AN EXPERIMENTAL INVESTIGATION OF SUBJECTIVE ORGANIZATION IN COLLEGE STUDENTS AND TRAUMATICALLY BRAIN INJURED INDIVIDUALS

by

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This is to certify that the thesis prepared by Sherry D. Nickerson entitled An Experimental Investigation of Subjective Organization in College Students and Traumatically Brain Injured Adults

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Abstract

Part-whole or whole-whole overlapping list learning paradigms have been used extensively to study verbal learning and memory for many years. This study compared three theories (organizational theory, frequency theory and list discrimination theory) of overlapping list learning. The first experiments compared the transfer effects with 141 college students using both verbal and non-verbal stimuli. A second experiment assessed transfer effects with TBI survivors who learned verbal stimuli. Experiment 1 replicated the often reported negative transfer phenomenon with overlapping word lists and then compared these results with those obtained when the overlapping lists were symbols. Results indicated negative transfer of performance for the old words relative to new words; new words were recalled better than old words on the second list. However, positive transfer occurred when symbols were used; old symbols were recalled better than new symbols on the second list. The difference between these findings indicates that verbal and visual information may be processed differently in the brain and that subjective organization may occur only with verbal information. Experiment 2 replicated previous research that showed a positive transfer using 60 brain injured individuals in an overlapping word list manipulation. The positive transfer resulted from an inability to subjectively organize information after a traumatic brain injury. The results of both experiments either supported or were consistent with Tulving's (1969) organizational theory.

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Subjective Organization of Non-Verbal Stimuli

Subjective organization (SO) refers to a person's ability to group seemingly unrelated materials together in order to facilitate learning. Miller (1994) posited that there is a limited amount of information that an individual is able to process and remember. However, people can organize information subjectively into groupings or "chunks" thereby managing to "break (or at least stretch) this informational bottleneck" (Miller, 1994; p. 351). Tulving (1966) studied SO using a "part-whole" learning paradigm with college students. There have been a variety of different interpretations of Tulving's (1966) published results (Anderson & Bower, 1972; Novinsky, 1972). A primary purpose of this study was to evaluate the various theories that have emerged that explain overlapping list transfer effects. This paper begins with a general discussion of subjective organization and the theories involved in the learning and retention of unrelated stimuli. It continues with a discussion of the differences between processing of verbal versus visual information, and summarizes the relevant research surrounding this topic. It goes on to discuss SO differences in brain injured individuals relative to non-brain injured individuals. It ends with a discussion of consistent findings, theory development, along with curious findings that will require additional research, and practical implications and applications.

Subjective Organization

Bousfield and Cohen (1955) attributed learning and retention of novel information to simple frequency of exposure to the events. Simply put, the more often one is exposed to a specific piece of information, the more likely that information will become

embedded in one's memory and the more easily it can be retrieved from memory. Tulving (1966), however, contradicted this theory by saying that mere repetition alone is insufficient for producing better recall. Tulving (1962) noted that when college students learned a series of unrelated words presented over a succession of trials, the students subjectively organized the information in memory. Because the words were presented in a random order from trial to trial, Tulving (1962) suggested that the participants imposed a unique sequential structure on their recall and that this structure increased with repeated exposure. He called this tendency to group the words "subjective organization" (SO). He also noted a positive correlation between the person's use of SO and their performance in a multi-trial free recall paradigm.

Subjective organization has been studied extensively using the part-whole list transfer paradigm (Tulving, 1966; Twum, 1994; Wilbur, Silver & Parente, 2007) as well as a variation of this model called the whole-whole transfer paradigm (Parente, DeMott, Johnson, Jennings & Silver, 2011). In the part-whole paradigm, the experimental and control groups learn different lists of unrelated words during the training phase. Following training, each group learns a second list that is twice as long as the first. This second list is identical for both groups. However, for the experimental group, the second list (whole-list) contains the entire first list plus an equal number of additional words. For the control group, the second list contains completely different words. During each phase of the experiment, the words are presented one at a time randomly over multiple trials. After each trial, the participants recall as many words as they can from the list in any order they wish (i.e., free recall).

Upon completion of the training phase, the transfer phase begins wherein the whole-list words are presented in the same manner as occurred during the training phase. Again, the participants recall as many words as possible following the presentation of the entire list. For the experimental group, the whole list contains all of the words that were in the part list and an equal number of new words. The control group learns the same whole list which contains completely different words from the part-list.

Several studies found that during list two (whole-list) learning, the experimental group demonstrated slower learning of the list relative to the control group (Tulving, 1966; Parente, Johnson, Jennings, and Silver, 2012; Wilbur, Silver & Parente, 2007). Tulving (1969) referred to this as a "negative transfer of learning" and opined that this phenomenon occurred because the experimental participants had already organized the words in the first list and had to reorganize them in order to accommodate the new words in the second list. He also asserted that the negative transfer of learning was evidence in favor of his subjective organization hypothesis. The negative transfer of learning disconfirmed strict frequency theory, which predicted that the increased frequency of exposure alone to half of the words during the training phase for the experimental participants should have produced more rapid learning of the whole list words. In fact, the control participants demonstrated a significantly steeper learning curve relative to the experimental participants, which directly contradicted the frequency model.

The part-whole negative transfer phenomenon was later replicated with a "whole-whole" procedure, which is a variant of the part-whole paradigm (Parente et al., 2011). Unlike the part-whole paradigm, participants in the whole-whole procedure learn two lists of words which are the same length. The second list contains half of the words from

the first list and an equal number of new words. Each participant learns both lists over a multi-trial study-test sequence and recall is plotted on the second list for both the new words and the old words. This procedure allows for potential use of the technique as a diagnostic tool in a clinical setting (Parente et al., 2011). The general finding using the whole-whole paradigm is the same as in the part-whole paradigm. Learning of the non-overlapping words is significantly better relative to the overlapping words.

Theories of Overlapping List Performance

Frequency theory (FT) is the idea that the more often an individual is exposed to an event, the more likely that person will retain the information and to retrieve it from memory at a later date (Postman, 1970). The positive correlation of word frequency to recall has been observed both after a single trial (Bousfield & Cohen, 1955; Deese, 1960) and in multiple-trial free-recall learning (Postman, 1970). Sternberg & Tulving (1977), however, observed that not only do individuals recall more words over successive trials but that they also tend to organize the recalled words the same way over successive trials. Therefore, although frequency theory may predict recall in some situations, it may not predict in all situations. For example, it may predict well when the materials are not easily organized or with people who have difficulty imposing mental organization on their immediate environment.

Tulving's (1966) SO notion posited that humans seek out semantic or categorical relationships in seemingly unrelated verbal materials and then use these relationships to promote learning. In order to test this theory, Tulving conducted a series of experiments, one of which became known as the part-whole transfer paradigm. The original Tulving

(1966) part-whole transfer paradigm involved learning two lists of common nouns; the first (part) list contained 18 words and the second (whole) contained 36 words. There were two groups participating in the study: a part-learning (PL) group and a no-learning (NL) group. The initial list given to the PL group contained 18 words that were randomly chosen from the whole list whereas the NL group initially learned 18 words that were unrelated to the whole list. Therefore, although both groups learned the same 36 item whole list, for the PL group, the second list contained all of the first list items whereas for the NL group, the second list words were all new. Results showed a definitive difference in the learning curves of the groups on the second list with the PL group starting out with higher recall on the early trials but the NL group surpassing the PL group in recall in later trials beginning on the forth trial. The difference in the slopes of the learning curves indicated negative transfer of learning for the experimental group.

