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The influence of word shape and letter case in word processing

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The Influence of Word Shape and Letter Case

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by

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Abstract

The perceptual strategies used by a skilled reader have been a controversial issue and the procedures by which readers identify words have not been clearly defined (Horton, 1989; Kolers & Roediger, 1984; Masson, in press; Tardif & Craik, 1989). The role of word shape remains unclear. Rudnicky and Kolers (1984) suggested that lowercase text may be processed more fluently than uppercase print because the reader may take advantage of features such as the pattern of extensions above and below midline provided by the lowercase letters. It may be that processing of lowercase text includes the utilization of a well-practiced shape sensing skill. With uppercase text the reader may apply a different set of strategies since this typography does not provide the reader with these additional shape features. The purpose of the present experiments was to assess the effect of word shape as manipulated by lower and uppercase letters in word identification. We have chosen six different word shape manipulations (fonts) consisting of regular as well as irregular word shape. Fonts 1 through 3 (lowercase, uppercase and alternating case, respectively) define the limits of our word shape manipulation, whereas Fonts 4 through 6 manipulate regular word shape by specific lower and uppercase letter positions. In Experiment 1 we assess the influence of these different fonts with paragraphs providing context information. Results indicated significantly faster processing for the lowercase text than either uppercase or alternating case typography and the equivalent speeds of regular lowercase and Font 6 suggested the importance of lettercase in shape defining positions. In Experiment 2 we attempt to focus encoding more specifically on perceptual features (word shape) by utilizing a list of 20 unrelated words. Results illustrated no effect of font. Experiment 3 utilized a list of 60 unrelated words and results showed a significant effect of font. However, surprisingly, uppercase words indicated a faster processing trend (approaching significance) than lowercase words. We discuss the possible implications of these findings and suggest some directions for future research.

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Introduction

Perceptual strategies used by a skilled reader have been a controversial issue and the processes involved in word identification have not been clearly defined. The focus of the present research is the assessment of the influence of perceptual information in the reading process. Specifically, our intent is to attempt to delineate the role of word shape and its relationship to lettercase in word identification.

Our introduction begins with the development of the assumed transient influence of perceptual features in the storage "structures" of the multi-store models (Atkinson & Shiffrin, 1968; Waugh & Norman, 1965). We then consider the levels of processing concept (Craik & Lockhart, 1972) in which memory was assumed to be dependent on the "depth of processing" as defined by the "meaningfulness" of the stimuli. The encoding of perceptual features was considered to be shallow and retention based on perceptual encoding was of short duration.

Our review details the research of Kolers (1975, 1976, 1979) who proposed that facilitation of reading was not a function of conceptual information alone, but words were processed also as visual patterns. We discuss the proceduralist view of Kolers and Roediger (1984) who proposed that reading should be considered as a process with the focus on procedural skills instead of a qualitative analysis of the memory trace. We consider their hypothesis that both skill and purpose can result in perceptual features being remembered as well as semantic components. Our introduction further reviews the dissociation between the perceptual and conceptual aspects of performance (Jacoby, 1983; Jacoby & Dallas, 1981; Roediger & Blaxton, 1987) and the involvement of data-driven and conceptually-driven processing (Jacoby, 1983, in press; Jacoby & Dallas 1981) as well as the importance of the dependent measure (implicit or explicit) utilized to evaluate remembering (Jacoby, 1983; Jacoby & Dallas, 1981; Kolers & Roediger, 1984). We follow with a focus on current views that have investigated the involvement and separation of perceptual and semantic information in the rereading of transformed text and consider suggestions that the interaction of both types of information is the determinant of memory performance (Horton, 1985, 1989; Masson, 1986; Tardif & Craik, 1989).

Our introduction concludes with concerns in our specific area of interest--the role of word shape as defined by lettercase. We outline research that was derived from the investigation of the word superiority effect (Baron, 1978; Reicher, 1969) and discuss the relevance of word shape information in different experimental manipulations (Havens & Foote, 1963; Johnson, 1975; Monk & Hulme, 1983). We especially consider the preliminary letter analysis model as proposed by McClelland (1977), the distinctive feature hypothesis of Smith (1969) and Smith et al. (1969), as well as the supporting evidence for the role of word shape indicated by Brooks (1977) and Coltheart and Freeman (1974). We detail the research of Rudnicky and Kolers (1984) who investigated the influence of size and lettercase on the reading process with an emphasis on the importance of word shape and its relation to lettercase. We follow the suggestions of these researchers and consider the shape-sensing skills that may facilitate performance in the processing of regular typography but may result in interference when word shape and lettercase are alternated.

Although the first systematic attempt to incorporate a multi-store model within a general theory of memory was by Atkinson and Shiffrin (1968), the modal model (Murdock, 1967) incorporated the general "gist" and overlap of the multi-store concept. It was assumed that information was initially received in a modality-specific sensory register where it was held in relatively uninterpreted (veridical) form for a very brief duration (1-2 seconds). Further maintenance of information was considered not possible and loss was due to decay. This sensory register for vision was referred to as iconic memory (Neisser, 1967), and often considered precategorical (information was not yet recognized or matched with an appropriate category).

From the information perceived by the sensory stores, a small fraction was passed on to short term memory (STM) where items were maintained by rehearsal. Forgetting was due to displacement by new incoming information (Waugh & Norman, 1965), and actively processed items were transferred into long term memory (LTM). Coding was initially considered to be largely phonemic (Baddeley, 1966), or possibly visual or verbal (Atkinson & Shiffrin, 1968), or representational (Posner, 1967). Capacity was thought to be limited (5-7 items) and often measured by the memory-span or an immediate memory task (Broadbent, 1958).

In contrast, the capacity of LTM was considered limitless and coding was presumed to be largely semantic. Long term memory was thought of as a permanent store and forgetting was either very slow or material was not forgotten at all (Atkinson & Shiffrin, 1968). Loss of information was a retrieval problem--the facts were in memory but we were unable to obtain access, possibly due to interference. Tulving (1972) proposed a division of LTM into the episodic and semantic systems. Episodic memory referred to the system that emphasized experiences from personal memories where the recollection of time and place of occurrence for an event was relevant. Semantic memory was considered responsible for general knowledge where recall of the time and place of occurrence was not of importance.

One of the major distinctions between STM and LTM was the qualitative difference in the coded trace and evidence for this was often drawn from Baddeley (1966). Subjects studied lists of either acoustically or semantically similar words. There were four study trials and a 15 minute rest interval, followed by a test in which subjects were given the test items and required to place them in the correct serial order. When compared to a control list of unrelated words, acoustically similar words impaired performance on the first four trials but there was no impairment on final recall. Semantic similarity failed to affect performance on the first four trials, but performance on final recall was reduced substantially. The lack of an acoustic similarity effect on the final test was interpreted as support for the conclusion that non-semantic factors did not influence long term retention.

Murdock (1962) used free recall in order to distinguish between STM and LTM at an experimental level. The subjects were presented with a list of words and at test had to recall as many of the words as possible in any order. It was found that the subjects recalled better from the beginning (the primacy effect) and the end (the recency effect) of the list, than from the middle (asymptote). It was assumed that recall fr the initial and middle portions of the list was from LTM, whereas recall from the last few serial positions was predominantly from STM.

The concept of a multi-store model produced its critics. Craik and Lockhart (1972) argued that there was no satisfactory evidence for distinguishing separate stores with distinct characteristics. There was disagreement over the durability of the visual trace in iconic memory. Neisser (1967) concluded that the duration of the icon was one second or less, Posner (1969) showed visual retention up to 1.5 seconds, while Phillips and Baddeley (1971) reported retention for 6, 10 and 24 seconds. Although the structural model regarded the extremely limited capacity of STM as one of its prime characteristics, Craik and Lockhart proposed that the exact nature of the capacity limitation of this storage structure was obscure. It seemed that attempts to measure this capacity produced a variety of results. Measures of memory span yielded results of 5-9 items and were dependent on whether items were words, letters or digits (Crannell & Parrish, 1957). Yet a span test with sentences resulted in memory of up to 20 words (Craik & Masani, 1969). Glanzer and Razel (1974) collected data from 21 free recall studies and found the mean estimate of STM was 2.2 words. These researchers also presented subjects with free recall tests consisting of proverbs and estimated that 2.2 proverbs (approximately 9 words) were held in STM. Although at first glance it would seem that STM was not as limited in capacity or as restricted in processing as had been suggested, there remained the practical problem of how to measure, empirically, the actual capacity of this memory store. Possibly the differential results were not unexpected if the various measurement techniques were considered. Attempts to explain the variations also induced some to consider the concept of "chunks." Miller (1956) proposed that approximately seven chunks of information could be stored in STM at any one time. However, there was no agreement as to the precise definition of chunks, and this along with the rather flexible notion of capacity created continuing problems for the multi-store model.

The structural theories considered rehearsal to be the process by which information was transferred from STM to LTM. Atkinson and Shiffrin (1968) proposed that information about an item was transferred to LTM while and only while it was being rehearsed. This seemed to suggest that the longer an item was maintained in STM by rehearsal, the better it should be recalled. However, in some experimental situations the sheer quantity of rehearsal appeared to be inconsequential. Weist (1972) utilized the overt rehearsal technique in a multi-trial free recall study and found that, although the number of rehearsals was positively correlated with the probability of recall on the first trial, the correlations were generally low thereafter. Craik (1973) found that subjects who were instructed to make sure that they recalled the last four items of a list accorded a disproportionate amount of rehearsal to these items. In an unexpected recall test of all words on all lists, the subjects showed poorer recall of the final items than the rest of the list (negative recency). Thus the quantity of rehearsal did not necessarily facilitate memory.

Although early evidence supported phonemic encoding in STM and predominately semantic encoding in LTM (Baddeley, 1966), Levy (1971) illustrated that STM encoding can be acoustic or verbal, and Glanzer, Koppenaal, and Nelson (1972) questioned the phonemic-semantic encoding distinction. Glanzer et al. (1972) reported numerous experiments with free recall in which phonemic and semantic familiarity were manipulated in various ways. Results indicated that regardless of the type of encoding (phonemic or semantic) the same effect appeared. Performance increased with the relations between words when retrieval was from LTM, whereas retrieval from STM was unaffected. The researchers speculated that if STM and LTM were specialized for different processes, results should have illustrated some differential effects of phonemic and semantic similarity on recall. Shulman (1971) indicated that much of the earlier evidence for phonemic encoding in STM only tested memory for the order of information and ignored memory for the item itself since at test subjects were usually only asked to order a random list of words (Baddeley, 1966). Gruneberg and Sykes (1969) found that 20-25 minutes after the presentation of lists of words, subjects were significantly more likely to recognize phonemically similar words than words phonemically dissimilar. Also, intuitively it would seem that phonemic information must be stored in LTM or reading aloud would indeed be difficult.

Thus, the proposed flow of information from a sensory store through STM to LTM seemed like a gross oversimplification, and previous discussion indicated that the characteristics of STM must be more complex than originally proposed. Baddeley and Hitch (1974) believed that the STM system, as described by Atkinson and Shiffrin (1968), was inadequate. They argued that the concept of a STM store should be replaced with that of an active working memory system. In place of a unitary STM system these researchers proposed three separate components of a working memory: a modality-free central executive, an articulatory loop and a visuo-spatial scratch pad. Later Salamé and Baddeley (1982) suggested a fourth component, the primary acoustic store. They proposed a hierarchical ordering of these components with the central executive at the top controlling or directing the articulatory loop, the visuo-spatial scratch pad and to a lesser extent, the primary acoustic store. The central executive allocated attention to inputs and directed the operations of the other components. Baddeley (1981) suggested it had a very limited capacity and described it as a purely attentional system. However, it was flexible in that it could process information in any sensory modality and store information over brief periods of time. The articulatory loop was regarded as a verbal rehearsal loop. For example, when we attempt to remember a telephone number for a few seconds by muttering it to ourselves, it is the articulatory loop that is utilized. This loop also held the words that we are ready to speak and it organized information in a temporal and serial fashion. The researchers considered this loop our "inner voice." The visuo-spatial scratch pad dealt with the visual and/or spatial information rather than the phonemic details used by the articulatory loop. It was considered our "inner eye." The primary acoustic store received auditory input directly whereas visual input could only be received after having been converted to phonological form by the articulatory loop. The acoustic store was our "inner ear."

In order to test the active working memory hypothesis, Baddeley and Hitch (1974) conducted a series of experiments. Subjects attempted to retain simultaneously a number of digits and perform a task of reasoning, comprehension or free recall. On all three tasks there was a substantial impairment in performance with six digits to be retained, but little or no performance decrement with three digits. This suggested that it was primarily the articulatory loop that was implicated when only three digits had to be retained, leaving the central processor free to handle the other tasks. However, with more than three digits the capacity of the articulatory loop was exceeded, and the central processor had to recode and organize the digits as well as process the other tasks. Additional evidence for the articulatory loop was obtained by Baddeley, Thomson, and Buchanan (1975) over a series of experiments in which they discovered that the immediate memory span for words was substantially influenced by the length of time required to read words aloud. Fewer multi-syllable than mono-syllable words were retained, and subjects were only able to remember as much as they could read out in about two seconds. This suggested that the articulatory loop was time based and had a temporally limited capacity. Since phonemic similarity and articulatory suppression had differential effects on what were considered STM tasks, the researchers interpreted this as evidence for the necessity of dividing the system into component parts. However, they agreed that the interaction of the components was unclear.

Craik and Lockhart (1972) proposed that the concept of capacity be considered in terms of limitations on processing, rather than the number of items, and that encoding was influenced by the processing demands of the task and stimulus. The forgetting characteristics were dependent on study time, stimuli and the skills of the subject as well as the familiarity, compatibility and meaningfulness of the material. They suggested that there was an attentional system (resembling the central executive) which could process a stimulus in a number of different ways. For example, if you see the word *chair* you may focus on the individual letters, on the sound of the word or on its meaning. According to Craik and Lockhart, processing varied in terms of its depth. "Depth is defined in terms of the meaningfulness extracted from the stimulus rather than in terms of the number of analyses performed upon it" (Craik, 1973, p. 48). The crucial assumption made by Craik and Lockhart (1972) was that the depth or level of processing determined the persistence of a memory trace in LTM. According to them, "trace persistence is a function of depth of analysis, with deeper levels of analysis associated with more elaborate, longer lasting, and stronger traces" (Craik & Lockhart, 1972, p. 675). They proposed that the focus should be on the encoding operations and that forgetting was a function of depth of encoding.

This hypothesis assumed that the analysis of stimuli occurred at a number of levels or stages. The early stage was concerned with the analysis of physical or sensory features, whereas the later stages concentrated on matching input with stored abstractions (pattern recognition and meaning). "This conception of a series or hierarchy of processing stages is often referred to as 'depth of processing'" (Craik & Lockhart, 1972, p. 675). Perception produced a memory trace whose durability was a direct function of the depth of analysis, with a more elaborate and enriched analysis associated with longer lasting traces. Highly familiar and meaningful stimuli could be processed deeply and more rapidly than less familiar stimuli. Thus, retention was not necessarily a direct function of processing time, but rather was a direct function of depth.

Craik and Lockhart (1972) also distinguished between two types of processing or rehearsal. Type I processing involved the repetition of analysis which had been previously carried out, and Type II involved a deeper analysis of the stimuli. "Only this second type of rehearsal should lead to improved memory performance" (Craik & Lockhart, 1972, p. 676). Craik (1973) pointed out that the high level of immediate recall combined with low levels of subsequent recall of the final items in a free recall test could be due to Type I processing only. When subjects were induced to spend a disproportionate amount of time rehearsing the last few items of a list, final recall of these items was still poor (Craik, 1973). Craik concluded that the type of processing was more important than the amount.

The primary experimental technique used to study levels of processing theory involved the use of different orienting tasks. An attempt was made to ensure that one or more of the orienting tasks demanded the processing of meaning (e.g., selecting the correct part of speech), and one or more that did not require semantic processing (e.g., selecting rhyme). Craik and Lockhart (1972) proposed that it was preferable for subjects not to know that there would be a memory test (incidental learning) because this would discourage subjects from additional analysis. When a memory test was expected (intentional learning), subjects could carry out extra processing in an effort to improve performance.

Hyde and Jenkins (1973) conducted a well known study in order to determine the effects of various orienting tasks on memory. They utilized five different tasks that appeared to vary in the type of processing. They predicted that tasks demanding processing of meaning would result in enhanced memory when compared with tasks that did not. A list of 24 words was presented (auditorily) at a rate of one word every three seconds. During presentation each subject performed one of the following orienting tasks: rate the word for pleasantness, estimate the word frequency, detect the *e's* and *g's* in words, decide on a part of speech (e.g., verb, noun, etc.) or decide if the word fitted into a short sentence frame (e.g., it is a _______). These tasks were performed either under incidental or intentional learning conditions. A control group received intentional learning instructions but no orienting task. Each subject performed only one orienting task and after the entire list of words had been presented, they were given a test of free recall.[1] Results did indeed confirm the levels of processing hypothesis that rating the pleasantness and frequency of words resulted in the highest recall performance. Also, there was no significant difference between the intentional and incidental groups on the same orienting tasks. Similarly, intentional learners with no orienting task (control group) did not demonstrate better memory performance than the incidental learners given a semantic task. These findings seemed to support the levels of processing concept in that what determines memory is the nature of processing rather than the intention to learn.

Other studies have replicated this pattern of results (Eysenck, 1974; Hyde, 1973). Schulman (1971) asked subjects to scan a list of words for targets defined either structurally (e.g., words containing the letter *A*) or semantically (e.g., words denoting living things). Subjects were subsequently given an unexpected recognition test. Performance in the semantically defined target condition was significantly superior to that in the structurally defined condition, although the scanning time per word was equivalent in the two conditions. The underlying assumption of these experiments was that semantic tasks result in better performance than the non-semantic

1. Hyde and Jenkins (1973) based their experiment on the assumption that rating pleasantness and frequency of usage were the two tasks demanding semantic processing. These researchers considered that deciding the part of speech to which a word belongs did not require semantic processing. There was no agreement as to the types of processing required by different orienting tasks since there was no independent measure of processing depth.

tasks, presumably due to a greater depth of processing. However, the data could equally well be explained by hypothesizing that semantic tasks merely lead to a stronger memory trace than nonsemantic tasks (Tulving & Bower, 1974).

The levels of processing theory argued that semantic processing usually led to better memory than non-semantic due to increased depth of processing. However, it did not explain why deep processing was more effective. The levels theory was extended to include the concept of elaboration (Craik & Tulving, 1975). The crucial assumption made by these researchers was that deep or semantic encoding was more elaborate than shallow or non-semantic. Thus, more information about the stimulus was stored in memory resulting in easier access. One of the earliest systematic investigations of elaboration was by Craik and Tulving (1975). They argued that both the depth of encoding and the spread or elaboration of encoding were important determinants of memory performance. The more attributes of a word that were encoded at input, the more elaborate would be the memory trace. These researchers manipulated the spread of encoding (Experiment 7) by asking the subjects whether a tachistoscopically presented word would fit a given sentence. The spread of encoding was manipulated by sentence frames varying from the simple (e.g., He dropped the ________.) to the complex (e.g., The old man hobbled across the room and picked up the valuable _______ from the mahogany table.). Subsequent retention of the target words was significantly better with the complex frames when compared with the simple frames. These results suggested that the elaboration of processing should be a consideration in the levels of processing.

The idea that the precise nature of the elaborations formed were also important was illustrated by Bransford, Franks, Morris, and Stein (1979). They presented subjects with multiply elaborated stimuli (e.g. A mosquito is like a raccoon because both have heads, legs and jaws.) or minimally elaborated (e.g., A mosquito is like a doctor because they both draw blood.). They assessed recall by presenting subject nouns from each sentence (e.g., mosquito) and asked for recall of the object noun (e.g., raccoon or doctor). Elaboration theory would predict better recall for the multiply elaborated similes. However, the results showed the opposite. The number of elaborations was not crucial; instead the more distinctive elaboration was more effective.

Such findings led some theorists (Jacoby & Craik, 1979) to propose that encodings that were distinctive or unique in some way were more likely to be remembered. Although the distinctiveness principle had intuitive appeal, it was often difficult to decide how distinctive an encoding was since an operational definition of distinctiveness was difficult. In part it depended on context. The name *Smith* presented in a list, *Jones, Robinson, Williams, Baker, Smith, Robertson* was obviously not as distinctive as in *Zzits, Zysblat, Vangersdaele, Vythelingrim, Smith, Uwejeyah* (London Telephone Directory) (Eysenck, 1984). Distinctiveness could also vary from individual to individual, depending on experience.

Tulving (1979) argued that elaboration of the memory trace should be considered as a part of understanding memory. He argued that the levels of processing concept initially was only concerned with how information was encoded and stored. Retention had been considered only with relation to encoding and there had been little concern with the problem of how knowledge affected retrieval or how stored information was used. Although retrieval factors were mentioned, they were never emphasized. Tulving noted that in many of the levels of processing experiments (e.g., Hyde & Jenkins, 1973), manipulation was of orienting tasks, learning instructions or context of target items. These experiments assumed that the manipulations induced the subject to engage in specific and differential mental processes at the time of study, resulting in qualitatively different memory traces of the to-be-remembered items. It was the characteristics of the traces, depth, spread and elaboration, that determined memory performance. Tulving argued that although the levels of processing manipulations influenced the strength of a memory trace, they did not provide evidence for the hypothesis that encoding operations created qualitatively different memory traces, a concept central to the levels of processing theory.

Tulving and Thomson (1973) proposed the encoding specificity principle asserting that "specific encoding operations performed on what is perceived determine what is stored, and what is stored determines what retrieval cues are effective in providing access to what is stored" (p. 369). Experiments manipulating the study (encoding) and test (retrieval) conditions while holding the subject variables and learning materials constant, provided evidence for the encoding specificity principle. Tulving and Osler (1968) presented subjects with a single study trial of 24 cue-target pairs and tested their ability to recall the target items in the presence of cues. The retrieval cues were either the same, in that they had been seen at study, or they were new, not encountered before. There were two encoding conditions in which the target word was presented with either Cue *A* or Cue *B*, and the two encoding conditions were crossed with the two retrieval conditions. Both cues were single words that, in a free association test, had elicited the target words as a primary response with a probability of .01. The results showed that when the retrieval cue matched the encoding cue, subjects recalled 62% of the targets, whereas when there was no match, the recall rate dropped significantly to 30%. Tulving (1979) drew four general conclusions from this experiment:

> The "goodness" of a particular encoding operation depends on the nature of the cues present at the time of retrieval. Effectiveness of a cue, with respect to a particular target item, depends on the conditions under which the target item was encoded. Successful recollection of an event depends on the compatibility between the trace and the cue. The compatibility relation between the trace and the cue, as a necessary condition of recollection of an event, is determined by specific encoding operations at the time of study and not by the properties of cues and target items, and their relations, in semantic memory. (p. 408)

He hypothesized that it was necessary to stipulate both encoding and retrieval conditions when describing data or proposing theoretical inferences and that it was futile to attempt to understand the memory process in terms of only encoding or only retrieval. It was the interaction between these conditions that was crucial to remembering.

Tulving (1979) also proposed that encoding conditions determined the effectiveness of retrieval cues even when the cues were strongly related to the to-be-remembered items prior to the experiment. It was the compatibility of the relation between traces and cues created at the time of study that determined memory performance and any previous relationship between the cue and target was of no direct consequence. Thomson and Tulving (1970, Experiment 2) presented subjects with items (response words from free association norms) either one at a time with the subjects expecting a free recall test, or as members of cue-target pairs with the subjects expecting to be tested with the cues seen at the time of encoding. The three test conditions were free recall (no cues), presentation of weak intralist cues utilized in one of the encoding conditions, and strong extralist cues or words not encountered by the subjects in the experiment, but strongly associated with target words in semantic memory. The study list was presented once, at the rate of 3 seconds per target, and the appropriate test condition followed immediately. Results indicated that strong extralist cues strongly facilitated recall of the singly presented items with the expected free recall test, but these strong cues were of no help when target items had been studied with weak cues and subjects expected to be tested with these weak cues. Tulving (1979) concluded that the "effectiveness of cue words strongly associated with target words in semantic memory depends greatly on the conditions of episodic encoding of target words. Conversely, 'goodness' of encoding depends on cue conditions at retrieval" (p. 414).

Tulving and Thomson (1973, Experiment 1) presented subjects with pairs of weak cue-target words and subjects expected to receive a recall test with the weak cues. After the presentation, the subjects were asked to produce free associations to strong extralist associates of the target words.

Many of these words resulted in the production of the actual targets. Subjects were then asked to perform a recognition test on the free association words with instructions to try to identify the to-be-remembered words from the studied list (subject-produced recognition test). This was followed by a cued recall test in which the weak cues they had seen in the study list were presented to facilitate retrieval of the target words. Thus, there were two test situations, recognition utilizing copy cues and cued recall (weak encoding cues). Results indicated that the weak retrieval cue was more effective following the encoding of the target in the presence of these cues. However, the copy cue was more effective following free recall encoding than weak cue encoding, but was considerably less effective than the weak cue following weak cue encoding. These results provided further evidence for the critical importance of the compatibility of traces and retrieval cues.

