Implicit and Explicit Memory as a Function of Data- and Conceptually- Driven Processing

by

Paul Reisdorf

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MASTER OF ARTS

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Abstract

The dissociation of effects on implicit and explicit memory tasks (Schacter, 1987) has been linked to the differences between data-driven and conceptually driven processing (Roediger & Blaxton, 1987a, b; Jacoby, 1983a). This conceptualization was tested with 54 subjects in a 2 X 3 experimental design. Subjects were presented with a list of 32 words in two different fonts. At test, each subject completed 16 new stems, 16 stems in the same font as the corresponding word in the first presented list, and 16 stems in a different font. One group was instructed to complete the stems with "the first word that comes to mind" (implicit memory task) while the other group attempted to complete the stems with "a word from the list" (explicit memory task). In both instructional conditions it was found that primed words were completed more often than nonprimed words and that physical similarity of the stem cues to the prime (same font) resulted in superior performance to physically different stimuli (different font). It was further found that the improvement in performance from the different font to the same font conditions was greater in the implicit condition than in the explicit condition. These findings suggest that implicit memory is primarily data-driven while

explicit memory is primarily conceptually driven but that there are components of both processes in each kind of memory.

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Appendixes

Implicit and Explicit Memory as a Function of Data-Driven and Conceptually Driven Processing

Memory is usually thought of as a conscious experience. Although remembering can sometimes be automatic rather than effortful (Hasher & Zacks, 1984) it is difficult to think of a non-procedural memory task which does not require awareness on the part of the rememberer. However, Graf and Schacter (1985) point out that there is much laboratory evidence that memory can be exhibited despite a total lack of conscious recall or awareness that one is using a form of memory at the time of recall. This phenomenon is revealed by enhanced performance on a task due to prior exposure to material (referred to as priming), even when intentional recall is impossible and without any cognizance on the subject's part of the fact that he or she is remembering the previously presented material. Memory on this kind of task has been referred to as *implicit* memory by Graf and Schacter (1985) who distinguish it from *explicit* memory which is memory that necessitates conscious awareness of what is being remembered.

Many tasks have been employed to demonstrate implicit memory which may occur without intention or awareness.[1] Several interesting dissociations, relevant to the present study, have been found in performance on implicit and explicit tasks. These differences should have bearing on processes underlying the implicit - explicit distinction.

One of the characteristics of implicit memory is that it seems to be more closely tied to the physical features of a stimulus than is explicit memory. An early demonstration was given by Winnick and Daniel (1970). Subjects either read words, generated them from pictures, or generated them from definitions. Free recall (explicit memory) was enhanced by the generation tasks (compared to the read condition). However, implicit memory, as indexed by speed of identification on a tachistoscopic task, was enhanced only in the read condition.

Also using a tachistoscopic identification task, Jacoby and Dallas (1981) obtained similar results. Subjects answered questions about the meaning of words, an elaborative processing task, or decided whether words

[1]For a review of the kinds of tasks that demonstrate implicit memory and the characteristics attributed to it see Appendix A.

contained a specified letter, a non-elaborative task. On a subsequent explicit memory task (yes/no recognition) they found the typical superiority for elaborative study of the words. On a tachistoscopic task they found no priming differences for elaborative versus non-elaborative processing. However, a modality shift (visual to auditory from study to test had a significant effect on implicit memory but little effect on the recognition task.

Many other studies have demonstrated that implicit memory is affected by changes in surface information (such as physical characteristics of the stimulus) but that recall and recognition are not. For example Kolers (1975) had subjects read pages of text which was inverted. After 160 pages of practice they were able to read inverted text almost as quickly as normal text, but with this increased skill, subsequent recognition of what they read declined. Kolers (1976) retested some of these subjects 13 to 15 months later. He found that they had retained a great deal of their skill for reading inverted text, but more significantly, they also read text that had been presented a year earlier more quickly than text that was being presented for the first time. This difference was most pronounced in a subject who could not explicitly differentiate between old and new material. Thus the implicit task (increased reading speed) demonstrated very long term retention which was poorly correlated with explicit memory for the same material.[2]

Another procedure which demonstrates implicit memory without the presence of explicit memory is word fragment completion. In this task subjects study a list of words, then complete partial words by filling in missing characters (word-fragment completion) or by completing the rest of a word from a three letter cue (word-stem completion). Warrington and Weiskrantz (1974) found, not surprisingly, that amnesics were significantly inferior to a control group for yes/no recognition memory. However, they also found that the amnesics were no different than the controls on a word-stem completion task. This suggested a dissociation between explicit and implicit memory and showed that implicit memory could occur in the complete absence of explicit recall for the material.

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[2]More examples of long-term retention and stochastic independence between explicit and implicit recall will be discussed in Appendix A. This is especially relevant in terms of activation accounts of implicit memory.

An additional study which shows that implicit memory performance is sensitive to changes in physical features was conducted by Roediger and Blaxton (1987a). In the first experiment they presented words either visually or auditorily then gave subjects a visual word-fragment completion test. Although both kinds of priming facilitated word-fragment completion, visual priming had a significantly greater effect than auditory priming. In another experiment (Experiment 3[3]) priming words were presented either in focus or blurred. Fragment completion was better when the fragment was displayed identically to the corresponding word in the study list. This shows that successful priming depends on matching physical characteristics of the study and test materials in word-fragment completion tasks as well as other implicit memory tasks.

Jacoby (1983b) has distinguished *data-driven* processing, which relies on physical characteristics of the stimulus, from *conceptually driven* processing, which relies more on semantic properties. Matching physical features of

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[3]Experiment 2 was essentially a replication of Experiment 1 with a 1 week delay between study and test, with similar results.

study and test stimuli should result in superior performance compared to unmatched features in data-driven tasks. Conceptually driven tasks should benefit from matching semantic features or conceptual elaboration of the study material. Jacoby had subjects generate words from their antonyms or simply read the words. His results were similar to Winnick and Daniel (1970) who had subjects generate words from pictures or definitions. Jacoby found the typical superiority for generated items on a yes/no recognition test but found that mere reading of the primes was sufficient to enhance performance on a tachistoscopic identification task.

One theoretical account of the contrasting results from implicit and explicit memory tasks suggests that the underlying processes can be considered data-driven and conceptually driven, respectively (Roediger & Blaxton, 1987a; Schacter, 1987).[4] In this processing theory, performing similar mental operations or processing in like ways at the time of study and the time of test facilitates recollection of the material. For most implicit tasks, physical features seem to be important to performance, and

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[4]Several other theories are discussed in Appendix A.

conceptual factors such as semantic category or elaborative processing do not seem to matter. However, conceptual factors greatly affect performance in typical explicit memory tasks such as free recall and recognition. Roediger and Blaxton (1987b) used these traits to propose two criteria for classifying memory tests as data-driven or conceptually driven. First, tests that are sensitive to changes in physical features are data-driven. Second, tests that are sensitive to conceptual or elaborative processing are conceptually driven. Therefore, if altering physical features, such as character fonts, between study and test reduces performance (relative to no change) the test can be considered to be data-driven. If there is no reduction, it is conceptually driven.

Roediger and Blaxton (1987a) considered the results of their Experiment 3 (blurred or in-focus stimuli) to be important because it shows that fragment completion can also be thought of as a data-driven task. They had reasoned that, while other implicit tasks are data-driven, this might not be the case with word-fragments because other implicit phenomena often rely on rapid processing (such as a tachistoscopic identification task) whereas word fragment completion relies on slow, laborious responses. Schacter (1987) pointed out that many implicit tasks may not be entirely data-driven. For example, in word-fragment completion subjects may explicitly remember the word and use this conceptual process to fill in the blanks. Explicit tasks may also have a data-driven component but the processing theory suggests that the observed differences are due to different tasks being primarily data-driven or primarily conceptually driven.

Although physical processing affects implicit memory more than explicit memory, the opposite seems true for elaborative processing. Sloman, Hayman, Ohta, Law, and Tulving (1988) showed that, although performance decreased as study list length increased, word-fragment completion did not show any susceptibility to proactive interference. They had subjects study and complete fragments for 10 word or 100 word lists. They found that the proportion of correct completions was lower for the 100 word list than the 10 word list but that there was no systematic decline in performance for successive deciles within the 100 word list (i.e., later deciles were completed as well as earlier deciles) indicating that there was no cumulative within list proactive interference. Proactive interference is most acute when material is conceptually similar and shows little effect for physically similar material (e.g., Wickens, 1970) which is additional evidence that implicit tasks are relatively unaffected by conceptual processes.

Hashtroudi, Ferguson, Rappold, and Chrosniak (1988) applied Roediger and Blaxton's criteria to recognition and identification of degraded word tasks. They found that changes in elaboration had no effect on identification but did affect recognition performance. They further found that changes in modality (a physical feature) reduced identification performance and therefore concluded that the degraded word task was data-driven. However, they found that recognition performance also declined with a modality change[5]. Their explanation for this was that recognition may rely on both data-driven and conceptually driven processes.

Several investigators have shown that implicit memory may still be intact if explicit recall is precluded. In

[5]This effect was not evident with hits, only with false alarms. The authors therefore suggested caution with this interpretation.

such a situation one might expect the conceptually driven component to be completely removed from the implicit task. One example is the previously mentioned equivalent performance between amnesics and normals on a word-stem completion task (Warrington & Weiskrantz, 1974). Explicit memory was very low for the amnesics yet implicit memory showed no degradation. Another example is given by Tulving, Schacter, and Stark (1982) who gave subjects a recognition and a word fragment completion test 1 hr, and 7 days after the study list. Implicit memory was unchanged after 7 days but recognition accuracy was greatly diminished. Komatsu and Ohta (1984) replicated this Tulving et al. (1982) experiment with a word completion task using nouns that were five or six Japanese *Hiragana* characters long. They used intervals of 8 minutes, 1 week, and 5 weeks. Although recognition memory declined sharply over intervals, implicit memory showed almost no change after 1 week and only a 10% drop after 5 weeks. These two studies show that, despite the loss of explicit memory for material over time, implicit memory is unaffected both by time and the absence of conceptually driven processes.

Graf, Mandler, and Haden (1982) demonstrated a way to eliminate the confounding effects of explicit memory when one is attempting to measure only implicit memory. They simulated amnesic symptoms by giving one group of subjects a vowel decision task in which they were required to decide whether the currently presented word had any vowels in common with the previously presented word. Another group was required to process elaboratively by rating their liking of each word on a 7-point scale. Both groups were then given a free recall test and a word-stem completion test. Word stems that were not primed were completed correctly 6% of the time but primed words were correctly completed about 30% of the time by both groups. On the recall test the liking group recalled 30% of the words but the vowel group recalled only 8%. This study was important in showing a strong effect due to priming in word-stem completion and further showed that implicit memory is unaffected by the almost total absence of explicit memory. This also showed that conceptually driven processes can be obstructed by the prevention of elaborative processing when emphasizing the physical features of the stimulus.