Although Tulving (1966) explained part-whole negative transfer of learning in terms of conflicting SO of the part and whole list overlapping items, other researchers offered alternative interpretations. For example, Anderson and Bower (1972) posited that each word was identified with a “list marker”. These authors suggested that negative transfer effects derive from participants’ difficulties in associating List-2 markers to words previously associated to several List-1 markers. As a result, the learning of new list-tags for the overlapping words on list 2 is retarded. This model assumes that the negative transfer in part-whole experiments is occurring in the recognition phase of free recall and not the retrieval phase. Schwartz and Humphreys, (1971) showed that negative transfer occurred if the participant was given two identical whole lists provided that he or she was led to believe that the first and second lists contained some differences.

There results were consistent with the list marker notion because the two lists were identical and all that could differ was the participants' confusion when mentally flagging the words.

Slamecka et al. (1972) also argued that on the transfer task, participants in the experimental condition recognized that some of the first list items appeared on the second list, but they were unsure that all of the old items were included. Their uncertainty, coupled with a desire to avoid intrusions, lead experimental participants to withhold responses that may have been correct if recalled. In this experiment, when participants were encouraged to guess, part-to-whole negative transfer disappeared.

Novinski (1972) disagreed with Tulving's notion that participants' failed to abandon a disoptimal SO from part to whole that accounted for the negative transfer. She posited that they failed to maintain the organization and to integrate it into the second list that caused the negative transfer. When she told participants that the items overlapped, then positive transfer of learning occurred in the part-whole paradigm.

Theory Development

With the exception of one unpublished study (DeMatt, 2009), SO using the part-whole or whole-whole paradigm has been studied only using word lists. It is therefore uncertain whether the use of non-verbal stimuli which are more difficult to organize subjectively would yield the same results. There is, however, clear neuropsychological evidence that suggests that words and symbols would be processed differently. Several published studies indicate that different areas of the brain are activated when presented with visual versus auditory stimuli (Schneiders, Opitz, Krick, and Mecklinger, 2011;

Salmon et al., 1996). Therefore different procedures are involved in the processing and retention of verbal versus visual stimuli. A study conducted by Salmon et al. (1996) showed that the lower left supramarginal gyrus and premotor area are the key regions of activation for short-term verbal memory processes whereas the superior occipital gyrus plays an important role in the visual short-term memory process. Paulesu, Frith, and Frackowlak (1993) studied six European males who were presented both English letters (which could be phonologically processed) as well as Korean letters (which included visual but not phonological components) and were asked to remember a string of letters and then to make rhyming judgments. The researchers used positron emission tomography (PET) to track regional cerebral blood flow (rCBF) during the completion of these tasks. The PET scans showed greater activation of the left hemisphere during the verbal task. Nystrom et al. (2000) replicated the prior study using abstract shapes instead of Korean letters for the visual task. Using an fMRI, the researchers found greater sensitivity in the left premotor and temporal regions during memory tasks involving letters than abstract shapes and a greater activation in the right hemisphere involving the visual task. These studies demonstrate differences in brain regions that show activation when presented with either verbal or visual information. The results suggest that the same memory test might produce quite different results if the procedure involved visual versus verbal materials.

Because verbal/auditory and visual information are processed differently in the brain then evaluation of overlapping list learning with non-verbal stimuli may provide an avenue for evaluating the various theories of part-whole learning outlined above. Because it is difficult to subjectively organize non-verbal materials, then, according to

Tulving's (1966) SO model, there should be relatively little first list SO to interfere with participants' learning of the second list. By implication, the SO model would not predict any negative transfer of learning with this type of stimuli. However, frequency theory (FT) would predict positive transfer because the overlapping items still would gain memory strength during first list learning. The various List Discrimination (LD) theories would also predict negative transfer because the participants' would still have difficulty discriminating the overlapping symbols from the first to the second list.

Another possible approach for testing the various theories of overlapping list learning involves using participants who have limited ability to organize. For example, Twum (1994) published results from a part-whole learning study with individuals who have suffered from Traumatic Brain Injuries (TBI). He noted that persons with TBI often lose the ability to organize effectively (Twum, 1994; Parente and Hermann, 2010). If, as Tulving (1966) asserted, the negative transfer in the part-whole learning paradigm derived from a mismatch of organization from first to second list, and given that persons with TBI had difficulty organizing, then it was reasonable to assume that a person with TBI would not experience the same negative transfer that was commonly found with college students. His results indicated that TBI survivors do not demonstrate a negative transfer of learning but instead experience positive transfer in the part-whole learning paradigm. Wilbur, Silver, & Parente (2007) replicated this finding using a whole-whole overlapping list paradigm.

Parente, et al. (2011) also used a whole-whole transfer paradigm to study SO with college students, persons with diagnosed learning disabilities, and TBI survivors. The

results indicated negative transfer with college students and persons with LD; however, the TBI survivors experienced positive transfer with the same lists of words.

Using participants with TBI might therefore be useful for theory development. As discussed above, if one assumes that persons with brain injury do not subjectively organize, the SO theory would not predict negative transfer of learning with this patient population. Twum's (1994) results were therefore consistent with this implication of SO theory; he showed that TBI survivors demonstrated significant positive transfer of part-whole learning with word lists. The FT does predict the positive transfer that Twum reported because the overlapping words gained memory strength in the first list. LD theory predicts negative transfer because it does not attribute the negative transfer to organizational interference but, moreso, to confusion resulting from difficulty re-associating list markers for the overlapping words. This confusion would presumably occur regardless of whether or not the person was a TBI survivor.

Although theory development generally takes precedence over empirical investigation in the academic arena, there are also several empirical questions regarding memory for overlapping lists that have been either under-researched or ignored entirely. First, Novinski, (1972) published the only study that evaluated overlapping list recognition. She did not report any differences in recognition; the null finding does not support the LD theory which posits that the negative transfer in part-whole learning derives from a failure to recognize appropriate list tags for the various overlapping items. Never-the-less, her reported null finding is a fact in need of replication. Second, there is little published information concerning which portions of the information processing system are responsible for the negative transfer that occurs in studies of overlapping lists.

It is therefore unclear whether short-term memory, long-term retrieval, or transfer among the memories is most affected. Third, other demographic or individual difference variables may affect performance. For example, does gender or race of the participant correlate with performance? Experiments 1 and 2 addressed each of these empirical questions.

Present Study

This sequence of experiments evaluated overlapping list learning with college students (Experiment 1) and with persons with TBI (Experiment 2). The first experiment was concerned primarily with recall and recognition differences that occur with overlapping lists of words and non-verbal symbols. The second experiment elaborated Twum's original findings with TBI survivors who learned overlapping lists. Specifically, the experiment evaluated the effect of overlapping list learning on several different cognitive measures: recall, short-term storage, long-term storage, retrieval from long-term memory, and consistent long-term recall. Both experiments provided answers to the various theoretical and empirical questions discussed above.

