other words, readers spatially encode the zone where cognitive processing takes place following a change in perspective—and that spatial memory for words is used once the subject must locate a word within the text. No effect of indentation was found, however, which
suggests that spatial memory for words are based mostly on semantic/referential cues rather than on physical cues of the text format.

**Experiment 3**

The above results argue in favor of the idea that readers mentally store the location of the area in a text where a change in perspective occurs. In other words, linguistic items that mark a break in coherence are easier to locate in a text. The next experiment was designed to directly test the effect of spatial encoding on text retention. Subjects were again asked to point to the words where a break in coherence occurred. The experiment was identical to the preceding one except that during the pointing phase the actual words were not displayed on the screen, but were replaced by a series of x's (with spaces between the words).

The second objective was to get a better idea of the nature of the encoded items. Is it the surface form of the words or the expressions which gets encoded—or more abstract concepts representing the meaning of the words? The subjects were instructed to use the mouse to point to the target word (ship) or to a synonym thereof (boat). If readers store the surface form of a specific word rather than its meaning, then we should observe a difference between word and synonym pointing behavior when a change in perspective occurs.

**Method**

*Subjects.* Forty subjects from the University of Nice participated in the experiment. All were right-handed, native speakers of French. They received course credit for their participation.

*Linguistic Materials.* The experimental material was identical to that used in experiment 2. Sixteen experimental texts and eight filler texts were processed.

*Procedure.* The text presentation modes and the pointing task were also the same as previously, except that during the pointing phase, the texts were displayed as a series of x's rather than as a series of words. The actual verb complement (ship) or a synonym (boat) was used as the target word. When the target was the synonym, readers were instructed to point the cursor at where the exact word (ship) appeared in the text. Synonyms and words were matched for length and frequency of occurrence in the language. There was no spatial separation between the two paragraphs, and the texts were right- and left-justified (similar to the nonindentation condition in experiment 2). After two practice trials, each reader processed the sixteen experimental texts and eight fillers. Half of the experimental texts had a change in perspective (I), while the other half did not (he). The text presentation order was randomized. The location of the target words in the filler texts was random and were also either synonyms or words.

**Results and Discussion**

The experimental design was 2 (TYPE OF TARGET WORD) X 2 (PERSPECTIVE). Type of target word and perspective were both within-subject factors.

### Table 5

Mean segment reading time (in ms) for the two test sentences, by paragraph format and perspective.

<table>
<thead>
<tr>
<th>Segment Example</th>
<th>Seg1</th>
<th>Seg2</th>
<th>Seg3</th>
<th>Seg4</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change (I)</td>
<td>867</td>
<td>706</td>
<td>796</td>
<td>1084</td>
<td></td>
</tr>
<tr>
<td>No change (he)</td>
<td>888</td>
<td>715</td>
<td>736</td>
<td>1018</td>
<td></td>
</tr>
</tbody>
</table>

### Table 6

Mean pointing time (in ms) for the mouse trajectory zones, by type of target and perspective.

<table>
<thead>
<tr>
<th>Word Change</th>
<th>Synonym Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Zone</td>
<td>2070 1967</td>
</tr>
<tr>
<td>Trajectory Zone</td>
<td>9723 10514</td>
</tr>
<tr>
<td>Total</td>
<td>11793 12481</td>
</tr>
</tbody>
</table>
Spatial Encoding and Referential Processing during Reading

Reading Phase. Since the reading phase in this experiment did not provide any information about spatial information during reading (the entire text was left and right justified), we report in Table 5 only the reading times by segments according to the Perspective Shift factor. Separate analyses of variance for each text segment showed very similar results to those obtained with no indentation condition in experiment 2.

As in experiment 2, no significant effects of perspective shift occurred with respect to the pronoun \( F(1,38) = 1.414, p > .05 \) but only with respect to the verb \( F(1,38) = 5.206, p < .05; F(2,12) = 6.316, p < .05 \). For Perspective Shift sentences verbs took longer to read (suggesting that some integrative operations are being worked out).

Pointing Phase. Table 6 gives the results for pointing time. ANOVAs were performed by segments for subjects (F1) and for items (F2).

Pointing Time. We should recall here that the task was to point to a target word that was not clearly displayed on the screen and replaced by a string of x’s of the same length. This explains why pointing times are nearly twice as long as in the previous experiment. The overall ANOVAs with zone as within factor showed a significant double interaction between perspective shift \( \times \) zones \( \times \) type of target \( F(1,39) = 8.90, p < .01; F(2,12) = 7.71, p < .025 \) and two significant interactions between perspective shift \( \times \) type of target \( F(1,39) = 7.14, p < .01; F(2,12) = 8.42, p < .025 \) and between zones \( \times \) type of target \( F(1,39) = 4.76, p < .05; F(2,12) = 5.38, p < .05 \). A significant difference was observed between the words and the synonyms, with longer times necessary for synonyms, both for the entire pointing trajectory \( F(1,39) = 8.74, p < .01 \) and respectively for each of the two pre-defined zones [starting zone: \( F(1,39) = 3.964, p < .05; \) trajectory zone: \( F(1,39) = 6.79, p < .01; F(2,12) = 8.78, p < .025 \)].