However, Fisher and Craik (1977) argued that a complete theory of memory must consider the depth of processing in addition to the interaction between encoding operations and retrieval cues. These researchers supported their hypothesis with findings that subjects' performance was better following semantic encoding than rhyme encoding even when rhyme-encoded target words were tested with rhymes as cues and associatively encoded target words were tested with their intralist associates as cues (Fisher & Craik, 1977). Also, in their Experiment 3, subjects studied target words either in a rhyming context (e.g., *CAT* studied in the context of *HAT*) or in the presence of associatively related words (e.g., *CAT* studied in the context of *DOG*). At test subjects received either the identical cue, similar cue (extralist cue related to the target along the same dimension as the encoding situation), or a different cue (extralist cue related to the target on a different dimension). Results showed that performance in the rhyme encoding and identical encoding/retrieval condition was essentially the same as performance in the condition in which associative encoding was combined with the different encoding/retrieval condition. Fisher and

Craik suggested that since the similarity between the cue and encoding was better in the former than the latter condition, the identical recall performance suggested the presence of a factor in addition to encoding/retrieval similarity. They proposed that this factor was the depth of initial encoding. Fisher and Craik also pointed out that the superiority of associative over rhyme encoding was positively correlated with the degree of similarity between the encoding context and retrieval cue. The difference between associative and rhyming encoding conditions became progressively smaller as encoding/retrieval similarity was reduced from identical through similar to different conditions. These researchers argued that it was the interaction between the level of processing (nature of the trace) and the degree of encoding/retrieval similarity which illustrated that the type of encoding (depth of trace) was important in addition to the trace/cue similarity. They proposed that "no one factor in isolation--the type of encoding, the type of cue, or the compatibility between encoding and cue--is by itself sufficient to describe performance" (Fisher & Craik, 1977, p. 710).

Tulving (1979) suggested that the above findings could also be interpreted as evidence that encoding/retrieval compatibility was sufficient to account for the data. The probability of retrieval was dependent only on the nature of the relation between the trace and retrieval information. He pointed out that the levels of performance were quite similar in the experimental condition in which similar encoding/retrieval was combined with the rhyme cue and the different encoding/retrieval was combined with the associate cue. He argued that since the trace/cue similarity was greater in the former than the latter condition, the virtually identical outcomes suggested that there was another important contributing factor--the type of retrieval cue. Results of Fisher and Craik (1979 Experiment 3) also demonstrated an interaction between type of retrieval cue and similarity of cue to encoding context, since the influence of the associative over the rhyme cue was greater at higher degrees of similarity. Thus, Tulving concluded that both the type of retrieval cue and the similarity of cue to encoding context were significant in recall performance. It was not necessary to consider either the type of encoding or the type of retrieval cue in addition to the trace/cue relationship in a complete account of memory.

These concepts were very similar to those expressed by Morris, Bransford, and Franks (1977) who suggested that the value of any processing task should consider the demands of the test situation. They based this conclusion on results of three experiments that demonstrated that a shallow orienting task (making rhyming judgments about words) led to higher performance than a deep task (making semantic judgments) if performance was measured by a recognition test demanding utilization of phonetic properties of the studied items. Morris et al. proposed that the value of an encoding process was dependent on particular goals and purposes.

Research on the memory process had begun a general shift of interest from external, or situational stimuli, to internal mental events or processes. Kolers (1979) proposed that "what is remembered better is what was analyzed more; the analytical operations themselves, their extent and complexity, account for performance" (p. 384). This conclusion was founded on several experiments carried out with spatially transformed text. Kolers worked with skilled readers of English and with natural language stimuli not totally familiar to the subjects. He felt that normal text would not enable the experimenter to delineate the components of the reading process. Spatially transformed text preserved the properties of normal text except for its graphemic familiarity. The importance of these perceptual components was illustrated by Kolers and Ostry (1974). Subjects read a deck of 60 sentences, 30 in normal orientation (N) and another 30 in inverted orientation (I). After a variable interval of time (few minutes to 32 days), the subjects read a second deck of sentences; 60 that had been read previously and another 60 read for the first time. The 60 reread sentences appeared half in the original typography and half in the opposite typography. This resulted in the following reread conditions: NN, II, NI and IN, where the first letter indicates the orientation of the sentence on the first reading and the second letter indicates the orientation on the second reading. The other 60 sentences were distractors with 30 presented in N and 30 in I orientation. After the second reading the subjects placed the sentence into one of three categories: a sentence read for the first time, a reread sentence appearing in the same orientation as in the initial reading, or a reread sentence appearing in another orientation. The researchers' interest was in the degree to which the typography influenced encoding and recognition.

They assessed performance in a variety of ways, each designed to isolate one critical component of the memory process. First, they compared recognition of old sentences against new sentences irrespective of typography (*d'all*). Sentences were evaluated as "semantic objects" (*d'sem*) by defining hits as old sentences classified as old and false alarms as new sentences classified as old. Memory for graphemic information (*d'new*) was determined by defining hits as old sentences correctly identified as same or different typography, and false alarms as new sentences classified as same or different typography. Sentence memory as "pictorial objects" (*d'old*) was evaluated by defining hits as old sentences correctly categorized as same or different typography, and false alarms as old sentences incorrectly identified as same or different typographies (see Horton, 1989; Kolers & Ostry, 1974). Kolers and Ostry postulated that reading involved a two stage process: The initial perception of the text was held in some sort of short-term storage and then its semantic features were extracted, recoded and stored. Consequently, the four kinds of sentences, NN, II, NI and IN could be regarded as equivalent in semantic content and they should produce equivalent degrees of recognition at the semantic level. As a result of the finding that d'(new) was greater than zero, even after intervals of 32 days, Kolers and Ostry (1974) concluded that typographical (graphemic) details were encoded and retained for at least 32 days. However, the various sentence pairings did not produce equivalent results. The II sentences were recognized the best, IN next, followed by NN and NI. According to Kolers (1979) the levels of processing theory would have predicted an equivalent degree of recognition since all pairings could be considered equivalent as semantic objects (d'sem). The different recognition results were not due to some pictorial representation of the sentence since the d'old values were equal across the categories. Kolers and Ostry proposed that these results could be explained by analytical activities and procedures. Information was obtained from the text by utilization of pattern analyzing operations through numerous encounters with the typography, and these analyzing operations became trained with successive re-encounters with like typographies. The pattern analyzing operations changed with acquisition of skill in a particular analysis. The less the skill the more analytical work was required, and more analysis resulted in a more extensive representation of the stimulus.

It was possible to assume that unfamiliar and difficult to read text induced subjects to relate the difficult typography with semantic information from the sentences. That is, it may be that the subjects recalled facts about the sentences that they had read, and when they encountered those sentences again, they may have recognized them due to memory of the semantic information. This possibility was addressed by Kolers (1974) with the introduction of a second transformation, reversed rotated text (rR). Thirty sentences were read in each of the three orientations N, I, and rR transformations at the first reading. One third of the sentences in each orientation were transformed to each of the other two transfomations for the recognition deck, and 30 new sentences were added as distractors. Kolers proposed that if the superior performance with the transformed sentences was simply due to the difficulty of orientation, then both the I and rR sentences should be recognized more readily than N, and there should be confusion between identification of the I and rR sentences. Results indicated that the transformed sentences were indeed recognized more frequently than those in normal orientation. However, the I and rR were readily distinguished from each other. Thus, Kolers (1974) questioned the assumption that difficulty by itself, longer processing, or semantic information accounted for the superior performance on the transformed sentences. Instead he proposed that it was more a matter of what the readers were doing to the sentences than what they were encoding about them that produced the superior performance. If perceptual analysis was demanded then it could be more influential than conceptual analysis.

Since classification or categorization did not necessarily provide the strongest evidence for processes utilized in pattern analyses, Kolers (1975) proposed a more direct measure of pattern analysis. Subjects read a long list of sentences twice. On the first reading the sentences were either in I or N orientation, but on the second reading all sentences were in I orientation. Of interest was the second reading time (RT) of the sentences as a function of the typography on the first reading. Kolers hypothesized that if only the semantic information was utilized then the RT should be equivalent regardless of whether the sentence was read in I or N on the first reading since sentences in various orientations were equivalent as semantic objects. However, if typographical analysis was part of the processing, then practice at reading a sentence in one particular orientation should influence the second reading in the same orientation. Results showed that the time to read an inverted sentence was longer when it had previously been read in normal orientation. The rereading time for NI was significantly slower than for II. Hence, "the facilitation of reading was not in the words alone, but in the words as visual patterns; not in the words as semantic objects only, but as graphemic objects as well" (Kolers, 1975, p. 373).

Kolers (1976) further tested the hypothesis that the advantage of rereading text was due to the pattern analyzing that was highly specific to the particular passages read. Subjects read 160 pages of inverted text. Forty-nine of the pages were reread by the same subjects after 13-15 months, along with 49 new pages (from the same source). The results showed that the previously read passages were reread five per cent faster when compared with new text--even after a delay of more than one year. Kolers rejected the idea that the advantage was due to retention of semantic information because recognition judgements about pages were not necessarily well correlated with reading speed. Instead, Kolers (1979) suggested that the reader applied many different analytical operations to the stimuli, and the more operations that were applied, the better the stimulus was acquired and the greater the subsequent opportunities for reapplication of processing. Whereas the levels of processing theory had postulated a hierarchical order of processing, Kolers proposed the interaction of various analyses. The levels theory would suggest that a sentence demanding extensive graphemic analyses would be less well remembered than one requiring semantic analysis. However, Kolers and Ostry (1974) showed that sentences requiring extensive graphemic analysis on the initial reading, II and IN, were recognized better than sentences which required less, NN and NI. Kolers (1979) suggested that the reader utilized all available processing skills demanded by the text and allowed by the constraints of the task (graphemic, syntactic, semantic, temporal, locative and contextual). Only the purpose or the need of the task could make one feature more significant:

> The semantic is richer or deeper than the graphemic only insofar as customary usage of language is directed as its reference or suggestion; change of skill or of purpose can change the importance and richness of a category of description. (Kolers, 1979, p. 382)

Thus recognition was not due to a list of operations that resided within memory, but "goes forward by a reinstitution of operations at a later time of those engaged in earlier" (Kolers, 1979, p. 383).

Kolers and Roediger (1984) proposed the proceduralist view of memory and hypothesized that knowledge was dependent on skills operating on symbols. These skills were often directed at the features of the stimulus (cadence, pitch of voice, typography, orientation of text, etc.). These researchers questioned the assumption that very little was remembered about surface structure, while considerable information was retained about meaning (Bransford & Franks, 1971; Sachs, 1974), and they were critical of the proposal that events were decomposed by sensory processes into distinguishing features, and these features were stored as aspects of the memory trace (Bower, 1967; Underwood, 1969). Similarly, Tulving and Watkins (1975) suggested that retrieval cues could influence the selection of features on perception and memory. Yet, there was no agreement as to what determined the skills utilized in the selection of these features for memory performance. Kolers and Roediger (1984) suggested that this failure may be due to the fact that memory was studied in terms of descriptions of knowledge rather than in terms of the procedures used to acquire or express knowledge.

Research on memory had often concentrated on the distinction between what was termed declarative versus procedural knowledge. The dichotomy was between "knowing that" (declarative) and "knowing how" (procedural) (Scheffler, 1965). This distinction was extended to define kinds of memory. Declarative knowledge was identified with semantic memory (Collins & Loftus, 1975) or with semantic and episodic memory (Tulving, 1983). Procedural knowledge was identified with skills, which when they did not require attention were thought of as automatic (Posner & Snyder, 1975). Kolers and Roediger did not deny this distinction, but questioned its relevance to memory theory. They attempted to account for all of a person's memory capabilities within the framework of skills or procedures and proposed that knowledge was means dependent. Thus, these researchers speculated that the perceptual features of a message played an important role in forming the memory representation. This was in direct contrast to previous assumptions which claimed that perceptual features of language were stored only briefly, whereas the semantic components were stored for longer periods (Anderson & Bower, 1973; Craik & Lockhart, 1972). The line of experimentation that emphasized the encoding of semantic attributes in preference to physical details of the stimuli claimed that knowledge was acquired from various stimuli by abstracting and storing their contents while discarding most of the source information (Bransford & Franks, 1972; Sachs, 1967). However, Kolers and Roediger suggested that the means of acquisition often formed a part of whatever a person knows. Although the distinction between structure and process prevailed in theorizing for a long time, these researchers argued that evidence against its relevance seemed very strong.

Kolers and Roediger (1984) proposed that "the effects of experiences depend upon the procedures used to realize them rather than upon some description of them, and that particular experiences train skills selectively" (p. 436). They hypothesized that if mind contained a single trace of an experience that varied only in strength, then various measures of memory would be affected in the same way. Kolers' (1975, 1976) results indicated that subjects were often able to reread a page faster than they read a companion (new) page, but did not recognize as having read it before, or subjects knew when or how often a page had been read but without any corresponding change in their reading speed. The various performances were said to be dissociated and these dissociations were between descriptions of a text or encounters with it, and the skill of reading it.

Recent literature has defined implicit performance as procedures demanding some cognitive or motor activity when no reference is made to previous events, whereas explicit performance directs the subject to previously experienced events (Richardson-Klavehn & Bjork, 1988). Current research on the relation between implicit and explicit performance began from at least two related lines of work. First, studies with amnesic patients illustrated that, although they performed poorly in recalling or recognizing recently presented information, their performance on more subtle transfer or priming measures indicated that they in fact stored information very effectively in many circumstances. Warrington and Weiskrantz (1970) compared performance of amnesic patients with normal patients on the retention of word lists. The subjects learned three lists of nine words each by the presentation of each word in two fragmented versions (more and less incomplete versions). Retention was assessed by recall, recognition and presentation of partial information (word fragments). The performance of the amnesics was dismal compared to the normals when tested for recall or recognition of recently presented information. However, when the patients were tested with a task in which they had to name severely degraded words that could not be identified without reliance on recently presented information, the amnesic subjects exhibited normal amounts of priming. Other studies confirmed the finding that amnesics demonstrated performance equivalent to that of normals, even on verbal materials, as long as it did not require conscious recollection (Graf, Squire, & Mandler, 1984; Shimamura & Squire, 1984).

The second line of research demonstrated the same phenomenon in normal adults. Normal subjects also showed dissociations between conscious recollection as assessed by recall or recognition, and retention as measured in ways that did not require conscious awareness of the prior learning experience. As mentioned previously, Kolers (1976) had subjects read passages presented in inverted typography. A year later the subjects were unexpectedly retested and asked to read the same inverted passages intermixed with new ones from the same source. Reading speeds for the previously read passages were faster when compared to new ones, but the benefits were uncorrelated with recognition judgments as to whether or not the sentences had been read previously.

Similar dissociations have been reported by Jacoby (1983) and Jacoby and Dallas (1981). Jacoby and Dallas (1981, Experiment 1) required subjects to answer a different question about each word in a long list. Three types of questions were used: questions about the constituent letters of words (e.g., does the word contain the letter *L*?), rhyme questions (e.g., rhymes with *train*?), and questions about the meaning of the word (e.g., is the center of the nervous system?). Retention of these words was assessed by either a recognition test in which subjects had to respond yes/no to a presented word, or a perceptual recognition test in which words were flashed across the screen and the subjects had to identify each word. Results showed that when words were presented with questions demanding attention to their graphemic, phonemic or semantic features, a typical levels of processing effect was found with the recognition test. Semantic encoding produced the best recognition, followed by phonemic and then graphemic encoding. However, on the perceptual identification test these conditions produced equal amounts of facilitation relative to nonpresented control words.

Dissociation was also illustrated in Jacoby's (1983) experiments in which subjects studied antonyms such as *cold* as target items in one of three contexts. In the No Context condition, three *X*'s alerted the subject to the appearance of a target item; in the Context condition the antonym *hot* preceded the target word; and in the Generate condition, subjects saw the word *hot* followed by three question marks and had to generate *cold*. In a later recognition test, subjects performed best in the Generate condition, next best in the Context condition, and worst in the No Context condition. This was a reflection of the generation effect (Slamecka & Graf, 1978) in that generated items were better remembered than items that were read. However, on the perceptual identification task, the No Context items were identified best and the Generate items identified least often. These results were interpreted as evidence that different study conditions and types of test demanded various kinds of processing and test performance was dependent on the overlap between processing at the encoding stage and that required by the test (Kolers & Roediger, 1984). Jacoby (1983) suggested that reading the word with No Context involved data driven (bottom-up) processing since there was no other means for the subject to produce *cold* than from the letters forming the word (data) to be "driven through" the cognitive system. However, the Generate condition demanded conceptually-driven (top-down) processing since the visual features (the letters) specifying the response *cold* were absent, and it was produced by inference from the related concept *hot* and the rule to produce opposites. Subjects in the Context condition used a mixture of these two forms of processing. It was assumed that recognition memory depended heavily on conceptually-driven processing, whereas perceptual identification was assumed to require data-driven processing. Thus Jacoby (1983) and Kolers and Roediger (1984) explained the interactions among study and test conditions by the kinds of processing required during study and test manipulations.

Gardiner (1988) reported evidence to suggest that recognition memory may entail both conceptually-driven and data-driven processes (Jacoby & Dallas, 1981). He utilized Tulving's (1985) approach to evaluate rather than manipulate the nature of the subjects' conscious awareness during a recognition test. Subjects were asked to put an *R* for remember next to items in the test if they could consciously recollect the item, and a *K* for know if they recognized the item on another basis (no conscious recall of prior occurrence). In Experiment 1 subjects were given either a phonemic or semantic encoding task, and in Experiment 2 subjects were given a list of words, half of which had to be generated in the context of a given rule and half of which had to be read. The subjects were given a recognition test and instructed to indicate with a *K* or a *R* the nature of the remembering. Results indicated that both levels of processing (Experiment 1) and generation effects (Experiment 2) were found only for the words whose recognition was based on conscious recollection (*R* condition). When subjects indicated that the word was recognized by some other means (*K* condition), recognition memory was totally independent of the encoding conditions. Gardiner proposed that recognition memory involves two processes. The implicit component may be a reflection of the data-driven processes (Jacoby & Dallas, 1981) and may be dependent on previous exposure to the stimulus. This would be reflected in the *K* responses. The

R responses may be primarily a measure of the explicit component and a result of the conceptually-driven processes.

One important difference between research that had illustrated no effect of how the stimuli were presented and that which had shown an influence was the dependent measures used. In studies in which there was no effect of presentation typically recall or recognition tests were utilized, whereas Kolers (1975) measured reading speed and Jacoby and Dallas (1981) and Jacoby (1983) tested perceptual identification performance. This indicated that the type of test was critical to whether effects of surface form were revealed in performance. Jacoby and Dallas (1981, Experiment 6) compared the effects of modality of presentation (visual or auditory) on a yes/no recognition test and on identification from brief word displays. Findings indicated a sharp dissociation, with modality having no effect on recognition, but a large influence on perceptual identification. In this latter measure, performance increased when the targets had been presented visually, but there was no benefit to auditorily presented items (when compared with non-studied items). The researchers concluded that perceptual identification was a data-driven task making it highly sensitive to how the data were presented at study. Recognition was largely a conceptually-driven task and therefore not as affected by the perceptual characteristics of the prior presentation. However, Jacoby (1983) suggested that recognition may also involve a data-driven component in that subjects may have judged an item to be familiar when it was rapidly processed, or when it seemed to "jump off the page" (see also Mandler, 1980).

Roediger and Blaxton (1987, Experiment 1) presented subjects with 96 words, half visually and half auditorily. Half of the 48 visually presented items were typed in lowercase type, whereas the other half were handprinted in uppercase. Twenty-four other items were presented auditorily and for another 24 auditorily presented items, subjects were required to form an image of the word as it would appear typed. The study conditions were manipulated within subjects but the type of test was a between subjects factor. One group of subjects received a standard yes/no recognition test in which 96 old items were randomly mixed with 96 new items. Each typography (lowercase typed or uppercase handprinted) was used for half the items in each study condition. Another group of subjects received a word fragment completion test in exactly the same form as that used with the recognition subjects, but only fragments of the words were presented. The subjects' task was to fill in the missing letters to complete the word correctly. Results showed that, in the fragment completion test, items presented under all study conditions primed their later completions. Also, there was cross-modal priming in the fragment completion condition. These latter data are in contrast to those of Jacoby and Dallas (1981, Experiment 6) who found that perceptual identification performance improved with the visually presented item but not with the auditorily presented word. However in Roediger and Blaxton's (1987) data, priming from visual presentations was greater than for auditory presentation (same modality priming exceeded cross-modality priming). Within the visual mode a slight but significant effect of typography was obtained. When words were studied in the handprinted (uppercase) condition and tested in the same condition performance was better than when the test was in the different (typed lowercase) condition. Similarly, when words were studied in the typed (lowercase) condition and tested in the same condition performance was better than when testing was in the different (handprinted uppercase) condition. However, when the words were handprinted at study (uppercase) and tested with typed lowercase, performance was marginally better than when words were both studied and tested in the same lowercase typed condition and tested in the same lowercase condition. Finally, when subjects were presented words auditorily but told to image what the word looked like typed, fragment completion improved about 5% when compared with auditory presentation (no image), however, this increase was not specific to the typography at test because the increase also appeared when subjects were tested with the handprinted fragments. This suggested that subjects encoded more perceptual information when instructed to image the word, but this was not specific to the typeface imagined. It was also noted that when subjects were instructed to image the typed word, word fragment completion performance was equivalent to that of items actually presented typed.

However, the recognition data showed a very different pattern of results. Visual presentation at study was not reliably superior to auditory presentation, nor was there any reliable effect of typeface. Whereas visual presentation produced the best performance in fragment completion, auditory presentation with instructions to image the word resulted in a better trend on the recognition test. Within the visual presentation conditions, there was a trend in favour of compatible typographies, but this trend was not statistically reliable.

Roediger and Blaxton (1987) performed a second similar experiment which included a delay of test (although not all conditions of Experiment 1 were included). The subjects studied 96 words in three blocks of 32, with one block presented printed, one presented typed, and one presented auditorily (same materials as in Experiment 1). They were then tested on 96 fragments (half old, half new), both a few minutes after presentation and again after a delay of one week. Printed fragments were always used during testing. Notably, there was significant priming on the word fragment completion task after a one week retention interval, although performance declined in all conditions during the delay. Thus, the results indicated that fragment completion was dependent on the relationship between the study and test conditions of both modality and typography. By contrast, recognition was less sensitive to typography as evidenced by the finding that modality had no effect. Overall, the data from the implicit measure were in agreement with those of Graf, Shimamura, and Squire (1985) who reported cross-modality priming for both amnesics and normals in a word stem completion task although same-modality priming was greater than cross-modality priming. However, the cross-modality priming data were unlike results obtained by Jacoby and Dallas (1981, Experiment 6). These data suggest that implicit memory measures are sensitive to perceptual features. However, the finding of cross-modality priming implies that other factors may also be critical for some of these measures.

The levels of processing theory proposed that experiences left memory traces which varied in depth along a single dimension. Different levels of performance reflected the varying depth (strength) of these traces. Thus, it would have been reasonable to assume that the ordering of performance in the various study conditions would generalize across memory tests. If trace *A* proved to be stronger than trace *B* on free recall, then this ordering should remain on a fragment completion test or on any other test. Yet the above mentioned experiments did not support this hypothesis.

It was also possible to account for the dissociation phenomenon by utilizing the concept of different memory systems. Tulving, Schacter, and Stark (1982) presented subjects with 96 words for study and then tested them both one hour and one week later with a recognition test and a word fragment completion test. On the completion test subjects were given word fragments (e.g., *_EX__NT, _G_O_T_C*) of both old and new words and asked to complete the word. Results indicated independence between recognition and fragment completion performance in two different ways. First, over the week delay, recognition performance dropped markedly, but priming in fragment completion did not decline at all (functional independence). Secondly, when the recognition test preceded the fragment completion test within a testing session, fragment completion was stochastically independent of recognition performance. That is, the fragment test was completed as well when the recognition items had previously been judged as old as when they had been judged new. These data were interpreted as support for the concept of different memory systems, the episodic and semantic (Tulving et al., 1982) which was later modified (Tulving, 1983) to include the procedural system. The researchers (Tulving et al., 1982) reviewed dissociation evidence in which independent variables affected an episodic memory task (recognition) but did not influence a semantic memory test (fragment completion or perceptual identification). For example, in the experiment by Jacoby and Dallas (1981) in which subjects processed words with regard to their appearance, sound or meaning, and then were tested by either a perceptual identification or a yes/no recognition test, results showed that the levels of processing manipulation had a large effect on recognition, but no effect on perceptual identification. Tulving (1983) suggested that these results supported the distinction between episodic and semantic memory. He noted that presentation facilitated performance on a semantic word completion test, but since performance did not decay (as it should if it was an episodic task), performance was delegated to a third system--the procedural. Tulving (1985) proposed that the three systems may constitute a monohierarchical system. The system at the lowest level, procedural memory, contained semantic memory as its single specialized subsystem, and semantic memory contained episodic memory as its single specialized subsystem. In this arrangement each higher system depended on, and was supported by, the lower system(s), but "it possesses unique capabilities not possessed by the lower systems" (Tulving, 1985, p. 387). The monohierarchical arrangement implied that only procedural memory could operate completely independently of the other two systems. Semantic memory could function independently of episodic memory but not independently of procedural memory. However, episodic memory depended on both procedural and semantic memory (although like each memory system, it also possessed its own unique capabilities). The episodic system was believed to be responsible for recollection of personal experiences demanding retrieval of time and place, whereas the semantic system emphasized permanent knowledge. Procedural memory enabled retention of learned connections between stimuli and responses, including those involving "complex stimulus patterns and response chains, and to respond adaptively to the environment" (Tulving, 1985, p. 387). This, however, left unresolved the problem of assigning boundaries to the episodic and semantic tasks.

