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Episodic Transfer and Automaticity: Integration of Data-Driven and Conceptually-Driven Processing in Rereading

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We propose that data-driven and conceptually-driven processing become integrated to form an episodic representation that mediates transfer to later reading and memory tasks. These experiments explored conditions that produce visual script specificity for episodic transfer. Earlier work suggested that script sensitivity is reliably found only when the script is unusual or difficult to read, leading some researchers to suggest that such transfer occurs only during unskilled reading. These studies, however, demonstrate reliable script sensitivity in an easy, semantically based reading task using normal scripts. Transfer to the second occurrence is harmed by a change in script when the subject's task is to silently read and answer short questions. No such script sensitivity is observed when the task is to read the questions aloud on each occurrence. The data are discussed in terms of automatic processing when reading is backgrounded in the service of a semantic task.

The contrast between data-driven and conceptually-driven processing has been important for both theories of reading and theories of memory. In recent reading research, the data-driven versus conceptually-driven distinction has been used to explain the sources of transfer that mediate gains in rereading fluency. In memory research, the same distinction has been beneficial in explaining the dissociation between performance on indirect and direct tests of memory (e.g., Roediger & Blaxton, 1987a). Used both to describe sources of transfer and to explain dissociations, data-driven and conceptually-driven processes have been assumed to be separable sources of information. Indeed, Tulving and Schacter (1990) have identified the two types of processing with anatomically distinct memory representations. In contrast, we argue that data-driven and conceptually-driven processes sometimes become *integrated* to form an episodic representation that mediates transfer to later reading and memory tasks. This episodic transfer view builds on earlier suggestions that memory for prior episodes serves as a basis for gains in fluency observed in rereading (Levy & Kirsner, 1989; Levy, Newell, Snyder, & Timmins, 1986; Masson, 1986) and for memory revealed by indirect tests such as perceptual identification and fragment completion (Jacoby, 1983; Jacoby & Brooks, 1984). Consideration of repetition effects leads to a discussion of episodic transfer in the context of current theories of automaticity.

In theories of reading, the data-driven versus conceptually-driven contrast is generally used as a summary statement to describe different levels of linguistic analyses that enter into the reading process (see Rumelhart, 1977). The notion is that reading relies on a variety of sources of information that include at the lowest level the visual features of a presented word, and at the highest level the communication context in which the word appears. Data-driven processing usually refers to processes that analyze the stimulus input, whereas conceptually-driven processing includes analyses that contribute contextual information and linguistic and situational knowledge. Because lower levels of analyses (features, letters, word units, etc.) may vary in their reliance on stimulus and knowledge sources, it is difficult to define exactly when data-driven processing ends and conceptually-driven processing begins. Consequently, theorists generally use the data-driven versus conceptually-driven dichotomy informally and attempt to define more precisely the component processes that contribute to reading (e.g., Rayner & Pollatsek, 1989).

An area of common concern to reading and memory researchers is understanding how data-driven and conceptually-driven processes mediate repetition benefits. In text processing research the focus has been on the transfer of knowledge across readings of the same passage. For example, Kolers (1975) demonstrated that subjects could reread sentences typed in a rotated typescript faster when they had previously read the sentences in that rotated script rather than in a normally oriented script. On the basis of observation that this rereading benefit was reduced when characteristics of the visual display were altered between readings (e.g., changes in typescript or spacing), Kolers, Palef, and Stelmach (1980) argued that transfer between reading occurrences was mediated by pattern recognition processes. The nature of those pattern recognition processes has been the subject of some debate, but the use of transfer measures to investigate the processes involved in reading has become common. The major issue has been whether the transfer effects observed in rereading are mediated entirely by data-driven processes or whether higher level conceptual processes also contribute to rereading fluency.

One can address this issue by measuring losses in the magnitude of rereading benefits when changes are made in

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the text between readings. For example, Carr, Brown, and Charalambous (1989) required subjects to read aloud short paragraphs and varied the similarity of visual features (handwritten vs. typed script) between readings of a paragraph. They found that the magnitude of the transfer benefit was the same whether the scripts were changed or remained constant between readings. That is, transfer was complete across variations in script. Carr et al. also found complete transfer when the linguistic structure changed between reading encounters (scrambled words vs. coherent sentences). They concluded that rereading transfer was at the word level, and that these word representations were abstract units, such as logogens (e.g., Morton, 1969). Such abstract representations do not preserve the physical appearance of presented words, nor are they sensitive to the discourse structure in which the word appears.

However, the Carr et al. (1989) findings and conclusions conflict with other rereading results. Levy and Kirsner (1989) found that although changes in script between readings had only a small, statistically unreliable effect, changes in modality caused a substantial loss in transfer. These findings indicate a role for specific visual processes, perhaps beyond the feature level, in mediating the rereading benefit. The finding of transfer across the modality change suggests that conceptual processes were also involved in transfer. Levy and Burns (1990) provided further evidence that conceptual processes play a role in rereading transfer. Their results directly conflicted with those of Carr et al. They found that the magnitude of transfer decreased as more of the linguistic structure was lost by scrambling first the paragraphs, then the sentences, and finally the words. Masson (1989) also found evidence of transfer from prior conceptual processing when subjects reread sentences typed in rotated typescript after a 4-month delay. A rereading benefit was found when the words were first read in meaningful sentences but not when they were first read in scrambled sentences. These findings indicate an important role for processes beyond the word level in mediating rereading transfer. The bulk of the evidence, therefore, indicates that both data-driven and conceptually-driven processes contribute to rereading transfer. The question is how those processes combine to determine transfer (Carlson, Alejano, & Carr, 1991; Carr & Brown, 1990). We return to that question after a brief review of a related controversy in recent memory research.

