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Construction, Integration, and Mind Wandering in Reading

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In two experiments, we investigated how text recall was related to moment-to-moment variations in mental state while reading, and how both recall and mental state were related to the interest value of the text. In both experiments, subjects read either an interesting text (a segment of Rice's *Interview with the Vampire* [A. Rice, 1997, *Interview with the vampire*, New York, NY: Ballantine Books] or a less interesting text (a segment of Thackery's *The History of Pendennis* [W. M. Thackery, 2009/1914, *The history of Pendennis*, Project Gutenberg, Retrieved from <http://www.gutenberg.org/ebooks/7265>]). The texts were read sentence-by-sentence on a computer screen, and subjects were periodically interrupted to answer a probe question. In Experiment 1, the probe asked whether subjects were attending to the text; in Experiment 2, the probe asked whether subjects were engaged with the story world. After reading the text, subjects were asked to recall as much of the story as possible. Recall of the material just prior to the probe was examined as a function of the whether the ratings were high, medium, or low. As expected, both on-task ratings and engagement ratings were higher for *Interview* than for *Pendennis*, but there were a substantial number of medium ratings given to both stories. In Experiment 1, there was a clear effect of story on recall over and above the effect of on-task rating. However, in Experiment 2, recall was purely a function of engagement rating. The results were interpreted in terms of a model in which recall is largely determined by the situation model representation of the narrative and in which engagement ratings (but not on-task ratings) provide a relatively pure index of the allocation of resources to processing of the situation model.

Keywords: mind wandering, construction and integration, reading, situation model

The present article builds on recent research on mind wandering in reading that demonstrates that with some frequency, readers fail to attend to the reading task. For example, readers report “zoning out” while reading with frequencies as high as 23% (Schooler, Reichle, & Halpern, 2004). Such inattention has, of course, negative implications for processing and later memory for the text (Schooler et al., 2004; Smallwood, McSpadden, & Schooler, 2008). However, in the present research we argue that in a complex task such as reading, the simple distinction between attending to the task and not attending to the task fails to capture important determinants of later memory. In particular, there is a range of different mental processes in reading to which one may allocate attentional resources. As a heuristic, we distinguish between *construction* processes that identify the meanings of words and sentences and *integration* processes that connect that information to long-term memory and build a situation model (Kintsch, 1988; Kintsch, Welsch, Schmalhofer, & Zimny, 1990). The two experiments reported here provide evidence on how the allocation of resources to off-task processes, construction processes, and integration processes affects subsequent memory.

In what follows, we first elaborate a characterization of mind wandering as the allocation of attentional resources to mental

processes unrelated to the text. Second, we discuss the relationship between resource allocation and subsequent memory. While it is intuitive that poor memory would result if one is not devoting resources to the task, the details of the relationship between how resources are allocated and what is remembered may be more complex. Finally, we describe the potential role of textual interest value in determining resource allocation and subsequent memory. The manipulation of the nature of the text provides the tool used in the present pair of studies for distinguishing different models of the relationship between resource allocation and memory. The first experiment demonstrates that interest value has an effect on subsequent memory that is not mediated purely by attention to the task. The second experiment provides evidence that this effect can be understood in terms of the differential allocation of resources to construction and integration.

Resource Allocation in Mind Wandering and Reading

Researchers have identified several different possible characterizations of mind wandering. Smallwood, McFadden, and Schooler (2007) differentiated between being on-task, mind wandering with awareness (“tune out”), and mind wandering without awareness (“zone out”). In their analysis, mind wandering without awareness involves a failure of meta-awareness—that is, awareness of one’s current mental activity—and was associated with poor response inhibition in a go/no-go task. Smallwood (in press) emphasised that mind wandering occurs when attention is directed to internal thoughts (as opposed to external stimuli). The prediction from this perspective is that responses to external stimuli should be slower or more error prone during periods of mind wandering. This has

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been confirmed by, for example, Smallwood, Beach, Schooler, and Handy (2008), who found smaller P300 evoked responses when subjects reported mind wandering. Mind wandering has also been described as a failure to inhibit task-unrelated thoughts (Kane et al., 2007; McVay & Kane, 2009). Mind wandering may be associated with other goals that subjects may have, beyond the current task (e.g., Smallwood & Schooler, 2006), perhaps coupled with a failure of executive control (e.g., McVay & Kane, 2010). Mind wandering may also involve the use of domain-general resources such as working memory to perform autobiographical planning and similar complex tasks (Smallwood et al., 2011). The critical aspect of these perspectives for the current research is that mind wandering is tied to the allocation of attentional resources. Broadly, we can describe mind wandering as a situation in which resources are allocated to processes that are unrelated to the current task.