Experiment I

This study used a whole-whole learning paradigm similar to the one described by Parente et al. (2011), and Wilbur, Silver, and Parente, (2007) with two different types of stimulus items. The first type was common nouns that could be semantically organized. The second type was symbols that were more difficult to organize semantically. Both conditions included a recall and a recognition task.

The a priori hypotheses of this study were:

1. The SO theory predicts that negative transfer would occur with materials that could be semantically organized. Specifically, participants' recall of non-overlapping words would exceed their recall of overlapping words on the second trial learning sequence. FT predicts that positive transfer would occur with words because of increased frequency of exposure of overlapping words in the first list. The LD theory predicts negative transfer with words because the learner withholds recall of the overlapping items during second list recall because they are uncertain as to whether the items belong to the first or second list.

2. With non-verbal items, SO theory predicts only that there will be no negative transfer from the first to the second list because no SO occurred for overlapping items on the first list. FT predicts positive transfer from first to second list because of increased memory strength of overlapping items that participants gain on the first list. LD theory predicts negative transfer because of the confusion the learner experiences when trying to discriminate the first and second list items.

Method

Participants

A total of 141 college students from two undergraduate basic statistics classes at Towson University, ages 19 to 58 years (M = 21 years; SD = 2 years) participated in the study and each received course credit for their participation. The sample consisted of

both males (n = 27; 19%) and females (n = 113; 80%). Following IRB approval, each participant volunteer was informed that they may withdraw at any time during the course of the study. Two groups of participants were tested during adjacent semesters. Each group learned both the words and the symbols however; the order of presentation was counterbalanced across groups. Group 1 learned the words first followed by the symbols and Group 2 learned the symbols first followed by the words.

Condition 1 - Verbal

Materials

Unlike previous studies where the items were presented individually, (DeMatt, 2009; Parente, et al., 2012; Wilbur, et al.(2007), the words from both lists were presented as a batch on a single slide and the participants viewed all of the items together. The words were the same common nouns that were used by Parente et al. (2011), Wilbur et al. (2007) and Twum (1994). (See Table 1). The first list consisted of 12 new words whereas the second list consisted of six old words (chosen randomly from the first list) and six new words (see Table 1).

Procedure

Training task. This study took place in a classroom setting. The experimenter displayed the first list of 12 words in batch, i.e., all on one page, presented as a slide via Power Point™. display to the entire group. The participants studied the page of words for 30 seconds and then wrote down all of the words from the list that they could remember in any order on a piece of lined paper. This study-test training task continued

over five additional trials with the words presented in a different randomly positioned display for each trial.

Transfer task. Participants began the transfer task immediately following the completion of the training task. During this task, the experimenter displayed the second list of 12 words, which contained six new words plus six old words that appeared in the previous list randomly positioned on a single slide. The participants wrote down all of the words from the list that they were able to recall on a piece of lined paper. The transfer task also consisted of six study and test trials of randomly ordered words.

Recognition task. After the transfer task, each participant was given a piece of paper that contained all of the words they had seen during the entire experiment (training and transfer) plus the same number of new words (none of which they had seen before). All of the words were randomly positioned on the page and the participants circled any that had been part of either the training or transfer task.

Condition 2 - Visual

Materials

The symbols used in this portion of the experiment were simpler shapes than those used by DeMott and were constructed to minimize the possibility that they could be subjectively organized (see Table 2). The first list contained 12 new symbols whereas the second list consisted of six symbols from the original list in addition to six new symbols. (See Table 2)

Procedure

Training task. The basic procedures that were used in Condition 2 were the same as those used in Condition 1. The symbols were again presented in batch via PowerPoint™. As in condition 1, the participants saw a page of symbols that were randomly distributed on the page and were then asked to write down as many as they could recall. This study-test procedure continued for six trials with 12 symbols per trial. The symbols were presented as a black icon on a white background at a font size of 200 points. The symbols were presented in a different randomly distributed display on each of the six training trials.

Transfer task. Immediately following the training task, the participants began the transfer task in which they were presented 12 symbols, six new, and six that were randomly chosen from the original list. Again, they repeated this task over six study-test trials recalling the symbols on separate sheets of lined paper on each trial.

Recognition task. Each participant received a final sheet of paper containing all of the symbols they had seen during the training and transfer tasks along with an equal number of symbols that are new. The participants circled all of the symbols that they were able to recall during the training and transfer trials.

Half of the participants learned the words first followed by the symbols (Group 1). The remaining half learned the symbols first followed by the words (Group 2). This grouping variable therefore described the counterbalancing of the two types of stimulus materials.

Results

These data were analyzed using a 2 (Group) x 2 (Old versus New words) x 6 (trials) analysis of covariance (ANCOVA). Group was the between subjects variable with two levels that referred to the counterbalancing of the word and symbol presentations (Group 1 & Group 2). Trials was the slowest moving within subjects variable with six levels (number of trials). Type of word (old vs. new) was the fastest moving within-subjects variable with two levels. The same analysis was used separately with the training and transfer data however with the words transfer data, the average of each participant's performance on the training trials was used as a covariate. The analysis for the transfer data was, therefore, a mixed design ANCOVA because the transfer data included the average performance on the training trials as covariates. In situations where the Mauchly's test of sphericity was violated, either the multivariate tests or the Greenhouse-Gieser corrected values were used to test the results.

Analysis of Words

An analysis of the training data showed a main effect of learning over the six trial sequence for all of the words $F(5,116) = 48.487$, $p < .05$, $\eta_\varrho^2 = .676$, power = 1.00 meaning that participants increased their recall of words over trials. Because all of the words were new to the participants in the verbal training task, it was hypothesized that there would be no difference in recall when the words were separated into those that were pre-selected as old and new; however, a main effect of type $F(1,126) = 8.876$, $p < .05$, $\eta_\varrho^2 = .066$, power = .840 emerged which indicated that the new words were recalled at a significantly higher rate than the old words in the training task. Because there was a

difference in recall of the old and new words during training, the averages of the old and new words were used as a covariate in the ANCOVA performed on the transfer data, which adjusted for any training recall differences that may have affected the transfer task performance.

Figure 1 presents the transfer data for the word learning portion of the experiment. In the transfer task, the second list words were classified into those six that were common to both lists (old) versus those that were new to the second list (new). Results of an ANCOVA showed a main effect of trials $F(5,120) = 2.564$, $p < .05$, $\eta_\varrho^2 = .097$, power = .778 which indicated that recall of all words increased over the series of six trials; and a main effect of type of words (old vs. new) $F(1,118) = 5.359$, $p < .05$, $\eta_\varrho^2 = .043$, power = .632 indicating that, overall, more new words were recalled than old words. The trials X slope interaction was not significant. Neither of the covariates (averages of the old and new words during training) was significant.