Investigators of memory have been impressed by the finding that transfer benefits can arise even when people are unable to recall or recognize the prior experience that gave rise to that transfer. Transfer measures, unlike tests of recognition and recall, do not require recollection of a specific prior experience, even though the transfer test might provide indirect evidence of memory for a particular experience. To emphasize that difference, transfer tests have been referred to as implicit or indirect tests of memory, and recognition memory and recall tests have been referred to as explicit or direct tests of memory. Dissociations of performance on indirect versus direct tests of memory are commonly found (see Hintzman, 1990, and Richardson-Klavehn & Bjork, 1988, for reviews). Most striking is that amnesics sometimes show near-normal effects of memory on indirect tests, although their performance on direct tests is badly impaired. Similar dissociations are found for normal subjects. For example, reading a word makes it more likely that that word can be perceptually identified when it is flashed briefly in a later test. This transfer benefit can be independent of ability to later indicate that that word was one of those presented earlier (e.g., Jacoby & Dallas, 1981). Some memory theorists have relied on the data-driven versus conceptually-driven distinction in explaining this dissociation of indirect and direct memory tests. They have suggested that dissociations arise when indirect and direct tests differ in their reliance on data-driven versus conceptually-driven processing. For example, the dissociation between effects on perceptual identification and recognition memory performance is explained as resulting because perceptual identification primarily relies on data-driven processing, whereas recognition memory primarily relies on conceptually-driven processing (e.g., Jacoby, 1983; Roediger & Blaxton, 1987a, 1987b).

As in the reading research (e.g., Carr et al., 1989), memory researchers have used visual specificity of effects to index the transfer benefits that originate from influences on data-driven processing. They have taken findings of complete transfer across changes in the visual details of presented words as evidence that repetition benefits rely on abstract representations. For example, Scarborough, Cortese, and Scarborough (1977) found no reduction in the repetition benefit in a speeded lexical decision task when the typescript differed on the two occurrences. In a similar manner, Rayner, McConkie, and Zola (1980) reported indifference to changes in letter case when measuring the effect of parafoveal preview on a later speeded pronunciation task, and Brown, Sharma, and Kirsner (1984) found no difference in the size of the repetition benefit in a lexical decision task, whether the repetitions were in the same or different writing systems for Hindi–Urdu bilinguals. From the abstractionist position, this insensitivity to visual script is because repetition effects reflect the activation or priming of a generic representation of a word (a logogen or lexical representation) that has been abstracted across variations in the surface form of the word so that it is now insensitive to these variations (for reviews, see Carr & Pollatsek, 1985; Dunn & Kirsner, 1989; Neely, 1991). Once again, however, there are conflicting results.

Transfer that is specific to the visual details of repeated items is sometimes found. For example, Jacoby and Hayman (1987) found that words presented in lowercase letters for a perceptual identification test were more readily identified if they had previously been read in lowercase, rather than uppercase, letters. Similar findings of transfer that is specific to the visual details of presented words have been reported by Kirsner, Dunn, and Standen (1987), Kolers (1973), Masson (1986), and Roediger and Blaxton (1987a, 1987b). These findings of specificity are important because they limit the level of abstraction of the memory representation that can be held responsible for repetition effects. For example, to account for the results reported by Jacoby and Hayman in terms of activation of an abstract representation, it would be necessary to claim that different logogens correspond to uppercase and lowercase versions of a word. It is clear that specificity of transfer to sensory details can be found. The question is, what conditions are necessary for those effects to occur?

When will transfer that is specific to the sensory details of presented items be found? By the remembering-operations view proposed by Kolers (1973), transfer should always be specific to visual details because memory for the meaning of a message is never separate from memory for the operations engaged in to gain that meaning. However, perceptual specificity has been most consistently found when the script is difficult to read (e.g., rotated or distorted) so that attention is focused on perceptual processing, leading some investigators to suggest that perceptual specificity results from a word-level focus during reading (e.g., Masson & Freedman, 1990). These investigators link transfer of data-driven, visual analyses to early stages of skill acquisition when the reader is still having trouble taking the print from the page.

In contrast, our experiments were done to investigate the possibility that perceptual specificity will also be found when reading is backgrounded, being in the service of some other task. That is, perceptual specificity might be found when reading serves as a tool for obtaining a message rather than being the focal processing activity (cf. Jacoby & Kelley, 1987). When language is backgrounded in the service of a higher order function, the language processes themselves must be more fluent or automatic. Such backgrounded reading may show greater perceptual specificity than does reading as a focal activity. The view is similar to Logan's (1988) account of automaticity. He suggested that automaticity comes about when people change from computing responses algorithmically to relying on memory for prior instances. As a commonplace example of the relation between backgrounding of a task and reliance on perceptual factors, consider the task of driving a car along a familiar route while engaged in an attention-demanding conversation. In that circumstance, changes in perceptual characteristics of the route would probably be much more disruptive than they would be if driving were the focal task. As applied to reading, the argument is that a word can be read in two qualitatively different ways: Reading can rely on an algorithm that is relatively invariant across situations (e.g., the uses of abstract grapheme-to-phoneme correspondence rules), or reading can rely on memory for prior encounters with the word (cf. Jacoby, 1978).