One of the advantages of using completion tests is that they can be used to assess either explicit or implicit memory. If instructions are to complete a stem with the first word that comes to mind, implicit memory should be assessed. If instructions are to complete the stem with a word from a previously presented list, the task becomes one of cued recall or explicit memory. This selection can be made at the time of recall by varying only one aspect of the test. This is very useful because it limits the number of factors that are varied between the two testing conditions. Usually it is difficult to compare two kinds of memory tests because the demands and tasks are very different. For example, when comparing implicit test results to the results of a typical explicit task, which is the most appropriate explicit task to use: free recall or recognition? Word-completion is more than recognition because the subject must recall some information, yet it is not like free recall because some cues are given. In almost all cases tests for differences in different retrieval processes also involve differences in stimuli or retrieval cues.

Graf and Mandler (1984) discovered a convenient solution to this dilemma. They gave subjects two lists of words which they processed either semantically or nonsemantically. The subjects then had to complete word stems from one of the lists with the first word that came to mind and for the other list with a word that they recalled from the list. The only difference between the tasks was the instructions for completion of the word stems. They found that the orienting task (semantic or nonsemantic) greatly affected the number of correct completions when subjects were trying to remember list words (an explicit task) but had almost no effect when subjects were completing with the first word that came to mind (an implicit task). Thus, one can force implicit or explicit recall simply by varying completion instructions while leaving all other aspects of the tests identical.

This finding has been further supported by showing typical implicit-explicit differences with amnesics. Graf, Squire, and Mandler (1984) found that amnesics were severely impaired compared with normals when given explicit instructions but performed as well as normals given the implicit instructions on a stem-completion task. Hashtroudi et al. (1988) found that instructions were also important in a degraded word identification task. When asked simply to identify words, elaborative processing had no effect, but when told to use the degraded words as cues for recalling previously studied items, elaborative processing enhanced performance.

Taking advantage of the capability to induce implicit or explicit recall while holding encoding and retrieval tasks constant allows scrutiny of the processing theory which suggests that the successful retrieval of an item depends on matching the type of processing done at encoding with the processing done at retrieval. Differences can be attributed to data-driven or conceptually driven processes, without confounding from different materials or cues. If implicit memory, as measured by stem completion, is truly a data-driven task, then changes in the character font of the letters between primes and stem cues should result in lower performance than if there is no change. Explicit memory, however, should not exhibit this difference - physical changes, such as varying the font, should have no effect on conceptually driven processes. The experiment carried out as part of my research attempted to equate performance on implicit and explicit memory tasks by employing Graf's et al. (1982) simulating amnesia technique, then compared performance between these two kinds of memory when the physical attributes of primes and stem cues were changed or held constant at test. Support for the processing view would be found if, as shown in Figure 1, the characteristic data-driven decrement in performance due to physical alteration was found for the implicit memory task but not the explicit task.

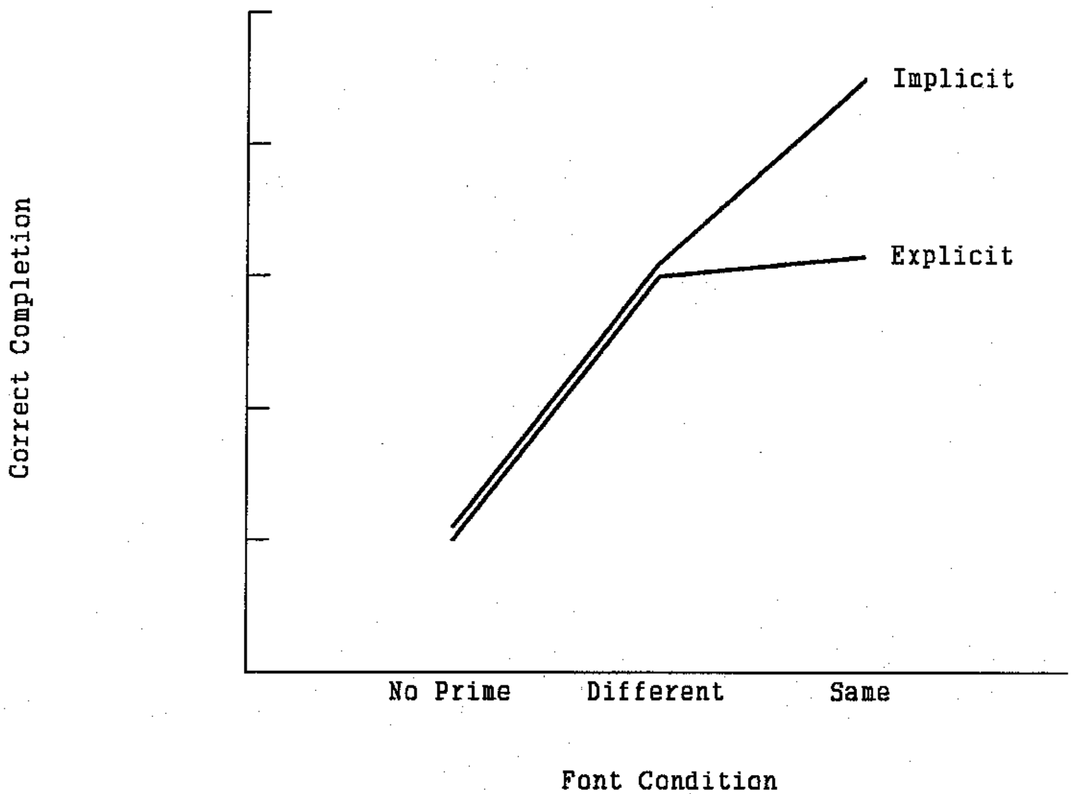

Figure 1. Expected performance on Explicit and Implicit memory tasks for No Prime, Different Prime and Same Prime Conditions.

Sometimes the level of performance on an implicit task can actually be higher than performance on an explicit task. Hashtroudi et al. (1988) found that the absolute level of cued recall was no higher than identification (of degraded words). Graf and Mandler (1984) found that the absolute level of cued recall was higher than stem completion with semantic processing but actually lower with physical processing. The vowel decision task which will be employed in this experiment is a physical processing task and should result in performance with implicit memory equal to performance with explicit memory when fonts are different. When fonts are the same, the additional physical cues should boost performance on implicit memory (suggesting a data-driven task) past that of explicit memory which should not increase (suggesting a conceptually driven task).

Method

Subjects

Subjects were 54 University of Manitoba introductory psychology students for whom participation in experiments was a course requirement.

Materials

Words were selected from Graf and Williams' (1987) completion norms for three letter stems. Graf and Williams list 40 word stems and the frequency with which various words are reported as the first completion of those stems. All 40 stems were used in this experiment. The number of different first completions for these stems ranged from 8 to 30 (M = 18.2). They also tabulated the second to sixth completions for each stem. The range of possible completions was 20 to 81 (M = 41.5).

Primes were selected from the many words they list as completions for the stems. Primes were usually the third but sometimes the second, fourth or (rarely) the fifth most frequent completion of a word stem. Emotionally charged or especially memorable words (in the experimenter's opinion) were not selected as primes. Most words (selected as primes) were five or six letters long, but some were four and some were seven letter words. Word stems were the first three letters of each of the primes. The mean probability of first completion of the word stems with the words selected as primes was 11.08% according to the Graf and Williams norms for unprimed completion.[6]

In addition, eight words and their stems were added to increase the total number of items to 48. This allowed the words to be evenly divided into three conditions. The additional eight words were chosen from a dictionary such that their first three letters could form a stem with at least eight alternate completions and that the stems were different than any of the other stems in the experiment.

<u>Design</u>

The experiment was a 2 X 3 factorial mixed design. Instruction for implicit or explicit recall was a between subjects two level variable, while priming condition (no prime, different font prime, or same font prime) was a within subject variable. The dependent variable was the number of word stems in each condition successfully completed with a word from the 48 item list.

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[6]See Appendix B for a list of the words used as primes in this experiment.

Procedure

Subjects were presented a list of 44 stimulus words. The first 8 and last 4 items were filler items to deal with primacy and recency phenomenon. The remaining 32 items were from the test list. Words were presented in two different fonts; half of the words were presented in Font A and half in Font B. Implicit and explicit memory for these words was measured with a stem completion task.

The 48 test words were randomly assigned to the three priming conditions so that there were 16 words in each of the no-prime, different font priming, and same font priming conditions. There was a unique random assignment of words to conditions for each subject. During the priming phase, each word from the different and same font conditions was displayed on a video monitor[7] such that half the words within each condition were presented in Font A and half in Font B[8].

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[7]The materials were displayed on a colour monitor driven by an EGA compatible card in an IBM XT clone running at 8 MHz.

[8]Font A was Turbo Pascal's "Default Font", and Font B was the "Triplex Font". See Appendix D for an example of a prime and a stem in Font A and Font B.

To reduce the effect of explicit recall on the stem completion task, Graf et al.'s (1982) vowel decision task was employed during the priming phase. The subjects were required to judge whether the currently presented word had any vowels in common with the previously presented word. Following Graf et al.'s procedure, eight filler words were used at the beginning of the list to acquaint subjects with the procedure, and four filler words at the end of the list to prevent rehearsal of the last few primes.

The primes were presented one word at a time in the centre of the screen. The rate was self-paced, with each prime displayed until the subject entered a Y or N in response to whether the word shared any vowels with the previous word.[9]

Following the vowel decision task, subjects were asked to complete 48 word stems (the first three letters of a word). Stems in the no-prime condition were new (the 16 words not seen in the priming phase) and half appeared in each font. The other stems appeared in either the same font or the different font to that font occurring in the priming

[9]See Appendix E for instructions.

phase. Each stem appeared in the middle of the screen and subjects typed their completions which appeared in the same font as the stem already on the screen. This task was also self paced.

All six possible font order combinations occurred equally often for each subject (e.g., same [eight primes and stems in Font A; eight primes and stems in Font B]; different [eight A prime, B stem; eight B prime, A stem]; and noprime [eight A stem; eight B stem]).

Priming condition was a within subject variable. The second variable - a between subjects variable - was the instructions given for completion of the stems. One group was told to complete the word stems with "the first word that comes to mind". This task has been referred to as a word completion task (Graf, Squire, & Mandler, 1984). Since the letter cues were the only aids to completing these stems this can be thought of as a data-driven task. The other group was told to complete the stems with "a word from the list". This has been called a cued recall task by Graf, Squire, and Mandler (1984). To avoid confusion with the conventional cued recall[10] task, the term constrained completion will be used to refer to the explicit attempt to complete a stem, constrained by the stipulation that it should be completed with a previously presented word. This may be thought of as a conceptually driven task since subjects should use higher concepts in an effort to complete the stems rather than only the physical cues (i.e., word fragments). Although subjects attempted to explicitly recall words from the previous task, this was very difficult because explicit memory for the items should have been virtually eliminated due to the vowel decision task (Graf et al., 1987).