In contrast to this description of mind wandering, there is less consensus concerning the allocation of resources while not mind wandering. In some tasks, being on task has been characterised as attending to external stimuli (rather than internally generated thoughts; e.g., Smallwood & Schooler, 2006). However, attending to the task of reading entails allocating resources to a variety of internal processes and representations (e.g., LaBerge & Samuels, 1974). As a rough characterisation, we suggest that skilled reading resources may be allocated to at least two types of processes. We describe these processes with reference to Kintsch's (1988) construction-integration model of comprehension (but without a strong commitment to that processing architecture). Constructive processes are those that activate concepts and propositional representations based on the text surface structure. Generally, constructive processing is largely determined by the meaning of the words of the text. However, attention to such processes could lead to more accurate or complete representations of word meanings (cf. Perfetti, 2007) and more text-based inferences. Generally, inadequate attention to these processes may lead to a representation of the text that is incomplete and in which the appropriate coherence inferences have not been made (cf. van den Broek, Bohn-Gettler, Kendeou, Carlson, & White, 2011). During integrative processing, the propositional representations of the text meaning make contact with other information in long-term memory, and a coherent overall representation of the text emerges. Although the original Kintsch model was primarily concerned with a propositional representation of the text, later analyses identified integrative processes with the construction of a situation model (e.g., Kintsch et al., 1990). Devoting attentional resources to integrative processes provides the basis of a detailed, elaborate representation of the story world, and without such resources a reasonable situation model might not be developed.

In sum, we believe that in reading, resources may be allocated to at least three different broad classes of processes. Resources may be allocated to off-task processes, as expected during mind wandering; resources may be allocated to constructive processing that identify the meaning of the words and sentences of the text; or resources may be allocated to integrative processing, leading to an elaborate and detailed situation model for the discourse.

Resource Allocation and Memory

The central question in the present investigation is the effect that resource allocation has on memory for the materials being read. In reading, memory for the text is commonly divided into memory for the surface structure, memory for the propositional content, and memory for the situation model. Previous research has demonstrated these distinctions by varying the nature of old-new recognition items (e.g., Schmalhofer & Glavanov, 1986; Singer & Kintsch, 2001). Memory for the surface structure is generally short lived and may begin to decay as soon as the current clause has been finished (Goldman, Hogaboam, Bell, & Perfetti, 1980). Thus, a recognition-memory test generally taps information from the propositional content and the situation model (Kintsch et al., 1990). Recall, on the other hand, may be especially sensitive to the adequacy of the situation-model representation. For example, Ericsson and Kintsch (1995) argued that the situation model provides a retrieval structure that organizes information from a narrative text and allows the reader to recall far more than they might if there were simply recalling unrelated sentences. In particular, the situation model can provide an integration of the events of the text with the reader's own knowledge and experience (Fincher-Kiefer, Post, Greene, & Voss, 1988). Thus, to the extent that such an integration is established during reading, recall should be enhanced.

A central development in the research on mind wandering is that allocating resources to off-task thoughts has an adverse effect on the current task (e.g., McVay & Kane, 2009). In particular, mind wandering while reading has been shown to reduce memory for the text. For example, Schooler and colleagues (2004) found that subjects who reported more "zoning out" while reading in response to online probes had poorer comprehension on a recognition-memory test. Further, there is a clear relationship between mind wandering over time and what information subjects fail to remember. For example, Dixon and Li (2007) found a correlation between on-task rating across text segments and recognition performance on items pertaining to those segments. Similarly, Smallwood, McSpadden et al. (2008) found that critical inferences in a Sherlock Holmes story were less likely to be drawn if the reader was mind wandering during relevant incidents in the text.

The relationship between memory and resources may depend in part on the nature of the memory test. Smallwood, McSpadden, and Schooler (2008) argued that mind wandering has a negative impact on the development of a situation model. In our terms, this means that mind wandering leads to a failure to allocate resources to integrative processes. This seems plausible in the Smallwood et al. task because it required subjects to make inferences concerning events in the story world. However, mind wandering would also minimise the attentional resources devoted to constructive processes, and this could have a negative impact on other aspects of memory. For example, without adequate resources, constructive processes may fail to make interconnections among concepts, and this could have an adverse effect on recognition (cf. Kintsch et al., 1990; van den Broek & Lorch, 1993). Whether memory is related to the lack of resources allocated to constructive or integrative processes may vary with the task requirements.

Resource Allocation and the Text

While it is clear that intentions and goals must have an effect on resource allocation, it is also intuitive that, over an extended period of time, resource allocation must also be affected by the nature of the text and its relationship to the reader. This relationship was demonstrated by Giambra and Grodsky (1989); they found that dull text produced more mind wandering than more interesting material. A relationship between mind wandering and the interest value of the text seems to have been assumed in previous experiments on mind wandering in reading in which the material seems to have been deliberately selected to be uninteresting for the subject population. For example, Reichle, Reineberg, and Schooler (2010) used *Sense and Sensibility*; Schooler et al. (2004) used *War and Peace*. On a related point, there is evidence that more interesting material may be better recalled than less interesting material (Hidi & Baird, 1986), and that texts are better remembered when one has a suitable background knowledge (e.g., Spilich, Vesonder, Chiesi, & Voss, 1979). These memory effects may be mediated by resource allocation: One is more likely to allocate resources to reading processes if the material is interesting, and greater resource allocation should produce better memory.