In our view, the episodic representation contains both perceptual and conceptual information, and these are integrated into a processing "package." When reading is backgrounded in service of gaining meaning, retrieval of that package might rely on the original perceptual information, so that transfer specificity will be observed. We contrast this view with the notion that perceptual specificity is most evident when the original and transfer tasks are data driven or focused at the word level.

Experiment 1

We examined visual specificity when subjects engaged in two different tasks, reading aloud and question answering. Subjects either read aloud or heard and repeated as rapidly as possible a series of questions and then immediately reread aloud that set of questions. Alternatively, subjects answered questions, which they silently read or heard, as rapidly as possible and then silently read and answered those questions again. The measures of interest were savings in rereading and in reanswering times. The main manipulation within each task was the physical similarity of stimulus questions on the two processing occurrences. In Phase 1 the questions were read in elite typescript from a computer screen or in script typefont from a card, or they were heard by means of a tape recorder. In Phase 2 all questions appeared in elite typescript on the computer screen. We were interested in whether the physical variations in Phase 1 would affect transfer to Phase 2 differently in the two tasks.

The tasks were chosen to emphasize different types of processing. The reading-aloud task is similar to the reading task used previously by investigators such as Carr et al. (1989). A feature of reading aloud is that it forces processing to occur in a word-by-word fashion, by virtue of the need to say each word. Thus, correct word articulation is the main task. The question-answering task, on the other hand, allows silent reading to be focused on message comprehension. The questions were designed to elicit rapid correct responses so that no laborious semantic processing was necessary. Rather, silent reading should provide rapid access to knowledge stored in memory without any emphasis on detailed word analyses. By an abstractionist view, this is precisely the sort of *semantic* reading task that is minimally reliant on data-driven processing and that should show little evidence of such processing as indicated by visual specificity in transfer. Any effect of earlier answering a question on the speed of later silently reading and answering the same question would be expected to reflect an influence on the associations between abstract concepts referred to by the question rather than reflecting memory for the sensory details of the earlier presented question. An abstractionist view, therefore, should hold that finding transfer specific to sensory details would be less likely for silent reading and question answering than for reading aloud.

In contrast, we made the opposite prediction. We expected reading to be backgrounded in the question-answering condition compared with the reading-aloud condition. Reading in the question-answering task serves as a tool for obtaining a message rather than being the focal processing activity (cf. Jacoby & Kelley, 1987). Silent reading in service of answering questions may be more automatic and, consequently, rely more heavily on reinstatement of the sensory details of the prior episode. We expect the question-answering task to be more robust in showing visual specificity than reading aloud, whereas the word-by-word focus may lead to reliance on algorithmic mechanisms.

Note that it is not the contrast between silent reading in the question-answering task and reading aloud that we expect to produce the difference in perceptual specificity for the two tasks. Rather, the important difference is thought to be between reading in service of (or the backgrounding of reading) versus reading aloud as a focal activity. Finding a difference between these two activities would be of interest for theories of automaticity as well as for theories of reading. We return to the relation between theories of automaticity and theories of reading in the General Discussion section.

Method

Subjects. Forty-eight undergraduate volunteers from an introductory psychology course participated in the study. They were tested individually in sessions lasting about 20 min. They received course credit for their participation.

Design and materials. Twenty-four subjects participated in each of two tasks, reading aloud and question answering. Surface form of the question during Phase 1 was varied within subjects for both tasks. Twenty-five questions appeared in elite typescript on the computer screen (Apple IIE), 25 were typed individually on cards in IBM script font, and 25 were played on a tape recorder. Asterisks appearing on the screen signaled subjects that they would receive a card to read, and a blank screen indicated auditory presentation of the question. For the reading-aloud task, questions in the elite and script typescript conditions were read aloud as quickly and accurately as possible. In the auditory condition, subjects repeated back the questions as they were presented. For the question-answering task, subjects answered each question as rapidly and accurately as possible for all three surface form conditions. In Phase 2 for both tasks the questions were always presented in elite typescript on the computer screen, and subjects either read them aloud or read them silently and answered them, as the task required.

The questions used in both phases of Experiment 1 varied in length from 36 to 40 characters (5 to 9 words). They were general knowledge questions that could be answered rapidly by most undergraduates (e.g., What do men do to remove their beards? Cereal is often served at what meal? What number is often considered unlucky?). All questions required unique answers of one or two words. They were evenly distributed across several topics (e.g., food, geography, science, animals, and famous people) and question types (e.g., what, where, which, and how questions), and there were approximately equal numbers of sentences that were 5, 6, 7, 8, and 9 words in length. Besides the 75 repeated questions from Phase 1, 25 new questions were included in Phase 2 for both tasks. In both phases, questions in the various surface form conditions occurred randomly across the question set. The new questions were also randomly distributed across the Phase 2 set. Across subjects, the 100 questions used in Experiment 1 occurred equally as often in the elite, script, auditory, and new conditions for each task. This counterbalance ensured that there were no differences in materials across the main experimental contrasts.