The proceduralist view as proposed by Kolers (1975, 1976, 1979; Kolers & Roediger, 1984) accounted for this dissociation with the hypothesis that the similarity between the processing at encoding and test directly influenced performance. These researchers considered dissociation a natural consequence because procedures were task specific and could readily appear to be dissociated. For example, in Kolers and Perkins' (1975) study, subjects read 24 pages in one of seven transformations and were subsequently tested by reading two pages of another transformation. The effectiveness of training was calculated as the per cent improvement in reading time from the initial stage of training on one transformation to test on another transformation. Findings indicated that the percentage transfer to any test transformation from any training transformation varied markedly. For example, training on I transferred 118% to reading R, whereas training on R transferred only 44% to reading in I. Kolers and Perkins concluded that readers did not merely learn a general skill in coping with transformed text but acquired a skill specific to a particular typography and transferred those skills to other transformations as particulars. Kolers and Roediger (1984) proposed that transfer was asymmetrical and it was "more appropriate to examine these results in terms of the operations the reader performs to carry out the tasks than to invent different perceptual states or memory systems to accommodate the 'dissociations' of data" (p. 439).

Craik and Tulving (1975) illustrated that word recognition performance varied according to encoding instructions. They argued that when subjects evaluated information for semantic features, encoding was deeper and richer than when making judgments about appearance as typographic objects. However, Kolers and Roediger suggested that requiring subjects to analyze stimuli at deeper or more elaborate levels does not necessarily yield superior performance, and "no such dimension or scale exists independently of circumstances; what is superficial and what is deep depends not on the stimulus but on skill, purpose, and the way that the stimulus is 'taken'" (Kolers & Roediger, 1984, p. 441). This implied that both skill and purpose can delegate perceptual features to be encoded and remembered as well as semantic components. These researchers postulated that treating the memory system as a composite of skills that transfer differentially to new tasks would enable researchers to utilize a "unifying principle" to organize memory research. Complex skills could be considered as being composed of simpler components and the organization and allocation of these simpler skills could be studied as a function of the experimental task. Jacoby (1983) included the proposal of data-driven (bottom-up) and conceptually-driven (top-down) processing in the understanding of these procedures. He suggested that some study and test conditions emphasized attention to presented information (the data), whereas others accented concepts (elaboration, association). Free recall and recognition were the paradigmatic conceptually-driven tests--subjects had to process information by using mental concepts or utilize previous semantic association. However, tests like perceptual identification and word fragment completion were more data-driven and emphasized processing associated with the initial identification of a stimulus. Consequently, tasks that emphasize data-driven processing at encoding may result in better performance on implicit memory tasks, whereas those that accentuate conceptually-driven processing may result in superior performance on explicit tests (Masson, in press).

Recent research (Horton, 1985, 1989; Kolers, 1975, 1979; Masson, 1986; Tardif & Craik, 1989) has focused on the involvement of perceptual (graphemic) and semantic information utilized in the implicit and explicit memory process. Horton (1985) noted that the extensive evidence presented by Kolers (1979) was based on the assumption that spatially transformed text did not change the semantic content presented to the subject and therefore, this semantic content was equivalent in the various orientations. Kolers (1979) had proposed that reading in normal typography involved little graphemic or semantic processing since reading normal text was a highly skilled behaviour. However, reading inverted sentences would result in extensive graphemic processing because of the unfamiliar typography, whereas the semantic (meaningful) content of unfamiliar typography would be the same as that of normal text. These assumptions enabled Kolers to conclude that II sentences were read significantly faster than the NI sentences due to increased processing of graphemic information on the first reading. Horton (1985) suggested an alternative hypothesis derived from theories that emphasized both bottom-up (graphemic analysis) and top-down (semantic analysis) processing. He proposed that both graphemic and semantic processing increased when reading transformed text and a skilled reader will utilize all available skills when confronted with typographically transformed text. Horton proposed that semantic information could be acquired by attempting to guess the identity of upcoming words from previously identified text. This should result in a greater abundance of semantic information than would be obtained from processing normal text and a subject should be able to utilize this information when re-processing the sentence. Thus, when reading II sentences, compared to NI sentences, the faster rereading times may be due to either or both graphemic or semantic information from the first reading.

Horton (1985) designed a series of four experiments to separate the graphemic and semantic information utilized in reading transformed text. Subjects read text in N (normal), I (inverted) or R (reversed) orientations and then reread the sentences in I or R (in the last three experiments, the N condition was eliminated). The primary interest was in comparing the II and RR conditions with the difference between the IR and RI conditions. Assuming that both graphemic and semantic analysis occurred in reading sentences in I and R orientations on the first presentation, then both types of information would be available or usable on the second reading in the II and RR conditions, respectively. However, in IR and RI, although both types of information were available, the pattern analysis from the first reading would not facilitate the second reading. Horton suggested the specificity of components in pattern recognition (Kolers & Perkins, 1975) as the basis for this assumption. He speculated that although the graphemic information in IR and RI changed from the first reading to the second, there was no reason to suppose that the semantic information varied. Horton predicted that the II and RR conditions would produce maximum benefit on the rereading task, whereas the IR and RI conditions would show less facilitation since only semantic information from the initial reading would be usable on the second reading. Thus, comparing the processing speed of the II and RR (same rereading orientation) conditions from the initial reading with that of the IR and RI (different rereading orientation) conditions should reflect the use of graphemic information. Comparing the speed of the IR and RI (different rereading orientation) conditions with that of the NI and NR (different rereading orientation) conditions should reflect utilization of semantic information. These predictions did not depend on the assumption that mainly graphemic processing occurred in reading transformed sentences (Kolers, 1979). The latter view proposed that IR and RI sentences would show less benefit than II and RR sentences because graphemic information from the first reading was of little benefit in the former conditions. Results indicated that the II and RR conditions did not differ from the IR and RI conditions, but all four conditions yielded greater transfer benefits than the NI and NR conditions. Horton concluded that subjects engaged in extensive semantic processing when reading transformed text along with graphemic analysis. However, Horton proposed that when either graphemic or semantic information, or both, could be utilized (II and RR), subjects relied on semantic information. These results were similar to those reported by Graf and Levy (1984, Experiment 3). Subjects read passages twice in Elite font, first in Script and then in Elite, or first as a paraphrase in Elite font and then in its original form in Elite. While all passages were in rotated typescript for rereading, half of them were normally oriented for the initial reading, one in each of the Elite, Script, and Paraphrase conditions. Results showed that the originally rotated passages conferred more facilitation than the normal orientation, but this was not diminished by a change in font or by a change of wording (paraphrase). The authors concluded that facilitation was due to conceptual (semantic) rather than perceptual (graphemic) factors.

Masson (1986) investigated the influence of perceptual features in word processing. He argued that word identification developed through memory for analysis of specific instances to which the subject was exposed. He proposed that this memory for procedures was not necessarily conscious (Kolers, 1976, 1979), but could be expressed by facilitation on repeated performance of the task. He suggested that the identification of a word was dependent on the similarity of the pattern analyzing operations applied to it and those applied to words previously experienced by the reader. The identification of transformed words was difficult because the visual pattern was not similar to previously experienced patterns and the features of such words had to be analyzed in greater detail before identification could occur. This analysis would facilitate identification when the same visual pattern was encountered again and if the same elements of the pattern analyzing process could be utilized. The greater the degree of similarity between a previously analyzed word and a new word, the greater the transfer (Kolers & Perkins, 1975). Included in the set of relevant features were individual letters, patterns produced by letters, letter clusters and word shape.

This instance based hypothesis was also advocated by Brooks (1977). Subjects conducted a skilled visual search through words that were printed in alternating uppercase (UC) and lowercase (LC). With training the search became as efficient as with regular LC. However, when the subjects were switched to the complementary alternating case, the identification time increased as if subjects were beginning to learn a new typography. Brooks concluded that the subjects had not learned a general skill of identifying alternating text, but had instead developed a specific skill dependent on a particular visual pattern.

Masson (1986) explored the nature of the skill acquired as a result of reading transformed words. In Experiment 1 training was based on 24 word triplets constructed from only 13 letters of the alphabet and presented in a LC mirror image of the normal counterpart. At test, three kinds of items were presented: words read during training, new words formed from the same letters utilized at training, and new words based on letters not experienced at training. Results indicated that identification of the training words was fastest, and somewhat longer for the new words formulated from the same letter set as training words. However, the identification time was significantly longer for new words based on the unfamiliar letter set. There was no difference in performance between words in the training phase and new words formed from unfamiliar letters during the transfer phase. This indicated that reading typographically transformed words did not transfer to new word triplets consisting of letters that had not previously been seen as transformed. These results were interpreted by Masson as evidence that word identification skill developed as a result of memory for analysis of specific instances (Brooks, 1977).

In Experiment 2, the subjects were exposed to all the letters of the alphabet in mixed UC and LC, although each letter appeared in only one case during the study trial. Again word triplets were presented in mirror image typography. At test, the case of each letter remained the same as at study (e.g., *e* stayed as *e*) or changed (e.g., *e* changed to *E*) and both old and new words were presented. Results illustrated that the skill of reading mixed case transferred to new words with a high degree of specificity, but new words with new alternating case pattern (words not visually similar to previously experienced words) did not benefit. Masson proposed this as further evidence that the transfer of skills is dependent on the similarity of patterns analyzed to those previously analyzed (as in Experiment 1). Word identification was not helped by other specific nonvisual characteristics such as phonemes or syllables.

In Experiment 3, Masson tested the influence of interletter features (shapes created by adjacent letters) and word shape in identification of transformed words. During training the subjects were exposed to mirror images of both UC and LC of each letter, and word shape was determined by the alternating case pattern of each word. At test, repeated words were presented in the original or complementary alternating case. If only individual letter features were important in word identification, changing the case pattern should not influence word identification because both UC and LC versions of each letter had been experienced at training. However, if interletter features and word shape were significant, changing the pattern of alternating case should disrupt features and slow identification. Masson also re-arranged half of the repeated word triplets at test to form novel word combinations. If the advantage for repeated words was due to conceptual analysis, intact triplets should provide a benefit, but if it was the repetition of the individual words that provided the advantage, re-arranging word triplets would have no effect. Results indicated that failure to repeat the alternating pattern produced significantly slower identification time. When the word was repeated in the complementary case alternation pattern, word identification was slower when compared to words that were repeated with the original pattern of case alternation. Since individual letters were equally familiar, Masson proposed that the pattern of interletter features and word shapes experienced in training were "the only form of visual information that could account for this effect" (p. 485). He suggested this as strong evidence that word identification of transformed words was facilitated by identification of interletter features and word shape (Brooks, 1977; Kolers & Roediger, 1984). The re-arrangement of word groupings did not reduce significantly the advantage of repeated words. This indicated that the repetition of an individual word influenced word identification, and combined with the results of Experiment 2, suggested that the influence of repeated presentation of a word concept and repetition of the original form of the word can be dissociated. In Experiment 4, Masson illustrated that even with a substantial increase in training time, subjects did not acquire the general skill of reading case-alternated text, but instead were dependent on memory for analysis of specific instances. Emphasis was on memory for specific training episodes and patterns of skill transfer that could be generated from them (Kolers & Roediger, 1984). Without shared features there could be no shared pattern analyzing operations--thus, no grounds for transfer.

Tardif and Craik (1989) questioned the type of information that facilitated rereading of transformed text. These researchers suggested that the data from Masson (1986), with the exception of Experiment 3, did not illustrate "memory for the analysis of specific instances encountered at training" (Masson, 1986, p. 487), but instead demonstrated two additive effects since there was no interaction between performances with the training words and new words with old letters. One effect was the general skill of learning a particular orthography and the second was the effect associated with the particular words encountered. Tardif and Craik proposed that the influence was additive since there was no further advantage to words repeated in the same typography. This absence of facilitation was also illustrated by Horton (1985) who found that II and RR sentences had no benefit over IR and RI sentences. However, Tardif and Craik did acknowledge that in Experiment 3, Masson (1986) demonstrated a small but reliable effect due to transfer of information from specific typography (alternating UC and LC). These researchers also suggested that although Horton (1985) proposed that the facilitation in II and RR was largely semantic even though there was the availability of both graphemic and semantic information, Horton's (1985) study did not clearly define the role between semantic information and the general skill of reading a particular typography. They suggested that Horton "may have swung too far in favor of semantics" (p. 119). He did not allow for the effects of skill learning of the new transformations (at the perceptual level).

Tardif and Craik had subjects read text in N (normal), A (inverted), or B (mirror image), and one week later read old and new passages in A, B or C (reversed spelling) with both new and old (Session 1) passages crossed with Session 2 conditions in all possible combinations. The three transformed typographies were allocated to A, B, and C in a counterbalanced fashion and the text passages were allocated in a semi-random fashion so that each passage appeared approximately once in each condition across the group of subjects. In the first session the subjects read three passages in each of the three typographies (A, B, N). In the second session, subjects reread the nine old passages, plus three new passages in the 12 possible combinations of the first reading (A, B, N, and new) with the three Session 2 typographies (A, B, and C). This resulted in an extension of Horton's (1985) design and enabled the researchers to compare results between completely new passages in an unfamiliar transformation (C) with those from old passages read in a new transformations (NC, AC, BC). The addition of a third unfamiliar typography (C) could reveal transfer of a general typographical skill as well as provide evidence for the contribution for general (gist) and specific (lexical and syntactic) information. Similarly, comparisons could be made with new passages read in a previously practiced orthography (new A, new B), and with old passages reread in either the same or a different old orthography (e.g., AA or BA respectively). This enabled the researchers to determine if facilitation was due to the repetition of a particular transformed typography, the repetition of the same passage, or possibly both. Results indicated faster rereading times if passages had been read in Session 1, and if the same type had been encountered in the previous session. There was transfer of a general skill of reading a particular typography as well as transfer associated with reading the same passage. However, since repeating the same passage did not interact with the type of transformation, Tardif and Craik described this as the retention of general conceptual information. Although this was evidence that both perceptual (graphemic) information (of a general kind) and conceptual details persisted over time, there was no evidence for retention of pattern analyzing operations specific to a particular typography, since repeating a passage in the same type, AA or BB, showed no significant advantage over AB or BA. Although these results were similar to those of Horton (1985), Tardif and Craik disagreed with Horton's conclusion that the results demonstrated utilization of mainly semantic information. Instead they suggested that both general perceptual and conceptual processes may be implicated, and further examined the role of these factors in Experiment 2.

Conceptual processing was manipulated by presenting either the same passages in both Session 1 and 2, or a sentence-by-sentence paraphrase of the passages read in Session 1. The researchers speculated that if only general gist information was retained, the paraphrased passages would benefit rereading to the same extent as would the original passages. However, the exact passage should show greater savings if specific perceptual information was retained. The two typographies were also manipulated. At study each subject read five passages, one practice and four experimental, all in one of the two transformations (A or B). One week later the same subjects read six passages, two of the original passages (identical to Session 1), two in a paraphrased version, and two which were completely new. In addition, one passage from each of the identical, paraphrased, and new conditions was presented in the original typography, whereas the other was in a new transformation. Tardif and Craik predicted that if only abstract propositional information was transferred, the old (identical) and paraphrased passages should be read faster than the new, but there should be no difference between the old (identical) and paraphrased passages. However, if rereading was facilitated by specific perceptual information, the identical passages should show a benefit when compared with the paraphrased text. There should also be an additional benefit from repetition of identical typography and this benefit should be greatest for the identical passages (Kolers, 1976, 1979; Masson, 1986). However the facilitation due to repeating the original type might be equal in all three semantic familiarity conditions, if the transfer effects are additive as suggested in Experiment 1. Tardif and Craik also asked subjects to make recognition judgments about passages read in Session 2, to determine if facilitation was linked to conscious awareness of change.

Results indicated that practice at reading a specific typography in Session 1 conferred a significant benefit a week later, however, this should be considered a transfer of a general skill of reading a particular transformation since the transfer was equivalent for the identical, paraphrased and new passages. There was no additional benefit for identical passages in the same typography. Also, repetition of Session 1 passages produced faster reading times than processing of new passages. Although this may have been due partially to retentio· of the general meaning of the passage, there was some influence of specific wording (perceptual effect), since the paraphrased text took somewhat longer to read than the identical text. This benefit to the identical passages occurred without the subjects' awareness that they were processing identical or paraphrased text since they were not generally aware of the change of wording in paraphrased passages. Tardif and Craik concluded that these data provided evidence for two general sources of facilitation for rereading transformed text--the general perceptual skill of reading a particular typography and conceptual information which may be partially gist as well as specific syntax or wording. They proposed that the two sources were additive since there was no evidence for the transfer of additional information specific to the original combination of a particular passage with a particular typography. Tardif and Craik agreed with Masson (1986) that the acquired skill was specific to a particular orthography and proposed that the skill generalized readily to new instances. Experiment 1 confirmed Horton's (1985) finding of no extra facilitation to rereading an old passage in its initial typography, however the introduction of a third new typography, C, revealed substantial transfer of a general skill, but there was no evidence for the retention of pattern analyzing operations specific to the typographies read. These results were in agreement with the findings of Kolers (1976, 1979) in illustrating a strong transfer effect due to the acquired skill of reading a new typography, and the persistence of the influence after a one week delay. However the finding that there was as much transfer of the acquired skill to new as to old passages and that the effects were additive, indicated that the skill was general and not dependent on particular words or phrases.

Horton (1989) questioned Kolers' (1974, 1975; Kolers & Ostry, 1974) method of analysis and the view that superior retention of transformed text compared to normal text was evidence for the influence of graphemic information on memory. Horton asked subjects to read sentences, each presented in one of three possible transformations, inverted (I), reversed (R) or combined (C). At test subjects were presented with a 3-alternative forced choice recognition test (the same sentence was presented three times, once in each of the possible transformations) and were asked to select the orientation of the previously read sentence. He assumed that choice of the correct transformation must be dependent on utilization of graphemic information. The recognition test indicated a reliable effect due to orientation. Since memory for all three orientations was above chance, it indicated that orientation was remembered quite accurately regardless of the amount of processing. However, the results were different from Horton's (1985) findings where memory for spatial orientation had no measurable effect on rereading of sentences, and that although relevant information about orientation of previously read sentences was available, it was not utilized or was ineffective. Since subjects found the recognition test demanding (the combined orientation required more than twice the reading time of normal text, and both the inverted and reversed text took substantially longer to read than the combined), Horton suggested that it may have been difficult to recall the orientation quickly or easily when rereading the sentence (as in Horton, 1985) and subjects may not have processed the sentences for orientation, or if they did, this type of processing may have been ineffectual. In Experiment 2 Horton (1989) illustrated that subjects could retain details of graphemic information over 48 hours although there was a substantial drop in recognition accuracy. In Experiment 3, anomalous sentences were presented to assess the effect of the meaningfulness of material. However, once again there was a reliable effect of orientation, but when compared with Experiment 1, there was no evidence that minimizing semantic or syntactic information improved memory for graphemic details. Horton suggested that possibly the elaboration of graphemic processing facilitated retention to some upper limit and further elaboration was ineffectual.

Horton (1989) concluded that the above three experiments provided unquestionable evidence that graphemic information from the reading of transformed text was available on an explicit memory test and proposed that demonstration of memory for both semantic and non-semantic processing was largely dependent on the measures utilized. When only graphemic information was usable, as in the above experiment, there was excellent memory for graphemic details. However, when both semantic and graphemic information were usable, there was a strong tendency for utilization of semantic features. Horton (1989) also considered the apparent discrepancy of the findings of Horton (1985) and Tardif and Craik (1989), who found no evidence of memory for specific nonsemantic features in a rereading measure, and those of Masson (1986), who did produce reliable evidence for the influence of non-semantic features. Horton proposed that the difference may be due to the materials utilized. In the former, meaningful sentences allowed for processing of context at both encoding and retrieval, whereas Masson utilized unrelated word triplets, possibly reducing contextual processing while facilitating the processing of perceptual details. The interaction of processing at encoding and retrieval was the important determinant of memory performance (Horton, 1985, 1989; Masson, 1986, in press; Tardif & Craik, 1989).

It seems evident that the perceptual strategies used by a skilled reader have been a controversial issue and the procedures by which readers identify words have not been clearly defined. The role of word shape (word outline) remains unclear. Since the last century it has been known that skilled readers may identify single words more readily than nonwords (Cattell, 1886, cited in Baron, 1978). Huey (1908, cited in Baron, 1978) has been considered the standard source on this work and he proposed that words were perceived as wholes (Baron, 1978). It is now thought to be an established fact that our experiences with printed words enables us to identify them more readily than unexperienced stimuli, and it is this experience that is crucial in word identification (Baron, 1978). This phenomenon is referred to as the word superiority effect (WSE) and can be defined as "a class of results than can be explained by the idea that experience with words helps us perceive something more quickly (or more accurately in a limited time)" (Baron, 1978, p. 131). Some research suggested that this "something" is the letters in words and words are identified by a letter-by-letter process (either serial or parallel) in which letters are individually identified before a word is recognized (Estes, 1975; McClelland, 1976, 1977). Yet, others proposed sophisticated "guessing models" which assumed that part of the presented word is perceived and identification is completed by guessing. However, there is also evidence to suggest that what is perceived by the reader are more global features of the stimulus (word) and word shape may be a significant component of these procedures (Coltheart & Freeman, 1974; Havens & Foote, 1963; Monk & Hulme, 1983; Rudnicky & Kolers, 1984).

Some early studies pertaining to word perception were conducted by Huey (1908, cited in Baron, 1978) who argued that both words and nonwords could be perceived as wholes. There was also evidence to suggest that our identification of words is facilitated by our experience with them since under certain conditions words could be recognized when their constituent letters could not be identified (Erdmann & Dodge, 1898, cited in Baron, 1978). Solomon and Postman (1952, cited in Baron, 1978) showed that words or pseudowords that had been seen more frequently could be identified more quickly than words that were less familiar. The researchers considered this to be an effect of experience. Similarly, Miller, Bruner, and Postman (1954) showed that more letters could be reported from a tachistoscopic presentation (10, 20, 40, 100 and 500 msec) of a string of eight letters when the string resembled the structure of a word (*VERNALIT*) (pseudoword) than when it did not (*OZHGPMJJ*) (nonword). This could not be attributed to word frequency since only pseudowords and nonwords were utilized. The researchers proposed that knowledge about the possible or allowable sequence of letters facilitated word identification. Similarly, Gibson, Pick, Osser and Hammond (1962) suggested that what facilitated perception of words may also involve some knowledge of the general rules of spelling. These researchers found that subjects could identify letters equally well within words (*GRUDGE*) and pseudowords (*GLURCK*), but not within nonwords (*CKRGUL*) where there was violation of orthographic rules (Fries, 1963).

However, some argued that the above results may be explained by response biases (Baron, 1978). Subjects may have perceived as much of the information about the nonword as the word and pseudoword but they may been induced to guess about what they did not see in the case of words and pseudowords. Reicher (1969) eliminated the option to guess by forcing subjects to make a choice between a few equally likely alternatives. The researcher presented subjects with a word (*WORD*), an anagram (nonword) (*OWRD*), or a single letter such as *D*. Subjects then had to choose between two letters that were equally likely to have been presented, such as *D* or *K*. Either one of the letters made a word when used in the same position of the word and either made a nonword when used in the same position of the nonword. Performance was better when the letters were presented in the word than in the nonword (anagram) or even in isolation. This result is usually referred to as the word superiority effect (Baron, 1978).