More generally, other aspects of resource allocation may also be influenced by the nature of the text. For example, texts that are deeply engrossing may lead people to devote a great deal of attentional resources to integrative processing. This notion is related to the concept of “transportation to the story world” introduced by Gerrig (1993). In our analysis, transportation implies allocating resources to aspects of the story world, presumably involving a detailed or otherwise compelling situation-model representation. Thus, transportation must entail allocating resources to integrative processing. Research on transportation has often identified the relationship of the text to the reader or individual differences among readers as a determinant of transportation (Green, 2004). However, again arguing from intuition, it seems likely that there is a role for the text in generating transportation. For example, it is commonly assumed that some stories are simply more engrossing or engaging than others (e.g., Warhol, 1986).

Present Research

In sum, the existing literature, together with some plausible extensions, provide a sketch of the relationship between resource allocation during reading and subsequent memory and how this relationship is mediated by the interest value of the text. In particular, interesting texts are likely to increase resources devoted to the task of reading, and especially engaging texts are likely to promote allocation to the integrative processes that are responsible for building a situation-model representation. In turn, allocating resources to the task of reading will tend to improve memory for the text content, and allocating resource to integrative processes in particular may enhance recall.

However, there are several missing elements in this sketch. First, the role of the text in promoting the allocation of resources to integrative processes in particular has not been clearly demonstrated in previous research. Although it is known that interesting material decreases mind wandering and increases the attentional resources devoted to reading, how those resources are used is unclear. Thus, at the moment, we only speculate that those resources will benefit the situation-model representation. Second,

the importance of integrative processes for subsequent memory, while plausible, has not been investigated. What needs to be demonstrated is that variables that affect allocation of resources to integrative processes produce a concomitant improvement in recall. Third, while recent research on mind wandering has often measured attention to the text over time (e.g., Reichle et al., 2010), the interest value of the text has only been measured in aggregate, over the text as a whole. Thus, one of the present goals is to examine the variation in resource allocation, processing, and memory over time while reading a text. This is critical in developing the argument concerning causal relationships between the allocation of resources and subsequent memory.

In the present research, we provide evidence for an analysis of the relation between the allocation of resources and subsequent memory. In particular, our argument is that recall is determined largely by the robustness of the situation-model representation, which in turn is determined by the allocation of resources specifically to integrative processes. We proceed in two steps. First, in Experiment 1, we demonstrate that failing to distinguish between allocating resources to construction and to integration provides an inadequate account of the effect of interest value on later recall. Thus, one cannot explain the effect of story interest simply in terms of whether subjects are on task or off task. Second, in Experiment 2, we describe how a plausible measure of integrative processing—engagement—does seem to capture the effect of interest value. Thus, we can predict subsequent recall on the basis of how engaged subjects were with the text and, by inference, the amount of resources allocated to integrative processes. Our conclusion is that an adequate account of resource allocation in reading must include something akin to our distinction between integrative and constructive processes.

As described above, an important aspect of the current investigation concerns the variation in resource allocation over the course of reading a text, not simply from one text to another. To this end, we used the experience sampling paradigm (e.g., Csikszentmihalyi, Larson, & Prescott, 1977; Kane et al., 2007), especially as applied to the study of mind wandering in reading by Schooler et al. (2004). We refer to this technique in the present research as a *mental state probe* procedure: While reading a text, subjects were periodically interrupted and asked to report their mental state. For example, in Experiment 1, subjects reported whether they were on task (allocating resources to the text) or off task (allocating resources to other processes). In our experiments, this happened 10 times over the course of reading a text, with a span between probes of approximately 3–5 min. We then examined memory for the material just prior to the probe. While this approach has been common in research on mind wandering, it has not been used to examine variations in other mental states while reading a text. As discussed subsequently, such variation has the potential to disentangle the memorial effects of different forms of resource allocation.

Experiment 1

The goal of the first experiment was to assess whether a distinction between constructive and integrative processes in reading is needed in accounting for subsequent memory. The critical manipulation was the interest value of the text. As described above, more interesting texts lead to less mind wandering and

more resources allocated to the task of reading. If no distinction is needed among the different possible ways in which resources might be devoted to the task, one may be able to predict subsequent memory on the basis of how much total resource is allocated to on-task processing rather than off-task processing. We may refer to this as a mediation account, in that the effect of textual interest value is mediated simply by allocating resources to the task of reading. In contrast, if there is an independent contribution of interest value to memory, over and above what might be predicted on the basis of attention to the task of reading, we might hypothesise that interest value is related to aspects of processing other than simply being on task. In order to distinguish these two possibilities, we asked subjects to read either an engaging or less engaging text and then recall as much of the text as they could. While reading, they were periodically interrupted and asked to rate the extent to which they were attending to the reading task or were thinking of something else. We then examined recall as a function of the on-task rating and the nature of the text. This form of mental-state probe distinguishes between being on task (allocating resources to some aspect of reading) or being off task (i.e., mind wandering).