Procedure. When subjects arrived at the experiment they were seated approximately 60 cm from the Apple IIE computer screen. In the reading-aloud condition they were told that they would read or hear 75 short questions, and they were fully informed about the three presentation conditions. They were told to read each visually presented question as rapidly and accurately as possible and to repeat back each auditory question as rapidly and accurately as possible. To encourage rapid responding, the subjects were told that their response times were being recorded, although they were not in fact recorded in Phase 1. Subjects were told to think of the task as a game show, in which the goal was to respond quickly but without making any mistakes. After all 75 questions in Phase 1 were presented, subjects were told that they would now read aloud another 100 questions, all in elite typescript from the computer screen. They were told again to adopt the game show orientation to the task. This time the computer recorded the interval from the stimulus presentation until the experimenter pressed a key to enter the completion of reading. These rereading times provided the data for the main experimental contrasts.

In the question-answering task the procedure was as described earlier, except that the subjects were told to answer rather than read or repeat the questions in both phases of the experiment. They were told to give one- or two-word answers as rapidly and accurately as possible. Once again, the game show orientation was used in both phases. The timing interval began with the stimulus presentation and ended with the onset of the subject's response, which was entered by the experimenter pressing a key. Thus, reanswering times included the time to silently read and to find an answer to the question.

Results and Discussion

The probability of a question being correctly answered in the question-answering condition was .92. To increase comparability with the reading-aloud condition, times to answer questions were not conditionalized on the correctness of the answer that was given for the analysis that we report. However, results from an additional analysis that examined only times for correctly answered questions parallel those for unconditionalized times. For both test conditions, median times for Phase 2 only were analyzed. Means of those medians are presented in Table 1. In these analyses we examined the effect of surface form variation during Phase 1 on the reprocessing times in Phase 2 for both tasks. All *F*s and *t*s that are reported are significant at or beyond the .05 level, unless otherwise noted. All *t*s reported in this article are Student *t*s using the error terms from the analysis of variance (ANOVA).

An ANOVA revealed that subjects were generally faster in silently reading and reanswering questions than they were in rereading aloud those same questions (1,986 ms vs. 2,235 ms), $F(1, 46) = 16.87$, $MS_e = 176{,}821$. The main effect of prior processing condition (elite, script, auditory, new) was also significant, $F(3, 138) = 120.74$, $MS_e = 9{,}266$, as was the interaction of prior processing condition with task, $F(3, 138) = 61.36$, $MS_e = 9{,}266$. Comparisons of the new condition with the reprocessing conditions indicated that there was significant transfer from Phase 1 for all surface form conditions, in both tasks ($ps < .01$, in all cases). As the means in Table 1 indicate, for new questions in Phase 2 reading aloud was faster than question answering, but for all reprocessing conditions questions were answered faster than they were read aloud.

The effect of changing sensory details between repetitions was examined separately for the two tasks (reading aloud vs. question answering). The reading-aloud results agree with

Table 1
Means and Standard Deviations of Median Reaction Times (in Milliseconds) for Experiment 1

	Question form			
Activity	New (Elite)	Auditory	Script	Elite
Reading-aloud				
M	2,300	2,226	2,205	2,209
SD	218	208	223	217
Answering				
M	2,374	1,902	1,858	1,808
SD	312	201	222	186

Note. These data are from Phase 2 of Experiment 1.

those reported by Carr et al. (1989) in showing no reliable difference in the transfer benefit whether the surface form was repeated (elite) or changed (script, auditory) between repetitions. Carr et al. took this complete transfer across sensory variations to indicate the role of abstract word representations in mediating transfer. In contrast with these results for the reading-aloud condition, times to answer questions showed clear evidence of sensory specificity. Answering times differed significantly across the three repetition conditions, $F(2, 46) = 7.86$, $MS_e = 6{,}707$. Questions were answered more rapidly when they were read in the same (elite) rather than different (script) typescripts on the two occurrences, $t(46) = 2.11$. This finding indicates sensitivity to visual features for a reading task using normal typescripts that do not slow processing. Visual specificity is further indicated by the finding that questions are answered more rapidly when they were previously read compared with when they were previously heard, $t(46) = 3.98$; $t(46) = 1.86$, $p < .10$, for elite and script comparisons with auditory. Thus, this semantically based reading task yields reliable visual specificity effects even though the more word-by-word reading-aloud task shows no perceptual specificity in transfer. This pattern of results is consistent with the suggestion that transfer is more specific to the sensory details of tested items when the task of reading is backgrounded, as in the question-answering condition, rather than made focal as in the reading-aloud condition. In this study the data-driven hallmarks travel with the more meaningful task, consistent with the findings of Levy and Kirsner (1989).