{Insert Figure 1 here}

Consistent with Tulving's (1966) organizational theory, Figure 1 shows that recall of old words was significantly lower than that of new words over the sequence of trials demonstrating a negative transfer effect; however, unlike previous studies, results of this analysis show a negative transfer of "performance" as opposed to "learning". Specifically, the participants recalled significantly more new than old words but they did not learn the new words faster than the old words across the trial sequence.

Analysis of Symbols

The ANOVA computed on the training data showed a main effect of trials $F(5,109) = 70.132$, $p < .05$, $\eta_\varrho^2 = .763$, power = 1.00 indicating that the number of symbols recalled increased with each trial. Because all of the symbols during the training task were new to the participant, the two types of symbols were not expected to differ in their overall level of recall or the rate with which participants learned them. The ANOVA did not indicate any effect of type of symbol nor was there a significant interaction between type of symbol and trials. It was therefore unnecessary to include the average recall of the old and new symbols as covariates in the transfer analysis.

Figure 2 presents the transfer results for the symbol recall portion of the experiment. An ANOVA computed on the transfer phase data showed a main effect of trials $F(5,109) = 48.243$, $p < .05$, $\eta_\varrho^2 = .689$, power = 1.00 which indicated that recall of the symbols generally increased over trials. A main effect of the type of symbols (old vs. new) $F(1,113) = 25.421$, $p < .05$, $\eta_\varrho^2 = .184$, power = .999 was also significant indicating that the old symbols were recalled at a significantly higher rate than new during the transfer task.

{Insert Figure 2 here}

Because the symbols could not be organized semantically, the FT predicted that the old symbols would be recalled significantly better than the new symbols on the second list. Figure 2 shows the absence of a negative transfer of learning on the second list symbols and supports the hypothesis that a positive transfer would occur with materials that could not be semantically organized.

Post Hoc Findings

There were no significant differences in recognition of the old and new words or symbols in Experiment 1. This null finding replicates Novinski's (1972) finding; results from both studies suggest that transfer effects in overlapping list studies are restricted to recall and not recognition. Additional analyses suggested that race may have significantly affected performance in Experiment 1. When participants were divided into Caucasian and non-Caucasian groups, an ANOVA showed a significant trials by type of word by race code interaction $F(5,114) = 3.108$, $p < .05$, $\eta_0^2 = .120$, power = .861 for the recall data indicating a difference in the learning curves of Caucasians versus non-Caucasians. Figures 3 and 4 show the recall of the second list words by Caucasians and non-Caucasians respectively. Figure 3 shows that the Caucasian group learned both the old and new words at approximately the same rate; Figure 4 shows that the non-Caucasian group learned the new words quickly but had difficulty in learning the old words.

{Insert figures 3 & 4 here}

Discussion

To summarize, the purpose of Experiment I was threefold: 1) evaluate which of three alternative theories provided the best explanation of overlapping list negative and positive transfer effects, 2) to assess if overlapping list transfer affected recognition as well as recall, and 3) to assess the effect of several possible methodological and individual difference variables on overlapping list learning that have been either previously overlooked or ignored. Regarding the first questions, the results provide

general support for the SO model and little support for the LD theories. SO predicted the negative transfer obtained with word lists. The positive transfer obtained with symbols was consistent with SO theory, which predicts only no negative transfer with items that could not be subjectively organized. The results provide partial support for FT which predicts positive transfer with verbal and non-verbal items which did occur with symbols. LD theory predicts negative transfer with both types of stimuli which also did not occur.

Regarding the second question, there was no evidence of recognition effects with either words or symbols. This finding is consistent with those reported by Novinski (1972). Both experiments indicate that the participants' had no difficulty recognizing items from either list regardless of whether they were present on both the first and second lists. This finding also does not support the LD theory, which predicts that overlapping list items would be more confusing. It also does not support FT because the overlapping items would have gained additional memory strength from the first to the second list, which suggests higher correct recognition for these items.

Regarding the post hoc findings, the data suggest that males and females experience similar transfer effects with overlapping lists. However, different racial groups differed markedly in their ability to learn overlapping word lists. These data show that Caucasians experience little transfer, either positive or negative. Non-Caucasians may experience more negative transfer with overlapping words. Both racial groups experience positive transfer with symbols.

Experiment II

Previous studies (Twum, 1994; Parente, et al., 2010) indicated that the usual finding of negative transfer that occurs with college students who learned word lists did not occur with TBI survivors. This effect was taken as validation of SO theory because persons with TBI would have lost the ability to organize, which would limit any subjective organizational interference they would experience when learning overlapping word lists. Twum (1994) was the first to demonstrate this effect although he did not include in his analysis additional data he had collected for other experimental and control conditions. In addition, Twum's part-whole paradigm used a selective reminding procedure (Buschke, 1974) which provided several different measures of memory; recall, long-term storage, short-term storage, long-term retrieval, and consistent long-term retrieval, across the trial sequence. This multivariate model allows an assessment of different aspects of memory, which vary in their sensitivity to the transfer effects in the part-whole task.

Method

The purpose of Experiment II was to further analyze Twum's published data to include not only two other conditions that he did not include in his original analysis but also to evaluate the other recall measures from the Buschke selective reminding task that he did not include in his interpretation of the results. These data were collected from participants with TBI in 1994. The re-analysis of these data begins with a replication of Twum's original finding of positive transfer for part-whole list learning for overlapping words for the Experimental group relative to a Traditional Control condition in which

there was no overlapping of the part and whole word lists. The original Experimental (un-informed) group learned the same word lists but was not informed of the overlap between them; whereas, the traditional control participants were told that there was no overlap of the words. The additional conditions that Twum did not report included an experimental group of participants, who were informed that the part and whole words overlapped, as well as, a second Control (no-pretraining) group that learned the same second list words without having any first list exposure or practice.

Hypotheses 1. SO theory predicts no negative transfer from part-whole because the participants have difficulty organizing the first list items. FT predicts positive transfer from part-whole because of increased memory strength that accrued during first list learning. LD theory predicts negative transfer from part-whole because of confusion regarding list membership. Novinsky (1972) would predict positive transfer for the group who was informed of the overlapping word lists because these participants could form transferable subjective organizations during first list learning.

Hypothesis 2. Experimental group participants would demonstrate significantly higher levels of long-term storage, long-term retrieval, and consistent long-term recall relative to the participants in the control conditions.

Results

These data were analyzed with several mixed design analyses of covariance with one between groups variable (groups) and two within subjects variables (word type – Old versus New, and Trials 1-12). The data from the first list learning trials was used as a covariate for all analyses that included the two experimental conditions and the

traditional control. Because there was no first list learning in the no pre-training condition, these second list data were simply plotted along with the data from the other conditions for comparison. In all of these analyses, there was no effect of the average of the first list training trials (covariate) on the second list results.

Test of Hypothesis 1: Figure 5 presents the recall data across trials. Analysis of these data indicated a significant effect of groups, $F(2,57) = 8.595$, $p < .05$. The effect accounted for 34% of the variance with 99% power. Individual Sheffe' contrasts computed on the various groups indicated that the informed and uninformed groups differed significantly from the traditional control group although the informed and uninformed groups did not differ significantly from one another. The averages of the first list recall scores were not significant covariates. These results confirm the first hypothesis; prior exposure to half of the second list during first list learning improved recall of the second list items relative to the traditional control group.