Johnson (1975) hypothesized that if words are identified as single-unit patterns (wholes), then additional processing would be needed to identify a letter within a word. However, if reading is a letter-by-letter process (letter-integration model), then the initial identification is of individual letters, and additional processing is required to identify the word. Thus, the pattern-unit model (whole word approach) predicted that the word *BLOCK* could be identified faster than any of its constituent letters. The letter-integration model (letter-by-letter approach) predicted that subjects could indicate that the word *BLOCK* contained the letter *B* faster than they could indicate that it was the word *BLOCK*. Also, the pattern-unit model predicted that speed of word identification should be independent of word length, whereas the letter-integration model predicted a positive relationship between word length and the time needed to identify it. Subjects were presented with single-word displays (4 to 6 letters each) in decks of 24 displays. Immediately before the items in a deck were presented, a particular item (either a word or a letter) was designated as the target for that deck. When each display appeared the subject was to indicate whether it was the target word or it contained the target letter. Results demonstrated that it took longer to identify a letter within a word than it did to identify a word, and word identification was not influenced by the number of letters in a word. Johnson concluded that this was damaging evidence to the letter-integration model which postulated that words were first identified by letters that make up the words. However, Johnson utilized only uppercase letters and concluded that "words are treated as patterns, and that letters lose their individual identities when they appear in word patterns" (p. 21). This left unanswered the role of word shape in these word patterns.

Support for the influence of word shape came from Havens and Foote (1963) who demonstrated that briefly presented lowercase words with uncommon outlines can be reported correctly more often than words with common outlines, and that words with common outlines are often incorrectly identified as other words with the same outlines. For example, the word *lift* (uncommon outline) was seldom confused with the word *list* (common outline), whereas the words *list* and *last* could often cause identification errors. Havens and Foote indicated that any high frequency response which remained faithful to the first and last letters and differed only in form similar middle letters would be strong competitors.

Similarly, Monk and Hulme (1983) provided evidence for the role of word shape in the word identification process. These researchers utilized a proofreading task in which critical words were mutilated by either deleting or substituting letters. Each word contained two critical letters: one was an ascender and the other was a small lowercase letter. When the changed letter was one with an ascender there was a considerable change in word shape (e.g., *latest* changed to *lacest* or *laest* in the substitution and deletion conditions, respectively). However, when the changed letter did not have an ascender or descender, the misspellings were similar in word shape to the original (e.g., *latest* changed to *latect* or to *latet*). Monk and Hulme proposed that changes that produced large differences in word shape would be more accurately detected as errors than those that did not. They argued that possibly the letter-level effect may influence performance in the substitution condition since changing *t* to *c* is more noticeable than changing *s* to *c*. However, in the deletion condition there is an equivalent degree of similarity in letter identity information since all remaining letters in the misspellings are still a part of the original word. Thus, the influence of the shape change in this condition cannot be attributed to any letter-level manipulations. Results indicated that misspellings that maintained word shape were less noticeable than those that did not, and this shape effect was just as strong in the deletion condition as the substitution condition. Monk and Hulme concluded that word shape has an effect on performance, and that this is a word-level effect. Word shape was identified as a supra-letter feature (features associated with groups of letters, such as the overall shape of the word).

However, McClelland (1977) explained the word-superiority results with the preliminary letter analysis model. He suggested that features associated with groups of letters (supra-letter features), such as the overall shape of the word, may be extracted prior to, or in parallel with, letter information. He proposed that word shape information could be obtained from a brief encounter with the stimulus and this could be used to determine which letters could have been present in the word at each letter position. For example, the word *ship* provides the reader with enough information to determine that the first and third letters must come from *a, c, e, i, m, n, o, r, s, u, v, w, x* and *z*; the second letter is either *b, d, f, h, k, l,* or *t*; and the last letter must come from *g, j, p, q,* or *y* The results from this preliminary analysis would be passed forward to a word identification process which would attempt to identify the word. Thus, word shape as a perceptual unit need not be stored in memory, but the shape could be an influential cue even if the word is treated as a collection of individual letters. This implied that both word shape and letter analysis are critical to word identification.

Similarly, Smith (1969) suggested that there is no reason to assume that the total configuration of a word is the dominant cue for word identification since previous research had illustrated that pseudowords are as easily identified as words (Gibson et al., 1962; McClelland, 1976). Instead, Smith proposed that letters, groups of letters, and words can be identified on the basis of distinctive features which reduce the set of possible alternatives for the entire configuration. Following Gibson et al. (1962), Smith described these distinctive features as some properties of uppercase letters, such as straightness, curvature and intersection. Similar features were assumed for lowercase letters alone or in sequences, with additional cues provided by the presence or absence of ascenders or descenders. However, unlike Gibson et al., Smith suggested that any minimum combination of features that enabled identification of a particular letter or word could be termed a criterial set. These criterial sets become functionally equivalent and elicit the same response (e.g., *a* and *A*, *hat* and *HAT*) because they represent the same letter or same word. He did not propose that words are identified letter by letter but "criterial combinations of features are discriminated simultaneously in different areas of the configuration and integrated for identification of the whole" (Smith, 1969, p. 261). Smith proposed that it did not matter if the feature combinations within a word were in the same typography (case), or even if they were all discriminable, provided that sufficient criterial combinations were discernible in the word. His hypothesis did not assume the necessity of familiarity with the word shape as a whole.

Smith (1969) wished to determine whether the disruptive effect of the alternation of case was due to destruction of a familiar word shape or interference with the discrimination of features of lowercase letters. He suggested that the alternation of case may be responsible for more than the distortion of word shape. It may also interfere with the discrimination of the relative size of the lowercase letters. He proposed that feature discrimination would be supported if alternating lowercase and uppercase text was not disruptive when the size of the uppercase letters was reduced so that letters with ascenders could be identified, even though the whole shape of the word was unfamiliar. Smith showed that adult readers did indeed suffer a reading deficit when reading aloud passages in which words were presented in alternating uppercase and lowercase when the uppercase letters were as tall as the ascenders of the lowercase letters. However, when the size of the uppercase letters was decreased so as not to disrupt the distinctive features of the lowercase letters, there was no disruption of reading speeds. According to Smith, this did indeed support the view that feature discrimination rather than familiarity with word shape is the critical variable in reading since it is possible to consider that both manipulations altered regular word shape, but only the first manipulation interfered with the discriminability of the lowercase letters. Smith's hypothesis suggests that it is the disruption of these feature sets that is critical to performance. In the second manipulation there was no interference with feature discrimination and although word shape was disrupted by alternating case, performance did not decrease.

Further support for this hypothesis came from Smith et al. (1969) in which subjects searched (silently) for target words. The alternating case manipulation was the critical condition. Results showed fewer correct word identifications for the alternating lower and uppercase condition when the uppercase letters were as high as the ascenders of the lowercase letters, but no decrement in correct identifications was found when the size of the uppercase letters was reduced. Smith et al. concluded that "readers identify words by (1) discriminating...feature sets and (2) integrating them for identification of the word as a whole" (p. 253).

However, Brooks (1977) was concerned with the potential lack of sensitivity of the Smith (1969) research because reading aloud has a response-speed limitation and this mode of testing may be incapable of detecting minimal differences in performance. The scanning task of Smith et al. (1969), albeit a silent task, was slow and laborious which may have rendered it insensitive to performance differences. Brooks (1977) proposed that a silent semantic scan through word lists might avoid the response-speed limitation and force subjects to depend strongly on the stimulus. Half of the subjects were asked to scan (silently) a set of 16 words and indicate if the set contained three, four or five first names. Another group of subjects had to report if the same set had three, four or five place names. Lowercase or alternating case was used and the size of the uppercase letters was decreased to prevent obscuring the relative height cues of the lowercase letters. According to Smith (1969) this type of pattern disruption caused no performance decrement when reading aloud. However, results from Brooks (1977) indicated a highly significant deficit in scanning in the mixed case condition when compared to regular lowercase.

The findings of Smith (1969) and Smith et al. (1969) were also questioned by Coltheart and Freeman (1974). These researchers proposed that if word shape is important for word identification, then case alternation should impair word identification. They postulated that word identification involves the recognition of trigram or digram features such as the "roundness of CO or the squareness of NI" (p. 102), as well as extraction of additional properties from the numerous combinations of lowercase letters (independent from individual letter features). They questioned the evidence provided by Smith (1969) who had shown that there was no reading deficit with alternating lower and uppercase text when the size of the uppercase letters was reduced so as not to obscure the ascenders of the lowercase letters. Coltheart and Freeman noted that in Smith's (1969) study, subjects had to read the passages aloud. However, with reading aloud there exists an eye-voice span (Morton, 1964). When reading aloud the reader has to articulate words that in silent reading can be inferred or otherwise understood. Consequently, there exists a floor effect with reading aloud and they suggested that only large processing differences would become evident. Similarly in Smith et al. (1969) the subjects had to search the 150 word texts for 20 target words which were printed on the facing pages of test booklets (text on the left and target words on the right). Although this was a silent search, Coltheart and Freeman suggested that it was unnecessary to utilize such a "complex multiple visual search task" (p. 102) and any effects of the text manipulations could be lost since subjects had to continually consult the list of target words and keep as many as possible in memory while scanning the prose passage. This could have rendered the manipulation insensitive to small differences. Instead Coltheart and Freeman presented subjects with 48 words for a duration of 50 msec each. Each word was presented three times to each subject; once in lowercase, once in uppercase and once in alternating case. In the latter condition, the uppercase characters were lowered so as not to obscure the ascenders of the lowercase letters. Results did indeed show that the alternating case condition produced impaired identification when compared to both regular lower and uppercase words. Coltheart and Freeman concluded that these results differed from Smith (1969) and Smith et al. (1969) because of the insensitivity of the latter experimental paradigms. This research provided evidence supporting the influence of word shape in word identification.

Similarly, Monk and Hulme (1983, Experiment 2) proposed that if word shape is influential in fluent processing, then the use of alternating case should eliminate the usefulness of this word shape effect. Materials were similar to those used in Experiment 1 (described previously), except that a random 50% of the lowercase letters were changed to uppercase. The deletion misspellings were changed so that the remaining critical letter and its immediate neighbours were lowercase and all the remaining letters were uppercase. The substitution misspellings were changed in the same way, but the substituted letter was also in lowercase. Thus, the base word *latest* became *LateT*, *LaesT*, *LatecT* and *LacesT*.[2] The relative height of the critical letters was still apparent, thus giving the maximum chance for letter-level effects to emerge, whereas word shape could no longer be considered regular. The researchers proposed that if the apparent shape effect (misspellings that alter the shape of a word were more often noticed than those that preserved word shape) was due to some nonvisual properties (pronounceability), then alternating case should have no influence on these shape effects. However, if the shape effect was indeed due to word shape, the use of alternating case should eliminate the benefit typically observed for changes which alter the shape of the word. Results indicated that the shape effect was completely abolished by using alternating case. Misspellings that did not maintain word shape were noticed just as frequently as misspellings that maintained word shape. Monk and Hulme interpreted these results as direct evidence for the influence of word shape in the reading process.

Size and case of letters are also of particular interest in word perception studies. In printed words, size does not influence the shape or figural relationship between patterns: A word typed in

2. This manipulation is as described in the materials and design section (p. 20). However, it leaves unclear the definition of "immediate neighbours" since the letters in these positions are not all in lowercase.

18-pt type (1 pt = 1/72 in.) is identical in shape to the same word typed in 8-pt type. However, size alternation does change the shape of the whole word. Case alternation also influences the shape of the word even though many letters are nearly shape invariant in upper or lowercase (e.g., *s,o,c,w*); with such letters, case alternation is really size alternation. The critical consideration is the effect of alternation on the word shape. Smith et al. (1969) had suggested that with mixed upper and lowercase, size alternation and not case alternation was responsible for slower reading and identification performance.

Rudnicky and Kolers (1984) proposed that alternating size and case orthogonally would afford an opportunity to delineate the influence of each of these variables. In Experiment 1, they varied size and case over a wide range of conditions and tested performance with both silent and oral (aloud) reading. Results indicated that both size and case alternations impaired reading speed, but the effect of size alternation was more substantial. Text that was alternated by case but kept at an 18-pt (lowercase) to 12-pt (uppercase) ratio did not obscure the lowercase ascenders, and produced less interference than text with alternating case at an 18-pt (lowercase) to 8-pt (uppercase) ratio. In normal text the ratio of small lowercase letters (e.g., *a,c,e*) to tall lowercase letters (e.g., *b,d,h*) is usually 9 to 12. Interference was also produced by mixed case and a 12-pt (lowercase) to 12-pt (uppercase) ratio since this manipulation produced text that was visually distinct or unusual. All the above manipulations resulted in altered (unique) word shape and slower than regular reading speeds. There was a trend toward increased interference (slower reading speed) as the size of the uppercase letters obscured the lowercase ascenders and the distortion of regular word shape increased. The slower reading speed of the mixed case and same size contrasted with the findings of Smith (1969) who, with a similar ratio (uppercase letters smaller so as not to hide lowercase ascenders), did not find a reading speed decrement. Rudnicky and Kolers suggested that since subjects in the Smith study read text aloud, this could have produced a floor effect, thereby rendering the test insensitive to this particular manipulation. This postulation also explained the *mixed-case* decrement in the experiments of Coltheart and Freeman (1974) and Brooks (1977). Both researchers utilized silent reading tasks.

Rudnicky and Kolers (1984, Experiment 3) explored the idea that reading speed should be inversely proportional to the magnitude of a size-ratio transformation (Bundesen & Larsen, 1975). Accordingly, as the size-ratio of letters increases, the speed of reading should decrease. This was based on the assumption that the time taken to perceive two objects (letters) as having the same shape increases monotonically with their linear ratio. Texts in all uppercase or all lowercase were manipulated by alternating size of the individual letters; case was constant but size of letters varied from 8:8-pt, 8:12-pt to 8:18-pt ratio. Results did indeed show that reading time increased with the magnitude of the size disparity. However, a much more interesting finding emerged. Text in size alternated lowercase took longer to read than text in size alternated uppercase.

A review of past research with regular lowercase and uppercase word processing has indicated a faster processing trend for lowercase than uppercase typography. However, the difference has not always been significant and processing has been measured by different tasks. For example, Rudnicky and Kolers (1984, Experiment 1) reported only a marginally faster speed for lowercase typography in comparison with uppercase text when subjects processed meaningful paragraphs (silently) and the dependent measure was reading speed. Coltheart and Freeman (1974) utilized a tachistoscopic presentation of individual words and reported a faster trend for identification (nonsignificant) of lowercase than uppercase words. Smith (1969) also indicated faster processing (but again nonsignificant) for meaningful text, but speed of reading aloud was measured. However, Tinker (1963) reported significantly faster speeds for reading meaningful paragraphs but experimental conditions were not clearly described. More recently, Levy and Kirsner (1989) reported a well detailed study illustrating significantly faster reading speeds (silent reading implied) for meaningful paragraphs in lowercase text in comparison with uppercase text when subjects were instructed to read for wording.

Rudnicky and Kolers (1984, Experiment 3) speculated that the cues given to the reader may be different in the lowercase and uppercase conditions. In normal lowercase text, the reader may utilize not only letters but also word shape features, including those provided by letter extensions above and below the line. Size alternation destroys this advantage in alternating lowercase print. However, with normal uppercase text there is no word shape provided by extensions above and below the line, thus destruction of regular word shape with uppercase letters could result in less deleterious effects. In Experiment 4, Rudnicky and Kolers confirmed again that size alternated lowercase text was more difficult to read than size alternated uppercase. They also illustrated that the effect persisted over training and that there was less transfer from size alternated lowercase to size alternated uppercase than from size alternated uppercase to lowercase.

The asymmetric transfer results were very similar to those found by McClelland (1977) in which subjects were taught to recognize and define 16 invented words (e.g., *BARDREL*) in either a script font (lowercase) or uppercase type. After practice subjects were tested for speed of responding to the meanings of the words in both familiar and unfamiliar fonts. Results indicated that practice at reading a word in uppercase type transferred better to reading the word in script than practice reading a word in script transferred to reading the uppercase version. Rudnicky and Kolers concluded that this phenomenon may be due to different text-processing strategies that the reader has developed. Words differ greatly in shape when printed in normal lowercase text. A skilled reader may use word shape cues and thus be able to perform well when reading normal lowercase text. It may be that identifying print as lowercase automatically activates this well-practiced shape-sensing skill. However, when a skilled reader identifies text as uppercase, there is no automatic activation of this shape-sensing skill since it has never before been useful in reading normal uppercase text. When the reader is confronted with lowercase text albeit size alternated with an unusual shape, the lowercase skill may be automatically activated. However, instead of being of benefit, activation of this skill may result in interference. Thus, the speed of reading size alternated lowercase may be slower because of the burden of a well practiced skill. With size alternated uppercase, there is no automatic activation, and thus no interference.

Shiffrin and Schneider (1977) defined an automatic skill as a process that was well learned and difficult to alter, ignore or suppress once learned. LaBerge (1975) considered automatic processing to go forward with high efficiency, without capacity limitation, and this processing could occur without utilization of conscious processing resources. Certain "slips of action" (pouring tea into the sugar bowl, sealing an envelope before putting the letter inside) mainly occur with highly practiced, over-learned routine activities (Reason, 1979). These highly practiced actions become automatic and are carried out according to pre-set instructions with little or no conscious monitoring. Automatic performance differs from attentional behaviours which are under moment-to-moment control. A good example of this distinction is driving a car. Emerging from a road junction is (or ought to be) an attentional process. Traffic must be scanned, distances and speeds assessed, and the driver is thinking about the decisions being made. However, for the skilled driver, changing gears is an automatic process and can be carried out successfully while attention is focused on something else, such as talking with a passenger. An action sequence (or processing) that is in frequent use is stronger than one that is used less often. There appears to be a tendency for a stronger program to take over a weaker program, particularly if they share component stages (Reason, 1979). James (1890) described a strong habit intrusion of this kind in the case of someone going to the bedroom to change his clothes, taking off a jacket, and then getting undressed automatically and going to bed. The "going to bed" program took over from "changing the clothes" program, because they both shared the common action of removing the jacket but the former represented the stronger habit. Norman (1981) proposed that several actions may be operative simultaneously, and may be linked into related sets. The highest level, *parent schema*, corresponded to the intention or goal (going to work, reading text). Subordinate, *child schemas*, corresponded to component actions in the sequence (getting out of car, identifying letters or letter clusters). Each schema had its own activation level determined by external events (the current situation) and internal events (plans and intentions). Each schema also had a set of triggering conditions. A given schema became operational when the activation level was sufficiently high and the current situation matched the triggering conditions.

It would be reasonable to assume that reading regular lowercase and uppercase text is a well learned process for the skilled reader. We further suggest that it may indeed be a process that is difficult to alter, ignore or suppress once learned (Shiffrin & Schneider, 1977)--it has become automatic and may normally proceed without conscious awareness. Accordingly, we propose that the processing may be facilitated by pre-set instructions with very little attentional monitoring (Reason, 1979). Since reading normal lowercase and uppercase text is a frequent process we can consider it to be a processing sequence that is stronger than those that are utilized less often (e.g., reading alternating case text). Reason (1979) suggested that there appears to be a propensity for a stronger sequence of operations to override a weaker sequence, especially if the two processes share component stages. Our question of interest is the strategy utilized by the skilled reader when the strong operations of the well practiced skill of reading normal text are confronted with unusual text that shares components of the original skill. Of particular interest here is the role of word shape in these processes.

For example, reading size alternating lowercase text was slower than reading size alternating uppercase text (Rudnicky & Kolers, 1984, Experiment 3 and 4). It is possible that the reading of lowercase letters became the well practiced components of a stronger skill that activated regular lowercase reading processes. However, since the new text did not provide normally encountered word shape this otherwise facilitative skill may indeed have become a source of interference. With size alternating uppercase text, the stronger skill (reading uppercase letters) should not activate the shape-sensing skill. Consequently, processing of alternating uppercase text may be faster than alternating lowercase text because of the absence of interference from automatic activation of a shape-sensing skill. Similarly, when the skilled reader encounters alternating case text where regular word shape is absent but some regular lowercase letters are present, it is possible that the presence of these lowercase letters and their discernibility may be the components of the well practiced skill of reading regular lowercase text that activate the shape-sensing skill. However, this usually facilitative skill may become interfering. This interference would increase as the application of the shape-sensing skill becomes more and more futile due to the deterioration of word shape as defined by the ascenders of the lowercase letters. This would be in accordance with the deterioration of reading speeds as reported by Rudnicky and Kolers (1984, Experiment 1).

Experiment 1

The proceduralist account of memory proposes that knowledge is expressed by operations and procedures in skilled interaction with the stimulus. It suggests a view of learning and memory in relation to the operation of analytical procedures that are directed at that which is perceived. "Perceptual operations are applied to organized or familiar patterns within a stimulus (e.g., words in a particular typography)" (Masson, in press, p. 6). A skilled reader is fluent in numerous skills and applies those procedures that are appropriate to the task, taking into consideration the available time as well as the goal or purpose of the task (Kolers & Roediger, 1984).

The aim of the present research is to assess further the procedures applied to the reading process and specifically the influence of word shape in these procedures. Of special concern was the importance of word shape and its relation to letter case. We wished to consider regularly applied shape-sensing skills, which may be facilitative with processing of normal text but may create interference when the stimulus characteristics are altered (Rudnicky & Kolers, 1984). We selected six different fonts designed to "tease apart" the influence of lower and uppercase letters and to consider the importance of these letters in defining word shape (see Figure 1).

In our experiment, Fonts 1 through 3 could be considered as typographies that define the limits of regular word shape as manipulated by letter case. Font 1 (regular lowercase) provided regular word shape by appropriate lowercase letters. Although Font 2 (regular uppercase) affords the reader regular uppercase word shape, word shape details as defined by the ascenders and descenders of lowercase letters are non-existent. It is assumed that with extensive practice the skilled reader develops procedures that result in fluent processing of normal lower and uppercase text. It is reasonable to suggest that "normally oriented text is almost transparent to the skilled reader in respect to its familiarity as a visible pattern" (Kolers & Roediger, 1984, p. 432). Past research has indicated a trend toward faster processing for lowercase than uppercase text (Coltheart & Freeman, 1974; Rudnicky & Kolers, 1984; Tinker, 1963). Rudnicky and Kolers (1984) suggested that faster reading of lowercase text may be due to the word shape cues afforded to the reader. Words differ greatly in shape when printed in lowercase and cues provided to the reader include not only the constituent letters but also "the shape of the word given by features such as...the pattern of extensions above and below the midline" (p. 241). It is possible to assume that a skilled reader will take advantage of this information in lowercase text (Huey, 1908, cited in Baron, 1978; Tinker, 1963). Rudnicky and Kolers further suggested that this word shape information may indeed be one of the features that allows more fluent processing of lowercase than uppercase text. Consequently, analysis of shape may be a well practiced procedure for skilled readers of lowercase print.

Figure 1.

Fonts utilized in Experiments 1, 2 and 3

FONT 1

people living together in groups come to control one another with a number of techniques. when an individual behaves in a fashion acceptable to the group,

FONT 2

PEOPLE LIVING TOGETHER IN GROUPS COME TO CONTROL ONE ANOTHER WITH A NUMBER OF TECHNIQUES. WHEN AN INDIVIDUAL BEHAVES IN A FASHION ACCEPTABLE TO THE GROUP,

FONT 3

pEoPlE lIvInG tOgEtHeR iN gRoUpS cOmE tO cOnTrOl OnE aNoThEr wItH a NuMbEr Of TeChNiQuEs. WhEn An InDiViDuAl BeHaVeS iN a FaShIoN aCcEpTaBlE tO tHe GrOuP,

FONT 4

pEOpLE LIVING TOGETHER IN GROUpS COME TO CONTROL ONE ANOTHER WITH A NUMBER OF TECHNIQUES. WHEN AN INDIVIDUAL BEHAVES IN A FASHION ACCEpTABLE TO THE GROUp, HE RECEIVES ADMIRATION,

FONT 5

peopLe Living ToGeTHer in groups come To conTroL one anoTHer wiTH a numBer oF TecHniQues. wHen an inDiviDuaL BeHaves in a FasHion accepTaBLe To THe group, He receives

FONT 6

pEOplE lIVINg togethER IN gROUPS COME to CONtROl ONE ANOther with A NUMbER of tECHNIQUES. whEN AN INdIvIdUAL bEHAVES IN A fAShION ACCEptAblE to thE gROUp, hE RECEIVES AdMIRAtION, Word shape is not a useful source of information in regular uppercase text since the skilled reader does not have the extra benefit of the ascenders and descenders of the lowercase letters, although the length of the word may provide some details. Uppercase text does provide properties such as the roundness of C and O or the squareness of N and I (Coltheart & Freeman, 1974; Smith, 1969; Wheeler, 1970), but these properties do not influence the general shape of the word (word envelope) as defined by the ascenders and descenders. Rudnicky and Kolers (1984) suggested that the skilled reader applies a different set of well practiced strategies with normal uppercase text, but since these do not include the benefit of word shape, reading speed may be slower than with regular lowercase text.

Font 3 (alternating case) could be considered a deviation from regular text and provided word shape that was unusual. The reader was confronted with both lower and uppercase letters in each word and therefore word shape was totally unfamiliar. For this manipulation, "it is assumed that fluent reprocessing involves recruitment of relevant procedures that have been applied to similar stimuli in the past" (Masson, in press, p. 9). We also assumed that "positive transfer occurs in relation to the similarity of procedures that two tasks exercise" (Kolers & Roediger, 1984, p. 435). The two tasks in this case were past practice at reading lower and uppercase texts and the current task of reading alternating case text. It is further assumed that "differential transfer after mastery of a task can be used to identify the components" (Kolers & Roediger, 1984, p. 444). We propose that the skilled reader has indeed mastered reading regular lower and uppercase text, and thus the speed of reading this deviant font will reflect the interaction of originally practiced procedures with the skills that have been recruited for processing this new text. The search for these relevant procedures may be automatic and go forward without awareness and the re-application of these operations to the current stimulus can also proceed automatically (Masson, in press). Thus, the reading fluency of this font could be considered in relation to the similarity of the procedures that the two tasks exercise. Our aim was to attempt to discern or tease apart these recruited procedures.