Experiments 2 and 3

The results of Experiment 1 provided evidence of episodic transfer by showing that questions were reread and answered more rapidly when typeface was held constant, rather than changed, between presentations of a question. Experiments 2 and 3 examined further this visual specificity during silent reading and question answering, specifically to test for the intentional use of memory for the prior presentation during the rereading and answering phase. Subjects may have noticed that the majority of the questions were repeated and may have developed the strategy of looking for key words in a question to be used as cues for recall of their earlier answer to that question, rather than fully rereading and then answering repeated questions. That is, the effect of change in typeface may have resulted from an intentional use of memory rather than from differential episodic transfer to the reprocessing of questions. In Experiment 2, we examined the effect of delay between repetitions of questions. For an immediate test condition, the experimental arrangement was the same as in Experiment 1, whereas in a delayed test condition there was a 24-hr delay between repetitions of the questions. Delaying repetition of a question should make it less likely that subjects could intentionally rely on specific memories from the prior day. Thus, one should find less transfer and less visual specificity in the delayed than in the immediate condition if intentional memory mediates the effects observed in Experiment 1. Experiment 3 pushes this argument further by reducing the proportion of questions in Phase 2 that are repeated from Phase 1. In Experiment 1, 75 of 100 questions used in Phase 2 had been presented earlier in Phase 1, whereas in Experiment 3, 75 of 300 questions in Phase 2 were from Phase 1. If the effects of change in typeface resulted from a strategy to intentionally use memory for the prior occurrence because of the high overlap of items in the two phases of the experiment, then these effects should be diminished when the majority of Phase 2 items are novel, as in Experiment 3. However, it should be noted that an effect of proportion overlap would not conclusively show that sensory specificity of transfer did arise from an intentional use of memory. Allen and Jacoby (1990) found that increasing proportion overlap between study and test enhanced perceptual identification performance, and the details of that effect were such that one could be certain that it did not arise from an intentional use of memory.

Method

Subjects and design. Twenty-four undergraduate volunteers from an introductory course served in Experiment 2, and 40 volunteers from the same course served in Experiment 3. They received course credit for their participation.

In Experiment 2, the delay between repetitions of questions was varied within subjects. In Phase 1, subjects answered 150 questions, 50 that were presented auditorily, 50 that were in script typefont on cards, and 50 that were in elite typefont on the computer screen. Phase 2 was conducted in two parts. Immediately following Phase 1, subjects were asked to answer another 100 questions, 25 questions repeated from each of the three surface form conditions used in Phase 1 as well as 25 new questions. The second part of Phase 2 occurred after a 24-hr delay. Here subjects again answered 100 questions that consisted of the remaining 25 questions from the three surface form conditions of Phase 1 plus 25 new questions.

Experiment 3 was identical to Experiment 1, except that 200 new questions were added to Phase 2 so that only 75 of the 300 questions were repeated from Phase 1. (The Appendix contains sample critical questions used in these studies.)

Materials and procedure. The guidelines used in constructing questions for Experiment 1 were used to construct 100 additional questions for a total of 200 questions for Experiment 2, and yet another 100 questions for a total of 300 questions for Experiment 3. For each of the experiments, materials were rotated through experimental conditions so that across subjects all questions appeared equally often in each experimental condition. The procedure used in Experiments 2 and 3 was the same as in Experiment 1, including the game show orientation to the task.

Results and Discussion

The probability of correctly answering a question was .91 in Experiment 2 and .92 in Experiment 3. Analyses were again conducted on median times to answer questions, without regard to the correctness of the answer.

Table 2 shows the mean median question-answering times for Phase 2 of Experiment 2 for each prior history condition, for both immediate and delayed tests. Increasing the delay between repetitions of a question did not produce a reliable effect on the time required to answer that question, nor did the interaction between delay and prior history condition approach significance ($Fs < 1$). In both immediate and de-

Table 2
Means and Standard Deviations of Median Question-Answering Times (in Milliseconds) for Experiment 2

Test	Question form			
	New (Elite)	Auditory	Script	Elite
Immediate				
M	2,319	1,873	1,817	1,779
SD	471	319	375	350
Delayed				
M	2,318	1,892	1,840	1,804
SD	541	380	364	344

Note. These data are from Phase 2 of Experiment 2. The delayed question-answering test was administered 24 hr later.

layed Phase 2 conditions, the results parallel those observed in Experiment 1. Questions that were earlier heard were answered more slowly than those that were earlier read in script typeface, $t(46) = 3.36$, and questions that were earlier read in script typeface were answered more slowly than those that were earlier read in elite typeface, $t(46) = 2.34$. Thus, once again we see visual and featural specificity in transfer, even after a 24-hr delay between repetitions. As in earlier studies of indirect tests, there was no loss in transfer over a 24-hr delay (e.g., Tulving, Schacter, & Stark, 1982) and there was no change in the visual specificity of transfer for this semantic reprocessing task. The episodic effects in transfer did not diminish with time as would be expected if intentional memory retrieval were involved.

The results of Experiment 3 are very similar to those of Experiment 1. The mean median question-answering times are shown in Table 3. Once again, questions that had earlier been heard were answered more slowly than questions that had earlier been read on cards in script typeface, $t(78) = 2.08$, which in turn were answered more slowly than questions that had earlier been read in elite typeface, $t(78) = 2.01$. The advantage in answering times for questions repeated in the same rather than a different typescript (56 ms) was nearly identical to the advantage observed for this comparison in Experiment 1 (50 ms). That is, a comparison of results across experiments indicates no reduction in the sensory specificity of transfer even though the majority of questions in Phase 2 were repeated in Experiment 1 but novel in Experiment 3. Once again, the consistency of specificity effects across this difference in proportion of item overlap suggests that specificity is not produced by an intentional use of memory to answer repeated questions. Rather, the visual specificity of transfer results from the automatic retrieval of memory representations during the reprocessing phase.