In the case of the TBI survivors, the positive transfer that resulted was predicted by the FT and was consistent with the SO theory. Regarding FT, this notion predicts that increased exposure to overlapping words in the first list would facilitate learning of the second list. Regarding SO theory, given that TBI survivors may lack the ability to organize information, they would not experience the SO interference when learning overlapping word lists; therefore they would experience either no transfer or possibly positive transfer on second list. The results did not provide support for either the LD notion or Novinski's (1972) explanation. Neither theory could account for the lack of a significant difference between the informed and uninformed recall data.

{Insert Figure 5 Here}

Figure 5 also plots the no pre-training data across trials. Covariance analysis was impossible because the no pre-training condition did not have a first-list learning component. Therefore, ANOVA (without covariates) was computed on these four conditions to assess differences among the informed, not informed, versus the no pre-training control and the traditional control groups. Individual Sheffe' post-hoc contrasts computed on these four groups indicated that only the traditional control differed significantly from the no pre-training group. Although all but one of the data points for the informed and uninformed groups exceeded those in the no pre-training group ($p < .05$ by sign test), the Sheffe' post-hoc ANOVA contrasts indicated that recall in these conditions did not significantly exceed the no pre-training group. This finding is difficult to interpret because in the no pre-training condition, there was no first-list learning so it is impossible to determine if the participants in this group were comparable to those of the other conditions. Nevertheless, the significant difference between the no pre-training and traditional control suggests that some amount of the part-whole transfer effect with Twum's TBI survivors resulted from suppression of recall in the traditional control condition rather than enhancement of recall in the informed and uninformed conditions.

Tests of Hypothesis 2: Figure 6 presents the data relevant to the second hypothesis. With the exception of Short Term Recall, the various panels in Figure 6 generally indicate the same pattern of effects. The plots indicated a significant difference among the informed, uninformed, and traditional control conditions across the 12-trial sequence. Individual Sheffe' contrasts computed on these groups indicated that the informed condition did not differ significantly from the uninformed condition although

these two conditions recalled significantly more words relative to the traditional control. This pattern of recall differences was also apparent in the analysis of the Short Term Recall data however, the plot of these data indicated generally decreasing short-term recall across the trial sequence. However, the rest of the plots indicate that the informed and uninformed conditions recalled significantly more words, and demonstrated significantly better long-term storage, long–term retrieval, and consistent long-term recall relative to the traditional control. The participants in the no pre-training and traditional control conditions showed more short-term recall relative to the informed and uninformed conditions across trials.

With the exception of the short-term recall measure, the informed and not informed groups recalled more words relative to the no pre-training group ($p < .05$ by sign test). For the long-term recall, short-term recall, and long-term storage variables, there was no significant recall difference between the informed and not informed conditions.

{Insert Figure 6 here}

Discussion

The importance of these experiments is that they replicate and extend a long line of published research in the area of overlapping list learning. There are a number of consistencies in these experiments that both support and disconfirm the various theories that have been proposed to explain part-whole negative transfer of learning. These consistencies lead to several firm conclusions regarding the stability of part-whole transfer effects. At the same time, these experiments also raise several curiosities that

will require replication and further study. In addition, the results lead to several practical suggestions for enhancing performance in situations that involve part-whole transfer.

Consistencies

The results of both Experiments 1 and 2 indicate that with overlapping word lists, both part-whole and whole-whole transfer paradigms produce negative transfer in college students. This same finding has been reported consistently since the mid-20th century. This entire line of research consistently shows that prior learning of unstructured word lists can produce negative transfer in college students when that information is later included as part of a larger list.

Experiment 2 also replicates a series of recently published results that show positive transfer of learning with TBI survivors (Wilbur, Silver, Parente, 2007; Parente et al. 2011). Specifically, these studies indicate that learning part of a larger body of verbal information initially, either in a part-whole or whole-whole paradigm, produces positive transfer relative to conditions where participants initially learn unrelated words. The positive transfer occurs regardless of whether the learner is aware or unaware of the relationship between the part and the whole.

The experiments also replicate the finding that both part-whole and whole-whole procedures produce the same transfer effects. Each procedure produces negative transfer with college students and positive transfer with TBI survivors. The fact that the whole-whole and part-whole procedures produce generally the same memory performance is important because it implies that the whole-whole procedure, which can display transfer effects with individual participants, can be used as a diagnostic tool.

The results of Experiment 1 also replicate Novinski's (1972) null findings with regard to recognition. Neither these data nor those of Novinski show any negative transfer effects in recognition. The analysis of the symbol recognition data also showed no differences among the various conditions. However, it is possible that these null findings were at least partially the result of the fact that the task did not involve many items, which could have produced a ceiling effect. Therefore, before concluding that overlapping list learning does not affect recognition, it would be prudent to replicate these findings with a more difficult task.

Conclusions

The results of these experiments generally support Tulving's (1966) organizational theory, which predicts that prior exposure to the first list items should produce negative transfer when the person learns the same items on the second list (Experiment 1). Likewise, the positive transfer that occurred in Experiment 2 for overlapping words is also consistent with Tulving's theory because TBI survivors are known to have poor organizational skills. Therefore, without the ability to organize, they would not experience interfering organizations from the overlapping lists. However, SO theory did not predict the positive transfer that occurred in Experiment 2, only that there would be no negative transfer. Therefore, the results of Experiment 2 do not necessarily confirm SO theory, they are simply not inconsistent with it.

The results of the symbol recall portion of Experiment 1 is also not inconsistent with Tulving et al. (1966) organizational theory for the same reasons outlined above. Because the symbols were difficult to organize subjectively, there would be little or no

SO to transfer from first to second list learning. It could be that the positive transfer that occurred in the symbol recall condition in Experiment 1 suggests that Tulving's organizational theory may only apply to semantic information that can be subjectively organized. Future research will be necessary to determine if other types of imposed organizations such as color grouping, size differences, or shape categories can also produce negative transfer with overlapping lists of shapes.

These results do not provide any clear support for other interpretations of part-whole transfer, (Bower, 1969; Novinski's, 1972). Bower proposed the LD notion, which suggested that the negative part-whole transfer was a byproduct of the participants' confusion about which list the overlapping words belonged to. Novinski reported that the part-whole negative transfer became positive when the participant was informed of the relationship between the lists. However, neither of these notions can explain the positive transfer that occurred when the students learned symbols in Experiment 1 or the lack of recall differences in the informed and uninformed conditions of Experiment 2.

In general, Tulving's SO model is the only interpretation of these combined results that either predicts the findings or is not refuted by them. However, there is one consistent result that SO cannot explain. Most of the published overlapping list research has documented a "negative transfer of learning" phenomenon in which the slope of the learning curve for the experimental group was less than the slope of the control group on the second list. The differences in slopes therefore demonstrated differences in learning. Most of the significant effect among groups in Experiments 1 and 2 involved differences in performance, not slopes. It is therefore unclear exactly how SO theory, or any of the other models, would explain the differences in performance but not learning.