In the present research, we used recall as our measure of memory for the text. Recall is useful in this context because it is likely to be sensitive to the organisation and content of the situation model, and thus, as discussed above, likely to index resources allocated to integrative processes during reading. To our knowledge, recall has not been used in previous research using mental-state probes. However, using this approach introduces a methodological complication. With recognition memory tests, test items can be designed to tap material found only in a particular point in the text. This is crucial if one needs (as in the present research) to correlate memory performance with the mental state probe response from various points in the text. However, with recall, there are no constraints on what might be recalled, and any given recall statement could be based on information garnered from a range of locations in the text. To minimise this problem, we adopted two procedures in assessing recall memory. First, we asked subjects to recall information in the order in which it was encountered in the text as much as possible. Thus, to the extent that subjects conformed to this direction, we would be able to identify from where in the text the recalled information came. Second, we compared each recall statement independently to each possible section of the text on which it might have been based. Thus, if a statement might have represented information recalled from several different segments of the text, it was counted more than once.

Method

Materials. An interesting and a less-interesting text were selected based on the judgment of the research team. The interesting text was *Interview with the Vampire* (Rice, 1997) and the less-interesting text was *The History of Pendennis* (Thackeray, 2009/1914). *Interview* describes a novel, fantastic scenario with strong emotions using easy-to-understand, evocative language. *Pendennis* is culturally remote for our subject population and concerns relatively more mundane events using fairly difficult language. Although the assessment of the interest value of these texts was subjective, it was clearly borne out by the results of this experiment and Experiment 2. Subjects read the initial portion of either

one novel or the other. The *Interview* text was 7,342 words and the *Pendennis* text was 7,753 words. Each text was broken into sentences for presentation, but some long sentences (especially in *Pendennis*) were also broken at clause boundaries marked by semicolons. There were 544 such presentation sentences in *Interview* and 271 in *Pendennis*. Ten interruption points were identified in each text. Within each text, the number of sentences between interruptions was approximately equal but not precisely predictable. In *Interview*, there was a mean of 58.7 presentation sentences between interruption points, with a range of 52–65; in *Pendennis*, there was a mean of 40.6 sentences between interruption points, with a range of 25–60. (The number of words between interruptions was similar in the two stories, but this corresponded to fewer sentences in *Pendennis* because the sentences in that story were longer on average.)

Subjects. Subjects were 55 introductory psychology students who completed the experiment in return for course credit. Each subject read one of the two texts. Recall data from one subject was lost because of a procedural error, leaving 27 in the *Interview* group and 27 in the *Pendennis* group.

Procedure. Subjects read the text one sentence at a time at their own rate by pressing the space bar. Sentences were presented left justified in the vertical centre of the screen. A plus sign on the left side of the screen indicated the beginning of the line. New paragraphs were indented from this position by 0.7 cm. The sentences were presented in 18-point Times font on a 51 cm iMac screen at an approximate reading distance of 50 cm.

When one of the interruption points was reached, pressing the space bar did not bring up the next sentence but rather the probe question, “Were you fully comprehending the story or were you thinking of something else?” Below the question was an 11.5 cm line with points labelled with the possible answers, *Definitely thinking of something else*, *Thinking of something else to some extent*, *Not sure*, *Comprehending to some extent*, and *Definitely comprehending*. Subjects answered the probe question by using the computer mouse to click somewhere along this line. The horizontal coordinate of the mouse click, truncated to the range of the actual line on the screen, was used as the probe dependent variable, leading to a measure that ranged from –250 to 250 pixels. After clicking a point on the response scale, the probe question was removed, and subjects pressed the space bar to get the next sentence in the text.

Subjects were informed that there would be a simple memory test and told that they would read the text one sentence at a time. The nature of the interruption task was described. After finishing the text, subjects were given a blank document in the Apple program TextEdit and asked to enter as much of the story as they could recall. They were encouraged to describe the events in the order in which they occurred in the story.

After completing their recall, subjects were given a pencil and paper questionnaire in which they were asked to report their general reaction to the text and their reading background and habits. These data are not reported in the current analyses. They were also asked to report whether they had read the text previously, and one subject in the *Pendennis* group who responded positively was omitted from the analysis.

Analysis. Each recall protocol was divided into statements, with each statement generally containing one substantive verb form corresponding to an event in the text. The text between

interruptions was divided in half by sentences, yielding 20 text segments. For each combination of text segment and recall statement, a judgment was made as to whether the statement could have been based on the information in the text segment. One of seven judgments was selected: *matching* information in the text segment; *corresponding* to information in the segment with minor inaccuracies; potentially *inferable* from information in the segment; clearly *incorrect* given the information in the segment; a high-level *gloss* of information from that segment with little detail; or *unrelated*. For each probe response, we counted the number of matching, corresponding, or inferable statements for the preceding text segment. Because the material between interruptions was divided into two text segments, these counts correspond to the number of recall statements that could have been based on material in the last half of the text since the preceding interruption.