In Font 3 there was a mix of lower and uppercase letters and the word shape could be considered unfamiliar to the skilled reader. Since the uppercase letters are as tall as the ascenders of the lowercase letters, any shape information provided by the ascenders was not very discriminable. Also, some of the shape information is provided by the uppercase letters which is unusual for the reader who usually receives this information from the ascenders and descenders of the lowercase letters. Thus, this font did not provide the same shape cues as were available with regular lowercase or uppercase text (Font 1 and 2, respectively). Thus, we considered Font 3 as most problematic for the reader and it should result in the slowest reading speeds.

Consequently, we suggest the fastest reading speed will occur for Font 1 (Rudnicky & Kolers, 1984; Tinker, 1963). This typography provided the reader with a regular word shape as well as very familiar lowercase letters. The reader could indeed make use of the well practiced shape-sensing skill in reading regular lowercase text. Similarly, with Font 2 we expect unhindered processing (no interference). However, we predict slower speeds than Font 1 due to the lack of word shape information as provided by the ascenders and descenders (Rudnicky & Kolers, 1984; Tinker, 1963). However, with Font 3 we expect significantly slower speeds than either Font 1 or 2 since word shape was unfamiliar and there was a presence of both lower and uppercase letters (Coltheart & Freeman, 1974; Rudnicky & Kolers, 1984; Smith, 1969; Smith et al., 1969). Consequently, the reader may process this text more slowly because the regular word shape-sensing skill creates interference in the word identification process.

More efficient processing of lowercase text is also supported by McClelland's (1977) hypothesis since the shape of the lowercase letters would enable the reader to extract information relevant to the possible letters for each position and pass the information forward to the word identification process. Uppercase letters do not have as much information to pass forward. A similar benefit for lowercase text is suggested by Coltheart and Freeman (1974) who proposed that processing of lowercase text involves identification of multiletter features (Wheeler, 1970) such as word shape. These multiletter features would allow additional details to be extracted from the various letter combinations. Uppercase text does not afford the reader the opportunity to extract any information from additional features (ascenders and descenders) since none is provided by the various combinations of uppercase letters. This text only provides specific letter information, such as the roundness of CO or the squareness of NI.

However, we would not expect a difference between regular lowercase and uppercase text according to Smith (1969; Smith et al., 1969). He suggests that groups of letters and words are identified on the basis of distinctive features which help to reduce the number of alternatives. Although this is very similar to the views of Coltheart and Freeman (1974) and McClelland (1977), it differs in that Smith further suggests that the sets of features can be considered equivalent "when more than one feature pattern represents a single letter or word" (Smith et al., 1969, p. 248). Accordingly, "alphabetic or typographic code" (Smith, 1969, p. 261) is not of importance and it is not necessary that all feature combinations are discriminable. If we consider lower and uppercase letters as functionally equivalent and alphabetic code not of importance, Smith's view would suggest that there should be no difference in reading speeds of lower and uppercase texts.

With Font 3 slower processing is supported by the findings of Rudnicky and Kolers (1984, Experiment 1) who reported a deleterious effect of case alternation on reading speed and it is also consistent with the findings of Coltheart and Freeman (1974) who reported slower identification speeds for tachistoscopically presented alternating case words when compared to regular lower and uppercase. The preliminary letter analysis view of McClelland (1977) also suggests slower processing speeds for Font 3 since the height of the uppercase letters inhibits the extraction of letter feature information from the lowercase letters. Similarly, this prediction is also in agreement with Smith (1969) and Smith et al. (1969) who found that mixing upper and lowercase was disruptive when capital letters were as tall as the ascenders of the lowercase letters. Thus, finding slower processing for Font 3 leaves open the possibility of processing influence due to word shape (Rudnicky & Kolers, 1984), multiletter features (Coltheart & Freeman, 1974), as well as the consideration that shape information extracted from lowercase letters enables the reader to reduce the number of possible alternatives of letters for each position (McClelland, 1977) or feature discriminability (Smith, 1969).

Fonts 4 through 6 preserved regular word shape but attempted to assess the influence of case in maintaining this shape. Since these three fonts all preserved regular word shape but the defining of this shape could be considered irregular, we would expect all reading speeds to lie somewhere between Font 1 (regular lowercase) and Font 3 (alternating case). Font 4 maintained regular word shape but utilized only uppercase letters in maintaining this shape. Thus, the shape of the word was familiar but the combinations of the components which created this shape (the uppercase letters) were not. With Font 4 we predict similar reading speeds as Font 1 (regular lowercase) and possibly faster speed than Font 2 (regular uppercase) if the regular word shape allows for the application of the shape-sensing skill (Rudnicky & Kolers, 1984). Speeds similar to regular lowercase could indicate the influence of word shape and utilization of the shape-sensing skill regardless of the fact that this shape is maintained by uppercase letters. Alternatively, reading speeds equivalent to Font 2 could be an indication that the reader ignores the regular word shape and processes Font 4 as regular uppercase text due to the uppercase letters. Finally, we could expect interference and slower speeds with Font 4 in comparison to Fonts 1 or 2 if the presence of uppercase letters evokes strategies normally applied to regular uppercase text (Rudnicky & Kolers, 1984) and there is an attempt to apply these strategies to words with regular lowercase shape. Rudnicky and Kolers (1984) suggested that reading text in lowercase letters may result in an automatic application of the shape-sensing skill, whereas reading in uppercase evoked different strategies. The question of interest is whether the reader was influenced by the regular word shape despite the fact that the shape was maintained by uppercase letters or if the presence of uppercase letters created interference by activating strategies applied to normal uppercase which now are ineffectual due to the presence of lowercase word shape. We would however predict faster speeds for Font 4 than Font 3 since word shape was very familiar to the reader when compared to the deviant shape of Font 3. Similarly, Font 4 utilized only uppercase letters whereas Font 3 contained mixed case and this should be of benefit for Font 4, unless the presence of the uppercase letters combined with regular word shape result in unexpected interference.

Font 5 was similar to Font 4 in that it maintained regular word shape, but this font introduced mixed case. Letters that in normal lowercase text provided shape by the ascenders and descenders were in uppercase, whereas the small lowercase letters remained in lowercase. In this font regular word shape was again maintained by uppercase letters (as in Font 4) but there was the added presence of lowercase letters. Our interest is in the presence of the lowercase letters in the non-shape defining positions and their influence on utilization of the shape-sensing skill. Reading speeds should be equivalent to Font 1 (regular lowercase) if there is no interference from either the shape defining uppercase letters or the small lowercase letters. If word shape is of benefit, then processing should be faster than Font 2 (regular uppercase) which lacked word shape features (as defined by the ascenders and descenders). We also predict faster processing for Font 5 than Font 3 (alternating case) because, although both fonts utilized mixed case, Font 5 provided regular word shape whereas Font 3 presented the reader with an unfamiliar shape.

It is also of interest to compare Font 5 with Font 4. Both fonts provided regular word shape with uppercase letters but Font 5 introduced mixed case. It is possible that the presence of the lowercase letters could strengthen the application of the shape-sensing skill which is normally applied to text of regular lowercase and reading speeds may become faster than Font 4. However, it is also possible that the presence of these lowercase letters create added interference. It may be that once the reader is exposed to the lowercase letters he will expect to see these lowercase letters in the normal shape defining positions. The appearance of the uppercase letters may then indeed become detrimental to the utilization of the shape sensing skill and this could result in slower speeds than Font 4.

In Font 6, regular word shape was maintained by lowercase letters, but the regular small lowercase letters were in uppercase. Thus, this font was in some sense a reversal of Font 5 in that in Font 6 word shape was defined by lowercase letters as opposed to uppercase letters in Font 5. If lowercase letters in shape defining positions are critical, then the reading speeds for this font should be faster than those for Fonts 4 and 5 in which shape was defined by uppercase letters. This font was also very similar to Font 1 (regular lowercase) except it utilized uppercase letters instead of regular small lowercase letters. Unless there is some interference from these uppercase letters we would predict reading speeds very similar to Font 1. Speeds should also be faster that Font 2 (regular uppercase) if the reader could make use of regular word shape skills. Similarly, we would expect a significantly faster speed than Font 3 which did not provide the benefit of regular word shape although it did contain the burden of mixed case.

We suggest that if regular word shape is indeed relevant in the reading process, Font 3 (irregular word shape) should be processed more slowly than any of Fonts 4, 5 or 6, since these three typographies all maintained regular word shape. Thus, if letter case is not of importance, we would expect the speeds of Fonts 4, 5 and 6 to be equivalent to Font 1 and consequently, illustrate a trend toward faster processing than Font 2. However, if reading of any of these three fonts is slower than Font 3, then it is possible that the relative influence of the various fonts is determined by mixed vs unmixed case (Fonts 5 and 6 vs Font 4) as well as the letters in the shape defining positions (uppercase letters in Fonts 4 and 5; lowercase letters in Font 6).

A number of researchers have proposed theoretical explanations which may account for the possible processing differences of Fonts 4 through 6. Coltheart and Freeman (1974) suggested that word identification moves forward by the identification of digram properties of uppercase letters (the roundness of CO or squareness of NI) as well as multiletter visual features, such as word shape, in the case of lowercase text. Destruction of this word shape produces processing decrements. If the additional multiletter information can be extracted from the regular word shape despite the fact that these features are provided by the roundness and squareness of uppercase letters, then these researchers would not predict differences in reading speeds of Fonts 4, 5 and 6. Their point of view would suggest speeds very similar to Font 1 (regular lowercase) and somewhat faster than Font 2. Accordingly, processing of Fonts 4, 5 and 6 should be definitely faster than Font 3 which provided no regular word shape.

However, McClelland (1977) proposed that processing is dependent on extracting information from word shape which is based on previous experiences with regular lowercase letters. This would suggest slower reading speeds for Fonts 4 and 5 when compared with Font 1 since the shape was defined by uppercase letters and the reader has no experience in extracting information about word shape from these letters (except from letters appearing at the beginning of a sentence). However, it also suggests that the speed of Font 6 could be comparable with Font 1 since in both of these typographies word shape was defined by lowercase letters and the reader may be able to extract the necessary shape information from these regular shape defining stimuli. Further, it would be reasonable to suggest that McClelland's preliminary letter analysis predicts faster speeds for Fonts 4 through 6 than Font 3, since in this font there was an absence of regular word shape from which to extract any preliminary letter identification information.

Smith's (1969) view of distinctive features would predict relatively fast (similar to Fonts 1 and 2) reading speeds with Fonts 4 through 6 since we could assume that "sufficient criterial combinations are discriminable in different parts of the word" (p. 261) and it is not important in what alphabetic or typographic code the features are presented. He defined these distinctive features as properties of letters or groups of letters (including words) "the discrimination of which reduces the set of alternatives that the total configuration or letter, might be" (Smith et al., 1969, p. 248). He further suggested that a criterial set of these features could be considered as "any minimum combination of features sufficient to determine uniquely a particular letter or word" (p. 248). Similarly, Smith et al. (1969) proposed that lower and uppercase letters can be treated as equivalent even when more than one feature pattern represents a single letter or word, as long as their discriminability is not hindered. Consequently, we can suggest that Fonts 4 through 6 would be viewed as similar to Font 1 because all three fonts contained letter combinations that are distinct and case (alphabetic code) is not relevant. Smith's view also suggests that Fonts 4 through 6 should be processed significantly faster than Font 3 because in Font 3 the criterial combinations were not discriminable in the word (due to the absence of regular word shape) and consequently the reader is unable to reduce the possible set of alternatives.

Thus, Fonts 1 through 6 manipulated word shape with the utilization of lower and uppercase letters. Results should show slower reading speeds as word shape (as defined by the ascenders and descenders of lowercase letters) deteriorates (Coltheart & Freeman, 1974; Monk & Hulme, 1983; Rudnicky & Kolers, 1984). We consider the importance of the presence as well as the position of the lowercase letters with reference to word shape and suggest that altering the letter case at shape defining positions may well influence speed of processing. We concur with the views of Rudnicky and Kolers (1984) who suggest that cues afforded by the ascenders and descenders of the lowercase letters may activate a facilitative shape-sensing skill. However, these researchers did not consider the effect of manipulating the case of letters within the regular word shape. Coltheart and Freeman (1974) suggest that word identification is dependent on the extraction of visual features from uppercase letters with additional multiletter features available from lowercase letter combinations. However, these researchers do not specify if the multiletter features of upper and lowercase letters can be considered equivalent when combined with regular lowercase word shape. However, the preliminary letter analysis view would suggest that altering the positions of the lower and uppercase letters should reduce reading speed since information is extracted from the lowercase letters in shape defining positions (McClelland, 1977). However, if only distinctive features of letters and their discriminability are significant, processing should not be influenced by a change in the positions of the lower and uppercase letters (Smith, 1969; Smith et al., 1969).

Method

Subjects. Twelve undergraduate volunteers from Wilfrid Laurier University were tested individually. Three subjects were replaced from the original twelve. One subject was replaced because the mean reading speed for all six fonts was more than three standard deviations (s.d.=16.91 s) above the average for the whole group (mean=103.10 s). The other two subjects who were replaced did not meet the required criterion (see Scoring).

Materials and Design. Six fonts were constructed utilizing both case and size of letters to manipulate word shape. Courier-type print was chosen and all fonts (with the exception of Font 2, regular uppercase) retained a 10:13-pt ratio (see Figure 1). The 10:13-pt ratio was selected since the more common 9:12-pt type resulted in variable density of print in some manipulations in which word shape was defined by uppercase letters.

Fonts 1 and 2 were in regular lowercase (10:13-pt ratio) and uppercase letters (13-pt), respectively (including the first letters of sentences). Font 3 resulted in a unique word shape with alternating lower and uppercase letters (13-pt) and each text began randomly with either a lower or uppercase letter. Fonts 4 through 6 preserved regular word shape. Font 4 used uppercase letters only and regular word shape was maintained by utilizing a 13-pt size for all letters that normally have ascenders or descenders when printed in lowercase and letters that normally have descenders were *dropped.* A 10-pt size was utilized for the smaller letters. Font 5 again maintained regular word shape by utilizing 13-pt uppercase letters for letters that normally have ascenders or descenders, but all other letters were in lowercase (10-pt). Font 6 was the reversal of Font 5 in that regular word shape was maintained by lowercase letters and the smaller letters were in uppercase (10-pt).

Six different passages were chosen from introductory psychology text books. Care was taken to select different subject matter (e.g., health, language acquisition, aggression, etc.) and still maintain a reasonably even degree of difficulty.[3] All passages were approximately 350 words in length. Text that normally required capital letters was avoided (e.g., proper names, places, etc.; see Appendix A). All of the six passages were printed in each of the six fonts on 8.5 in. x 11 in. white paper. Each passage was double spaced with an indentation at the beginning of the paragraph. The six passages were arranged according to a Latin square (Wagenaar, 1969), combining text and font (see Appendix E). Each paragraph appeared equally often (twice) with each font over the course of the experiment. One subject was assigned to each row of the squares. Thus, we utilized a within-subjects design with one factor (fonts) at six levels. The dependent variable was reading speed measured to the nearest second.

3. This degree of difficulty was assessed in a pilot study by presenting 24 subjects with 12 different passages (all containing different subject matter and each being approximately 350 words in length) and a set of ten YES/NO type questions based on the previous passage. Selection of the 6 passages for our experiment was dependent on silent reading speeds within 2 minutes for each passage as well as a score of at least 7 out of 10 on the question test.

Scoring. Silent reading creates problems of measurement. In order to insure that passages were actually read, a word recognition test was given (see Appendix C). The reader was presented with 30 words and asked to circle the ten words that appeared in the previous passage. Ten of the words (each 4 to 10 letters in length and appearing only once in any passage) were from the previous passage whereas the other 20 were distractors. All distractor words were 4 to 10 letters in length, of the same frequency as the 10 target words, and did not appear in any previous passage.

Subjects were required to meet the criterion of at least five out of ten correctly identified words on each of the word identification tests. The mean number of correctly identified words for the recognition tests was 7.3 words.

Procedure. To establish reading competence as well as to afford a practice session, each subject silently read a lowercase practice passage of about 350 words taken from one of the same sources as the experimental passages. This was followed by the word recognition test. Each subject was required to complete the reading task in less than two minutes (cf. Rudnicky & Kolers, 1984) or they were excused from the experiment.

Following the practice text, subjects were encouraged to take a comfortable reading position and asked to indicate verbally or with a tap on the table when they were ready to start and when they finished reading each paragraph. They were asked to read each text as quickly as possible while still gaining an understanding of what was read. Each subject was also informed that each paragraph would be followed by the word recognition test. This test was completed at the subjects' own speed, after which the reading of the next text commenced. When all six texts and recognition tests were completed, subjects were debriefed and thanked for their participation.

Results

The criterion for statistical significance was established as an alpha level of .05 for all experiments.

Our experiment utilized a 6 x 6 Latin square design with paragraphs (rows) and subjects (columns) as our two nuisance variables. The critical independent variable was fonts. Our original intent was to utilize a Graeco Latin square and thereby allow us to assess the influence of the order of paragraphs. However, a Graeco Latin square consists of two superimposed orthogonal Latin squares and no orthogonal pair of 6 x 6 Latin square exists (Fisher & Yates, 1934, cited in Kirk, 1982). Consequently, we chose two 6 x 6 Latin squares for our design, with paragraphs and fonts as within subjects variables. With the Latin square design we assume that the nuisance variables (paragraphs and subjects) do not interact with the variable of interest (font), and also do not interact themselves.

Table 1

Experiment 1: Mean reading times and standard deviations (in seconds) as a function of font

	Means	Standard Deviations
Font 1	95.42	16.13
Font 2	105.83	17.04
Font 3	106.17	13.16
Font 4	106.17	23.95
Font 5	106.83	13.71
Font 6	98.75	15.23

LSD=6.72

Analysis of reading times revealed a significant effect of font, $F(5,50)=4.23$, $MS_e=283.49$, as well as significant effects of subjects, $F(11,50)=19.56$, $MS_e=1311.78$, and paragraphs, $F(5,50)=3.30$, $MS_e=221.36$. A comparison of the two Latin squares revealed no significant difference, $F(1,10)=1.41$, $MS_e=1780.06$. The data are presented in Table 1.

A Fisher's test (LSD=6.72) indicated that the reading times (RTs) for Fonts 1 and 6 did not diffe- ᵇᵘt both were significantly faster than Fonts 2 through 5. The RTs for Fonts 2 through 5 did not ıffer.

We suggested that Fonts 1 and 3 define the limits of word shape as manipulated by letter case. Font 1 utilized regular lowercase text, and did indeed produce the fastest RT (95.42 s). However, although the RT of Font 3 (alternating case, irregular word shape) slowed significantly (106.17 s) when compared with Font 1, it was not reliably different from Font 2 (regular uppercase, 105.83 s). Font 2 (regular uppercase) was also significantly slower than Font 1 (regular lowercase).

Fonts 4 through 6 all retained regular word shape, but in Fonts 4 and 5 this shape was maintained by uppercase letters, whereas in Font 6, shape was defined by lowercase letters. With Fonts 4 through 6 we had predicted processing speeds similar to regular lowercase if word shape was of importance and the case of shape defining letters was inconsequential. However, we suggested slower speeds than regular lowercase if the case of the shape defining letters was influential. Results indicated that the RT for both Fonts 4 and 5 (106.17 and 106.83 s, respectively) was significantly slower than for Font 1 (regular lowercase). However, a most interesting finding emerged with Font 6. We can consider Font 6 as a reversal of Font 5 in that both fonts contain mixed case, but the shape defining letters were changed from uppercase (in Font 5) to lowercase (in Font 6). This change of lettercase resulted in a significant decrease in RT of Font 6 (98.75 s) when compared with Fonts 4 and 5. In fact, the RT of Font 6 is not significantly different from Font 1 (regular lowercase).

Discussion

We assumed that reading regular lowercase text (Font 1) is a well practiced skill for all our subjects. We also suggested that this skill can be considered as a strong process that has become automatic and is difficult to alter (Shiffrin & Schneider, 1977). We followed the suggestions of Reason (1979) that a stronger process may override a weaker sequence, especially if the two processes share component stages. Our concern is with the strategies utilized by a skilled reader when the strong operations of reading normal text are confronted with unusual typographies that share components of the original skill. Our specific interest is the influence of word shape and letter case in these processes.

We considered Fonts 1 through 3 as defining the limits of word shape as manipulated by letter case. We expected Font 1 (regular lowercase) to be processed most quickly since it is a well practiced skill providing the reader with regular word shape information via the ascenders and descenders of the lowercase letters (Rudnicky & Kolers, 1984). Although Font 2 (regular uppercase) is also a familiar typography, it does not afford word shape information (as defined by the ascenders and descenders of lowercase letters) and consequently we predicted slower processing than regular lowercase. We predicted the slowest processing speed for Font 3 (alternating case). This font was considered unusual for the skilled reader, providing the reader with deviant word shape and a mix of lower and uppercase letters with the uppercase letters being as tall as the ascenders of the lowercase letters. In our experiment, Font 1 was processed most quickly (95.42 s) and significantly faster than Font 2 (105.83 s) and Font 3 (106.17 s). However, there was no significant difference between Fonts 2 and 3.

In previous research, reading speed for regular lowercase text has been numerically faster than for regular uppercase (Coltheart & Freeman, 1974; Rudnicky & Kolers, 1984; Smith, 1969; Smith et al., 1969), and a reliable difference has been reported by Tinker (1963) as well as Levy and

Kirsner (1989). Further, reading speed for alternating case text (when the uppercase letters are as tall as the ascenders of the lowercase letters) has usually been reliably slower than for regular uppercase (Rudnicky & Kolers, 1984; Smith, 1969; Smith et al., 1969). For example, Smith (1969) found no significant difference between regular lower and uppercase, but reported a reliable difference between these two fonts and alternating case (when the uppercase letters were as tall as the ascenders of the lowercase letters). However, meaningful comparisons are difficult since in Smith's study subjects read aloud (which may result in a floor effect since the reader has to articulate the words [cf. Rudnicky & Kolers, 1984]), and the author provides little information about the 150 word passages. Also, Coltheart and Freeman (1974) reported a nonsignificant trend for faster processing for lowercase than uppercase, but significantly faster speeds for both typographies relative to alternating case. However, their task (identification of tachistoscopically-presented words) was markedly different from the task given to the subjects in the present study.

Rudnicky and Kolers (1984) suggested that a skilled reader may apply a different set of well practiced strategies with uppercase than lowercase text, and since uppercase text does not include the benefit of word shape, the reading speed of uppercase typography may indeed be slower. In our experiment the RT of regular uppercase (Font 2) was significantly slower than regular lowercase (Font 1) but it did not differ from that of Font 3 (alternating case). Yet, our experiment was very similar in design to that of Rudnicky and Kolers (1984, Experiment 1). Both studies required undergraduates to read silently meaningful paragraphs of approximately 300 (Rudnicky & Kolers, 1984) or 350 (our experiment) words. Rudnicky and Kolers instructed subjects to read for speed and comprehension and we asked subjects to read as quickly as possible but yet understand what was read. However, these researchers found only marginally slower speeds (nonsignificant) for regular uppercase text when compared with regular lowercase text. While it is possible, based on the results of previous studies, that the reliable difference in reading speed betweeen regular lowercase and uppercase found here may not be replicable, it may be that some experimental features of the present study contributed to this finding. Since this study is most comparable to that reported by Rudnicky and Kolers (1984), we will consider some of the differences between their research and the present study in order to determine if the contrasting findings may be explicable.

In Experiment 1 Rudnicky and Kolers (1984) reported that the reading speed of lowercase and uppercase paragraphs (approximately 300 words) was 56.07 and 56.93 s, respectively. This translates into speeds of 5.357 and 5.263 words per second, respectively. This is indeed a marginal difference. In our Experiment 1 the paragraphs (approximately 350 words) yielded reading speeds of 95.42 and 105.83 s for lowercase and uppercase typographies, respectively. These translate into 3.668 and 3.307 words per second for the lowercase and uppercase texts, respectively. Intuitively it seems reasonable to suggest that one factor which may have contributed to the slower processing of our texts may be the difficulty of the context. Although all paragraphs in our experiment were chosen from introductory psychology text books (as were those used by Rudnicky & Kolers), all texts could be considered somewhat heavy reading which may have demanded considerable amounts of processing time in comparison to easier texts. Consequently, we must consider the influence of processing speed (possibly as a result of difficult context) as a possible basis for the inconsistencies in lowercase, uppercase and alternating case typographies between our study and that of Rudnicky and Kolers (1984).