Curiosities

There have been no previous publications that have included a no pre-training control condition. Experiment 1 did not contain a no pre-training condition so it is difficult to evaluate the effect of pre-training. The Experiment 2 results showed that the no pre-training condition recalled more words overall on the second list relative to the traditional control. The fact that the no pre-training condition performed significantly better than the traditional control in Experiment 2 suggests that some portion of the negative transfer in this experiment was due to suppression of performance in the traditional control condition rather than to enhancement of performance in the experimental conditions. Persons with TBI are likely prone to rapid mental fatigue; therefore, it is reasonable to suggest that the improved recall of words in no pre-training condition of Experiment 2 was due in part to the mental fatigue that developed in the traditional control group.

The post-hoc evaluation of race differences in Experiment 1 was especially curious. There were no significant differences between recall of old and new words for Caucasians. However, non-Caucasians recalled relatively more new words and fewer old words. This finding suggests that the overlapping list paradigm with words creates more organizational interference for non-Caucasians. However, with symbols, both groups recalled more old symbols relative to new over the trial sequence. The positive transfer that resulted from prior learning seemed to benefit both race conditions equally.

It was also curious that in Experiment 2, there were no significant differences between the informed and not-informed conditions. Earlier research with college

students (Novinski, 1972) showed that informing students of the relationship between the lists was sufficient to eliminate the negative transfer effects. The students were able to use the information, which allowed them to maintain their first list organization and to integrate it into the second list. It is likely that persons with brain injury lack the attentional skills to benefit substantially from prior knowledge of the relationship between the lists. It is also possible that because the transfer effects were at least partially the result of proactive inhibition, providing the TBI participants with knowledge of the list's composition had only minimal effect.

Application

The fact that the whole-whole transfer effects in Experiment 1 were consistent with those obtained in earlier published studies (Parente, et al. 2011; Tulving, 1966; Wilbur, Silver, & Parente, 2007) indicates that the negative transfer with verbal materials is consistent and replicable with this paradigm as well as the part-whole paradigm. The advantage of the whole-whole paradigm however, is that it can be used to investigate transfer effects with individual participants which makes it potentially useful as a diagnostic tool. For example, when used in this manner, a clinician could simply plot second list old and new word recall for a patient and then inspect the plot to determine if it showed negative or positive transfer for the old words. Negative transfer would suggest that the person subjectively organized the old words during first list learning and that this organization interfered with learning of the same words during second list learning. Positive transfer or no transfer of the old words would suggest that the person did not subjectively organize the words during first list learning. Because persons with

TBI often have difficulty organizing, this test could be used to assess the extent of their organizational deficit.

These results suggests that part-whole learning provides one effective technique for expediting training with TBI survivors. Teaching the survivor small segments of a larger body of material will likely accelerate the acquisition of the larger whole. For example, Wilson (1994) has shown that programmed instruction materials that emphasize errorless learning can be effective for teaching TBI survivors new skills. Programmed instruction is essentially a sequential part-whole transfer paradigm in which large sections of material are broken down into smaller portions and the learner is not permitted to advance to the next portion until he or she first demonstrates mastery of the smaller segments.

Twum (1994) showed that one way to enhance positive part-whole transfer is to pre-organize the initially-learned materials so that the organization transfers to the second task. He showed that by providing categorized word lists during the first task and maintaining the organization of the old words in the second task, participants demonstrated positive transfer of part-whole learning. He also demonstrated positive transfer when the organizational categories but not the original words were maintained from part to whole. This finding suggests that the best training approach with TBI survivors is one in which a larger task is broken down into smaller pieces that are pre-organized for the survivor. Positive transfer will occur when the pre-organized pieces are transferred intact to the larger task.

The Future

Theoretical - The results of these experiments suggest that Tulving's organizational theory may be the most useful explanation of the transfer effects that occur in both verbal and non-verbal part-whole manipulations as well as the same performed by persons with brain injuries. However, it will be necessary to elaborate the theory so that it makes testable predictions regarding visual versus verbal learning, recognition and recall, and learning versus performance.

The disparity of overlapping word recall between races requires replication. Because of the dearth of non-Caucasian participants in the present study, we were unable to delineate the racial groups other than to dichotomize them in to Caucasian versus non-Caucasian. However, future studies should investigate these overlapping list differences with clearly delineated racial groups.

Finally, this research suggests a need to include a no pre-training group in any future studies. Because the non-overlapping list condition is the appropriate control for practice effects, it is clearly a necessary condition in any overlapping list experiment. However, these data suggest that part of the negative transfer that occurs may be due to proactive inhibition, progressive fatigue, or loss of motivation which suggests the need for a no pre-training control group in any future overlapping list experiment.

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Tables

Table 1

Words for first and second whole lists

List 1	List 2
Sand	**Diamond**
Seed	**Sand**
Plane	Garden
Wool	Hero
Diamond	**Wool**
Dawn	Dollar
Fruit	Student
Jail	Tree
Bee	**Jail**
Judge	**Choice**
Choice	Court
Passion	**Judge**

Note. Overlapping words are bolded in list 2

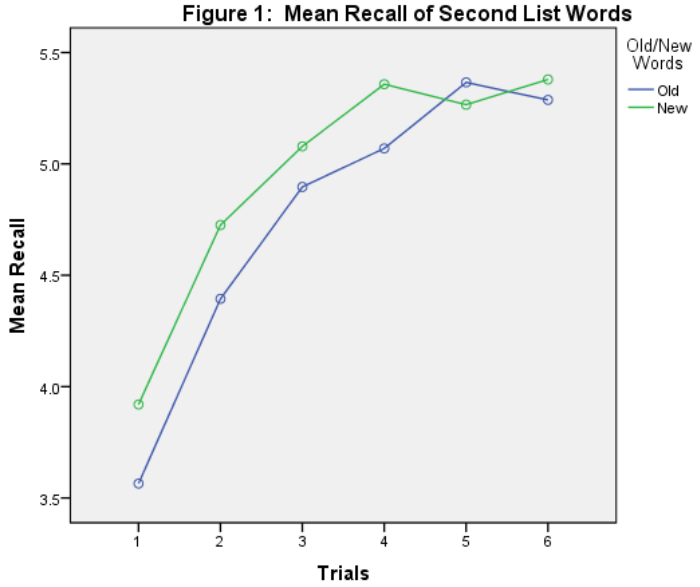
Table 2

Symbols for first and second whole lists.