Separate analyses of variance were carried out for each zone. During the starting zone there was no effect of perspective shift and no interaction involving this factor (all \( F \)'s < 1). On the other hand, when the mouse was in action (trajectory zone) the interaction between perspective shift \( \times \) type of target was significant \( F(1,39) = 8.162, p < .01; F(2,12) = 9.63, p < .025 \). Partial comparisons revealed that the effect of perspective shift was more sensitive for synonyms \( F(1,39) = 13.44, p < .001; \) \( F(2,12) = 10.66, p < .01 \) rather than for words \( F < 1 \). For synonyms, pointing times were faster when a perspective shift occurred in the text. In this case, since the target word was not matched to any form (word) in the text; to complete the task subjects relied only on the spatial cue given by the perspective shift. In other words, perspective shift was spatially located during reading (maybe by increasing the attention level), and the subject was able to do the task using only spatial memory since no exact word existed.

Pointing Dispersion. As in experiment 2, dispersion from the trajectory was not as great in the trajectory zone when the narrative contained a change in perspective \( F(1,39) = 3.834, p = .054; F(2,12) = 2.855, p < .05 \). The subjects hesitated much less in locating the target when it was associated with a change in perspective. Type of target and perspective did not interact on this variable. Results for dispersion are given in Table 7.

In summary, these data indicate that subjects did not locate the actual words better than they did synonyms (no significant differences between words and synonyms), but that they did accurately locate the area in the text where a change in perspective took place. This result is consistent with the idea that readers memorize the spatial location in the text or on the screen of words where an important break in narrative coherency occurred. This experiment does not allow us to draw any conclusions concerning the exact form in which such words are encoded.

### Table 7

Mean dispersion (in squ/pix) for the mouse trajectory zones, by type of target and perspective.

<table>
<thead>
<tr>
<th></th>
<th>Word Change (l)</th>
<th>No change (he)</th>
<th>Synonym Change (l)</th>
<th>No change (he)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting zone</td>
<td>287</td>
<td>139</td>
<td>175</td>
<td>196</td>
</tr>
<tr>
<td>Trajectory zone</td>
<td>35636</td>
<td>38186</td>
<td>38324</td>
<td>37495</td>
</tr>
<tr>
<td>Total</td>
<td>35923</td>
<td>38325</td>
<td>38499</td>
<td>37691</td>
</tr>
</tbody>
</table>

© 1998 Hogrefe & Huber Publishers
General Discussion and Conclusion

In a comparatively old study, Black, Turner, and Bower (1979) showed that subjects read sentences more quickly and remembered them more accurately when the same point of view was maintained, because they adopted spontaneously the main character’s perspective. One of the characteristics of point of view consists of getting to know the relationship between the narrator and the action. Thus, a sentence such as “Bill was sitting in the living room reading the paper when John came into the living room” has a consistent point of view because John’s movement induced by the verb “to come” meant it was directed towards the narrator (Bill), i.e., the narrator and Bill are located in the same place, here the living room. On the contrary, employing the verb “to go” in the same context—“Bill was sitting in the living room reading the paper when John went into the living room”—means the narrator and the character (Bill) were not in the same place, which violated the coherence of the statement.

Like the study by Black, Turner, and Bower (1979), this article studied the implications for the reader of having to deal with a shift in perspective within a text, achieved through a change from an external point of view (the narrator and the character are two different entities) to an internal point of view (the narrator and the character are the same person). The results of experiment 1 indicated substantial lengthening of reading time in the area in which the change in perspective took place, but it failed to show any effect of spatial presentation. Experiments 2 and 3 replicated the same effect of perspective shift during reading.

Using a new methodology (pointing task with mouse) developed to provide some information about the spatial encoding of texts, experiments 2 (visual search) and 3 (memory search) showed that readers memorize the spatial location in a narrative of the area where a change in perspective occurs, leading to faster and more accurate pointing. A possible interpretation of these data is that spatial encoding occurs in text areas where the integration of information is more complex due to new episodes or referents being introduced. Several studies have shown that sentences introducing a new discourse topic or new episode are allocated more processing time because of the integration of the new information (Lorch, Lorch, & Matthews, 1985; Lorch, Lorch, & Morgan, 1987; Hyona, 1995). The additional cognitive effort required of the reader (brought about by the more comprehensive memory search) might result in the memorization of the spatial location where the effort was made.

Our findings are compatible with other experiments showing that readers are better at retaining words that cause comprehension difficulties (Albrecht & O’Brien, 1993; O’Brien & Myers, 1985). O’Brien and Myers noted that improvement in text retention is triggered by the reprocessing of previous parts of the text: Readers remember the associated linguistic expressions, since more time is required to assimilate them. We showed that, in addition to remembering the surface form, readers retain the spatial location where a difficulty was encountered. One might wonder, however, about the utility of such spatial landmarks. It seems reasonable to assume that they serve to optimize any necessary backtracking by dividing the text into zones (or areas) for potential searching. When scanning a text to find the expression representing some referent, for example, the reader may first select the appropriate search area based on his/her memory of the location of a coherence break, and then later precisely locate the word in question (e.g., a pronoun antecedent, see Baccino & Pynte, 1994).

From a practical standpoint, spatial encoding seems to play a particularly important role in reading on a computer screen, where spatial stability is perturbed (McKnick, Fisher, & Bridgeman, 1991). Adding physical marks such as underlining, highlighting, and annotations to the places in a text where integration operations take place (Virbel, Pascual, & Mazhoud, 1994) probably reinforces spatial encoding and optimizes subsequent memory searches for the corresponding linguistic items. It is well known that information is remembered better when it is associated with a predetermined location. Physical cues may serve as pointers to the important items in the logical or linguistic structure of a text, and they may aid in the spatial locating process likely to occur naturally as reading progresses.

References


© 1998 Hogrefe & Huber Publishers
Spatial Encoding and Referential Processing during Reading