Generalised linear mixed-effects models were fit to the count of recall statements using the Poisson family with a log link function. This procedure provides fits of linear models to the log of the statement count; thus, the parameters estimated in the model are on a log scale. To simplify the presentation of the results and the comparison of the two texts, on-task rating was changed into a nominal scale by classifying ratings as low (below the 25th percentile of -103 pixels), high (above the 75th percentile of 137 pixels), or medium. Thus, the independent variables in the models consisted of text (*Interview* or *Pendennis*) and on-task rating (low, medium, or high). (The pattern of results is unchanged if rating is used in the models as a continuous variable.) The models were fit using the program lmer (Bates, Maechler, & Bolker, 2011) running in the R environment (R Development Core Team, 2012). The intercept in the fit models were assumed to vary randomly with subject and text segment (nested within text). Because text segment was included as a random effect in the models, variation in the memorability of different portions of the text are independent of the estimated fixed effects for on-task rating. Following the suggestion of Glover and Dixon (2004), models were compared by calculating a likelihood ratio that described how likely the data were given one model relative to how likely they were given another model. The likelihood ratio was adjusted for the varying number of parameters in the model based on the Akaike Information Criterion (AIC; Akaike, 1973). Thus, the model assessment procedure was tantamount to comparing models based on AIC values, a common technique in the model selection literature. We use the symbol, λ_{adj} , to refer to this adjusted likelihood ratio; Burnham and Anderson (2002) refer to this quantity as an evidence ratio.

Results

The distribution of low, medium, and high on-task ratings for the two stories is shown in Table 1. As expected, there were relatively few low ratings for *Interview* and relatively few high ratings for *Pendennis*. However, critically, there was a substantial degree of overlap in the ratings for the two texts, and there were a substantial number of medium ratings for both stories. Generally, on-task ratings were higher for *Interview*: The mean rating for *Interview* was 100.2 pixels ($SE = 7.4$), and for *Pendennis* was -12.1 pixels ($SE = 8.2$).

The relationship between on-task ratings and recall performance is shown in Figure 1. In this graph, the vertical error bars indicate

Table 1
Distribution of Level of Rated Engagement Across Texts in Experiment 1

	Level of Rated Engagement		
	Low	Medium	High
<i>Interview</i>	36	119	115
<i>Pendennis</i>	94	148	18

the standard error for recall derived from the fit of the best model. The horizontal position of the points indicated the mean rating within story and low/medium/high rating group; the horizontal error bars indicate the standard deviation of those within-group scores. Thus, the vertical position and error bars can be used to assess the effect of rating and story on recall; the horizontal position and error bars can be used to assess the distribution of ratings for each story. Because of the paucity of low ratings for *Interview* and of high ratings for *Pendennis*, these points have little effect on the model fits and are omitted from the graph. Thus, the effect of story on recall is largely a question of whether the stories differ in the medium-rating condition. As can be seen, recall improved with on-task rating. However, with the intermediate ratings, for which there were a substantial numbers from both texts, *Interview* still produced more recall statements even though the on-task ratings were similar.

In order to quantify the evidence for this pattern of results, nested linear models were fit to the data. A model incorporating the effect of rating type (low, medium, or high) was substantially better than a null model in which none of the conditions differed ($\lambda_{\text{adj}} = 597.10$). However, adding an effect of story, independent of rating, provided a clear improvement in the model ($\lambda_{\text{adj}} = 4.99$). Thus, recall increased with on-task rating as expected, but the nature of the text also determined recall for comparable levels of on-task rating.

Discussion

The critical result from Experiment 1 was that for comparable levels of on-task rating, *Interview* had substantially higher recall. Thus, one cannot claim that the more interesting story is recalled better simply because readers attend to it more fully. Equivalently, the results demonstrate that recall is not simply a function of the total resources allocated to reading, and that our manipulation of interest value must affect some other aspect of processing as well. This pattern disconfirms the mediation account of interest value.

In addition to this critical result, we also verified three general trends that could be anticipated on the basis of past research: First, recall increases with on-task rating. This conforms to the results found previously by Dixon & Li (2007); Schooler et al. (2004), and Smallwood, McSpadden et al. (2008). It suggests that when subjects are not on task, their representation of the text is not as complete or perhaps not as durable as those representations are when resources are devoted more fully to the task of reading comprehension. Second, the data demonstrate that on-task rating is higher, on average, for the more interesting story. This confirms our subjective analysis of the relative interest value of *Interview* and *Pendennis* as well as the intuition that more interesting stories

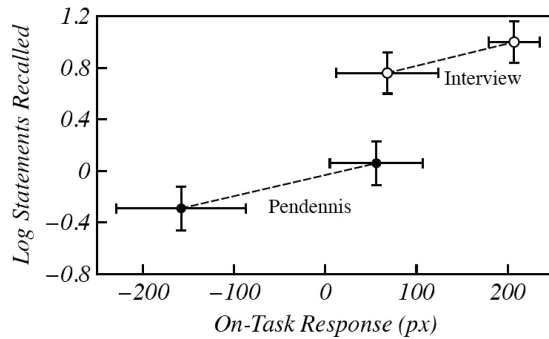


Figure 1. Recall as a function of on-task rating and story. The horizontal positions of the points indicate the mean of the low and medium ratings for *Pendennis* and the medium and low ratings for *Interview*. (There were relatively few high ratings for *Pendennis* and few low ratings for *Interview*, and these points are not plotted.) The horizontal error bars indicate the standard deviation of the ratings within each of those groups. The vertical positions of the points indicate the corresponding number of recall statements that could be attributed to the material in the text segment prior to the mental state probe, expressed on a log scale. The vertical error bars indicate the standard error. The mean and standard error were derived from the generalised linear model fit to the data and described in the text.