List 1	List 2
Ϫ	ⲫ
ϕ	ⲗ
⊿	ⲥ
∞	ϟ
⊓	ϕ
⊃	∧
⋐	⊢
ю	⊿
⋠	⊃
⊓	∞
∩	⊓
◊	⋐

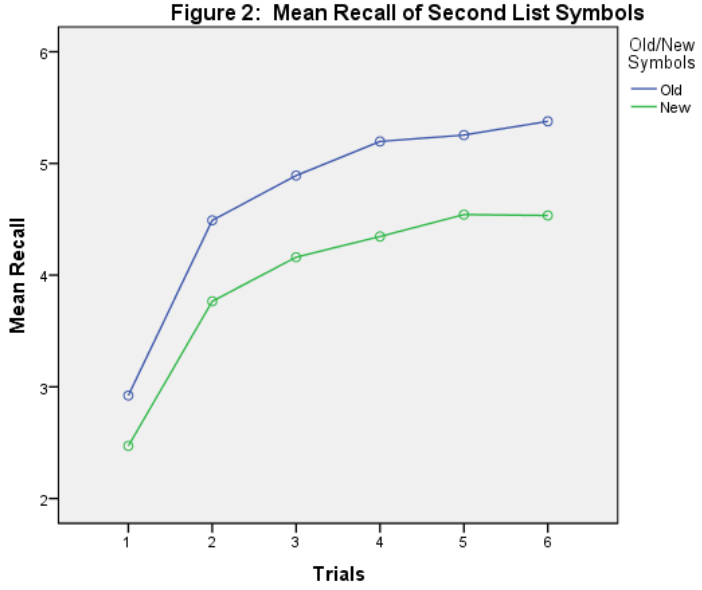
Note. Overlapping symbols are bolded in list 2

Graphs



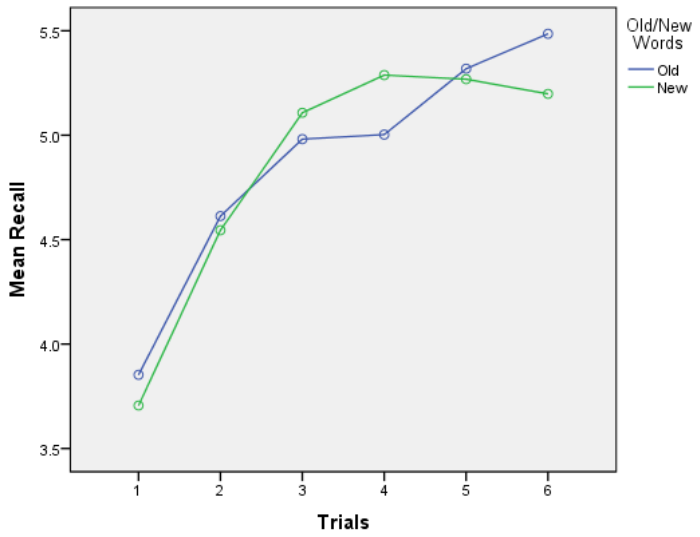
Covariates appearing in the model are evaluated at the following values: WTransferOld = 4.7630, WTransferNew = 4.9544

Figure 2: Mean Recall of Second List Symbols



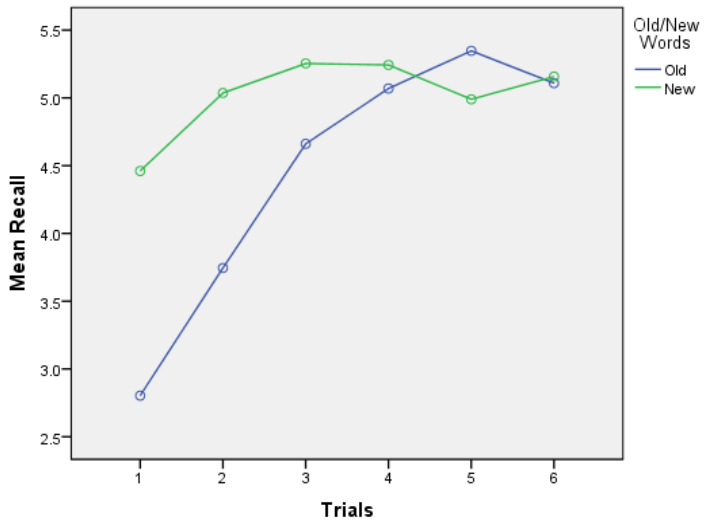
Covariates appearing in the model are evaluated at the following values: STransferOld = 4.6887, STransferNew = 3.9697

Figure 3: Mean Recall of Second List Words - Caucasian



Covariates appearing in the model are evaluated at the following values: avgOldTrain = 4.6549, avgNewTrain = 4.8216

Figure 4: Mean Recall of Second List Words - Non-Caucasian



Covariates appearing in the model are evaluated at the following values: avgOldTrain = 4.6549, avgNewTrain = 4.8216

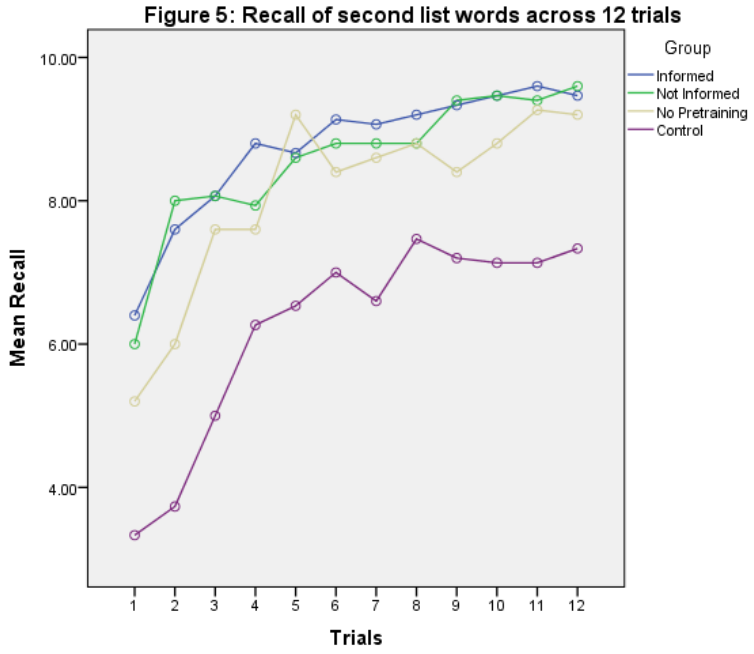


Figure 5: Recall of second list words across 12 trials
Group
Informed
Not Informed
No Pretraining
Control
Mean Recall
10.00
8.00
6.00
4.00
1
2
3
4
5
6
7
8
9
10
11
12
Trials

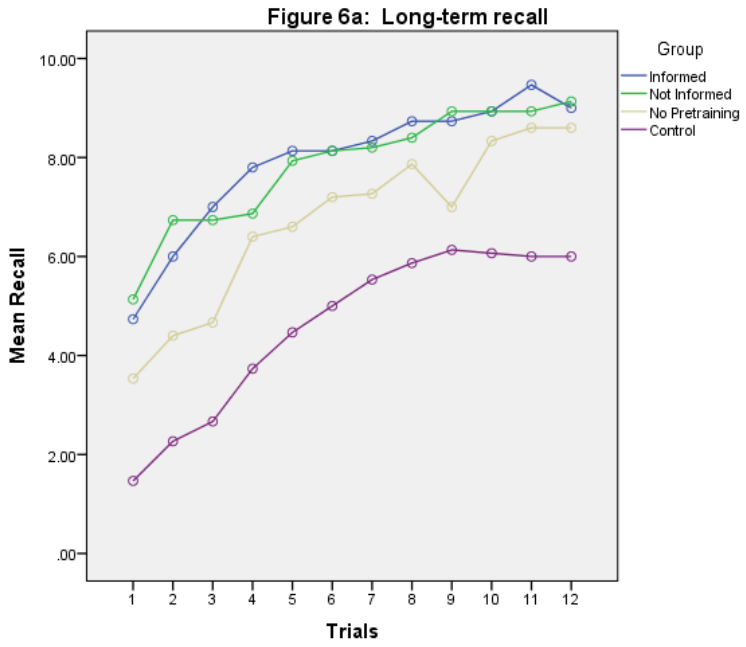


Figure 6a: Long-term recall
Group
Informed
Not Informed
No Pretraining
Control
Mean Recall
10.00
8.00
6.00
4.00
2.00
.00
1
2
3
4
5
6
7
8
9
10
11
12
Trials