The software to control the experiment and collect the data was written by the experimenter in Pascal using Borland's Turbo Pascal, Version 4.0.[11] This implementation of the language allowed screen output to be displayed in several typographic fonts in any specified size. It also supported the Hercules monochrome graphics card and EGA

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[10]In the typical cued recall task a pair of words is studied, then one of the words is given as a cue to aid recall of the other.

[11]See Appendix C for a complete listing of the Turbo Pascal program used to run this experiment.

graphics cards which produce a high resolution display. Randomizing the order of the list of primes and the order of the stems, as well as random assignment of the 48 words to the three priming conditions was done with the Pascal program.

Results

Assumptions Checks

The data were examined for potential irregularities that may bias the results or violate the assumption of the statistical tests. One such possibility was potential outliers. Stevens (1986) has suggested that any value that is more than three standard deviations from the mean could be a potential outlier. Only one subject exceeded the 3 s value when using the overall pooled mean (subject 29). When the data were considered by instructional condition, this subject no longer had an outlying score but subject number 18 did. The data were analyzed with subject 29 deleted, with subject 18 deleted, and with both subject 18 and subject 29 deleted. Appendix F shows the analyses of variance (ANOVA) summary tables for all combinations of potential outliers deleted from the data. Because the interpretation of the results following the deletion of outliers did not differ from the results with all data included the reporting which follows is on the data with all subjects included.

The assumption of homogeneity of variance was also considered. For the F_{Max} test of homogeneity of variance in

Tabachnick and Fidell (1983) to yield significant results the ratio of the maximum to minimum variance must be about three to one (3:1). Because all variances were very close, it was concluded that the assumption of homogeneity of variance was not violated.

On a post experimental questionnaire, subjects were asked questions about their native language and about the strategy that they employed during the experiment to complete the stems. Due to a high proportion of foreign students in the sample it was speculated that language differences may have affected the results. The data were analyzed with a three-way General Linear Model (GLM) procedure with language as one of the factors. No main effects or interaction effects involving the language factor were found (see ANOVA summary table, Appendix F).

Many subjects answered the questions related to their strategy use with an unexpected response for their instructional condition. For example, some subjects that were told to use the first word that comes to mind to complete the stem reported that they always tried to complete the stems with a word presented in the vowel decision task - a strategy appropriate for the other group, not for theirs. To rule out an effect that might be due to a strategy other than the one intended for each group's use by the experimenter, the data were also analyzed on the basis of the subject's reported strategy. It was found that there were no differences due to the subject's reported strategy (see Appendix F).

Correlations were obtained between all variables to ensure that there were not any unintended relations. Some variables that were transformed or created from other variables or otherwise expected to be related were found to be correlated. For example, reported strategy was correlated to instruct condition (r = .417) as was subject number (r = .265, because subjects were tested in blocks). Except for such expected associations, there were no significant correlations between variables (see Appendix G).

Data Analyses

The mean number of correct responses in the no prime condition was 1.98 (out of a possible 16). This serves as a baseline measure (or control condition) for the probability of completing the set of stems used in this experiment with the words that had been selected as desired responses because the subjects would have been unbiased by experimental manipulations in their completion of these stems. In the different font condition the mean was 3.18 correct and in the same font condition the mean was 3.87 correct. A 2 X 3 mixed model analysis of variance (ANOVA) showed that font condition had a significant effect on the number of correct responses, $F(2, 104) = 24.83$, $p < .0001$.[12] The same analysis also showed that there was no significant effect on the instruction factor, that is, the implicit group ($M = 2.80$) scored just as high as the explicit group ($M = 3.22$), $F(1, 52) = 1.77$ $p > .05$. There was also no interaction effect, $F(2, 104) = 1.46$, $p > .05$. A subsequent Duncan test on the font condition factor revealed that all three conditions were significantly different from each other. Scores in the different font condition were higher than scores in the no prime condition but lower than scores in the same font condition. (See Table 1 for a summary of these findings.)

[12] Type 1 error was set at = .05 for all tests.

Table 1.

Mean Number of Correct Stem Completions as a Function of Font Condition and Completion Instructions

	Instruction Condition	
Font Condition	Explicit	Implicit
No Prime	1.96	2.00
Different Font	3.63	2.74
Same Font	4.07	3.66

Because the groups were not expected to differ in the no prime condition, this condition was deleted leaving only the two experimental conditions and the data was re-analyzed with a 2 X 2 mixed model ANOVA. The results reconfirmed the outcome of the first ANOVA. Instructions had no significant effect ($F(1, 52) = 2.39$, $p > .05$) nor was there an interaction between instruction and font condition ($F(52, 1) = 0.94$, $p > .3359$). Font condition had a significant effect overall on response scores ($F(1, 52) = 7.64$, $p < .0079$).

Within subject t-tests were conducted to analyze the simple main effects of font for each instruction condition using the mean square error ($MS_E = 2.00547$) from the overall one-way ANOVA (collapsed over instruct conditions) as an error term with its associated degrees of freedom (*df* = 106). For the implicit condition there was a significant difference between same font and different font scores ($t_{(106)} = 3.74$, $p < .0005$). In the explicit condition the results were also significant, but only marginally so ($t_{(106)} = 1.99$, $p < .05$).

In spite of the fact that the interaction effect was nonsignificant in both data analyses, and that in both the implicit and the explicit conditions there were significant differences between same font and different font conditions, the difference between same and different font conditions for the implicit instruction group appeared to be of a greater magnitude. As a result, the implicit and explicit groups were compared on the magnitude of improvement from the different font to the same font conditions. To accomplish this analysis, a dummy variable was created in which the values 0 and 1 were assigned to the different and same font conditions. The dummy variable was then used as the independent variable and the two scores for each subject on the different and same font conditions were the dependent variable in the calculation of two regression equations -

one for each instruction conditions. The slopes were then compared with the appropriate t-test (Kleinbaum, Kupper, & Muller, 1988, p 266). The slope of the implicit group was found to be significantly greater than that of the explicit group ($t_{(50)} = 3.56$, $p < .0005$). Further evidence from the slopes of these regression equations comes from the SAS t-tests generated by default for all regression equations. The slope of the explicit regression line (.444) did not significantly differ from 0 (a horizontal line), suggesting that there was no improvement in score in the same font condition compared to the different font condition, $t_{(1)} = 0.841$, $p > .05$. The slope of the implicit regression line (.926) did differ significantly from 0 implying that the score was higher for the same font condition than the different font condition, $t_{(1)} = 2.095$, $p <.0411$.

Discussion

The experiment was designed to test the hypothesis that stem completions in the explicit condition would be no better than the implicit condition due to the vowel decision task which was designed to prevent elaborative processing of the primes. This was the case as there was no main effect for instruction condition. The primes were effective in eliciting the selected completions for each stem as could be seen from the marked increase in correct completion performance between the control (no prime) and the experimental (same and different font) conditions.

It was hypothesized that the same font condition would be completed better than the different font condition for the implicit group but not for the explicit group because physical cues are important for implicit memory. Explicit memory, which uses semantic or conceptual cues, would be unable to make use of the additional information from the similarity of the fonts. The clearest way to demonstrate this would have been to show a font condition by instruction condition interaction such that the implicit same font condition would be completed significantly more often than the explicit same font condition, while the different font conditions would not differ in the explicit and implicit conditions as shown in Figure 1. This was not the case.

Another way to demonstrate the hypothesis would be to show that the same font stems were completed significantly more often than different font stems in the implicit instruct condition but not for the explicit condition. Due to the mixed model nature of the design, it may have been possible to obtain such a result despite not finding a significant interaction. Here the results were ambiguous. When the simple main effects were tested using the error term obtained from all data, there were significant differences between the two font conditions in both the explicit and implicit conditions. This test, therefore, did not demonstrate any differences between explicit and implicit memory because the similarity of fonts aided stem completion in both cases. Although both instruction conditions showed differences between font conditions there was the possibilty that in one case the differences were significantly greater than in the other. This possibility was indicated by the magnitude of the difference in the implicit condition relative to the explicit condition.

Analysis of the slope of the regression lines showed that the change from different font to same font was significantly greater in the implicit condition than the change in the explicit condition. This suggests that implicit memory makes greater use of the physical cues than explicit memory, although explicit memory may also make some use of the cues. The finding that the slope of the explicit line is not significantly different from 0 would suggest that for explicit memory there is no benefit from the similarity of fonts.

Several conclusions can be drawn from the analyses of the data. Same font scores were decisively better than different font scores when subjects were given implicit memory instructions. The outcome of the tests in the explicit instruction condition also indicate that the same font scores were, although only marginally significant, better than the different font scores. These results, along with the lack of a significant difference between the implicit and explicit conditions on the same font scores, fail to differentiate between implicit and explicit memory. What can be said is that, based on the results of the regression analyses and marginal effects of tests for explicit scores, the improvement of the score in the same font condition over the score in the different font condition seems to be greater for implicit memory than for explicit. (See Figure 2 to compare the slopes of the lines.)

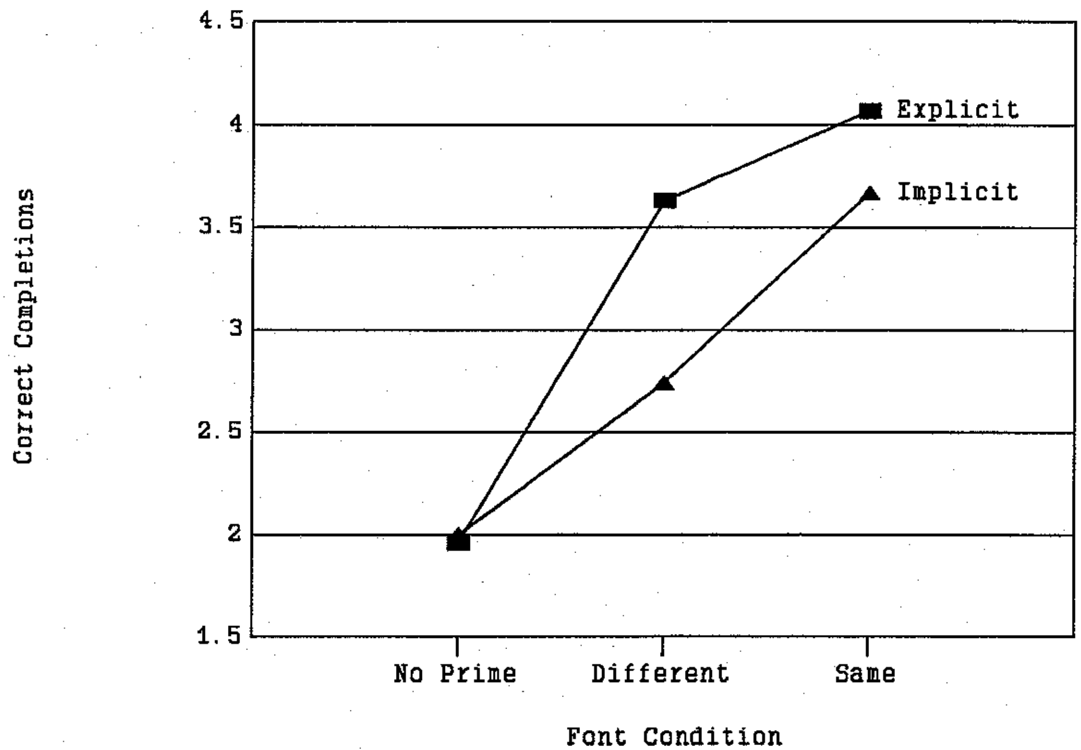

Figure 2. Results shown as number of correct completions (out of a possible 16) as a function of Font Condition and Instruction Condition.