lead to less mind wandering. It is consistent with the retrospective reports of Giambra and Grodsky (1989), who found more task-unrelated thoughts with more boring material. Finally, recall is greater for the more engaging text. Again, this result is intuitive: One would assume that a more interesting story would be read more deeply and provide the basis for a more elaborate and persistent memory representation. However, these three trends do not predict the central result that the nature of the story has an effect on recall, independent of the effect of whether subjects are on task or not.

Experiment 2

In Experiment 2, we tested a possible explanation for the critical feature of the results of Experiment 1. Specifically, we assessed whether making a distinction between the allocation of resources to integrative processes and to constructive processes could provide a better account of subsequent recall. As we argued in the introduction, devoting resources to constructive process will produce more accurate lexical representations, more complete text-based inferences, and a more precise representation of meaning. On the other hand, allocating resources to integrative processes should produce more interconnections with long-term memory, a greater use of personal knowledge, and a more elaborate and detailed situation model. As outlined below, this difference in the effect of resource allocation could have produced the pattern of results in Experiment 1.

We use the term *engagement* to refer to the allocation of resources to the integrative processes responsible for building a representation of the story world. In terms of common models of comprehension, we assume that engagement produces two kinds of changes in the situation model. First, attention may allow more relevant information from long-term memory to be activated and connected to the propositional representation of the text. Thus, more world knowledge would be incorporated into the situation

model as appropriate, and the situation model would become more connected to related personal experiences. We refer to this possible effect as *elaboration*. Second, engagement may allow more extensive situation-model-based inferences including, for example, inferences related to spatial relationships, character motivations, and story theme. Many of these kinds of inferences fall under the general heading of *search after meaning* as described by Graesser, Singer, and Trabasso (1994). We use the term *situation-model extension* to refer to this effect.

Both situation-model elaboration and extension should improve recall. Following the logic of Ericsson and Kintsch (1995), we assume that the situation model provides a mnemonic for organizing and retrieving information about the story world. To the extent that it is elaborated, there will more cues associated with story world details and consequently more paths for retrieval of that information. Situation-model extension may improve the mnemonic value of the situation model by providing more organizing features and structure. Such improvements should be particularly important in free recall of the material as measured with the current method. Thus, the pattern of results found in Experiment 1 could have occurred if the more interesting texts lead to relatively more engagement.

In order to test this hypothesis, we used a mental-state probe designed to elicit information about engagement (rather than simply whether subjects were on task or not). If our analysis of the effects of resource allocation is correct, then the measurement of engagement should provide an index of situation-model elaboration and extension. In turn, this should be closely related to subsequent recall. Further, if engagement captures the critical information about the processing of the situation model, there is no reason to think that the interest value of the text would have any further effect on recall. That is, unlike the pattern of results found for on-task ratings in Experiment 1, comparable levels of engagement should lead to comparable recall, regardless of which story is being read. It is important to note that there are several ways in which this analysis might be incorrect. For example, if recall is not determined primarily by integrative processes, the measurement of engagement might produce the same results as on-task ratings. Alternatively, subjects may be unable to accurately assess their level of engagement, in which case recall should be unrelated to the mental state probe responses. Thus, finding the predicted pattern would provide evidence in favour of our analysis.

Method

The materials, equipment, and procedure were generally the same as in Experiment 1. The only difference was that the probe consisted of the question, "Do you feel like you're experiencing the story as if you were there or are you just reading superficially?" Points along the response scale were labelled with the alternatives, *Definitely reading superficially*, *Reading superficially to some extent*, *Not sure*, *Experiencing the story to some extent*, and *Definitely experiencing the story*.

Subjects. Subjects were 60 undergraduates who volunteered to participate in exchange for course credit. Half were assigned randomly to read *Interview* and the other half were assigned to read *Pendennis*. Three subjects who indicated that they had read *Interview* before and one who indicated that he or she had read *Pendennis* before were omitted from the analysis.

Analysis. Comparable to the procedure in Experiment 1, engagement ratings were divided into low ratings (below the 25th percentile of -113 pixels), high ratings (above the 75th percentile of 119 pixels), and medium ratings. As in Experiment 1, using rating as a continuous variable produced the same pattern of results.

Results

The distribution of engagement ratings is shown in Table 2. The distribution is comparable to that observed in Experiment 1, with relatively few low ratings for *Interview* and relatively few high ratings for *Pendennis*. The mean rating for *Interview* was 97.9 pixels ($SE = 7.8$), and for *Pendennis* was -53.6 pixels ($SE = 7.6$).