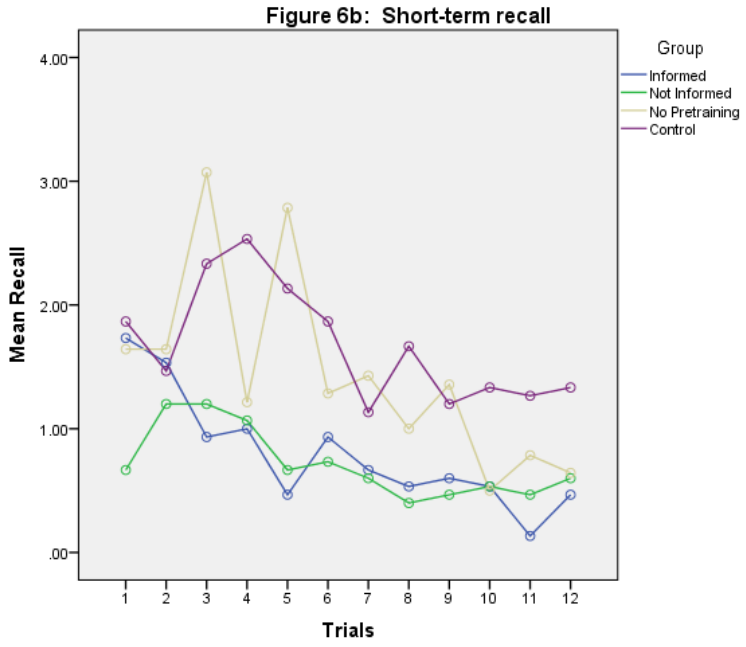


Figure 6b: Short-term recall
Group
Informed
Not Informed
No Pretraining
Control
Mean Recall
4.00
3.00
2.00
1.00
.00
1
2
3
4
5
6
7
8
9
10
11
12
Trials

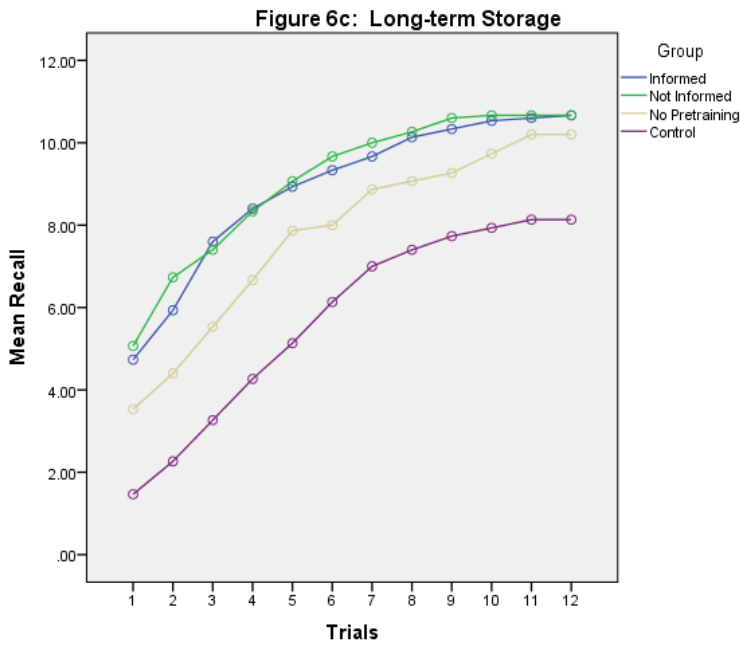


Figure 6c: Long-term Storage
Group
Informed
Not Informed
No Pretraining
Control
Mean Recall
12.00
10.00
8.00
6.00
4.00
2.00
.00
1
2
3
4
5
6
7
8
9
10
11
12
Trials

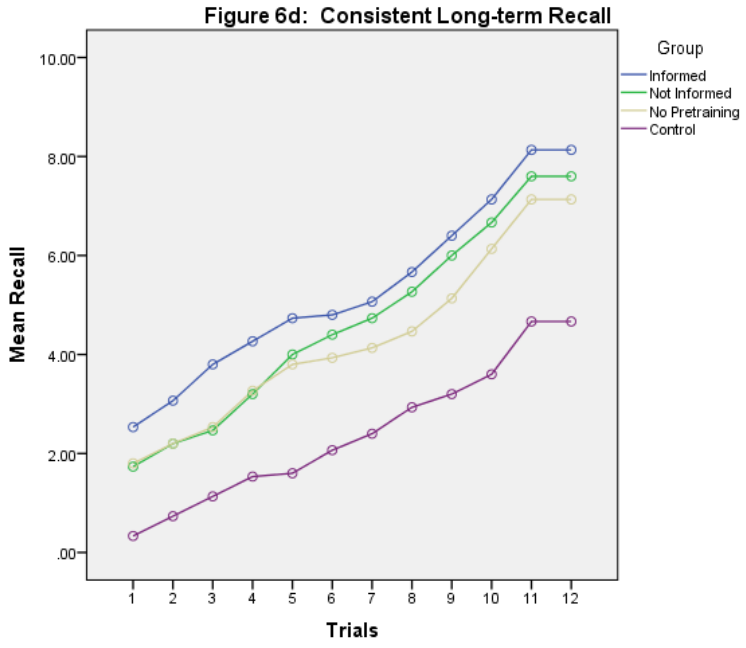


Figure 6d: Consistent Long-term Recall
Group
Informed
Not Informed
No Pretraining
Control
Mean Recall
10.00
8.00
6.00
4.00
2.00
.00
1
2
3
4
5
6
7
8
9
10
11
12
Trials

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Center for Eating Disorders, Sheppard Pratt; Towson, MD
Research Assistant **June 2013-present**
Assist in the research and writing of literature reviews, data entry, helping to create study protocols, Data entry, analyzing results of current studies

Self Employed; Parkton, MD
Governmental Affairs Consultant **January 2007 – January 2013**
Represented the interests of various clients in front of federal and state regulatory officials as well as legislatures.

Campaign to Re-Elect Governor Bob Ehrlich; Towson, MD
Field Operative **July 2006 – November 2006**
Coordinated grassroots activities throughout the state, assisted in organizing fundraisers, defended the candidates record and discussed issues with constituents related to the Governor's platform.

Capital Clinical Research Associates; Rockville, MD
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Responsible for recruiting and enrolling patients for various clinical trials involving the efficacy of psychotropic medicines, responsible for data collection and proper recording and maintenance of information used to ascertain results and interview patients to assess their eligibility for trials.

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