This conclusion is compatible with the data-driven versus conceptually driven theory of implicit and explicit memory. The theory states that implicit memory is primarily data-driven while explicit is primarily conceptually driven. Schacter (1987) argues that there are components of each process in both kinds of memory and the present data are certainly compatible with such a conclusion. Thus we would expect data-driven processes to result in improved performance when physical cues are matched at the time of acquisition and at the time of test compared to an unmatched condition. This improvement would be most evident in implicit memory situations where the primary processes acting are data-driven. However, some evidence of data-driven processes may also be evident in explicit memory which is primarily, but not solely, data-driven.

The present results are consistent with many other findings in the literature. Jacoby and Dallas (1981) found that modality shift had a significant influence on implicit memory (tachistoscopic identification task) and had little effect on an explicit task (recognition). Hashtroudi et al. (1988) found that changes in modality reduced identification on a degraded word task and concluded that it was data-driven. They also found that, depending on how the data was analyzed, recognition also declined with modality change.

They concluded that these results were consistent with the data versus conceptually driven hypothesis but that several inconsistencies must be accounted for. The first was that, due to the decrease in recognition performance with modality change, recognition must rely on both conceptually driven and data-driven processing. The second is that, because there was substantial priming in the identification task even when modality was changed, there must also be some conceptually driven components to that task. In Hashtroudi's et al. experiment the relative rates of decline between the explicit and implicit tasks cannot be directly compared because of the different natures of the tasks. In the present experiment, however, the relative changes can be compared because both explicit and implicit tasks were examined with identical tests - stem completion.

Although this experiment did not provide as clear evidence as had been hoped for in support of the processing theory of implicit memory the results were nevertheless encouraging. A feature of this experiment that clouds interpretation of the results is the mixed model design. This design allows more power to detect effects between font conditions because it is a within subject factor, yet differences between instruction conditions (implicit and explicit memory), a between subject factor, had less power which may help account for the lack of an interaction effect in the analyses. Future research should replicate this experiment with the intent to make interpretation of the results more straightforward. This can be accomplished by introducing a few modifications such as the use a completely between subjects design. Statistics are easier, results are more clear, but power is not as great compared to within or mixed designs. The decrease in power could be compensated for by using more subjects.

Another useful change would be to ensure that the subjects are actually following the explicit or implicit instructions. The results of the post-experimental questionnaire suggest that there may have been some confusion over how to complete the stems; however, analysis of these responses indicated that lack of unity in reported strategies within groups did not result in differences in performance. Using Graf and Mandler's (1984) instructions verbatim may help to unify the strategies that subjects report as having been used. A related change to ensure that subjects in the implicit group do not spontaneously recognize that the words from the vowel decision task can be used to complete words in the stem completion task is to take additional steps to reduce explicit recall of the primes. This could be done by using a filler task between vowel decision and stem completion or by having subjects return the next day for the stem completion task. This would also have the effect of reducing the level of performance on the explicit task which was a little higher than that of the implicit group (but not statistically significant). Graf and Mandler (1984) found that the absolute level of cued recall (explicit instructions) was actually lower than the level of stem completion (implicit instructions) when primes were presented with a physical processing task, while Hashtroudi et al. (1988) found that implicit memory was just as high as explicit memory on a degraded word task.

Research on implicit memory is important in discovering clues about retrieval processes in memory, and inferences that people make which are often based on knowledge that sometimes can't be explicitly remembered. An example is performance on multiple choice exams. Students may choose the right answer more often than expected by chance even though they cannot recall or even recognize the answer in a meaningful way. For these reasons and others, such as understanding amnesia or aging in memory, research on implicit memory should continue. The particular paradigm used here could be used to inventory factors, such as which physical features are important (colour, size etc), that dissociate implicit and explicit memory. The computerized implementation of this experiment allows many aspects of implicit memory to be explored with only minor changes to the program and experimental design.

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Appendix A: Literature Review

Graf and Schacter (1985) have used the terms *implicit* and *explicit memory* to describe the difference between consciously recalled and indirect expression of previously acquired information. They use these terms because they are not as saturated with multiple meanings or conceptual ambiguity as terms such as unconscious or unaware memory (Schacter, 1987). Schacter also reports that these terms were first used by McDougall in 1924 who described "explicit recognition, which involves conscious recollection of a past event, and implicit recognition as a change in behavior that is attributable to a recent event yet contains no conscious recollection of it or explicit reference to it" (in Schacter, (1987), pp 505). Even though Schacter has claimed that the terms are descriptive concepts (they neither refer to, nor imply separate memory systems) there has been some ambiguity in referring to these terms. Richardson-Klavehn and Bjork (1988) pointed out that the terms implicit and explicit are often used to refer to tasks, as Schacter claimed, but that they are also used to describe hypothetical forms of memory. For example, Graf and Schacter (1987) stated that "they have used the terms explicit and implicit to describe the forms of memory indexed by these two type of tests" (p. 45). Richardson-Klavehn and Bjork (1988) argued that implying memory forms from types of tasks cannot be justified. For this reason they endorsed the terms used by Johnson and Hasher (1987), *indirect* and *direct measures of memory,* which refer only to methods of testing memory and which have no theoretical connotations. There have also been other names ascribed to traditional measures of memory such as *autobiographical, episodic*, and *intentional* tests of memory, while *unintentional, indirect*, and *incidental* have been used to refer to what Graf and Schacter call implicit memory tests (Richardson-Klavehn & Bjork, 1988). In this paper, the terms explicit and implicit will be used both to describe ways of measuring memory, and, as many current authors do, to refer to hypothetical memory structures or systems.

Examples of Implicit Memory

Implicit memory has been revealed on a great variety of tasks. The most popular test for implicit memory is the word stem completion task and the closely related fragment completion task. On the word stem completion task, subjects are presented with the first three letters of a word and asked to complete the stem with the first word that comes to mind. Typically, there are several words that are valid completions of the stem and the target word is not the most frequently completed word in non-priming conditions. Implicit memory is shown for words that had been primed because these words are used to complete the stem with a greater frequency than baseline performance (i.e., in a non-priming condition). The fragment completion task diverges slightly from stem completion in that the word fragments are words with several letters arbitrarily missing. There is typically only one completion possible for any given fragment.

Stem completion is currently the more frequently used task because of the possibility of measuring both implicit and explicit memory with identical retrieval cues for both tests. Graf and Mandler (1984) found that, when instructed to complete a stem with the "first word that comes to mind", subjects performance reflected characteristics peculiar to implicit tasks (in this case indifference to semantic or nonsemantic processing), but that, when instructed to complete the stem "with a word from the list" of primes, they performed as if it were an explicit memory task (semantic level of processing very important).

Another demonstration of implicit memory is the *lexical decision* task. On this task subjects must decide whether or not a string of letters is a legal word. The latency of making this lexical decision is reduced for words that have been presented previously, but nonwords show no or little priming (Kirsner & Smith, 1974).

A closely related test is the *tachistoscopic identification* task in which subjects are given a brief exposure (about 30 ms) to a stimulus and must identify it. Implicit memory is evident when the identification accuracy increases, or the necessary display time for accurate identification decreases, due to a prior presentation of that particular stimulus (Jacoby & Dallas, 1981). This task may also be referred to as *word identification* or *perceptual identification* (Schacter, 1987).

A phenomenon that has often been likened with implicit memory is that of procedural or skill learning. Glisky, Schacter, and Tulving (1986) reported that an amnesic woman was taught to enter data into a computer. It took many teaching sessions, and although she could not remember ever having done this task in a previous session, she gradually learned the skill. In fact, Schacter reports that she did not tire or become bored with the task, suggesting that she may not be able to remember that she had already been doing it for hours. Other researchers have found similar situations where a procedure can be learned even in the absence of explicit knowledge of that procedure. One such case is Lewicki, Hill, and Bizot (1988) who found that subjects (with normal memory) learned where on a computer screen a target would appear. The target's location followed a complex pattern. The subjects not only couldn't explicitly identify the pattern but they didn't even realize that there was a pattern or guess that the pattern of locations might be the experimental manipulation. That their decrease in reaction time and increase in accuracy was due to implicit knowledge of the pattern and not merely due to practice effects was shown by two factors. First, some of the target's locations could not be predicted on the basis of the pattern. Although the subjects' performance improved over time on these trials due to practice effects, it did not improve as quickly as "predictable" trials. Second, performance decreased sharply when the pattern was changed.

In 1911, Claparède (in Schacter, 1987) demonstrated a case of implicit memory when an amnesic woman refused to shake his hand. He had previously pricked her with a pin while shaking hands. Although she could not remember the incident, by refusing to shake hands she demonstrated an implicit memory for the incident.

In 1885 Ebbinghaus noted that not all memory is expressed with conscious awareness (Schacter, 1987). Using himself as a subject he found that he could learn items with fewer trials when these items had been learned 24 hours earlier, even though he could not explicitly remember the items. Savings for this material can be deemed to be implicit memory because performance was facilitated in the absence of explicit recall.

Degraded words are another method of assessing implicit memory that has many of the same features as the word fragment completion task. One of the similarities is that subjects are tested for response latency or accuracy to degraded words, some of which had been previously presented to the subjects as whole words and some of which are seen for the first time in the experimental setting. The major difference is that, instead of removing whole letters from the word, parts of each letter are missing. The letters are degraded by masking 25, 50 or 75% of the word with the background colour. This is one of the tasks that Warrington and Weiskrantz (1968) originally used to demonstrate that, in some situations, amnesics perform as well as normals on a memory test. A similar task that has been used by several investigators (Snodgrass, 1987; Snodgrass, Smith, Feenan, & Corwin, 1987; Weldon & Roediger, 1987) is the degraded picture task in which subjects must identify pictures that have been degraded in the same fashion as the letters.

Hashtroudi, Ferguson, Rappold, and Chrosniak (1988) used degraded letters to demonstrate many of the characteristics (originally found in other experiments) of implicit memory such as long-lasting resistance to extinction (24 hr in their case), not affected by elaborative processing, reduced performance due to modality change (auditory to visual, and auditory while imaging the text to visual) and the potential to change a typical implicit test to an explicit test by changing only the retrieval instructions.