Some support for this hypothesis comes from a recent study by Levy and Kirsner (1989, Experiment 2) in which a significant difference was reported between lowercase and uppercase typographies. These researchers required subjects to read meaningful paragraphs of approximately 525 words. They found a significant difference between processing uppercase and lowercase text when subjects were asked to read and remember the wording of the text (silent reading is implied but not clearly indicated). In fact, in this study the processing speeds were 3.341 and 3.110 words per second for lower and uppercase, respectively. These speeds are indeed very similar to those of the equivalent fonts in our study, 3.668 and 3.307 words per second, respectively. Levy and Kirsner (1989, Experiment 2) clearly illustrated that the effects of word shape can indeed be very evident in a text-level indirect measure (reading speed). However, we are again left with the problem of equating the contexts in our study and the research of Levy and Kirsner. Yet, it is feasible to entertain the possibility that as speed of contextual information processing decreases, possibly due to difficulty of the material, the influence of perceptual processing may become increasingly evident on the reading time measure. We suggest that stimulus analysis seems to be altered by contextual constraints (Levy, 1981), although further research is needed here in order to directly assess this hypothesis.

Early evidence in support of significantly slower processing of uppercase text in comparison with regular lowercase typography was reported by Tinker (1963). Studies by Starch (1914, cited in Tinker, 1963) illustrated that text in lowercase was read 10% faster than similar material in uppercase letters. Similarly, Tinker (1963) reported a study in which 60 college students read material in lower and uppercase texts for four successive 5-minute periods. Reading speeds were measured and all differences were statistically significant and in favor of the lowercase. Tinker (1963) concluded "that all capital printing retards speed of reading to a striking degree, and that most readers consider lowercase print faster and easier to read than all capitals" (p. 58). However, it is difficult to compare these earlier studies with our experiment since Tinker (1963) does not describe the materials utilized to obtain these results.

In the preceeding discussion we have suggested some possibilities for the unusually slow speed of regular uppercase in comparison with regular lowercase typography. We proposed that these findings may have been influenced by processing speeds. However, there was also another difference between our research and that of Rudnicky and Kolers (1984). This was the test given after processing each paragraph. Rudnicky and Kolers utilized a set of YES/NO questions based on information from the previous text, whereas our experiment utilized a word recognition test. Thus, the reading strategies of the subjects in each of the experiments may have been different due to the influence of the test demands. Task demands as well as the subjects' goals can result in differential emphasis on the perceptual features during processing (Tardif & Craik, 1989).

Evidence of the influence of instruction on processing is not clear. For example Horton (1989) had subjects read sentences in various orientations (inverted, reversed and combined). One group of subjects was given no information about a recognition test (for orientation) which was to follow, whereas a second group was instructed that they would receive the test. However, the main emphasis for both groups was on the speed and accuracy of the reading task. Results indicated that instruction had no effect on reading speed. However, Levy and Kirsner (1989, Experiment 2) clearly showed that subjects were influenced by instructions given for initial reading of the paragraphs. Subjects were asked to read texts of approximately 525 words in lowercase type, uppercase type and handwritten script. One group was instructed to read for meaning and the other was asked to read to memorize the wording. Yet, both groups were told that reading speed was being measured. Results indicated that the subjects were indeed sensitive to instructions. The reading times were significantly longer for subjects who were asked to read for wording than for those asked to read for meaning. For the purpose of our experiment, the interesting finding was that for the meaning group the initial reading times were equivalent for the three typographies, lowercase (3.695 words per second), uppercase (3.726 words per second) and script (3.732 words per second) (no alternating case was used). However for the wording group, the reading speeds between lower (3.341 words per second) and uppercase (3.100 words per second) were significantly different. There was also a significant difference between lowercase and script

(3.017 words per second), but no significant difference between uppercase and script.

These findings would seem to suggest that the reader of meaningful paragraphs is indeed sensitive to instructions and may possibly employ different strategies relative to the demands of the task (Kolers & Roediger, 1984). In our experiment we may have inadvertently influenced the reading speed task with the demand of the word recognition test. The subjects in the Rudnicky and Kolers experiment received the YES/NO test based on the meaning of the previous paragraph, and processing may have been similar to the group that read for meaning in the Levy and Kirsner study. In our study, the subjects may have utilized strategies similar to the group that read for wording in the Levy and Kirsner study since they knew that they would be presented with the word recognition test. Consequently, it seems reasonable to suggest that the effect of the font manipulations in our research may indeed be influenced by the test-relevant strategies adopted by our subjects compared to those utilized by the subjects of the Rudnicky and Kolers research.

Relevant to this discussion are the results of a pilot study which was conducted in order to determine whether the type of test had an effect on reading speeds. The design and materials were as in Experiment 1, except one group of subjects (six undergraduate volunteers) received a set of YES/NO questions (similar to the Rudnicky & Kolers test) while the other group (six undergraduate volunteers) received the word recognition test used in the present experiment. Results indicated no reliable effect of type of test on reading speed. Consequently, our pilot data suggested that the type of test was not a significant factor when used with paragraphs that demand considerable contextual processing. These results conflict with the findings of Levy and Kirsner (1989) if we assume that their paragraphs were of equivalent contextual difficulty to ours. Their research indicated an effect of instruction on perceptual processing in the wording condition. We should note however that in the Levy and Kirsner study subjects were told to read for meaning, to recall the main ideas or to read for wording in order to fill in words that had been deleted from the text. Following the rereading of each passage a test appropriate for the instructions was given in order to reinforce the instruction manipulation. In our study the subjects were instructed to read as quickly as possible while still understanding what they read and were then given the word recognition test. Thus, we instructed our subjects to read for meaning and speed, but tested them with word recognition. Our intent was to measure reading speed and the purpose of our test was to assure reading of paragraphs and not to reinforce instruction. Yet this procedure resulted in a nonsignificant effect of test.

However, an interesting finding emerged when we examined the speeds of Fonts 1 and 2 in our pilot study. The group that received the YES/NO meaning test yielded RTs of 101.5 and 105.33 s for the lowercase and uppercase, respectively. However, with the word recognition test group the mean speeds were 93.5 and 102.2 s for the lowercase and uppercase, respectively. While the interaction of type of test and font was not reliable, a Fisher's LSD test (LSD=6.52) revealed that the reading speeds for lower and uppercase typographies in the meaning test condition were not significantly different, whereas in the word recognition test condition there was indeed a significant difference between these two typographies. Consequently, it would seem that our conclusions from the pilot data were premature and we may suggest that instructions about the type of test can indeed influence the processing of perceptual features (as in Levy & Kirsner, 1989).

However, if we suggest that in our experiment the processing of regular uppercase (Font 2) was indeed legitimately slow (possibly due to contextual constraints), we also have to consider the relatively fast reading of the alternating case typography (Font 3). One possibility is that again, for some unknown reason, the processing speed of this typography is just not replicable. Since this typography provides the reader with a deviant word shape and a mix of letter case, it would seem reasonable to expect that speeds should be significantly slower than with the more familiar regular uppercase text. Indeed, past research has indicated a significant difference between the two typographies (Coltheart & Freeman, 1974; Rudnicky & Kolers, 1984; Smith, 1969; Smith et al., 1969). However, we should also consider the possibility that the reading speed of Font 3 in our experiment may indeed have been accurate. It may be that the processing of Font 3 reached some sort of floor effect. Font 3 utilized regular lower and uppercase letters that were indeed familiar to the reader and although the word shape was unusual, this type of text alteration may have some sort of limit as to the amount of interference that can be produced. Contextual difficulty may indeed have slowed the RTs sufficiently so as to subdue the influence of irregular word shape and, consequently, there may be a level below which the reading speed of a skilled reader will not drop, at least within the constraints of the present methodology.

Again, we can not rule out the possible effect of type of test with Font 3. If we examine our pilot data, we find that with the word recognition test, subjects had a mean processing speed of 100.83 s for the alternating case. This speed indicates a slightly faster trend than regular uppercase (102.2 s), but is significantly slower than regular lowercase (93.5 s). However, with the YES/NO meaning test results indicated a processing speed of 118.2 s for the alternating typography. This speed is significantly slower than either regular lower (101.50 s) or uppercase (105.33 s) in this condition. Consequently, we again suggest an interaction of type of test and processing of perceptual features, but propose that the nature of this interaction may be sensitive to the influences of several factors. The present research was not designed in such a way as to isolate these variables.

In summary, the processing of Fonts 1 through 3 defined the limits of our word shape manipulation. Results suggested a reliable influence of these perceptual features in the processing of meaningful text. However, we also noted significant differences in the results of our experiment and those of previous research. We raised questions concerning the influence of processing speed (possibly due to contextual constraints) as well as the effect of instruction and awareness of type of test. Consequently, any relevant interpretations and generalization must be cognizant of the limitations of our experimental conditions.

A similar caution is applicable when relating our data to theoretical models. At a theoretical level the RTs of Fonts 1 through 3 are compatible with the views of McClelland (1977) and the preliminary letter analysis hypothesis. Font 1 (regular lowercase) would provide the opportunity for the reader to extract information from the ascenders and descenders of the lowercase letters (word shape) and thereby facilitate the speed of the word identification process. Font 2 does not afford any word shape information from ascenders or descenders. Consequently, some decrease in reading speed is expected for the uppercase text. Since Font 3 does not provide any shape information from the ascenders (uppercase letters are as tall as ascenders), it is reasonable to suggest that the RT of Font 3 should be slower than Font 2 (regular uppercase) and Font 1 (regular lowercase). The magnitude of the difference should be at least partially dependent on the amount of information usually received from the ascenders and descenders as well as any interference due to an inability to apply this information to the alternating case typography.

A benefit for Font 1 (lowercase text) is also in agreement with the ideas of Coltheart and Freeman (1974) who proposed that the reading of lowercase text involves the utilization of additional multiletter features from the ascenders and descenders of lowercase letters. Consequently, the reading of uppercase text should not show as much facilitation since this typography does not provide additional information from these multiletter features. Similarly, there should be a retardation of RT for Font 3 (alternating case) since the height of the uppercase letters again hinders the extraction of details from the lowercase letters. However, it is not clear whether the processing of alternating case should be significantly slower than regular uppercase. This would seem to depend on the amount of facilitation from the roundness of the CO and the squareness of the NI in the uppercase typography, or the extent of interference from the deviant word shape.

However, Smith (1969; Smith et al., 1969) proposed that word identification involves minimum combinations of features (criterial sets) and it is not necessary that these feature combinations are in the same letter case, nor that they are all discernible. This suggests that the reading speeds of Fonts 1 and 2 should be equivalent. However, our results illustrated that there was indeed a significant difference between these two typographies. According to Smith's hypothesis this would imply that in Font 2 (regular uppercase) insufficient criterial combinations were recognizable although the lack of opportunity for discrimination is not obvious if the lower and uppercase letters are considered equivalent. Also, it is not evident from the Smith (1969) study what is meant by the discriminablility of sufficient feature combinations. Thus, these results also raise the possibility that all criterial sets are not functionally equivalent and letter case is indeed of importance. Smith's hypothesis does however account for the reliably slower RT of Font 3 than regular lowercase since the uppercase letters "hide" the discriminability of the lowercase letters and accordingly it is this manipulation that is critical to performance. However, our findings of nonsignificant difference between regular uppercase and alternating case are not explicable by this hypothesis.

Fonts 4 through 6 preserved regular word shape. Our aim was to assess the influence of letter case in maintaining this shape. Font 4 provided word shape that is familiar, but the components creating this shape as well as the other letters usually associated with regular shape, were all in unexpected uppercase. Font 5 was similar except that the lowercase letters were presented in the small letter positions. We predicted speeds similar to regular lowercase (Font 1) and possibly faster than regular uppercase (Font 2) if the regular word shape allows for the application of the shape-sensing skill (Rudnicky & Kolers, 1984), even though the shape is defined by uppercase letters. Results showed that the RTs of both Fonts 4 and 5 were significantly slower than that of Font 1 (regular lowercase), but were not significantly different from Font 2 (regular uppercase) or Font 3 (alternating case). This could lead us to suggest that if the regular word shape did indeed activate the shape-sensing skill, the presence of the uppercase letters may have produced interference and this interference may have been responsible for the slower processing speed than regular lowercase. Alternatively, we can suggest that the presence of these uppercase letters may have evoked strategies normally applied to regular uppercase text (Rudnicky & Kolers, 1984) but the effectiveness of these strategies was hindered by the presence of the regular word shape. However, the results of Font 5 may question this hypothesis. With Font 5, it does not seem reasonable to suggest that the strategies used to process a typography that contains regular word shape as well as some lowercase letters should be similar to those used to process regular uppercase text (although it could be argued that the presence of the uppercase letters induces reading without reference to word shape since the processing of Fonts 2 through 5 was equivalent). Consequently, it seems that Fonts 4 and 5 are processed in a very similar manner, and the presence of the lowercase letters in these small letter positions in Font 5 is inconsequential. It is also interesting to note that the processing of both Fonts 4 and 5 is very similar to Font 3, a typography that has an irregular word shape and a mix of letter case. With Font 5 it is possible to suggest that this font is treated just as typography with an uncommon word shape and mixed case--that is, word shape is just not important. However, this does not account for its similarity to Font 4 which contains only uppercase letters. Consequently, the results of Fonts 4 and 5 seem to indicate that the presence of word shape alone or word shape in combination with lowercase letters per se is not sufficient to evoke the usually beneficial shape-sensing strategies, or if activated they may be ineffective when uppercase letters are encountered. Results of Font 6 seem to indicate a consideration of both word shape and letter case in specific positions.

Font 6 was considered as a reversal of Font 5. It contained mixed case but regular word shape which was provided by lowercase letters. The RT of Font 6 was significantly faster than either Font 4 or 5 (98.75, 106.17 and 106.83 s, respectively). In fact, the speed of Font 6 was not significantly different from Font 1 (regular lowercase). Yet the only difference between Fonts 5 and 6 was the letter case of the shape defining letters. The significant differences in processing speeds between Fonts 5 and 6 seem to indicate the importance of the shape defining letters. Similarly, the lack of a significant difference between Fonts 1 and 6 points to the influence of letter case in the shape defining positions. Font 6 was also processed significantly faster than Font 2 (regular uppercase) and Font 3 (mixed case). This strongly suggests that processing of text may indeed be facilitated by regular word shape and the presence of lowercase letters in the shape defining positions.

We should also consider the theoretical explanations which may account for the processing differences among Fonts 4 through 6. Coltheart and Freeman (1974) proposed that word identification is facilitated by the digram properties (roundness and squareness of the uppercase letters) as well as the multiletter visual features (word shape) of lowercase letters. The researchers suggested that the destruction of this word shape results in processing decrements because multiletter features from the lowercase letters are not available. This hypothesis would suggest that the processing of Fonts 4 and 5 should be equal since no multiletter features from the lowercase letters are discriminable, and speeds should be slower than regular lowercase. These researchers would also predict a faster processing speed for Font 6 if enough visual feature information can be extracted from the lowercase letters in the shape defining positions, and there is no interference from the small uppercase letters. Our data support the above predictions.

Our findings are also consistent with the views of McClelland (1977) who suggested that processing is dependent on the extraction of information provided by lowercase letters that define word shape. The slower RTs of Fonts 4 and 5 are supportive of this hypothesis since word shape is provided by uppercase and not the usually experienced lowercase letters. Similarly, the faster RT for Font 6 concurs with the preliminary letter hypothesis, since word shape information is indeed provided by lowercase letters.

However, the hypothesis of Smith (1969; Smith et al., 1969) does have a problem with our findings. Smith proposed that processing is facilitated by the discriminability of sufficient criterial combinations and the case (typographic code) of these combinations is not important because they are equivalent. This would indeed suggest that Fonts 4 through 6 should have been processed with equal speed, and the processing should have been equivalent to Font 1. Fonts 4 through 6 certainly provide clearly defined feature combinations and, according to Smith, the uppercase letters providing this information are equivalent to lowercase letters. Due to the significantly faster processing speed of Font 6 in comparison with Fonts 4 and 5, we may question the hypothesis of equivalent alphabetic or typographic code.

Experiment 2

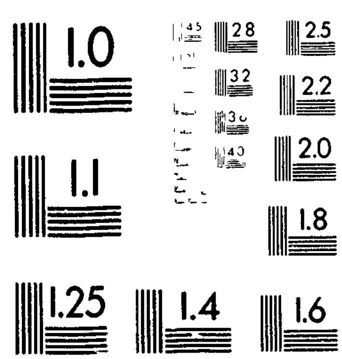
"Words, like many other objects, are seen in many aspects; in all the aspects that their reader can command in the time available--graphemic, syntactic, semantic, temporal, locative, etymological, contextual, and so on" (Kolers, 1975, p. 382). Kolers attributed the fluent reprocessing of transformed text to memory for the pattern analyzing operations directed at the perceptual features of the sentences. Horton (1985) suggested that extensive perceptual (graphemic) and semantic processing both occur in reading spatially transformed text. When both types of processing are available on a subsequent reading of the same material, though, the reader seems to rely singularly on semantic information. However, when only nonsemantic features are usable, the reader can effectively utilize these perceptual features (Horton, 1989). Tardif and Craik (1989) proposed that the effects of surface features (perceptual) and the influence of the message (conceptual) both have a role to play. Different kinds of information are encoded during initial processing (e.g., lexi[illegible] phonemic, propositional, orthographic) and changes in the materials, task demands as well as the subjects' goals can all lead to differential emphases on the various types of information (Tardif & Craik, 1989). There seems to be general agreement that performance is largely determined by the interaction of the processing at study and test (Graf & Levy, 1984; Horton, 1985; Jacoby, 1983; Masson, 1986; Tulving, 1983).

In Experiment 1 all font manipulations were presented in meaningful paragraphs and thus appeared with an abundance of contextual information. Our intent with Experiment 2 was to attempt to eliminate most of the contextual details in order to force the reader to rely more on perceptual information--specifically, word shape, as defined by lower or uppercase letters. Thus, we were attempting to alter the focus at encoding in order to increase perceptual processing by a change in the study materials from meaningful passages to isolated words. We were following the view of Kolers (1975; Kolers & Roediger, 1984) in that the skilled reader will make use of any source of information that is available and pertinent to the task. We propose that the word shape alterations that we have selected are not fixed properties of the words, but are instead a reflection of the "endowments projected onto them by the trained perceiver; hence they derive their importance largely from the occasion of usage" (Kolers, 1975, p. 382). Our attempt here is to alter the "occasion of usage" by the elimination of contextual information.

Underwood and Bargh (1982) proposed that "the recognition of words depends upon the simultaneous synthesis of information from all available sources" (p. 197) and suggested that word shape is of importance when a single word is to be recognized. However when another source of information is available, the loss of word shape information may become less important. Underwood and Bargh (1982) investigated the interaction between sources of information (context, shape and orthographic regularity) during word recognition. Subjects were presented with lowercase or uppercase target words (orthographically regular or irregular) which were preceded by an incomplete congruous or incongruous sentence or by a fixation dot. Subjects were instructed to read the target word aloud as quickly as possible. They were told that sometimes the context would help them recognize the word and sometimes it would not. Results indicated that target words were named faster when they appeared as part of a congruous sentence rather than in isolation or as part of an incongruous sentence. The interaction between congruity and case of presentation indicated that although the identification of both lower and uppercase words was facilitated by the congruous sentences, the effect was more apparent with uppercase words. Underwood and Bargh suggested that the uppercase letters resulted in "impoverished" word shape information, thus diminishing the reliance on this perceptual feature and increasing dependence on another source (context).

Similarly, Auble and Franks (1983) used an auditory presentation of easy or difficult to complete sentences to prime target words. Subjects were asked to repeat the target words masked

2 OF/DE 2



by white noise. The target words were either appropriate to the meaning of the sentence (easy or difficult) or were unrelated to the sentence. For example, a difficult sentence may have been "The breakfast was excellent because the thread was sticky" followed by the target word *web*. A relatively easy to comprehend sentence may have been "The room was cool because the windows were closed" followed by the target *air conditioning*. The task of listening through white noise was considered to be a measure of perceptual fluency which according to Jacoby and Dallas (1981) involves fast, automatic processing as opposed to more analytical, conscious processing. Auble and Franks suggested that the context effects may be due, at least partly, to top-down (conceptual) constraints. Results indicated that priming for a related target word did not occur if that sentence was difficult to comprehend. The researchers concluded that "the sentential context elicits sentence comprehension processes...and when such processes are engaged, words are no longer treated as independently understood units" (p. 404).

Jacoby (1983) proposed that an implicit memory test (perceptual identification, reading fluency) can be a reflection of data-driven processing whereas an explicit test (recognition) may reflect conceptually-driven processing. This differential processing allows for the dissociation of performance across different tests. Jacoby (1983) varied the contextual support for word processing. Target words were read in isolation, in the context of a semantic associate, or they were generated from antonyms. Results of a perceptual identification test indicated that targets generated or studied in context were less well identified than words read in isolation. Jacoby proposed that perceptual identification tapped the data-driven processes that had been used at study. In the context and generate conditions, more conceptual processing was utilized at study and less data-driven processing resulting in poorer performance on a test emphasizing data-driven processing.

However, Jacoby (in press) also suggested that "there is not a one-to-one mapping between type of retention test and the type of prior processing that is most compatible with the test" (Jacoby, in press, p. 26). When the stimulus (target) item is a nonword there is no dissociation of performance with a perceptual identification and a recognition test (Johnston, Dark, & Jacoby, 1985). Jacoby (in press) attributed this to the fact that there is no contextual information provided by nonwords and the subjects must rely exclusively on data-driven processes--there is only one type of information to tap. Accordingly, recognition memory can be dependent on the materials and other details of the situation--it can be facilitated by either conceptually-driven or data-driven processing. Jacoby further suggested that perceptual identification can also depend on either of these two kinds of processing. When study context is re-presented at test, prior conceptually-driven processing becomes influential for perceptual identification performance. However, when items are tested out of context, data-driven processing becomes most relevant. Thus, when words are initially processed in a semantic context (as in Experiment 1), less data-driven processing may be observed. Consequently, in Experiment 1, we may have tapped the effects of conceptual processing (due to availability of context) and our materials may have reduced the potential for perceptual processing effects to be observed. Oliphant (1983) also provided support for the proposal that context induced conceptual processing with less reliance on data-driven operations.

Subjects encountered target words in discourse conditions (instructions or questionnaire) or as single words. Performance on a subsequent lexical decision task indicated no reprocessing benefits to words originally encountered in the text form.

Drewnowski and Healy (1977) proposed the *unitization hypothesis*. These researchers suggested a hierarchy of processing levels and defined these levels in terms of units (e.g., letters, words, phrases). According to this hypothesis, tasks that require subjects to identify targets at a given level allow us to monitor the processing at that level (e.g., letter detection tasks allow one to monitor the processing at this level). These researchers further proposed that once a unit has been identified at a given level, the subject will proceed to the next level without necessarily completing the processing of lower level units. For example, when processing text, subjects may process in terms of phrases and not attend completely to the processing of individual words or letters per se. In our Experiment 1 it may indeed be that subjects processed some of the text at the phrase level and did not complete the processing of lower level units (words). This may reduce the influence of perceptual features, including word shape. Healy (1980) provided supporting evidence for the unitization hypothesis by illustrating that in reading normal text, subjects were able to process common words automatically in units larger than letters. However, when the formation of these larger units was disturbed, by alternating upper and lowercase type, or when misspellings were introduced, the subjects were more likely to complete the processing of the word at the letter level since they were able to detect significantly more letter errors in words.

In Experiment 2 we attempted to diminish the influence of context by asking subjects to read the font manipulations in isolated words. We hoped to induce an increased reliance on perceptual processing and consequently, an increase in dependence on word shape features. By reducing the availability of conceptual information we hope to induce subjects to depend more on data-driven processing (Jacoby, 1983; in press). An indication of data-driven processing can be considered as a reflection of the reader's dependence on perceptual details. In our experiment word shape and its defining letter case were the perceptual details of interest. Consequently, if the reader is forced to rely more exclusively on these perceptual features, the significance of their influence may indeed become more apparent even though the actual amount of data-driven processing may not necessarily have increased. Performance under these conditions may help us in identifying the role of word shape in word processing and enable us to more clearly assess the benefits as well as costs (interference) of any automatically activated shape-sensing skills. Consequently, a change in the test condition from reading text to processing unrelated words may reflect the relative influence of different processing operations. Our wish is not to separate the shell from the pearl (Kolers, 1975), but instead to expose the operational processes without destroying or changing the whole concept.

With Experiment 2 we predict a pattern of results similar to that suggested in Experiment 1 but with an increase in the magnitude of the effects of the perceptual features (word shape). We suggest that with Font 1 (regular lowercase), the reader may be able to make maximum use of the perceptual cues provided by the word shape as defined by the ascenders and descenders of the lowercase letters. However, with Font 2 (regular uppercase), the reader was faced with no word shape features from the ascenders and descenders as well as an absence of context. This should result in slower processing speeds for Font 2 when compared with Font 1. This result would be in agreement with the findings of Underwood and Bargh (1982) who reported a greater influence of incongruous sentences with uppercase words. Slower speeds for Font 2 (uppercase) would also be suggested by Drewnowski and Healy (1977) if attention is focused on word level processing since words in uppercase do not provide as much discriminating perceptual (word shape) information as lowercase words.