General Discussion

Despite Kolers et al.'s (1980) demonstration of sensitivity to typescript and spacing changes during the rereading of transformed typographies, it has been remarkably difficult to consistently find evidence of sensitivity to changes in visual features across repetitions when normal typographies are used (e.g., Feustel, Shiffrin, & Salasoo, 1983; Levy et al., 1986). However, script sensitivity is reliably obtained when unfamiliar typographies are used (e.g., Jacoby & Hayman, 1987; Masson, 1986). These findings led Masson and Freedman (1990) to argue that:

> Aspects of word identification that are supported by many prior experiences will be executed with a high level of skill and will not be susceptible to significant improvement when a word is repeated. The vast experience normal readers have with identification of words in a variety of alphabetic styles suggests that the source of repetition effects probably does not lie with visual analysis of the word. Therefore, it is not surprising that repetition effects are sustained across changes in type case or script [and that] operations responsible for developing a conceptual interpretation of a word are critically implicated in word repetition effects found in paradigms involving normally printed, whole words. (p. 356)

This view of skilled word identification postulates a clear separation of roles played by data-driven and conceptually-driven processes in mediating repetition effects. Data-driven visual analyses are linked with early stages of skill acquisition when the reader is still having trouble taking the print from the page. Once experiences are sufficiently numerous to allow skilled reading, then repetition effects are totally reliant on higher level processes.

The results that we present here question the generality of that view. Transfer originating from prior data-driven processing is not limited to the reading of unusual typography. Rather, we have shown perceptual specificity of transfer using a normal typography in a task that emphasizes reading for meaning. In Experiment 1, insensitivity to changes in visual features between repetitions occurred in oral reading, a task that by some arguments is largely data driven, or forces word-by-word reading. Sensitivity to changes in visual features occurred in question answering, in which reading is silent and the task is meaning based. Thus, sensitivity to changes in the visual array traveled with the more semantic rather than the more word-oriented task. In our view, these results stem from the greater reliance on perceptual characteristics of text to access episodic memory representations when the skilled reader processes the print in a more automatic fashion in the service of a meaning-based task.

That the visual sensitivity during silent reading to answer questions, observed in Experiment 1, is reliable across substantial changes in the paradigm is shown in Experiments 2 and 3. Here changes in the delay between the question repe-

Table 3
Means and Standard Deviations of Median Question-Answering Times (in Milliseconds) for Experiment 3

Measure	Question form			
	New (Elite)	Auditory	Script	Elite
M	2,491	2,074	2,018	1,964
SD	589	400	378	385

Note. These data are from Phase 2 of Experiment 3.

titions, and in the proportion of repeated versus novel questions used, did not alter the visual sensitivity observed. This consistency of results would argue against any notion that the visual sensitivity resulted from the intentional retrieval of the prior experience. Intentional memory retrieval would be susceptible to forgetting over a 24-hr delay and would be less optimal when the majority of questions are novel rather than repeated. The results of Experiments 2 and 3 show no effect of either manipulation. Thus, the transfer observed during question answering appears to rely on the automatic retrieval of the prior processing representation during the repetition phase. Even though the task requires access to the conceptual knowledge needed to answer the question, the episodic representation reinstates the perceptual processes as well. That is, the episode is a processing package of perceptual and conceptual information. When reading was backgrounded, in service of gaining meaning, reprocessing effects were mediated by both perceptual and conceptual factors.

The results of our experiments are consistent with those of Levy and Kirsner (1989). They found sensitivity to changes in modality between repetitions when the entire text was reread but not when individual words from the text were reprocessed. They argued that the individual words did not retrieve the text episode but that when the entire text was reread, the episode was reinstated and the conceptual and perceptual package then mediated transfer. That argument was developed further by Levy, Masson, and Zoubek (1991). They demonstrated that contextual specificity in text reprocessing occurred whether the reading orientation was data driven or conceptually driven. They argued that text reprocessing effects occur in a "Stroop-like" fashion and are independent of the reader's intention. However, Carlson et al. (1991) demonstrated contextual insensitivity during oral reading when subjects were told to process each word as a unit, never relating any two words in the text. This finding suggests that word-by-word processing may result in transfer mediated by context-insensitive word representations, indicating that the mere presence of a text is not sufficient to retrieve prior text episodes. The task of silent reading to answer questions can be seen as at the opposite end of the continuum as compared with the task used by Carlson et al. In this regard, the perceptual specificity in silent reading for question answering is in agreement with the *focus of attention* argument of Carr and Brown (1990) and Carlson et al. (1991). They suggested that episodic effects are more likely to occur in reading when the reading task is oriented to comprehension. For the task of silent reading for question answering, those episodic effects extended to perceptual specificity of transfer.

Our data add to the earlier work in showing script sensitivity in a meaning-based task. The data also show limitations on the strategy of treating data-driven and conceptually-driven processes as fully separable sources of information. When reading is backgrounded in service of gaining meaning, reprocessing effects are mediated by the perceptual–conceptual package, as argued by Kolers (1973), not by either type of process in isolation. Indeed, there is reason to argue that even identification of words presented out of context depends on episodic transfer that reflects the integration of prior data-driven and conceptually-driven processes (e.g., MacLeod & Masson, 1990; Toth & Hunt, 1990; Whittlesea & Jacoby, 1990) rather than on prior data-driven processing alone.