Characteristics of Implicit Memory

One very notable characteristic of implicit memory is that it is intact in amnesics. Their explicit memory is not available to them but many experiments have shown performance equal to or almost equal to normals on implicit tasks. Schacter (1987) claimed that whether or not amnesics show normal retention "depends critically on the implicit/explicit nature of the test" (p. 509). The first to demonstrate normal or near normal memory in amnesics were Warrington and Weiskrantz (1968, 1970a, 1970b). Subjects were presented with fragmented words or pictures which were presented in successively less fragmented form until the stimulus could be correctly named. The memory test was a repetition of this procedure and memory for the item was demonstrated by identification at more fragmented levels than were first required during the initial presentation stage. Amnesic patients showed similar retention to normals when tests were conducted 1 min after presentation but on free recall and recognition, amnesics performance was much worse. Although amnesics didn't perform as well as controls at 1 hr and 24 hr intervals they still exhibited some savings by identifying the stimulus earlier than they had at the initial presentation.

More recently Squire, Shimamura, and Graf (1985) studied patients who were treated for depression with bilateral Electroconvulsive Therapy (ECT). When tested for recognition, all ECT patients performed at or near chance level. When tested for word fragment completion, the ECT patients performed as well as control subjects. As the amnesic effects of ECT wore off, recognition performance improved markedly, but word fragment completion remained stable.

Hashtroudi, Parker, DeLisi, Wyatt, and Mutter (1984) examined the effects of alcohol induced amnesia. Subjects who had been administered alcohol to a blood alcohol level of .08 g/100 ml were impaired on a free recall test after a single exposure to the test items, compared to subjects who had taken a placebo. The intoxicated subjects' performance on a degraded word identification task was unaffected. These results are similar to those found in other studies with chronic amnesics. A major difference, however, was found between alcohol amnesia and chronic amnesia in that recognition memory in alcohol amnesia was unimpaired.

Light and Singh (1987) found that older adults (mean age = 67.7) were impaired on memory tests which involved conscious recollection but were unimpaired on tests that implicitly measure memory. Their explicit measures were free recall, cued recall, and recognition. Their implicit measures were word completion and perceptual identification. The only difference between cued recall and word completion was instructions after the Graf and Mandler (1984) manner. Light and Singh noted that Craik's (1983) suggestion that age differences are due to differences in environmental support (older people needing more cues) is contradicted by this evidence because the least support is offered by free recall, an explicit task, and the most by cued recall and recognition, also explicit tasks. Word completion, which offers an intermediate degree of environmental support, resulted in equal performance regardless of age. They also noted that age related effects, when viewed in terms of implicit and explicit memory, closely paralleled those of amnesics and normals. Elderly people, like amnesics, are unimpaired on implicit tasks but are disadvantaged on explicit memory tasks.

Two other kinds of findings have especially demonstrated an independence between explicit and implicit memory. One is the statistical independence of items retrieved under explicit and implicit conditions. This measure of independence is based on an item by item analysis rather than on average performance of one task compared to another. Jacoby and Witherspoon (1982) found that performance on a perceptual identification task was independent of performance on a recognition task when measured by comparing the degree to which retrieval of any given item predicts successful recall of that item on the other task. Although they examined this in terms of the episodic-semantic memory distinction to account for the difference between memory with and without awareness, it should be pointed out that their tasks also fit the implicit - explicit distinction. Kolers (1976) also found statistical independence between an implicit memory task (speed of reading inverted text) and an explicit task (recognition that a specific passage had been read before).[13]

Tulving, Schacter, and Stark (1982) claim to have found stochastic independence between recognition and word fragment completion. When they tested fragment completion before recognition, they found that the two were positively

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[13]Koler's study will be discussed later.

correlated. They state that this is not surprising because completion of a fragment would increase the likelihood of a positive response on a recognition test (because the subject saw the word twice: priming and fragment completion). However, when recognition was tested first, the probability of correct fragment completion was completely independent of recognition accuracy. Their conclusion was that the probability of remembering an item on a recognition test is completely independent of the probability of correctly completing a word fragment with that item. However there is no way to measure stochastic independence with their paradigm. The fact that a recognition test was given before fragment completion means that there would be priming due to the items on the recognition test, regardless of whether these items were judged as old or new. In fact, they found that priming from the recognition test resulted in greater correct fragment completion than priming from the original study trial (5 s study time per item). Thus, any relation between implicit memory performance and explicit memory of the study trial would be greatly overshadowed by the priming effects of the recognition test. Their claim that fragment completion is equally probable whether a person correctly recognized that item or not does not mean that an item can be stored in one kind of memory but not another. It simply means that presentation of these items on a recognition test, regardless of subject response, results in equal priming on word fragment completion tests. Tulving (1985) defended this conclusion by pointing out that a dependency is found between individual items on recall and recognition tests. Perruchet and Baveux (1989) pointed out, however, that this argument is irrelevant because recall and recognition are both highly sensitive to repetition effects. If, for example, one recalls an item on a free recall test, that person is more likely to subsequently recognize it than items that were not recalled but were in the original study list.

According to Witherspoon and Moscovitch (1989), stochastic independence is not found between recognition and free recall. This is consistent with the view that similar processes may underlie both tasks. Evidence for independence between explicit and implicit tasks may suggest separate processes or systems for each. However, Parruchet and Baveux (1989) found dependence between some implicit tasks and explicit tasks (perceptual clarification and word fragment completion were related to recall and recognition) and independence between some implicit tasks (tachistoscopic identification and anagram solution are implicit tasks, but were not related to the other two implicit memory tasks). Witherspoon and Moscovitch (1989) also found statistical independence between two implicit tasks (word fragment completion and perceptual identification). The theoretical implications of these findings will be dealt with when I discuss multiple memory systems.

Another class of findings that supports independence between explicit and implicit memory is the time course of forgetting for the two kinds of memory. Implicit memory for items lasts much longer than explicit memory. In this case Tulving et al.'s (1982) results are more clear cut. They measured explicit memory (recognition) and implicit memory (fragment completion) 1 h, and 7 days after the study list. They found that explicit memory declined markedly over the seven days but that implicit memory remained the same. According to the fragment completion test there was no forgetting over the period of one week.

This finding of resistance to extinction in implicit memory was replicated and extended by Komatsu and Ohta

(1984). They measured recognition and fragment completion 8 min, 1 week, and 5 weeks after subjects saw a priming list. They found that recognition performance dropped substantially over each retention interval, but that fragment completion showed almost no difference when compared at 8 min or 1 week and declined only about ten percent after 5 weeks (Experiment 1). In a second experiment they found that word fragment completion was the same whether tested 1 min., 1 hr, or 1 week after study.

Sloman, Hayman, Ohta, Law, and Tulving (1988) studied fragment completion performance over six different intervals from 18 min. to 16 months (Experiment 2). Although performance dropped considerably over this time interval, completion was still facilitated by the study list 16 months later. This time frame is similar to that of Kolers (1976) who found that passages of inverted script that had originally been read a year earlier (also in inverted script) were read faster than inverted passages seen for the first time.

Various encoding manipulations and retrieval cues affect implicit and explicit memory in different ways. In general, any manipulations that have to do with levels of processing have quite dramatic effects on explicit recall, with deeper or more elaborative processing resulting in greater recall than shallow or non-elaborative processing. Levels of processing, however, has no effect on implicit tasks. For example, Jacoby and Dallas (1981) asked subjects to process a list of words elaboratively (answer questions about meaning) or non-elaboratively (deciding whether word contains a certain letter). They found that recognition test performance was greatly influenced by type of study processing. However, on a word identification test, the study manipulation had no effect. Graf and Mandler (1984) found similar results when test cues were identical (first three letters of a word) and only completion instructions were varied to produce an implicit or explicit test. Implicit memory was unaffected by an elaborative processing manipulation but explicit test results varied depending on degree of elaboration.

Another line of evidence that suggests that conceptual factors that are important to explicit recall don't affect implicit memory is that of interference. Using an AB, AC interference paradigm, Graf and Schacter (1987) showed that retroactive and proactive interference do not have an effect on the word stem-completion task. Subjects studied a target list of pairs of words designated AB (e.g., shirt-window). They also studied an interference list of words designated AC (e.g., shirt-finger) in the experimental conditions and CD (e.g., rock-phone) in the control conditions. While the experimental conditions shared the first or A word in a pair between the target and interference list, the control conditions had unique words between the two lists. The AB target list was studied after the interference list in the proactive interference conditions and before the interference list in the retroactive interference conditions. Memory was then tested with both cued recall (explicit) and stem completion (implicit) by changing the recall instructions. Cues were a complete A word along with the first three letters of a B word (e.g., shirt-win). The AB pairings were either the same as in the study target list (same context) or in a different context. They found that the experimental group did not differ from the control group when memory was tested with stem completion. This held for same context and for different context conditions. However, on the explicit task both proactive and retroactive interference was found in both context conditions. Sloman et al. (1988) also failed to find proactive or retroactive interference in a word-fragment completion task.

Although interference affects explicit but not implicit memory, changes in surface information or physical attributes of the stimulus and cues seem to have the opposite effect. Implicit memory appears to be greatly dependent on changes of this nature while explicit memory is unaffected.

Koler's (1975, 1976) had subjects read inverted text, some of which had been read (inverted) 13 to 15 months earlier. He found that skill for reading inverted text increased with practice but also that performance (speed and accuracy) of previously read text was enhanced above that of normal practice effects. This was uncorrelated with subjects's explicit memory of whether the sentences were old or new.

According to Roediger and Blaxton (1987b), modality has no effect on free recall, and typography has little effect. Jacoby and Dallas (1981) showed that changes in modality (from auditory at study to visual at test) had no effect on recognition but had a large effect on a speeded word identification task. That is, they found that on a visual recognition test, performance was equal for auditory and visual study conditions. Changes or no changes in modality did not matter. However, only visual presentation (not auditory) at study primed items for the word identification task, showing that changes in modality are of critical importance in implicit tasks.

Roediger and Blaxton (1987a) used a word completion task and in Experiment 1 found that auditory presentation did facilitate performance but not as much as visual presentation. They also found that words studied in hand-printed form were better completed when the fragments were also in hand-printed form than when they were typed. In Experiment 3 they presented the study materials either in focus or blurred and found that, when the fragments matched the study condition, performance was superior to when they didn't match. Likewise, Graf, Shimamura, and Squire (1985) found shifting modality reduced performance on a stem-completion task, but that, when the stems were completed in the explicit instructional condition (cued recall), modality had no effect.

Theoretical Accounts of Implicit Memory

There have been many explanations offered as to the underlying basis for producing the observed differences in implicit and explicit memory. I will discuss several of these theories including two activation models - the threshold model and a semantic activation model, two multiple memory system theories - one in which memory is divided into episodic and semantic memory, and one in which memory is divided into implicit and explicit memory systems, and finally I will take a processing approach and examine transfer appropriate processing.