Font 3 did not provide any regular word shape information or context and the reader was essentially dependent on other forms of perceptual information. This should indeed slow reading speed and it may increase the influence of any interference due to an irregular word shape provided by alternating case. We would again predict slower reading speeds than in Fonts 1 and 2. Accordingly, Underwood and Bargh (1982) would also predict slower performance for Font 3 than Font 1 since they suggested than the lack of useful shape information induced the reader to rely more on contextual details as illustrated by the more influential effect of congruous sentences on uppercase words when compared with lowercase words. A similar outcome could be predicted by Jacoby (1983; in press) since the reader may rely almost exclusively on data-driven processing indicating a dependence on perceptual details. Drewnowski and Healy (1977) would also predict slower performance if the reader concentrates on word level processing since there is an absence of useful contextual information.

If the presence of the uppercase letters interfered with the attempted application of the shape-sensing procedures, then performance on Fonts 4 and 5 may again slow when compared with Font 1. Underwood and Bargh (1982) would predict slower speeds if the reader is influenced by the uppercase letters which would induce him to look for contextual help. However, speeds should be comparable with Font 1 if regular word shape allows for the utilization of word shape information. Jacoby (1983; in press) would again predict reliance on data-driven processes which would result in relatively similar speeds for Fonts 4 and 5 when compared with Font 1 if word shape strategies were applied and not hindered by the presence of the uppercase letters. Similarly, Drewnowski and Healy (1977) would predict word level processing which could be influenced by the effect of the regular word shape (faster performance) or the interference of uppercase letters (slower performance). Thus, with Fonts 4 and 5 we should consider the possibility of either an increase or decrease in the magnitude of the differences (depending on the influence of word shape and the shape defining uppercase letters) between these fonts and Font 1. Also, we predict faster processing speeds for Fonts 4 and 5 than Font 2 if the shape-sensing skill is utilized. Similarly, Fonts 4 and 5 should be processed faster than Font 3 which provided no regular word shape information. However, if regular word shape has no influence on processing then we would expect Font 4 to be equivalent to Font 2 (regular uppercase) and Font 5 possibly equal to Font 3 (mixed case, no regular word shape).

With Font 6, Underwood and Bargh (1982) would predict performance similar to Font 1 if the word shape provided enough information so the reader does not have to look for help from context. However, if the presence of the uppercase letters interferes (albeit they are not in shape defining positions), then the reader may indeed look for contextual help (as with uppercase and incongruous sentences), and since this is not available, performance should slow (relative to Font 1). Drewnowski and Healy (1977) would predict reliance on data-driven and word level processing, respectively, and performance should be relatively fast (similar to Font 1) if word shape information is utilized and there is no interference from the uppercase letters.

We would again look at the increase or decrease in reading speed with Font 6 in relation to Font 1 and 2. We predict faster processing than Font 3, because, although both fonts utilized mixed case, Font 6 provided the reader regular word shape. If the lowercase letters in the shape defining positions in Font 6 were processed in a similar manner as the uppercase letters in these positions in Fonts 4 and 5, then the processing of all three fonts should be similar. However, there is also the distinct possibility of faster speeds for Font 6 than Fonts 4 and 5, if there is an advantage of having the lowercase letters in the shape defining positions.

Method

Subjects. Twelve undergraduate volunteers from Wilfrid Laurier University were tested individually. One of the original twelve subjects was replaced because of failure to meet the criterion on the word recognition test (see Experiment 1, Scoring).

Materials and Design. Twenty target words were chosen from each of the texts in Experiment 1. They were 4-10 letters in length, ranged from frequencies of 46 to 100 words per million (Thorndike & Lorge, 1944) and no word appeared more than once in each text. These target words were printed in one straight column on the left side of the page (see Appendix D).

Each of the word-sets appeared in all of the six fonts described in Experiment 1 and were printed on 8.5 in. x 11 in. paper. Again the six word-sets were ordered according to a Latin

Square (see Appendix B). Each word-set appeared equally often with each font over the course of the experiment. We utilized a within subjects design with one factor (fonts) at six levels. The dependent variable was reading speed.

Scoring. In order to insure that the word-sets were read by the subjects, each reading of the word-set was followed by a recognition test (identical to the tests of Experiment 1). Ten words were chosen randomly from the word set and 20 distractors of the same length and frequency were added. Immediately after processing each word-set, the reader was asked to circle the ten words that they remembered from the previous word-set (Appendix C). Subjects were required to meet the same scoring criterion as in Experiment 1. The mean number of correctly identified words for the recognition tests was 7.2 words.

Procedure. Each subject was asked to process one practice word-set in normal print followed by the recognition test. The subject was then encouraged to take a comfortable reading position and asked to indicate verbally or with a tap on the table when they were ready to start and when they had finished reading each word-set. They were asked to process the material as quickly as possible while still understanding each word. Each word-set was followed by the appropriate recognition test which the subjects completed at their own speed. When all six word-sets and recognition tests were completed, the subjects were debriefed and thanked for their participation.

Results

Analysis of reading times revealed no significant effect of font, $F(5,50)=1.79$, $MS_e=52.51$. However, both the nuisance variables, paragraphs, $F(5,50)=3.86$, $MS_e=113.51$, and subjects, $F(11,50)=11.42$, $MS_e=335.95$, were significant. Performance on the two Latin squares did not differ, $F(1,10)=.11$, $MS_e=42.01$. The data appear in Table 2.

Table 2

Experiment 2: Mean reading times and standard deviations (in seconds) as a function of font

	Means	Standard Deviations
Font 1	27.17	10.58
Font 2	25.75	8.19
Font 3	27.58	5.78
Font 4	31.33	12.54
Font 5	28.75	10.77
Font 6	25.83	9.19

LSD=4.45

We had predicted a pattern of results similar to that found in Experiment 1. We hoped to diminish the influence of context and thereby induce the reader to rely more on perceptual features, most notably, word shape. However, a change in the test condition from paragraphs with meaningful content to isolated words produced some surprising results. Most notably, the influence of the fonts completely disappeared.

Keeping in mind the nonsignificant effect of font, we conducted a Fisher's LSD test (LSD=4.45). As with Experiment 1, we had predicted that Fonts 1 through 3 should define the limits of our word shape manipulation. However, the trend in reading speeds of the three fonts did not support this prediction. There were no significant differences among these three typographies according to the LSD test which would seem to imply that there are no differences between these upper and lower limits of our word shape manipulation. Consequently, neither word shape or letter case appear to be influential although the lack of a statistical difference may also be due to the influence of other undetermined factors. By contrast, in Experiment 1, Font 1 was processed significantly faster than Fonts 2 and 3.

It was our intent to compare the reading speeds of Fonts 4 through 6 with the processing speeds of the limits of the word shape manipulations of Fonts 1 through 3. However, since these latter three fonts showed no significant differences in Experiment 2, comparisons and interpretations are difficult. In Experiment 2, Font 4 (regular word shape, all uppercase) (31.33 s) was the slowest read typography. According to the LSD test, the only significant difference in this experiment was the faster processing of Fonts 2 and 6 in comparison with Font 4.

Discussion

Experiment 2 revealed no reliable effect of our font manipulation when subjects were presented with a list of 20 unrelated words. Although some previous research has illustrated a significant influence of font with manipulations of lowercase, uppercase and alternating case typography with isolated words, differences in task requirements make parallel conclusions difficult. For example, Brooks (1977) did report a significant difference in processing speed, but the task required subjects to scan silently read lists of words presented in regular lowercase or alternating case. Similarly, Coltheart and Freeman (1974) reported a significant font effect but with a tachistoscopic presentation of words in lower, upper and alternating case.

However, these earlier results leave open the possibility that Experiment 2 may simply have been insensitive to the effects of the font manipulations. This may have been due to the relatively short list of words which the subjects were required to read. In Experiment 1, subjects read paragraphs of approximately 350 words (mean RT=103.19 s), and consequently were exposed to the font manipulation for more than a minute and one half. In Experiment 2, each word set contained only 20 words (mean RT=27.74 s), resulting in an exposure time of less than half a minute. Consequently, before dismissing the possibility that font may affect reading speed with lists of unrelated words, we designed Experiment 3 as a replication of Experiment 2, but included a longer list of words. If the lack of a reliable effect of font in Experiment 2 was the result of using too few words, it is expected that these effects should appear with the longer list.

Experiment 3

Method

Subjects. Twelve undergraduate volunteers from Wilfrid Laurier University were tested individually. One of the original subjects was replaced because he did not meet the word recognition test criterion (see Experiment 3, Scoring). One other subject was replaced because reading time of all fonts was more than two standard deviations (s.d.=9.7 s) faster than the grand mean.

Materials and Design. Forty new words were added to the 20 words in each word-set used in Experiment 2. All new words again ranged from frequencies of 46 to 100 words per million (Thorndike & Lorge, 1944) and all were four to ten letters in length. Thus, the new word-set contained 60 words printed in three columns of 20 words each (see Appendix E). In all other respects the design of this experiment was identical to Experiment 2.

Scoring. Subjects were given the same word identification test (as in Experiments 1 and 2) with 10 targets and 20 distractors to insure reading of the word-set. The scoring criterion was lowered from Experiments 1 and 2 due to the difficulty of the task with 60 isolated words. All subjects were required the identify an average of 4.0 words on the combined recognition tests. The mean number of correctly identified words for the tests was 4.8 words.

Procedure. The procedure of this experiment was identical to Experiment 2.

Results

An analysis of reading times revealed a significant effect of font, $F(5,50)=2.74$, $MS_e=17.09$, as well as significant effects of the nuisance variables subjects, $F(11,50)=28.54$, $MS_e=487.82$, and paragraphs, $F(5,50)=2.73$, $MS_e=46.73$. The two Latin squares did not differ, $F(1,10)=.22$, $MS_e=524.84$. The data are shown in Table 3.

Table 3

Experiment 3: Mean reading times and standard deviations (in seconds) as a function of font

	Means	Standard Deviations
Font 1	38.67	13.07
Font 2	35.50	7.00
Font 3	40.75	11.39
Font 4	37.33	9.35
Font 5	39.42	9.64
Font 6	36.33	7.55

LSD=3.39

A Fisher's LSD test (LSD=3.39) indicated that Fonts 1 and 2 (lower and uppercase, respectively) did not differ significantly from each other, but notably, the uppercase typography revealed somewhat faster processing than lowercase typography, and the difference (3.17 s) approached significance. A similar pattern appeared in Experiment 2, but again the difference was not reliable. Font 3 (alternating case) resulted in the slowest processing speed (40.75 s) and was significantly slower than the regular uppercase text, but did not differ reliably from regular lowercase. In Experiment 2, Font 3 did not differ reliably from any other typography. Consequently, Fonts 1 through 3 did not set the limits of our word shape manipulation as expected, and surprisingly, as with Experiment 2, the regular uppercase typography revealed the fastest processing.

Since Fonts 1 through 3 did not define the limits of our word shape manipulations in the predicted manner, interpretations based on the influence of word shape and lettercase in Fonts 4 through 6 are again problematic. Both Fonts 4 (37.33 s) and 6 (36.33 s) were read reliably faster than alternating case, but neither differed from any other condition. In Experiment 2, these two fonts were not significantly different from the alternating case condition, but Font 4 was significantly slower than Font 2 (regular uppercase) and Font 6 (mixed case, word shape defined by lowercase). In Experiment 3, Font 5 (mixed case, shape defined by uppercase) (39.42 s) illustrated a significantly slower speed than regular uppercase but did not differ significantly from the other fonts, whereas in Experiment 2, Font 5 did not differ significantly from any other typography.

Discussion

The purpose of Experiment 3 was to replicate Experiment 2 using longer lists of words. We hoped to determine if the lack of a reliable effect of the font manipulation in Experiment 2 was due to the insensitivity of a short word list. Our results indicate that providing a longer word set and consequently increasing the exposure time of the test materials did indeed result in a significant effect of font. A surprising finding was the relatively fast processing of regular uppercase typography. In both this experiment and Experiment 2, uppercase was processed faster than any other typography (although not always significantly so). However, in this experiment the difference approached significance when compared with regular lowercase. By contrast, in Experiment 1 in which contextual information was provided, the processing of regular uppercase was significantly slower than regular lowercase. Previous research has also indicated slower processing (although not necessarily significantly) for regular uppercase typography in comparison to regular lowercase typography (Coltheart & Freeman, 1974; Rudnicky & Kolers, 1984; Smith, 1969; Tinker, 1963). In Experiment 1 we suggested that the significantly slower processing of regular uppercase may be due to the difficult context and the lack of word shape information (as defined by the ascenders and descenders). Yet, in both Experiments 2 and 3, the same font manipulation produced somewhat faster processing for regular uppercase than lowercase fonts. Thus, while the elimination of context was expected to enhance perceptual processing effects due to word shape, these results suggest that in fact this manipulation had exactly the opposite effect, namely, a reduction of these effects. There seems no obvious explanation for this, except that we are reminded of the conclusions of Levy (1981) "that context may influence processing in a variety of ways. That is, there is no single form of contextual effects" (p. 14) It seems reasonable to suggest that the lack of context associated with isolated words may also affect processing in as yet undetermined ways.

It was interesting to note that increasing the length of the word list threefold extended the reading time only 10.26 sec (20 words=27.74 s; 60 words=38.00 s). This may be an indication of rapid development of a skill for each of these fonts. If we compare this exposure time with that of Experiment 1 (103.19 s) and take into consideration that in Experiment 2 a mean exposure of 27.74 s eliminated the effect of the font manipulation, it seems indeed possible that with an even longer list of words, the font manipulations may show even stronger effects, or perhaps even different effects altogether. The present research, however, offers no clear suggestions as to whether total exposure time per se is related to the effects of these font manipulations. A factorial combination of the font variable with total reading time and availability of context would seem to be the next logical step in assessing the role of some of these factors.

In Experiment 3, the slowest processing occurred for the alternating case text and the speed was significantly slower than regular uppercase but not reliably different from regular lowercase. In Experiment 1 the results showed a significant difference between alternating case and regular lowercase, but only a slower trend between alternating case and regular uppercase. However, in Experiment 2, there was no significant difference among Fonts 1 through 3. Previously we suggested the lack of a reliable difference between regular uppercase and alternating case (in

Experiment 1) may have been a result of a "floor" effect in the alternating case condition. However, this explanation seems unable to account for the lack of a reliable difference between regular lowercase and alternating case in Experiments 2 and 3.

Although past research has shown a significant difference between alternating case and lowercase typography (Brooks, 1977; Coltheart & Freeman, 1974), we must note that Brooks (1977) utilized 16 lists of 16 words per list and required subjects to scan the lists for proper names and places. In this task it would not seem necessary for subjects to read words in their entirety. Indeed, they may have eliminated possible targets by partial word identification. Coltheart and Freeman (1974) utilized a tachistoscopic presentation of 48 words. Each word was presented at a fixation point for 50 msec and the number of correct and incorrect responses as well as omissions were counted. It seems reasonable to suggest that there are considerable differences between measuring reading speed of 60 printed words (20 per column) and a visual search task or a tachistoscopic identification task. Processing of isolated words may not result in the same effects across paradigms (Levy, 1981).

Jacoby (1983) also proposed that the influence of perceptual and conceptual processing may vary during presentation and encoding of words. This researcher illustrated that when a word was presented for reading with no context (*xxxx cold*), in the context of an antonym (*hot, cold*) or when the word was to be generated from its antonym (*hot ???*), performance on a later perceptual identification test and recognition test dissociated. With the perceptual identification test, performance was best in the no context condition and poorest in the generate condition. However, with the recognition test, an opposite ordering of conditions resulted. Jacoby (in press) concluded that conceptually-driven processing was dominant in the generate condition, and data-driven processing was most influential when words were read in isolation. He suggested that recognition memory improves from previous conceptually-driven processing, whereas with isolated words "it is the extent of data-driven rather than that of conceptually-dr. ·n processing that is the important determinant of later performance" (Jacoby, in press, p. 23). Although, in our Experiments 2 and 3 words were processed in isolation (implying a reliance on data-driven processing), it seems reasonable that the expected word recognition test may have altered dependence on the data-driven component of processing. Consequently, the processing of isolated words in our experiment may have produced different trends than those found in previous research (Brooks, 1977; Coltheart & Freeman, 1974). Varying the type of test may provide some answers to the apparent deviations of our reading speed data from reading speeds reported by others.

Again our intent with Experiment 3 was to consider the manipulations of Fonts 4 through 6 in terms of the influence of regular word shape and lettercase. However, since Font 1 (regular lowercase) was not processed significantly differently from either alternating case or regular uppercase, meaningful interpretations are difficult. In Experiment 3, the speed of processing of Font 4 was very similar to that of regular lowercase, whereas in Experiment 1, it was significantly slower than this typography. We suggested (in Experiment 1) that this difference may be due to the presence of the uppercase letters in the shape defining positions. However, in Experiment 3, there seems to be no interference from these uppercase shape defining letters. In fact in this experiment the speed of Font 4 is significantly faster than the alternating case (again possibly an indication of either the application of the shape-sensing skill or processing as with regular uppercase). However, in Experiment 1 the speed of Font 4 was identical to the processing speed of the alternating case typography and very similar to regular uppercase.

In Experiment 3, Font 5 (mixed case, shape defined by uppercase letters) was processed significantly more slowly than the regular uppercase text but there was no significant difference with the other fonts. Yet, the only difference between Font 4 and Font 5 was the addition of the lowercase letters in the non-shape defining positions in Font 5. However, in Experiment 1, Font 5 was significantly different from regular lowercase, but not regular uppercase. Again, these findings seem to support the view that the processing of words in isolation may not result in the same effects as processing words in context.

Font 6 (mixed case, shape defined by lowercase letters) was the interesting result in Experiment 1 since its speed was significantly faster than Font 5. The only difference between Fonts 5 and 6 was the "switch" of the shape defining and the small letters. In both Experiments 1 and 3 (as well as Experiment 2), Font 6 was processed at speeds similar to regular lowercase. In fact, in Experiment 3, Font 6 was processed slightly faster than regular lowercase. In Experiment 1, we suggested that the relatively fast speed of Font 6 may be due to the presence of the lowercase letters in the shape defining positions since in this experiment processing was significantly faster than Font 5. Yet, in Experiment 3, the speed was not reliably different from any other font except the alternating case typography. However, it is worth noting that the difference between Fonts 6 and 5 did approach significance. Possibly a longer total reading time may result in a reliable difference.

We should also consider the theoretical implications of our findings in Experiments 2 and 3. The preliminary letter identification hypothesis (McClelland, 1977) suggested that the reader extracts letter information from the ascenders and descenders of the lowercase letters and this facilitates determination of the possible letters for each position. This hypothesis would predict the fastest processing for regular lowercase, followed by regular uppercase (since the typography is familiar to the skilled reader even though it does not provide possible letter information by lowercase ascenders and descenders) and the slowest speeds for alternating case. The findings of Experiments 2 and 3 are not consistent with this hypothesis: While there was no significant difference in reading speed between uppercase and lowercase typography in either experiment, uppercase text actually illustrated a faster processing trend than regular lowercase. Similarly, alternating case did not provide any letter identification information from the ascenders since the uppercase letters were as tall as the ascenders (although some details were available from the descenders), and yet this font was not processed significantly slower than regular lowercase in either Experiment 2 or 3. This finding also fails to support McClelland's hypothesis.

In Experiment 3, Font 4 was processed significantly faster than alternating case but did not differ reliably from the other typographies, whereas in Experiment 2, this font was not significantly different from any other font. Font 4 provided word shape by uppercase letters. Yet, the preliminary letter identification hypothesis suggests that letter determination details can only be provided by lowercase letters. Thus, our finding of a reliably faster speed for Font 4 than the alternating case in Experiment 3 does not support this hypothesis. However, in Experiment 2, Font 4 is not processed reliably faster than the alternating case typography, which may be a possible indication that letter determination information was not available from either font.

When lowercase letters were added in the non-shape defining positions (Font 5) the speed decreased reliably in comparison with Font 2 (regular uppercase) in Experiment 3. This is again not supported by the preliminary letter hypothesis unless we assume that the presence of the lowercase letters produced interference. However, in Experiment 2, there was no significant difference between Fonts 5 and 2.

In Experiment 3, the results of Font 6 are compatible with this hypothesis since this font did provide the reader with information about the possible letters for the letter positions and its speed did increase significantly when compared with alternating case and illustrated the slightly slower trend (insignificant) in comparison to regular uppercase. Yet, it would not predict the faster trend (insignificant) in comparison to regular lowercase. In Experiment 2, the significantly faster processing of Font 6 in comparison with Font 4 is supported by this hypothesis, but the similar speeds of Font 6 and alternating case are again not supportive. Consequently, our data do not seem consistent with many of the predictions of the preliminary letter analysis model.

Coltheart and Freeman (1974) suggested that the reader receives perceptual information, such as the roundness of CO and squareness of NI, from the uppercase letters. However, lowercase type provides additional information from the combinations of lowercase letters, independent of the specific letter features. The faster processing trend of uppercase text when compared with lowercase type in Experiments 2 and 3 does not conform with this hypothesis. However, the significantly faster processing of uppercase when compared with alternating case in Experiment 3 is compatible with these views due to the added information extracted from the roundness of CO and squareness of NI. However, the similar processing speeds of Fonts 4 and 5 in which additional information is provided by uppercase and a mix of case, and Font 1 in which these details were provided by lowercase letters, can not support this hypothesis if we assume that the additional feature information is available only from the ascenders and descenders of the lowercase letters. Yet, the significantly faster processing of Font 6 in comparison with alternating case in Experiment 3, and also its reliably faster speed than Font 4 in Experiment 2, may be predicted by this hypothesis, if we assume that enough additional information is provided by the lowercase letters in the shape defining positions.

Smith (1969) and Smith et al. (1969) suggested that word recognition is dependent on the identification of minimum combinations of features (criterial sets) and it is not necessary that these feature combinations are in the same letter case. Although regular uppercase showed a faster processing trend than regular lowercase, they were not significantly different, and consequently, the processing speeds of Fonts 1 and 2 in both Experiments 2 and 3 are supportive of this hypothesis. However, it does not afford an explanation for the faster trend of the uppercase typography. Similarly, it is reasonable that alternating case should be processed significantly more slowly than regular uppercase (as in Experiment 3) since, in the alternating case, uppercase letters are tall enough to hide the ascenders of the lowercase letters resulting in interference with the discriminability of combinations of features. However, this hypothesis does have a problem with the finding that regular lowercase was processed at the same speed (although it illustrated a faster trend in Experiment 3) as alternating case. Certainly regular lowercase allows for the identification of a minimum combination of the criterial sets. In Experiment 3, Font 4 was processed significantly faster than the alternating case type but did not differ in speed from regular lower and uppercase. This again may be explained by the discriminability of the letter features. However, the significantly slower processing of Font 4 than regular uppercase in Experiment 2 is not explicable.

In Experiment 3, Font 5 was processed significantly more slowly than regular uppercase. If letter case is not of importance and the combination of features in both fonts is discriminable, there does not seem to be an explanation for this finding. Yet, in Experiment 2 this reliable difference disappeared. However, the relatively fast speed of Font 6 in Experiment 3 is predicted by this hypothesis since Font 6 again provides discriminable features and equivalent lettercase is not of importance. It is significantly slower than alternating case which lacks the clearly discriminable features. However, in Experiment 2, the reliably faster processing of Font 6 than Font 4 was again not supportive of this hypothesis.

In summary, the results of Experiment 3 did indeed produce an effect of font when we increased the number of words in the word-sets. Surprisingly, in both Experiments 2 and 3 uppercase was the fastest processed typography and demonstrated a faster trend (although not significant) than regular lowercase. In Experiment 3 alternating case was processed significantly more slowly than regular uppercase and Font 4 (all uppercase, regular word shape defined by uppercase). However, in Experiment 2 there was no reliable difference between the alternating case and these two typographies. In Experiment 3, Font 5 was processed significantly more slowly than regular uppercase, whereas in Experiment 2, it was Font 4 which was processed reliably more slowly than these two typographies.

We should also consider the empirical differences between Experiments 1 and 3. Methodologically the two experiments were similar in design, except for the materials. Experiment 1 provided the reader with 350 words of contextual text, whereas Experiment 3 provided 60 isolated words. We could assume that in Experiment 3, Fonts 1 through 3 did define the limits of our word shape manipulation, except that the fastest speed was produced by uppercase instead of lowercase typography. If we consider that the processing speeds of upper and lowercase text were equivalent (there was no significant difference), we are left with the problem of equivalent speeds for lowercase and alternating case typography in Experiment 3. In Experiment 1 there was a significant difference between these two conditions. With contextual information (Experiment 1) Font 4 (all uppercase, regular word shape defined by uppercase) was processed significantly slower than regular lowercase, however, in Experiment 3 there was no significant difference between these fonts. Yet, Font 6 (mixed case, shape defined by lowercase) was processed at similar speeds as regular lowercase in Experiments 1, 2 and 3 and this could again be an indication of the influence of lettercase and word shape. Consequently, we have to conclude that even though the elimination of the context may indeed increase the reader's reliance on perceptual features such as word shape and letter case, we must also suggest that it seems to influence processing in "a number of ways." The same operations that produce the font effect in contextual settings may not be utilized, or may be utilized differently, with a list of unrelated words.