The relationship between engagement rating and recall is shown in Figure 2. The construction of this graph is the same as Figure 1: The vertical position and error bars allow one to assess the effect of story and rating on recall, while the horizontal position and error bars allow one to assess the distribution of ratings for each story. As anticipated, *Interview* had both higher levels of engagement and better recall. However, recall appeared to be purely a function of engagement, and there was no clear effect of text independent of the level of engagement.

As before, to quantify the evidence for this pattern, nested linear models were fit to the results. A model incorporating the effect of rating type (low, medium, or high) was substantially better than a null model in which none of the conditions were assumed to differ ($\lambda_{adj} > 1,000$). However, adding an effect of text, in addition to the effect of rating, failed to improve the model ($\lambda_{adj} = 0.23$). Thus, recall can be construed as purely a function of the level of engagement, with little further effect of the nature of the text.

Discussion

The results of Experiment 2 have a simple description: The greater the degree of engagement, the better the recall. Critically, this differs from the pattern of results in Experiment 1 in that there was no (independent) effect of interest value of the text as a whole. Rather, engagement alone appeared to capture the major part of the processing variation that affected recall. Equivalently, segments that had comparable levels of engagement had comparable recall regardless of whether the story overall was interesting or less interesting. These results are consistent with a distinction between resource allocation to constructive processes and to integrative processes. This interpretation is based on two assumptions: First, we argue that the engagement probe provides a suitable index of how much resource is directed to integrative processes. Second, we assume that recall is determined largely by the quality of the situation-model representation. Thus, when resources are allocated

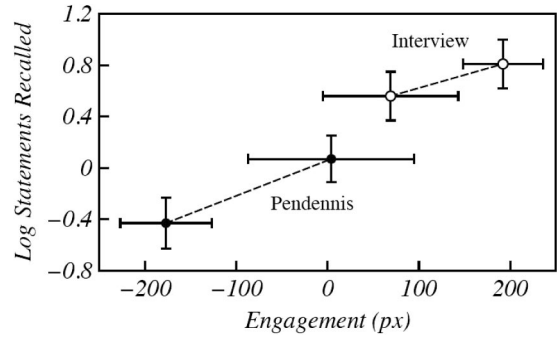


Figure 2. Recall as a function of engagement rating and story. The horizontal positions of the points indicate the mean of the low and medium ratings for *Pendennis* and the medium and low ratings for *Interview*. (There were relatively few high ratings for *Pendennis* and few low ratings for *Interview*, and these points are not plotted.) The horizontal error bars indicate the standard deviation of the ratings within each of those groups. The vertical positions of the points indicate the corresponding number of recall statements that could be attributed to the material in the text segment prior to the mental state probe, expressed on a log scale. The vertical error bars indicate the standard error. The mean and standard error were derived from the generalised linear model fit to the data and described in the text.

to integrative processes, the situation model is likely to be elaborated, with more connections to world knowledge and personal experience, and extended, incorporating more situation-model-based inferences. Both of these effects should improve subsequent free recall.

General Discussion

The results of the present two experiments provide some insight into how variations in resource allocation are related to later memory for the text. In both experiments, variations over time in mental state had concomitant effects on subsequent recall: In Experiment 1, increased on-task rating was associated with better recall, and in Experiment 2, increased engagement rating was associated with better recall. However, the interest value of the text had an effect on recall in Experiment 1 independent of whether readers were attending to the task. In contrast, in Experiment 2, for text segments for which levels of engagement were similar, there was little evidence for a difference in recall between the interesting and less interesting texts.

These contrasting patterns can be explained by considering the processes to which resources might be allocated while reading. We begin with the common assumption that readers generate three levels of representation in reading: the surface structure, the propositional content, and the situation model (e.g., Kintsch et al., 1990). Further, we distinguish between constructive processes that build representations of propositional content and integrative processes that build the situation model. Our interpretation of the present results is that readers can differentially allocate attentional resources to these constructive and integrative processes when they are on task. Allocating resources to the constructive processes would produce more precise representations of the meaning and may be necessary for some text-based inferences such as identifying distant anaphors (Garrod & Sanford, 1982) or establishing local coherence based on world knowledge (Singer, Halldorson,

Table 2
Distribution of Level of Rated Engagement Across Texts in Experiment 2

	Level of Rated Engagement		
	Low	Medium	High
<i>Interview</i>	26	123	121
<i>Pendennis</i>	111	160	19

Lear, & Andrusiak, 1992). In contrast, allocating resources to integrative processes would be necessary for identifying the overall structure of the text and building a situation model incorporating long-term knowledge. Allocating ample attentional resources to integrative processes should allow more elaboration—that is, more extensive connections to long-term memory—and extensions based on attention-demanding inferences.