The most obvious interpretation is what could be called a threshold model (Schacter, 1987) or a trace strength theory (Roediger & Blaxton, 1987b). Different tests have different thresholds at which memory traces can be detected. Implicit tests are simply more sensitive measures of memory than explicit tests and thus weaker memories can be detected. This would account for the long lasting effects found on some tasks. As the strength of a memory trace decays, less sensitive tests, such as free recall, will no longer detect that trace but more sensitive tests may. This notion parallels old theories that suggested that recall and recognition differences reflected differences in trace strength. Schacter (1987) does not give this view serious consideration. He points out that the differential effect of some variables and the statistical independence between implicit and explicit tests rules out an interpretation where differences are due only to sensitivity to trace strengths. Roediger and Blaxton (1987b) pointed out that, according to this model, remembering relies on the strength of the trace and that, if one trace is stronger than another, it should be stronger no matter which test is used. The relative strengths cannot be apparently reversed on different tasks.

Mandler (1980) has proposed that two processes are necessary for recall - activation and elaboration. When a word is presented it is automatically activated which increases (temporarily) the availability of the word. This fits with Anderson's (1983) semantic activation model in which memory traces that are activated are more accessible and more likely to be selected in a retrieval task. For explicit recall to occur, there must also be elaboration where the word is effortfully related to the experimental context and to other items in memory. A widespread interpretation of implicit memory is that priming activates preexisting memory traces which, even in the absence of elaboration, allow more probable responses for those traces on implicit tasks. This line of reasoning can be seen in the title of Graf and Mandler's 1984 paper, "Activation makes words more accessible but not necessarily more retrievable".

Some evidence that supports this theory is a perceptual-identification task in which amnesics did not show a priming effect for pseudowords (Cermak, Talbot, Chandler, & Wolbarst, 1985). This would be expected since there are no preexisting traces to be activated (i.e., the amnesics would never have encountered these pseudowords before). Rozin, 1976 (in Graf, Mandler & Schacter, 1984) suggested that the ability to activate old mental representations may be intact in amnesics. The activation view is supported by the findings that amnesics show normal priming for items that have preexisting memory representations and perform normally on implicit tests but do not seem to acquire new material and perform poorly on explicit tests.

However Graf and Schacter (1985) point out that most tests that demonstrate lack of the ability to acquire new associations have been explicit tasks. They describe Moscovitch, (1984) (in Graf & Schacter 1985) who had amnesics memorize word pairs. Subjects then had to read the words in the same or different pairings from a degraded display. Moscovitch found faster reading times with the same pairings suggesting retention of this newly acquired contextual information on an implicit measure. Graf and Schacter (1984) added to this evidence by using word-pair primes on a word stem completion task, where the cue was the first word plus the first three letters of the second word. The first word was either the same as the word originally paired with the second word or a different pairing. When previously paired words were used as cues, greater priming was observed than when new pairs were used (in some conditions). This was true for both memory non-impaired college students as well as amnesics showing implicit memory for new associations, even where explicit memory could be ruled out.

Graf and Schacter (1987) confirmed that new associations could be detected with implicit tests and further found that interference affects explicit but not implicit memory (i.e., their AB-AC paradigm discussed in a previous section).

When dissociations begin appearing in the literature the first suggestion many people have is multiple memory systems. This is especially appealing in cases where there is stochastic independence between two memory measures (compared to, for example, a trace strength theory). The general idea is that an item can be stored in one memory system while not necessarily being stored in another system. It seems to make intuitive sense that, if item retrieval is independent on two tasks, the underlying memory systems may be independent. This has resulted in the suggestion that Tulving's episodic/semantic distinction could account for the observed differences where explicit tasks are really a form of episodic memory and implicit tasks are a form of semantic memory. Tulving (1983) has used the term episodic to describe memory for a specific time and place or occasion, and semantic for memories that don't require reference to a particular incident. Thus, knowledge that fire will burn is semantic memory because one doesn't know (or need to know) when that knowledge was first acquired. The recall of a specific incident in which you burned yourself is episodic memory. This taxonomy has been used to describe both two kinds of memories and two distinct hypothetical underlying memory systems responsible for dissociations in the recall of these types of information.

Tulving's division is not adequate to describe the memory dissociations that recent research has been demonstrating. Specifically, it does not deal with memory of which a person is unaware, since episodic memory requires an episode and semantic memory, while not requiring autobiographical details, may very well be fully in a person's consciousness. Obviously, attributing implicit and explicit tasks to different memory systems is not consistent with Perruchet and Baveux's (1989) and Witherspoon and Moscovitch's (1989) findings of independence between some implicit tasks and of dependence between some implicit and explicit tasks, unless one invents a new memory system every time a dissociation is found (e.g., Tulving, 1984).

Blaxton (in Roediger and Blaxton, 1987b) tested the utility of Tulving's episodic/semantic distinction against the data-driven/conceptually driven classification. Data-driven processes operate on physical features of the stimulus while conceptually driven processes rely on abstract or mentally constructed features of the stimulus.

She found that tasks viewed as data-driven or conceptually driven better accounted for the data than when tasks were viewed as episodic or semantic memory. Typically, tasks that have been attributed to episodic memory by Tulving have been conceptually driven and those attributed to semantic memory have been data-driven. With only these two cells in most experiments, Roediger and Blaxton were not surprised that Tulving found dissociations in accordance with his distinction. Blaxton, however, used four cells in her experiment. Two of the tasks (graphemic cued recall[14] and free recall) are episodic tasks and two (word fragment completion and a general knowledge test) are semantic tasks according to Tulving's criteria. In addition to this categorization, one task from each class can be classified as data-driven (graphemic cued recall and word fragment completion) and the other two as conceptually driven (free recall and general knowledge test). Words were studied in either no context, context, or generate conditions. The pattern of performance for each retrieval task across the

---

[14]The graphemic cued recall test uses cues that look like the target item (e.g., CHOPPER for COPPER.) Subjects were instructed to try to recall words that looked like the cue and that the meaning of the cues is irrelevant.

three study conditions should reveal which tasks are more closely related (and thus which should be under the same classification). Her results showed that free recall and general knowledge showed the same pattern (generation superior to context which was superior to no context study conditions) and that graphemic cued recall and word fragment completion showed the opposite pattern (no context superior to context which was superior to generate conditions). These pairings suggest that, if two memory systems are involved, the implicit/explicit classification better explains the results than the episodic/semantic classification.

A theory supported by Blaxton's results is the Processing Model (Schacter, 1987). This view emphasizes the kind of processing done at time of retrieval and how it matches processes carried out at time of encoding. This is different than the standard levels of processing approach where different processes at encoding produce different degrees of recall. In this case the more the processes required by the retrieval test parallel those executed at encoding the better recall for that material will be. The most popular and well described implementation of this concept is Jacoby's (1983b) data-driven (bottom-up) and conceptually driven (top-down) processing model. Processing requirements which emphasize perceptual information or physical features is said to be data-driven. Semantics, meanings, and abstract associations of the stimulus exemplify conceptually driven processes, which are subject initiated. Data-driven processes are initiated and regulated by the physical information that is actually in the test stimulus.

When a stimulus is presented, subjects process it in several ways. This processing usually involves both the physical features of the stimulus and conceptual attributes of it. At the time of retrieval different aspects of the stimulus may be recalled, depending on the nature of the retrieval test. Differences between explicit and implicit memory are thus due to differences in the processes used to retrieve the items. Explicit memory is the result of conceptually driven processes and implicit memory is the result of data-driven processes. It has been argued that some recall tests have components of both kinds of processes (e.g., Roediger & Blaxton, 1987b, Schacter, 1987). For example, in a word-fragment completion task subjects may use the pattern of given letters and blanks to find a word that fits (data-driven) but they may also try to explicitly recall the entire list of words in an attempt to stumble across one that fits (conceptually driven). While it is acknowledged that some tasks may be both, this theory argues that implicit tasks are mostly data-driven and explicit tasks are mostly conceptually driven. Some tasks can be found that more obviously involve processing of only one kind or the other. Free recall, for example, is conceptually driven since no data is provided. Implicit tasks such as word stem completion or perceptual identification are more obviously data-driven because, in some circumstances, conceptual attributes cannot be involved such as when the subject makes no attempt to recall material or where the subject cannot explicitly recall the items (e.g., amnesic subjects, the vowel decision task, or where sufficient time has elapsed).

This model neatly fits the results of Blaxton's study as well as most of the other findings already discussed. Multiple memory systems are not necessary for this theory, different processing strategies account for the observed differences. Especially relevant to this model are the results of experiments where instructions are varied. Although the processing theory states that what is remembered depends on the match between processes at encoding and retrieval the implicit/explicit instruction paradigm equates encoding in both conditions because the instructions are given after the materials have been presented for encoding. This technique seems clearly to direct one's attention toward either the physical attributes or higher conceptual processes involved in the retrieval procedure. The fact that nothing about the encoding of items or the retrieval cues has been changed leaves only retrieval strategy to account for the differences.

Appendix B

Experimental Materials.

ABOLISH
ACCENT
AFFIRM
BANISH
BRIDE
CHASE
CLAP
COLLAR
DECIMAL
DEFEND
DEPART
DRAGON
ENGAGE
EXPLAIN
FILTER
FLOOR
FORT
FRAGILE
GARDEN
GENTLE
GRAPE
GROUP
HARASS
IMPLICATE
JUNIOR
LAMBASTE
LEAN
MARRY
MORAL
NORMAL
OBSTACLE
PARTY
PERPLEX
RELATE
RESIST
RETINA
SALUTE
SCAR
SCOLD
SHAPE
SHOE
SPIDER
TENDER
THINK
THREE
TRADE
TRITE
WEAVE

Appendix C

Font Experiment Program

The computer program that controlled the stem completion experiment was written in *Turbo Pascal 4.0*. The program first asks for the subject number and experimental condition, then reads a file of filler items and a file of experimental materials. The experimental items are assigned three sequences of random numbers (seeded from the system clock). One sequence determines the font assignment pattern for primes and stems and the other two sequences determine the order of presentation of primes and of stems.

The program waits for the keys **Cntrl** and **S** to be depressed simultaneously to prevent subjects from starting the experiment before instructed to do so. The fillers and primes are then presented, the program stores the yes no responses and again the program pauses to ensure that subjects await further instructions before beginning the stem completion portion of the experiment.

Cntrl R restarts the program which presents the first three letters of a word, displays the subject's response in the appropriate font and size, and stores the completed word. Provisions are made to allow subjects to correct mistakes by erasing the letters that they typed using the back space or left arrow key. The raw data is then sorted in alphabetical order according to prime and written in its entirety to a file. Tabulated data is also written to a file. The file names have the subject number appended to them to facilitate organization and assimilation into a comprehensive raw data file.