General Discussion

Kolers and Roediger (1984) suggested that research in memory should be considered in terms of the procedures used to acquire or express knowledge and experiences train skills selectively. Our research considered the effect of perceptual features in the recruitment and utilization of the procedures in word identification. Our specific interest was the influence of word shape. We assumed that fluency of performance is a function of the similarity between previous experiences and test episodes (Kolers & Roediger, 1984; Masson, in press).

Previous research (and our Experiment 1) has shown that regular lowercase text is read more quickly than regular uppercase (Coltheart & Freeman, 1974; Rudnicky & Kolers, 1984, Experiment 1; Tinker, 1963). Rudnicky and Kolers (1984) speculated that a skilled reader may apply different strategies with these two typographies since each provides the reader with different cues. In the case of lowercase text, the reader may make use of the ascenders and descenders of the lowercase letters, whereas with uppercase text, this type of information is absent.

The findings of Experiment 1 provide supporting evidence for the influence of word shape as defined by letter case in word processing as well as the possible utilization of different strategies with the two typographies. However, the results of Experiments 2 and 3 pose problems for this hypothesis. The most interesting finding is the relatively fast processing of uppercase words in comparison with lowercase typography when meaningful contextual information is deleted. These findings would seem to suggest that if the reader does make use of a different set of strategies with uppercase than lowercase type (Rudnicky & Kolers, 1984), then these uppercase strategies seem to become more facilitative with isolated words than the lowercase strategies. Alternatively, the presence of word shape as defined by the ascenders and descenders of lowercase letters causes interference when words are processed in isolation. That is, contextual information may be necessary for these strategies to be applicable.

The present research was not designed to investigate in detail the possible influence of the above contextual manipulations. A first obvious step should be the replication of Experiments 1 and 3 possibly with only lowercase, uppercase and alternating case typographies. The statistical power of the analysis could be heightened by increasing the number of subjects from 12 to possibly 24. Similarly, the variance could be decreased by altering the experimental design to require subjects to process a particular font (with different paragraphs or word lists) more than once (and accounting for the practice effect).

In Experiment 1 we suggested the difficulty of our reading material as a possible reason for the slow processing and the reliable difference between lower and uppercase typography. We proposed that as speed of processing decreases, possibly due to difficulty of the material, the influence of perceptual processing may become increasingly evident on the reading time measure. We concurred with Levy (1981) that stimulus analysis seems to be altered by contextual constraints. A logical next step would be the manipulation of these contextual constraints. Meaningful contexts of similar lengths could be classified according to conceptual difficulty (as in Levy, 1981) and the influence of these manipulations on font could be assessed. Contextual influences could also be assessed through the manipulation of contextual restrictions. For example, reading materials could be varied from sentences that form meaningful paragraphs, unrelated grammatically correct sentences, a series of phrases, groups of unrelated words through to isolated words. Again the influence of the font manipulation could be assessed.

In a similar manner, other features of isolated words deserve consideration. For example, the 20 words of Experiment 2 were selected from the texts of Experiment 1 and varied in length from 4-10 letters but ranged from frequencies of 46 to 100 words per million (Thorndike & Lorge, 1944). The 40 additional words in Experiment 3 were chosen with the same frequency limitation. However, there is evidence from previous research that prior exposure to high and low frequency words differentially influences later perception of these words (Jacoby & Dallas, 1981, Experiment 3). A direct assessment of the effects of our font manipulation as a function of word frequency seems warranted.

We also commented (in Experiment 3) that tripling the number of isolated words only increased processing time by approximately 10 s (27.74 to 38.00 s). In Experiment 1 subjects were exposed to the font manipulation for 103.19 s. Since the short duration of 27.74 s in Experiment 2 eliminated the effect of font, it would be interesting to increase exposure time to isolated words to that of exposure to meaningful context. This manipulation may further alter the influence of perceptual processing since it seems reasonable that if difficulty of context and the resulting slower processing influence processing with contextual material, different effects due to longer exposure may also be found with isolated words. It may be that as the availability of conceptual information decreases (due to lack of context), the skilled reader may recruit and consequently process perceptual information in a different manner. The nature of the necessary operations (conceptual or perceptual) may indeed vary due to the available stimulus material which in turn may result in different forms of remembering (Masson, in press). Consequently, our reading fluency test may be susceptible to these processing changes. As indicated previously, a factorial combination of the font variable with total reading time (exposure to font manipulation) and availability of context would seem to be the next logical step in the assessment of the influence of each of these factors.

In Experiment 1 we also suggested that the word recognition test may be a possible influencing factor on processing and proposed that the role of instruction is not clear. We reported that the results of our pilot study did not indicate an influence of assessment test. However, only six subjects were tested in each condition. Increasing the statistical power of our analysis by utilizing more subjects may indeed result in a significant effect of assessment test, as suggested by the more in-depth analysis of these pilot data reported earlier. We considered the research of Levy and Kirsner (1989) which did indeed illustrate a significant effect of instruction (and test) with meaningful material when subjects were asked to read for wording. In our study subjects were aware of the word identification test and it seems reasonable that this could influence processing strategies if we view reading as a consequence of integrating perceptual and conceptual analysis (Masson, in press).

Silent reading presents an assessment problem. Our word recognition test was designed for the purpose of assuring ourselves that subjects had processed all words. With contextual material we could have utilized a YES/NO meaning test (as in Rudnicky & Kolers, 1984), however with isolated words this was not possible. Consequently, although the word recognition test may have provided us with the assurance that all words were processed, it may have inadvertently altered the type of processing. Recognition tests may involve both data-driven and conceptually-driven processing (Jacoby, in press) and although the isolated words may provide a focus on perceptual features, reconstruction of the word lists may be demanded by the word recognition test. Consequently, it is possible that although Experiments 2 and 3 presented the reader with an increased focus on perceptual details, the processing of these features may have involved considerable conceptual operations because of the awareness of the word recognition test.

It is difficult to suggest another type of test which will not influence performance. Scanning a list for certain target words (Brooks, 1977) leaves us with the possibility that subjects may eliminate, and thus not process, certain words, and a tachistoscopic presentation (Coltheart & Freeman, 1974) necessarily sets a limit to the duration of the stimulus. Yet reading aloud presents us with a possible floor effect due to articulation (Rudnicky & Kolers, 1984) and may render the test insensitive. Possibly a silent reading task without a test may provide some answers (although it obviously leaves us with the problem of "proof of processing"). Thus, although we suggest an investigation of test-relevant strategies, we are cognizant of the difficulties.

The results of our three experiments indicate the influence of word shape as defined by lettercase when processing difficult contextual material. Howeve , our research also points to the conclusion that word identification involves recruitment of different processes with isolated words. The reader must process the perceptual data that are provided and these operations are dependent on the skills of the reader as well as the purpose of the task (Kolers & Roediger, 1984). Although the skilled reader may bring well practiced perceptual skills that include word shape and lettercase details to the task, the specific experimental circumstances may induce the reader to apply these skills to different degrees or in different ways. If we propose to account for memory in terms of encoding and retrieval interactions (Jacoby, in press) or as experiences which are represented as procedures applied during interaction with a stimulus (Kolers & Roediger, 1984), the investigation of the recruitment of processes and their application during word identification under varying circumstances needs to be pursued.

Appendix A

Study Paragraphs for Experiment 1

in a country founded in part on a belief in rugged individualism, it is a curious fact that with every passing year, it seems to become more difficult to be one's own individual self. it is commonly pointed out that we have been moving rapidly toward an organizational society where the individual tends to become lost in the large scale unit such as a corporation, union, government, university or church. the structure of such organizations is designed to meet the goals of the group, and before he knows it, the individual finds himself falling in line with group pressures regardless of whether it is in his own fundamental interest to do so or not. the young executive may want to live where he grew up and where he deeply enjoys living, but he knows he has to take the offered transfer if his career is not to be blocked. he wants to spend his evenings and weekends with his wife and children, but instead brings home a briefcase full of work in order to meet the pressures that come down on him from above. he enjoys good literature and the theater, but the circle of associates who hold the reins to his future favor evenings of canasta, bridge, and social drinking. he dislikes parties, but knows that not to be seen at the organizational gatherings would be fatal. the scientist is subject to the same forces. we may have thought that research flourishes in proportion to the freedom of the individual genius and that the fundamental premise of the laboratory is that the inquirer must be his own judge of what he considers the most promising line of work. but it is the relatively rare scientist who can do just what he wants. he too must conform to views of the large foundation or government bureau as to what deserves research funds. too often our scientists find themselves offered large grants to work on something considered valuable by someone else but are unable to get a few thousand dollars for research on their own ideas. these influences tend to dry up the wells of rich emotional living.

animals achieve dominance by actual fighting, but also by less destructive methods such as threatening displays, loud noises and bird-song. such behavior has two main functions: the selecting and keeping of a mate and the defence of territories. the biological value of dominance fighting could be that the rearing of young is carried out more efficiently; but it also has the effect that the more dominant animals are, the more the species benefits in the long run. hierarchies emerge as the result of such fighting, and they are very clear in the monkey and ape groups, where there is usually a single male overlord. human societies also have their hierarchies, but they are established through more subtle means than fighting, threatening or shouting. nevertheless there is a strong element of aggression in the methods used by man to achieve status, and this is true of laughing when it is used in this particular way. there remain several kinds of laughter in which it is difficult to see a biological function. for example, laughing after a period of tension; laughing at jokes or antics; laughing at deformities and stuttering; laughing caused by tickling. animal behavior can throw light on the first of these. when two herring gulls meet at the boundary of their territories, the tendencies to fight and to flee may be in balance, and the result is a conflict between these opposing tendencies. on these occasions gulls often indulge in what appears to be quite irrelevant behavior: they peck at bits of grass and twigs, and throw them sideways. this looks like part of their nest-building behavior appearing out of context and is known as displacement activity. the ethologists have suggested that this is an accumulation of energy in the nervous system as a result of the blocking of the usual outlets. everyday observations suggest that laughter may result from a similar mechanism. subjectively it feels as if tension builds up and is relieved by laughing. this can happen after the natural response to a situation has been inhibited.

the typical experience of the prisoner of war was divided into two broad phases. the first phase lasted anywhere from one to six months. it began with capture, followed by exhausting marches to the north country and severe privation in inadequately equipped temporary camps, and terminated in assignment to a permanent prisoner of war camp. the second phase, lasting two or more years, was marked by chronic pressures to collaborate and give up existing group loyalties in favor of new ones. thus, while physical stresses had been outstanding in the first six months, psychological stresses were outstanding in this second period. the reactions of the men toward capture were influenced by their overall attitude toward the war situation. many of them felt inadequately prepared, both physically and psychologically. the physical training, equipment, and rotation system all came in for retrospective criticism, though this response might have been merely a rationalization for being caught. when the enemy entered the war they penetrated into rear areas, where they captured many men who were taken completely by surprise. the men felt that when positions were over run, their leadership was often less than adequate. thus, many men were disposed to blame the command for the unfortunate event of being captured. on the psychological side, the men were not clearly aware of what they were fighting for or what kind of enemy they were opposing. in the weeks following capture, the men were collected in large groups and marched north. the stresses during these marches were very severe; there was no medicine for the wounded, the food was unpalatable and insufficient, clothing was scarce in the face of severe winter weather, and shelter was inadequate and overcrowded. the enemy set a severe pace and showed little consideration for weariness that was the product of wounds and frostbite. men who were not able to keep up were abandoned unless they were helped by their fellows. the men marched only at night and were kept under cover during the day.

people living together in groups come to control one another with a number of techniques. when an individual behaves in a fashion acceptable to the group, he receives admiration, approval, affection, and many other reinforcements which increase the likelihood that he will continue to behave in that fashion. when his behavior is not acceptable, he is criticized, censured, blamed, or otherwise punished. in the first case the group calls him good; in the second, bad. this practice is so thoroughly ingrained in our culture that we often fail to see that it is a technique of control. yet we are almost always engaged in such control, even though the reinforcements and punishments are often subtle. the practice of admiration is an important part of a culture because behavior which is otherwise inclined to be weak can be set up and maintained with its help. the individual is especially likely to be praised, admired, or loved when he acts for the group in the face of great danger, or sacrifices himself or his possessions, or submits to prolonged hardship, or suffers martyrdom. these actions are not admirable in any absolute sense, but they require admiration if they are to be strong. similarly, we admire people who behave in original or exceptional ways, not because such behavior is itself admirable, but because we do not know how to encourage original or exceptional behavior in any other way. as long as this technique of control is misunderstood, we cannot evaluate correctly an environment in which there is less need for heroism, hardship, or independent action. we are likely to argue that such an environment is itself less admirable or produces less admirable people. in the old days, for example, young scholars often lived in undesirable quarters, ate unappetizing or inadequate food, and performed unprofitable tasks for a living or to pay for necessary books and materials. older scholars and other members of the group offered compensating reinforcement in the form of approval and admiration for these sacrifices.

the fact seems to be that aggressiveness usually develops in the child as a result of frustration, that is to say, the blocking of expected satisfaction. the infant expects to have its needs satisfied; if those needs are not satisfied he feels frustrated and normally reacts with aggressive behavior. recently it has become understood that aggression is, in effect, a technique or mode of compelling attention to, and satisfaction of, one's needs. it is becoming increasingly clear that the infant is born not only with the need to be loved, but also with a need to love; he is certainly not born with any need to be aggressive. this view of human nature paints a very different picture from the traditional one, with its conception of man born with an aggressiveness which the process of socialization must suppress or eradicate. modern research has shown that this view of human nature is erroneous. man is not born evil or aggressive; he is rendered so. this being the case, it is incumbent upon us to realize that we can best change human nature for the better not by working on man's biological inheritance, but by working on his social inheritance by changing those conditions which produce disharmony in the person and corresponding disharmony in his society. the school of evolutionary thought which preached the struggle for existence and the survival of the fittest gave a one sided view of nature as a competitive process, and omitted almost entirely the factors of co-operation and mutual aid, which play so great a role in the ecology and the balance of nature. perhaps one of the most important of our conclusions is that never was there a stereotype more unsound than that enshrined in the view that you can not change human nature. on the contrary, we find that man is the most plastic, the most malleable, the most educable of all living creatures. man is the learning animal; he is capable of learning and changing his views and his habits throughout his life.

the goal of psychology is to provide a scientific account of the behavior of man and other animals. of course, other fields such as literature, the arts, philosophy, and religion are also concerned with behavior and have contributed important and significant insights to our present understanding of the nature of man. while psychology shares its subject matter with these humanistic disciplines, it differs from them in its methods of observation and in its emphasis upon experimental procedures. as a branch of natural science, psychology is committed to search for comprehensive and detailed explanations of behavior that are founded on communicable and verifiable observations, and on objective and experimental methods. through research, psychology seeks to discover laws that specify relationships between behavior and the many different conditions and circumstances that influence it. but it is obviously not possible to investigate the infinite number of factors that affect behavior, nor is it even possible to study all the activities of only one person at any given time. consequently, for practical reasons, the research psychologist must restrict himself to limited segments of behavior and to selected conditions and circumstances under which it occurs. thus, in psychology, as in every science, there has developed a division of labor based on the particular aspects of behavior that are selected for study. some psychologists choose to investigate the dependence of behavior on biological mechanisms, others study the processes whereby people obtain knowledge about the world through the various senses, and still others are mainly concerned with individual differences in intellectual and personality characteristics. as a consequence of this division of labor, a number of major areas within the discipline have been established. these areas are defined, not only by the kind of behavior that is investigated, but also by the research methods that are used and the theoretical explanations that are given to account for experimental findings.

the use of language by adult human beings is so natural and automatic that a naive person might conclude language is innate. but we know from observations of very young children that language is not present initially and does not begin to appear in a form that we can readily understand until around the age of two. however, if deprived of the opportunity to practice, a child may never begin talking. therefore, language must require learning as well as an adequate nervous system and speech apparatus. careful analysis of the structure of language suggests that speakers act as though they know a fairly complicated set of rules for a game, even though they may not be able to state these rules. it would seem that the language game cannot be played without the rules, for the words alone are not sufficient. since rules appear to be essential in language acquisition, it is difficult to apply the theories of learning that are used to explain animal behavior. in fact, there is reason to believe that a quite different kind of learning may be operative. at the age of about one, a normal child, not impaired by hearing loss or speech impediment, will begin to say words. by a year and a half or two years, he will begin to form simple two and three word sentences. by four years he will have mastered very nearly the entire complex and abstract structure of our language. in slightly more than two years, therefore, children acquire full knowledge of the grammatical system of their native tongue. this stunning intellectual achievement is routinely performed by every pre-school child, but what is known about the underlying process? the process is one of invention. in order to understand the creation of language, one must understand something of what is created. a sentence consists of words arranged in a particular order; it has structure. the words fall together in certain definite ways, and grammatical relations such as subject and object, are carried by structures not directly apparent in the surface of sentences. these are the abstract features of a sentence.

Appendix B

Latin Square Designs

Subjects (Group 1)

Order of passages or word sets

	1	2	3	4	5	6
1	1	2	3	4	5	6
2	2	4	6	1	3	5
3	3	6	2	5	1	4
4	4	1	5	2	6	3
5	5	3	1	6	4	2
6	6	5	4	3	2	1

Subjects (Group 2)

Order of passages or word sets

	1	2	3	4	5	6
6	4	5	6	1	2	3
5	5	1	3	4	6	2
4	6	3	5	2	4	1
3	1	4	2	5	3	6
2	2	6	4	3	1	5
1	3	2	1	6	5	4

Appendix C

Word Identification Tests For Experiments 1, 2 and 3

Circle the *ten* words that appeared in the previous paragraph.

golden	neck	nitrogen
express	thousand	electric
contain	greet	distant
conform	regardless	scale
foundation	factory	dislikes
scene	valuable	lofty
deeply	magnitude	harden
perch	feudal	treasure
investment	politely	represent
remember	commonly	theater

Circle the *ten* words that appeared in the previous paragraph.

depart	male	stuttering
happen	shoulder	villages
hospital	glow	suffocate
freight	league	sideways
occasions	opulence	pound
fountain	mundane	everyday
noises	ghastly	minute
strategies	generosity	discovery
piracy	irrelevant	shouting
express	rearing	steady

Circle the *ten* words that appeared in the previous paragraph.

treason	phases	rotation
provoke	abandoned	assignment
premature	goblet	observe
permanent	passage	introduce
lily	surprise	gloomily
interior	father	engross
command	exercise	economy
performer	woman	devotion
weather	clothes	wounds
hustle	taste	equipped

Circle the *ten* words that appeared in the previous paragraph.

forget	fail	twelve
dignity	crack	retain
heroism	tribe	inclined
strength	novice	books
maim	weak	solid
wonderful	trouble	bystander
increase	martyrdom	faithful
absolute	crazily	encourage
door	powerful	gloriously
evaluate	mystery	overseas

Circle the *ten* words that appeared in the previous paragraph.

deluge	paints	redemption
gland	plank	cheese
stretch	fiery	barn
habits	tighten	behold
certainly	recreation	flashing
marriage	lottery	plastic
frustrated	jubilee	straight
island	erroneous	officer
desire	whittle	existence
role	recently	conception

Circle the *ten* words that appeared in the previous paragraph.

chief	porter	invite
broken	provide	handsome
findings	regulation	groom
article	world	restrict
dependence	flower	infinite
comet	hurry	frail
declare	journal	enhance
moth	branch	diverse
oddly	practical	defined
shares	middles	crystal

Circle the *ten* words that appeared in the previous paragraph.

innate	manner	reduce
canteen	justice	apparatus
accomplice	inside	acquire
without	three	liberty
bravely	conclude	ocean
consumer	hunter	please
herself	crew	pretty
suggests	noon	rather
inquiry	maple	features
spacing	hearing	consists

Appendix D

Word Set Study Tests For Experiment 2

rugged
scale
falling
deeply
briefcase
dislikes
gatherings
premise
conform
thousand
commonly
church
regardless
wife
theater
future
genius
bureau
foundation
valuable

noises
male
stuttering
shouting
occasions
irrelevant
everyday
sideways
happen
rearing
actual
species
monkey
emerge
element
antics
context
energy
inhibited
kinds

phases
assignment
permanent
rotation
surprise
command
weather
wounds
abandoned
equipped
typical
existing
reactions
overall
merely
caught
following
collected
clothing
shelter

techniques
increase
blamed
fail
engaged
inclined
weak
maintained
especially
martyrdom
absolute
similarly
encourage
evaluate
heroism
argue
quarters
tasks
books
older

develops
frustrated
reacts
recently
compelling
certainly
paints
conception
suppress
erroneous
incumbent
existence
fittest
sided
role
stereotype
plastic
educable
creatures
habits

provide
arts
religion
shares
humanistic
branch
verifiable
seeks
specify
infinite
practical
restrict
segments
dependence
whereby
world
senses
major
defined
findings

automatic
conclude
innate
deprived
apparatus
suggests
without
alone
explain
hearing
half
three
complex
acquire
native
stunning
consists
arranged
definite
features

Appendix E

Word Set Study Tests For Experiment 3

rugged	hang	knit
fraud	wife	instruct
nuisance	yard	premise
commonly	union	episode
doubtful	briefcase	denote
emergency	diamond	conform
scale	balance	bewitch
pupil	future	poetic
huge	fruit	foundation
church	history	generally
example	theater	crop
ground	represent	bureau
falling	perfect	midst
continue	dislikes	operate
produce	hound	valuable
regardless	impose	virtue
assail	gatherings	struggle
flit	logical	thousand
deeply	fleece	leader
journal	genius	forget

actual
citizen
fencing
noises
loose
sorrow
rearing
duke
engine
species
routine
internal
essence
traitor
refuge
monkey
amid
diminish
male
pigeon

ripe
shouting
notice
instead
element
advice
governor
kinds
thought
support
antics
botany
grapple
stuttering
roughen
marinate
occasions
numerous
flatly
irrelevant

griddle
crocus
sideways
mindful
enclosure
context
aptly
neuter
energy
hasten
normal
everyday
prose
malice
happen
rolling
narrow
inhibited
muffler
pilfer

typical
washing
sturdy
phases
memorial
lessen
equipped
fuel
furious
assignment
baptize
clerical
permanent
monument
literary
expensive
factory
gradually
reactions
perfume

mercury
overall
muskrat
jeer
rotation
prowl
obedient
merely
locate
knock
caught
crossing
given
surprise
thin
view
command
broken
attempt
following

space
prepare
collected
establish
justify
clothing
examine
inquire
weather
pleasant
supply
shelter
protect
original
wounds
struck
string
abandoned
dreamily
indoor

techniques
spouse
formulate
increase
heaven
grant
blamed
concern
display
fail
horse
industry
engaged
greed
mileage
inclined
slightly
alike
weak
victory

tremble
maintained
observer
misery
especially
discover
crowd
martyrdom
monetary
pivot
absolute
crazy
dignity
spindle
resound
orderly
encourage
mate
organize
evaluate

jargon
limbo
heroism
itch
frivolous
argue
betray
clever
quarters
record
teacher
tasks
arose
brave
books
effort
rather
older
scene
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develops
exactly
excuse
frustrated
indigo
jazz
illegal
suitcase
unwise
recently
harm
handle
compelling
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detail
certainly
picture
filling
further
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paints
conception
alight
battery
suppress
paste
mutual
erroneous
foreseen
hopefully
incumbent
listless
marker
existence
feast
grief
fittest
distance
carry
queen

street
ocean
legitimate
notch
graphic
stereotype
skewer
rating
plastic
octave
massage
educable
moisture
gravely
creatures
conduct
broad
plenty
orange
political

provide
opinion
geography
arts
bridge
condition
religion
shame
tender
share
weight
valley
humanistic
habitat
fought
branch
different
enjoy
verifiable
warden

tolerate
seeks
report
position
specify
omen
mangle
infinite
hiss
grease
practical
nobody
kingdom
restrict
pyramid
muzzle
segments
halter
gobble
dependence

whereby
world
conspire
breeding
ultimate
tick
usually
system
senses
last
obtain
major
congress
level
defined
crimson
builder
findings
gardener
legion

automatic
denounce
enlist
conclude
friendly
majestic
lunge
innate
mermaid
deprived
learned
jungle
apparatus
obstacle
promote
suggests
trust
water
without
either

during
alone
blood
family
explain
health
knowledge
hearing
lining
successor
half
idea
machine
three
yellow
written
complex
escort
flicker
acquire

contrary
decision
native
pick
quickly
stunning
umpire
twirl
consists
glance
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drove
northern
butler
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pillow
features
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similar

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