Our suggestion that data-driven processing is integrated with conceptually-driven processing and serves as a source of episodic transfer is consistent with recent theorizing about automaticity. Neumann (1984) criticized the notion that automaticity reflects *stimulus-driven* processing, by arguing that all behavior, even simple reflexes, is never totally stimulus driven. He suggested that automatic processes are not independent of a person's intentions and direction of attention. The term *data-driven* processing is synonymous with *stimulus-driven* processing. In a similar vein to Neumann, we are suggesting that effects on data-driven processing observed in rereading are dependent on a person's intentions and direction of attention. Perceptual specificity in rereading transfer is found when the reader's current task orientation reinstates conditions of earlier processing and the task of reading is backgrounded in service of gaining meaning. It is the interaction of perceptual and memorial processes that produces this visual specificity. Logan (1988) argued that automatic responding is tightly controlled, rather than uncontrolled, as is implied when automatic processing is contrasted with controlled processing. In a similar manner, we hold that episodic transfer is an important source of control for automatic processing. In the episodic transfer view, repetition effects arise when memories from prior processing occurrences are reinstated by the current retrieval conditions and then act to guide current processing. In this sense, the notion of automaticity when applied to reading fluency may be better related to episodic processes than to *priming* or *automating* individual abstract component processes. Jacoby (1991) related memory dissociations to automaticity.

We end by returning to the question of when transfer that is specific to the sensory details of presented items will be found. Such specific transfer is found when words are presented singly, particularly when they are presented in an unusual typography so as to produce reading that is unskilled (Masson & Freedman, 1990). Visual specificity of transfer is also found when reading is very skilled or automatic as occurs when reading is backgrounded in service of some other task. What defines the backgrounding of reading? It might be argued that reading is backgrounded when people silently read a passage in preparation for a later test of comprehension. However, in that case, transfer is not greatly influenced by changes in typography between readings of a passage (Levy & Kirsner, 1989). Perhaps the unit of processing is an important factor determining the sensory specificity of transfer. Silent reading for an unspecified test of comprehension might encourage word-by-word processing of a sort that is not engaged in to silently read a short question that is to be answered. In that vein, Woltz (1990) found striking visual specificity of transfer when subjects judged whether or not words in a pair were semantically related. Woltz's finding of visual specificity contrasts with the failure of Scarborough et al. (1977) to find a reduction in transfer in a speeded lexical decision task when the typescript was changed between repetitions of an item. The unit of processing is probably different and, intuitively, reading seems backgrounded to a larger extent when judging the relatedness of words in a pair than when making lexical decisions about single items.

We cannot provide a rigorous definition of *backgrounding of reading* nor can we provide a complete theory that will specify when sensory specificity of transfer will be found. However, we are convinced that problems for the contrast between data-driven and conceptually-driven processing are the same as those described by Neumann (1984) for the contrast between stimulus-driven and intention-driven processes, drawn in theories of automaticity. In that light, the factors determining the sensory specificity of transfer might be those that influence the unit of processing along with the integration of different levels of processing. Regardless, data-driven processing is not always separable from the task for which the data are being processed (Kolers, 1979). Attempts to order tasks with regard to a quantitative difference in data-driven processing (e.g., Jacoby, 1983; Roediger, 1990; Tulving & Schacter, 1990) ignore this qualitative difference in processing and so are of limited utility.

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Appendix

Examples of Questions Used in the Three Experiments

(The full set of questions is available on request.)

What bird looks dressed in a tuxedo?
How many nickels are there in a quarter?
What grain grows well in the prairies?
Name the shop in which bread is baked.
From what vegetables are pickles made?
Where was Little Red Riding Hood going?
Which racquet sport uses the term *love*?
What is another name for a frankfurter?
Ink is contained in what writing tool?
What red leaf is found on Canada's flag?
These doctors treat disturbed minds.
Which travels faster, light or sound?
Sleds are pulled by what breed of dog?
Adam and who were in the Garden of Eden?
This insect collects nectar for honey.
What tool is usually used with nails?
Name the dividing line between nations.
What is the name of a famous snowman?
In which room does one prepare food?
What yellow vegetable grows on cobs?
What sport involves horses and mallets?
John Lennon was one of the four what?
Meteorology helps us to forecast this.
What do women color their nails with?
The Sphinx is located in what country?
What two-wheeled vehicles are pedaled?
What is the hair above the eye called?
From what direction does the sun rise?
In what structure do you keep a car?
What hot material flows from a volcano?
What fruit a day keeps the doctor away?
The third pig's house was made of this.
What is the name of Canada's mountains?
Cereal is often served at what meal?
Into what does a caterpillar change?
What letter follows *O* in the alphabet?
Give Sherlock Holmes's associate's name.
Beavers build this obstacle in water.
Name the playing fields used in tennis.
This flower is worn on Remembrance Day.
Young bears are called by this name.
A round solid map is known by what name?
This is the name for a male chicken.
What type of clock is used to awaken us?
What meal combines breakfast and lunch?
Quills are part of this animal's armor.
This red sauce is put on french fries.
What's a painful hole in a tooth called?
Name Santa's famous red-nosed reindeer.
A right angle has how many degrees?
What word is the opposite of singular?
Tadpoles become what when they mature?
What gemstone is produced by oysters?
What book contains definitions of words?
What city in Canada has the most people?
Cigarettes are made from which leaf?
Humpty Dumpty sat where before falling?
Hockey has how many 20-minute periods?
Liberace played what musical instrument?
Which beautiful red flower has thorns?
This chemical helps bones grow strong.
Which large desert is located in Africa?
A migraine refers to what kind of ache?
A dozen contains how many of an item?
What is Scotland's Loch Ness famous for?
Who is known as the King of Rock 'n' Roll?
This head is used in making up salads.
For what cute bear is Australia famous?
What is a carved Indian pole called?
Jack and Jill climbed up what obstacle?
Switzerland is known for what sweet?
Name the ship that travels underwater.
What slow-paced animal has a hard shell?
We use this appliance to keep food cool.
This food is often eaten with meatballs.
What is McDonald's clown's first name?