Descriptions of the individual procedures are included as comments in the program listing.

```
program Exp_Font;

uses
   crt,
   graph;

type
   Word_Rec =  record
  {stores all relevant information about a stimulus item}
     prime,              {original item from stimulus list}
     Resp   : string[10];            {subjects' response}
     stem   : string[3];        {1'st 3 letters of prime}
     Font_Cond,          {same of different font condition}
     score,     {Is response the same as prime? (1 or 0)}
     prime_order,           {stores presentation position}
     stem_order           {stores stem presentation order}
            : integer;
     Rnd1,            {random assignment of font condition}
     Rnd2, Rnd3          {random order of primes and stems}
            : real;
     Y_N    : char;     {response to vowel decision task}
     end;   {record}

const
   f : string[8] = 'prime48';  {name of ASCII prime file}
   h : string[8] = 'filler12'; {ASCII filler file}
   lsize = 48;                 {size of prime list}
   fsize = 12;                 {number of fillers}
   black = 0;                  {background colour}
   white = 15;                 {colour of letters}
   FontA = 0;                  {FontA = DefaultFont}
   FontB = 1;                  {FontB = TriplexFont}

var
   Gd, Gm,                     {graphics variables}
   Font,                       {holds current font style}
   count :integer;   {# of letters currently in subject's
                                                 response}
   PEQ   : char;             {post experimental question}
   raw_dat_subn,          {Handles for raw data file and
                                                tabulated}
   tab_dat_subn : string[8];  {data file. Equiv to f for
                                            the read file}
```

```
   sub_n        : string[3];              {subject number}
   Group,     {Implicit or Explicit instruction condition}
   Language1,  {records Y/N if English is first language}
   Language2    : char;       {language of preferred use}
   item   : array[1..lsize] of Word_Rec;      {stimulus
                                               materials}
   filler : array[1..fsize] of String[10]; {filler items}
   X : char;

{--------------Request Subject Number----------------}

procedure Request_Subject_Number;
begin
   ClrScr;
   write('Type your subject number and press the RETURN
                                               key. ');
   Readln(sub_n);
   write('Enter Between Factor Condition  (I/E) :  ');
   Read(Group);
   ClrScr;
   raw_dat_subn := Concat('r_dat',sub_n);
   tab_dat_subn := Concat('tab_d',sub_n);
end;

{------------------Read Stimulus----------------------}

procedure Read_Stimulus;
{reads stimulus items and assigns three random numbers to
each item}
var
   primefile : text;
   i         : integer;       {index}
begin
   randomize;
   assign(primefile,f);
   reset(primefile);
   for i := 1 to lsize do
      with item[i] do begin
         readln(primefile,prime);
         stem := prime;
         Rnd1 := Random;
         Rnd2 := Random;
         Rnd3 := Random;
```

```
         Y_N := 'U';          {U for unititialized}
         end;    {with  (for)}
   close(primefile);
end;

{-----------------Read Fillers-------------------------}

procedure Read_Fillers;
{reads practice and filler items from a filler file}
var
   fillerfile : text;
   k          : integer;
begin
   Assign(fillerfile,h);
     Reset(fillerfile);
     for k:= 1 to fsize do
        Readln(fillerfile,filler[k]);
end;

{--------------------Sort-------------------------------}

procedure Sort(key:integer);
{Case statement selects which random number to use in sort.
        Rnd1 randomizes assignment of font conditions
        Rnd2 randomizes order for presentation of primes
        Rnd3 randomizes order for presentation of stems   }
var
    last,current : integer;
    left, right  : real;
    temp         : Word_Rec;
begin
    for last := lsize downto 2 do
       for current := 1 to last-1 do begin
          Case Key of
             1 : begin left  := item[current].Rnd1;
                       right := item[current+1].Rnd1 end;

             2 : begin left  := item[current].Rnd2;
                       right := item[current+1].Rnd2 end;

             3 : begin left  := item[current].Rnd3;
                      right  := item[current+1].Rnd3  end
                 end;   {case}
```

```
          if left > right then begin
               temp := item[current];
               item[current] := item[current+1];
               item[current+1] := temp;
               end;  {if}
          end;      {for current}

    for current := 1 to lsize do  {saves order in which
                                                   primes}
        Case Key of       { or stems were presented}
         2 : item[current].prime_order := current;
            3 : item[current].stem_order  := current
               end
end;  {sort}


{--------------Alphabetical Sort-----------------------}

procedure Sort4;
{alphabetizes experimental materials for neater raw data}
var
    last,
    current : integer;
    temp    : Word_Rec;
begin
   for last := lsize downto 2 do
      for current := 1 to last-1 do
          if item[current].prime > item[current+1].prime
      then begin
             temp := item[current];
             item[current] := item[current+1];
             item[current+1] := temp;
             end;  {if}
end;    {sort}

{--------------Set Font---------------------------------}
procedure Set_Font;
{Sets the size and style of FontA and FontB}
begin
    SetTextJustify(0,0);
    case Font of
         FontA : SetTextStyle(Font,0,7);
         FontB : begin
                      SetUserCharSize(3,1,5,2);
```

```
                   SetTextStyle(Font,0,usercharsize);
                end;
         end;   {case}
end; {set_font}

{-------------Present Primes----------------------------}

procedure Present_Primes;
const
  x = 130;
  y = 200;
var
  current   : integer;
  Start ,
  letter,
  Y_N_Resp  : char;
  i         : integer;

  procedure Present_Fillers(first,last:integer);
  var
     k : integer;

  begin
     for k := first to last do begin
        If Font = FontA then   {alternates between fonts}
               Font := FontB
            else
               Font := FontA;
        Set_Font;
        OutTextXY(x,y,filler[k]);
        Y_N_Resp := UpCase(Readkey);
        While Y_N_Resp <> CHR(13)do
              Y_N_Resp := UpCase(Readkey);
        cleardevice;
        end;   {for k}
  end;       {present fillers}

begin    {present primes}
   current := 0;
   Repeat
     Start := ReadKey;    {pause until control S pressed}
     Until Start = CHR(19);
     Present_Fillers(1,8);
     for i := 1 to lsize do begin
```

```
      with item[i] do
      if (Font_Cond <> 1) AND (Font_Cond<>2) then begin
         Inc(current);
         prime_order:=current;    {saves order of
                                           presentation}
         Case Font_Cond of      {assigns font to prime}
             3,4 : Font := FontA;
             5,6 : Font := FontB;
             end;   {case}
         Set_Font;
         OutTextXY(x,y,prime);
         Y_N_Resp := UpCase(Readkey); {because only some
                                              items are}
         y_n := Y_N_Resp;   {primes and therefore
                                          assigned Y_N,}
         While Y_N_Resp <> CHR(13) do     {this value
                                 has been initialized to}
            Y_N_Resp := Readkey;  {'U' in the read
                                      stimulus procedure}
         cleardevice;    {to prevent problems in datafile}
         end     {if font_cond then}
      else
        prime_order := 0;    {if not primed, assign
                                          position of 0}
    end;     {for}
    Present_Fillers(9,12);
end;     {present_primes}

{--------------Present Stems----------------------------}

procedure Present_Stems;
var
   Resume, letter : char;
   Prev_letter : array[1..12] of char;
   letter_pos  : array[1..12] of integer;
   x: integer; {index}

   procedure Erase_Letter;
   begin
      if count = 3 then exit;
      moveto(letter_pos[count],200);
      setcolor(black);
      outtext(prev_letter[count]);
      setcolor(white);
```

```
      moveto(letter_pos[count],200);
      Dec(count);
   end;      {erase_letter}

   procedure Display_Letter;
   begin
      Inc(count);
      letter_pos[count] := GetX;
      OutText(letter);
      prev_letter[count] := letter;
   end;      {display_letter}

   procedure Collect_Letters;
   var
      i : integer;
   begin
      with item[x] do begin
        Resp := Stem;
        for i := 4 to Count do
            Resp := Concat(Resp,prev_letter[i]);
        end {with}
   end;     {collect_letters}


begin
   Repeat
     Resume := ReadKey;   {pause until control R pressed}
     Until Resume = CHR(18);
   for x := 1 to lsize do
     with item[x] do begin
        Case Font_Cond of
           1,3,6 : Font := FontA;
           2,4,5 : Font := FontB;
           end;    {case}
        Set_Font;
        Count := 3;
        prev_letter[count] := letter;
        MoveTo(130,200);
        OutText(stem);
        letter := UpCase(Readkey);
        While letter <> CHR(13) do begin    {13 =return}
          if letter = #0 then begin  {checks for extended
                         character(#0) then for left arrow}
             letter := UpCase(Readkey);   {(75). Must be}
```

```
            if letter = CHR(75) then   {done this way so
                                         that k (also 75)}
             Erase_Letter;             {is not treated
                                          as a back arrow}
            end
          else
             if letter = CHR(8) then     {backspace = 8}
                Erase_Letter
             else
                Display_Letter;
             letter := UpCase(ReadKey);
             end;        {while}
       ClearDevice;
       Collect_Letters;
       end;              {with}
end;            {present_stems}

{-----------------Save Data----------------------------}

procedure Save_Data;
var
   fcond_score            {# correct in each condition}
               : array[1..6] of integer;
   cfile, dfile : text;             {data file handles}
   i : integer;                     {index}
begin
   for i := 1 to 6 do     {initializes score in each}
      fcond_score[i] := 0;  { font condition to zero}
assign(cfile,raw_dat_subn);
   rewrite(cfile);                    {SAVES RAW DATA}
   for i := 1 to lsize do
      with item[i] do begin
         if prime = Resp then
            score := 1
         else
            score := 0;
         writeln(cfile,sub_n:3,prime:10,' ',Resp:11,
              score:2, Font_Cond:2, prime_order:3,
              stem_order:3,Group:3,Language1:2,Language2:2,
              PEQ:2,Y_N:2);
         if score = 1 then         {counts total score }
         Inc(fcond_score[Font_Cond]); {in each condition}
         end;    {with item}
      close(cfile);
```

```
        assign(dfile,tab_dat_subn);
        rewrite(dfile);                    {SAVES TABULATED DATA}
        write(dfile,sub_n:3);
        for i:= 1 to 6 do
           write(dfile,fcond_score[i]:2);
        writeln(dfile,' ');
        close(dfile);
  end;  {save_data}


          {========== MAIN == PROGRAM ===========}

  begin          {main}
       Read_Stimulus;      {reads stimulus file}
       Read_Fillers;       {reads practice and filler items}
       Request_Subject_Number;
       Sort(1);
       for count := 1 to lsize do  {randomly assigns fonts}
           item[count].Font_Cond := (count-1) div 8 +1;
       Gd := detect;          {initializes graphics screen}
       InitGraph(Gd,Gm,'');
       SetGraphMode(EGAhi);  {needed for non-standard lab
                              computers because autodetect}
       Sort(2);                    {doesn't recognize them}
       Present_Primes;
       Sort(3);
       Present_Stems;
       CloseGraph;
       writeln('Please answer a few questions. ');
       writeln;
       write('Is English your first language? (Y/N) ');
       Language1:=UpCase(Readkey);
       Readln(X);
       writeln;
       write('Is English your preferred language?  ');
       Readln(Language2);
       writeln;
       writeln('In attempting to completeetheofiaswotdree ');
       writeln('1)  never             ':35);
       writeln('2)  occasionally      ':35);
       writeln('3)  about half the time':35);
       writeln('4)  frequently        ':35);
       writeln('5)  always            ':35);
```

```
     writeln('attempted to recall a word from the
                         previous (vowel decision) task. ');
     write('Type the number that is most appropriate :');
     readln(PEQ);
     writeln;
     Sort4;
     Save_Data;
     writeln('The experiment is now over.  Thank you for
                                       participating.');
     writeln('Please wait quietly until everyone has
                                finished the experiment.');
end.
```

Appendix D

Figure 1. Example of a prime (SPIDER) in *Turbo Pascal's* Triplex Font (Font B) and a stem (SPI) in the Default Font (Font A). Approximately actual size.