An essential component of this account of the present results is that the situation model is important for free recall. This idea can be found in a number of previous accounts. For example, Ericsson and Kintsch (1995) argued that the situation model provides a retrieval structure that allows readers to recall information encountered in a narrative. More generally, though, it seems reasonable to suppose that the greater the degree of interconnections to other information in long-term memory, the better the recall. The present results make sense if the engagement rating provides an index of the degree to which such interconnections are made.

The Retrospective Nature of Mental-State Probes

Our view is that the responses subjects make to mental-state probes must be inferred based on the contents of working memory and other mental representations. In turn, these representations allow subjects to make retrospective inferences concerning their recent resource allocation. This interpretation contrasts with the suggestion that mental state probes (such as those used by Smallwood et al. [2007]) reflect subjects' "meta-awareness" of their ongoing mental activity. In a meta-awareness analysis, mind wandering reflects a property of how the mind monitors its own activity, and it is assumed that the processing of task-irrelevant information can proceed with or without awareness. From this perspective, one might suppose that the response to a mental state probe would be immediately available in consciousness as an aspect of meta-awareness. However, one need not assume that the mind includes such meta-awareness in order to understand how subjects are able to respond to a mental state probe. Indeed, it seems unlikely to us that subjects would have a chronically available metacognitive state variable that indicates whether one is on task or not, whether one is zoning out or not, whether one is engaged with the task or not, and so on. For example, these concepts need to be clearly explained to subjects in order to generate consistent performance. Instead, our sense is that making responses to the mental state probes is an inferential, problem-solving task for subjects. This problem solving can be accomplished by assessing the current contents of working memory and then making inferences about what their mental state must have been to generate those contents.

Based on this perspective, we assume that the different patterns of results for the mental-state probe tasks used in Experiments 1 and 2 were due to the tasks' differential sensitivity to propositional-content and situation-model representations. In particular, we suppose that high engagement responses would be produced when the reader can identify elaborate and extended situation-model representations corresponding to the story world. These would most be likely to be constructed if ample resources were devoted to integrative processes. On the other hand, high on-task ratings would be produced whenever the reader identifies any representations of the text. While this

might include story-world representations, it would also include propositional representations of the text meaning. Thus, on-task ratings would be high if resources were directed to either constructive or integrative processes. The net result is that while on-task ratings would be influenced by the information in a situation model representation, they would also be influenced by text representations that are not part of the situation model. Because on-task ratings can reflect representations other than the situation model, they would not predict recall as accurately as engagement ratings.

Conclusions

In sum, the present research provides an expanded perspective on the role of mental states in reading. Not only can a reader allocate resources to the task of reading or to other, nonreading mental processes, he or she can also allocate attentional resources to different aspects of the reading task. In our analysis, we distinguish between constructive processes that are responsible of the identification of text meaning and integrative processes that build a situation model. The results of the two experiments indicate that moment-to-moment variation in the allocation of resources specifically to integrative processes has an effect on later recall.

Résumé

Dans le cadre de deux expériences, les auteurs ont cherché à déterminer de quelle façon le rappel d'un texte était relié à des variations momentanées de l'état mental durant la lecture et de quelle façon à la fois le rappel et l'état mental variaient selon l'intérêt à l'égard du texte. Pour les deux expériences, les sujets devaient soit lire un texte intéressant – un passage du roman *Entretien avec un vampire* (A. Rice, 1997, *Interview with the vampire*, New York, É.-U. : Ballantine Books) –, soit un texte moins intéressant – un passage de *L'histoire de Pendennis* (W. M. Thackeray, 2009/1914, *The history of Pendennis*, Project Gutenberg; consulté à <http://www.gutenberg.org/ebooks/7265>). Les textes ont été lus phrase par phrase sur un écran d'ordinateur, et les sujets ont été périodiquement interrompus afin qu'ils répondent à une question approfondie. Dans l'Expérience 1, on a demandé aux sujets s'ils consacraient de l'attention au texte; dans l'Expérience 2, on a demandé aux sujets s'ils se sentaient interpellés par l'univers du récit. Après la lecture du texte, on a demandé aux sujets de se rappeler le plus d'éléments possibles du récit. Le rappel du matériel juste avant les questions a été examiné en vue d'établir un classement, élevé, moyen ou faible. Comme on s'y attendait, les résultats des deux évaluations, au sujet de l'attention à la tâche et du niveau d'engagement, étaient plus élevés pour *Interview* que pour *Pendennis*. Toutefois, un nombre important d'évaluations moyennes ont été attribuées aux deux récits. Dans l'Expérience 1, on a constaté un net effet de l'histoire sur la capacité de rappel, au-delà de l'évaluation de l'attention consacrée à la tâche. Toutefois, dans l'Expérience 2, le rappel était purement fonction du niveau de l'engagement. Ces résultats ont été interprétés au moyen d'un modèle selon lequel le rappel est largement déterminé par la représentation du modèle de situation du récit et où les évaluations de l'engagement (et non celles de l'attention consacrée à la tâche) fournissent un indice rela-

tivement pur de l'allocation des ressources au traitement du modèle de situation.

Mots-clés : rêverie, construction et intégration, lecture, modèle de situation.

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