(*Appendix continues on next page*)

This bird is used to symbolize peace.
What power source operates flashlights?
"Merci" translates to what in English?
What are Innuit ice houses known as?
Name the huge flowers with edible seeds.
Give the name of McMaster's newspaper.
What sport uses a springboard and water?
What is the name of Charlie Brown's dog?
Which is the coldest season in Canada?
What little grey rodents do cats catch?
Name the short skirt worn by ballerinas.
A wooden border for a picture is what?
Timex is a very common type of what?
This orange cartoon cat is very popular.
What actor hosts the "Tonight Show"?
Red is the color of what precious gem?
A number of these are on birthday cakes.
What domestic animal barks and growls?
What festive holiday falls on January 1?
This breed of cat has light blue eyes.
Name Canada's red-coated mounted police.
What fish is featured in *Jaws* movies?
Fear of enclosed places is called what?
Long hair is tied back in a pony what?
What flows from a faucet into a sink?
What do spiders weave to catch flies in?
What vital part of the body pumps blood?
On what material do we use pen and ink?
There are how many provinces in Canada?
Poinsettias are associated with what?
Bambi's mother is what kind of animal?
What board game uses the term *checkmate*?
You wear a wedding ring on which hand?
A photo is taken with which instrument?
What reading system do blind people use?
This unpopular animal howls at the moon.
Circles contain 360 of what measurement?
Which city is the capital of Canada?
This storm has funnel-shaped clouds.
A fabled frog became what when kissed?
The doorway in a fence is called what?
A decade covers a time span of ten what?
What food is grown in paddies in China?
Which animal is *Black Beauty* about?
Florists grow flowers in these sheds.
What beverage contains lots of caffeine?
Prince Edward Island grows lots of what?
Blue jeans are made from what fabric?
This famous collie dog starred on T.V.
A man's formal evening suit is called?
Which animal is King of the Jungle?
What gas do we release when we exhale?
One uses these as warm floor coverings.
What bird is known for its red breast?
Pods contain this tiny green vegetable.
Snow White had how many dwarf friends?
This animal looks like a striped horse.
An artist often paints on this material.
What is the center of the eye called?
Give the name of the Queen of England.
What is found on the end of a pencil?
Name the smallest Canadian province.
What expensive material uses cowhide?
The Irish shamrock leaf is this color.
Cats are known to have how many lives?
This portable shield is used in rain.
What usually comes before an answer?
Does Canada have provinces or states?
What did pirates accumulate and bury?
What jungle animal runs the fastest?
What word is the opposite of vertical?
Heads or tails appear on tossing this.
In this sport a hole-in-one is possible.
This fowl is thought of at Thanksgiving.
What season is associated with harvest?
What animal slithers along the ground?
How many cents are there in one dollar?
Sandy areas beside lakes are known as?
The Statue of Liberty is in what city?
A dried grape is better known as what?
What scared Little Miss Muffet away?
In which sport are there touchdowns?
From what substance are car tires made?
Name the apparatus skydivers must wear.
What man filled his ark with animals?
What animal delivers eggs at Easter?
What were prehistoric animals called?
What fish swims upstream to lay eggs?
Who lives in the American White House?
What is Canada's most western province?
Pie à la mode is pie served with what?
What product is made by churning milk?
Which English king married seven times?
What color is traditional for a bride?
What month of the year has a fool's day?
Of what material are piano keys made?
What word describes the taste of lemon?
These men defend us in courts of law.
This thick liquid is put on pancakes.
What number is often considered unlucky?
The fabled one-horned animal is called?
A diameter is the distance across what?
What do you call your mother's sister?
The Great Wall is located where in Asia?
What orange vegetable grows underground?
What boy climbed up the giant beanstalk?
Which sport has the term *gutterball*?
Mix yellow with what color to get green?
Kids collect candy and dress up when?
Which color is associated with evil?
Which German city is divided by a wall?
What do we squeeze on our toothbrushes?
Funny men in a circus are called what?
Taking items of others is what crime?
We climb these to go to the next floor.
Marilyn Monroe had what color hair?
What sea creature has eight tentacles?
What is between your head and shoulders?
What substance writes on blackboards?
What does an amber traffic light mean?
This is called the "Honeymoon Capital."
What flying monster often breathes fire?
Toronto is located on which Great Lake?
In what public building are books kept?

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