Appendix E

Experimental Instructions

E.1 Vowel Decision Task Instructions

In this task, you will see words presented, one at a time, on your computer screens. Your job is to decide whether the currently displayed word shares any vowels with the immediately preceding word. If the two words have at least one vowel in common you are to press the "Y" key, if the two words have No vowels in common, press the "N" key. After pressing the Yes or No key, press the "Return" or "Enter" or [describe arrow that hooks to left] key to record your response with the computer and to display the next word.

For example, you must compare the second word to the first word and press Y or N then Enter. You must then compare the third word to the second, the fourth to the third etc. Because the first word has no word preceding it simply answer Y and continue by comparing the second word to the first.

Are there any questions?

E.2 Implicit Stem Completion Instructions

In the next task you will see stems, or the first the letters of a word on the computer screen. Your task is to complete the word by typing in the rest of the letters to form the first word that comes to mind.

If you make a mistake while typing the letters you may erase the letters by typing the backspace key or the left arrow key before you press enter (or return). Once you hit enter you cannot go back and change what you have typed.

Are there any questions?

E.3 Explicit Stem Completion Instructions

In the next task you will see stems, or the first the letters of a word on the computer screen. Your task is to complete the word by typing in the rest of the letters to form a word from the list of words that you saw in the previous vowel decision task.

If you make a mistake while typing the letters you may erase the letters by typing the backspace key or the left arrow key before you press enter (or return). Once you hit enter you cannot go back and change what you have typed.

Are there any questions?

Appendix F

Analysis of Variance Summary Tables

F.1 Overall Analysis of Variance

F.2 Analysis of Variance with Two levels on the Font Factor

F.3 Analysis of Variance with Language as a Third Factor

F.4 Analysis of Variance with Subject 18 deleted

F.5 Analysis of Variance with Subject 29 deleted

F.6 Analysis of Variance with Subjects 18 and 29 Deleted

F.7 Analysis of Variance employing Reported Strategy as the Between Subjects Factor

F.1 Overall Analysis of Variance

Source	df	Anova SS	F Value	p > F
Instruct[a]	1	7.1358	1.77	0.1890
Font Condition[b]	2	98.7530	24.83	0.0001
Instruction X Font Condition[b]	2	5.7901	1.46	0.2379

[a] Hypothesis tested using the ANOVA MS for SUB(Instruction) as an error term (MS = 209.506 / 52). [b]Hypothesis tested using the ANOVA MS for SUB X Font Condition(Instruction) as an error term (MS = 206.790 / 104).

F.2 Analysis of Variance with Two levels on the Font Factor

Source	df	Anova SS	F Value	p > F
Instruct[a]	1	11.3425	2.39	0.1284
Font Condition[b]	1	12.6759	7.64	0.0079
Instruction X Font Condition[b]	1	1.5648	0.94	0.3359

[a] Hypothesis tested using the ANOVA MS for SUB(Instruction) as an error term (MS = 247.074 / 52). [b]Hypothesis tested using the ANOVA MS for SUB X Font Condition(Instruction) as an error term (MS = 86.259 / 52)

F.3 Analysis of Variance with Language as a Third Factor

Source	df	Anova SS	F Value	p > F
	Error = MS for Sub(Lang X Instruction)[a]			
Language	1	0.260	0.06	0.8021
Instruction	1	5.305	1.29	0.2612
Language X Instruction	1	3.911	0.95	0.3338
	Error = MS for Sub X Font(Lang X Instruction)[b]			
Font Condition	2	100.590	25.25	0.0001
Language X Font Condition	2	3.517	0.88	0.4168
Instruction*Font Condition	2	4.140	1.04	0.3576

[a]MS = 205.4048(SS) / 50(df). [b]MS = 199.2251(SS) / 100(df).

F.4 Analysis of Variance with Subject 18 Deleted

Source	df	Anova SS	F Value	p > F
Instruct[a]	1	10.1044	2.65	0.1097
Font Condition[b]	2	94.2390	24.26	0.0001
Instruction*Font Condition[b]	2	4.9832	1.28	0.2817

[a] Hypothesis tested using the ANOVA MS for SUB(Instruction) as an error term (MS = 194.4615 / 51). [b]Hypothesis tested using the ANOVA MS for SUB*Font Condition(Instruction) as an error term (MS = 198.1111 / 102).

F.5 Analysis of Variance with Subject 29 Deleted

Source	df	Anova SS	F Value	p > F
Instruct[a]	1	4.5545	1.19	0.2810
Font Condition[b]	2	87.7862	23.13	0.0001
Instruction*Font Condition[b]	2	5.3553	1.41	0.2485

[a] Hypothesis tested using the ANOVA MS for SUB(Instruction) as an error term (MS = 195.621 / 51). [b]Hypothesis tested using the ANOVA MS for SUB*Font Condition(Instruction) as an error term (MS = 193.525 / 102).

F.6 Analysis of Variance with Subjects 18 and 29 Deleted

Source	df	Anova SS	F Value	p > F
Instruct[a]	1	6.9808	1.93	0.1706
Font Condition[b]	2	83.5512	22.60	0.0001
Instruction*Font Condition[b]	2	4.2692	1.15	0.3193

[a] Hypothesis tested using the ANOVA MS for SUB(Instruction) as an error term (MS = 180.577 / 50). [b]Hypothesis tested using the ANOVA MS for SUB*Font Condition(Instruction) as an error term (MS = 184.846 / 100).

F.7 Analysis of Variance employing Reported Strategy as the Between Subjects Factor

Source	df	Anova SS	F Value	p > F
Strategy[a]	1	0.6049	0.15	0.7043
Font Condition[b]	2	83.0334	20.67	0.0001
Strategy X Font Condition[b]	2	3.7284	0.93	0.3985

[a] Hypothesis tested using the ANOVA MS for SUB(Strategy) as an error term (MS = 216.037 / 52). [b]Hypothesis tested using the ANOVA MS for SUB X Font Condition(Strategy) as an error term (MS = 208.852 / 104).

Appendix G

Correlation Matrix of Relevant Variables

The correlation matrix shows the independence of experimental variables such as the order of presentation of primes to the order of stems or font conditions or scores and so on. The headings in the correlation, abbreviated for space considerations are explained below.

Sub	Subject number.
Score	Correct or incorrect completion of stem.
Font	Font Order.
Prime	Prime order.
Stem	Stem order.
Strategy	Subjects' response to strategy question.
Instruct	Stem completion Instructions.

	SUB	SCORE	FONT	PRIME	STEM	STRAT
SUB	1.0000					
SCORE	0.0103	1.0000				
FONT	0.0000	-0.0293	1.0000			
PRIME	0.0000	-0.0016	-0.0458	1.0000		
STEM	-0.0394	-0.1026	-0.0215	-0.0059	1.0000	
STRATEGY	0.1281	0.0685	0.0000	0.0000	-0.0104	1.0000
INSTRUCT	0.2654	0.0489	0.0000	0.0000	-0.0153	0.4171

Appendix H

Tabulated Data

The complete listing of the raw data file is over 2500 lines long. Consequently, only a summary of the data is presented here. The heading abbreviations are as follows:

OBS	Observation number.
Instruct	Instruction condition (Explicit or Implicit).
Sub	Subject number.
Diff	Score in Different Font Condition.
No	Score in No Prime Condition.
Same	Score in Same Font Condition.
Eng1	Is English your first language?
Eng2	Is English your preferred language?
Strat	How often subject employed requested strategy (scale 1-5).

OBS	Instruct	Sub	Diff	No	Same	Eng1	Eng2	Strat
1	E	23	2	2	3	Y	Y	2
2	E	24	1	0	2	N	Y	2
3	E	25	4	0	8	N	Y	4
4	E	26	2	3	3	Y	Y	4
5	E	27	2	1	3	N	N	2
6	E	28	6	1	6	Y	Y	4
7	E	29	5	2	9	N	N	5
8	E	30	3	3	3	Y	Y	4
9	E	31	0	2	2	N	Y	2
10	E	32	6	1	5	Y	Y	3
11	E	33	3	2	3	Y	Y	3
12	E	34	4	3	5	-	Y	3
13	E	35	5	4	6	N	Y	2
14	E	37	4	2	3	Y	Y	4
15	E	38	5	1	5	N	Y	-
16	E	39	4	3	3	N	N	2
17	E	41	3	0	2	N	Y	1
18	E	43	1	1	5	Y	Y	4
19	E	44	5	3	4	Y	Y	2
20	E	47	2	2	4	Y	Y	3

OBS	Instruct	Sub	Diff	No	Same	Eng1	Eng2	Strat
21	E	51	7	4	6	N	Y	2
22	E	70	2	1	3	Y	Y	2
23	E	71	4	3	1	Y	Y	1
24	E	73	8	1	6	Y	Y	-
25	E	80	6	1	4	Y	Y	4
26	E	81	2	2	2	Y	Y	3
27	E	82	2	5	4	Y	Y	5
28	I	1	1	4	2	N	Y	1
29	I	2	2	1	3	N	Y	2
30	I	3	1	1	4	Y	Y	1
31	I	4	4	2	5	Y	Y	1
32	I	5	2	0	4	Y	-	3
33	I	6	4	3	4	Y	Y	-
34	I	7	1	3	3	N	N	1
35	I	8	2	0	3	N	N	2
36	I	15	3	4	3	Y	Y	1
37	I	16	1	2	4	N	Y	2
38	I	17	5	2	5	N	N	2
39	I	18	3	4	8	N	N	4
40	I	19	3	1	1	N	Y	5
41	I	21	4	3	7	N	Y	2

OBS	Instruct	Sub	Diff	No	Same	Eng1	Eng2	Strat
42	I	22	3	3	6	N	Y	-
43	I	52	2	3	3	N	N	3
44	I	53	4	2	2	N	Y	-
45	I	54	3	0	2	Y	Y	2
46	I	55	3	1	2	Y	Y	-
47	I	56	3	3	1	N	Y	1
48	I	57	0	1	1	N	Y	2
49	I	58	1	2	5	Y	Y	1
50	I	59	3	2	4	N	Y	2
51	I	60	5	2	5	Y	Y	3
52	I	61	6	3	5	Y	Y	1
53	I	62	4	0	4	N	Y	-
54	I	63	1	2	3	N	Y	1

Table of Authorities

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