Subjective organization of overlapping word lists after traumatic brain injury

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ABSTRACT

This study examined Subjective Organization (SO) among survivors of a Traumatic Brain Injury (TBI) by measuring recall of word lists in four different conditions. Participants learned two lists of words, the second being twice as long as the first. Those in the Experimental conditions learned overlapping word lists in which the first list composed half of the second. Participants in one experimental condition was informed of the relationship between the two lists and the other experimental group participants were uninformed. For participants in the traditional control condition, there was no overlap between the first and second list. Participants in the no-pretraining condition were only exposed to the second, larger list. Results indicated that recall was enhanced in the overlapping list conditions. Pretraining with unrelated words diminished recall relative to all of the other conditions.

Keywords: Subjective organization; Traumatic Brain Injury; Overlapping list recall

1. Introduction

Subjective Organization (SO) refers to a natural human tendency to impose organization on seemingly unrelated events in one's environment. Tulving (1966) and Miller (1956) were among the first to observe that people organize information, such as word lists, into higher order units, usually consisting of two or more related words. Miller (1956) speculated that this process of "chunking" information together is necessary to recall the information. Although, the extent to which the person organizes varies from person to person (Parente & Finley, 2017), SO can be demonstrated indirectly. For example, Tulving (1966) demonstrated negative transfer of learning in a part-whole transfer paradigm that he interpreted as evidence for organizational interference. In this experiment, participants learned two lists of words; the second was twice as long as the first. The experimental group learned a second list that contained the first list words whereas the control group learned unrelated lists. Intuitively, if the experimental participants have already learned half of the words on the second list, then recall should be superior on the second list relative to the control. The counterintuitive finding, however, is that with college students, the experimental group initially experiences positive transfer but their rate of learning is less than the control. The reduced rate of learning is attributed to interference the experimental group experiences when trying to reorganize the first list of words when learning the second. An example of this well-replicated phenomenon is presented in Figure 1a.

These data were collected from 50 college students who learned two lists of words (Nickerson, 2013). Half of the first list was included in the second list. Figure 1a is a plot of recall for the overlapping words (old) versus non-overlapping words (new). The graph illustrates the typical negative transfer effect in which the slope of the learning curve is significantly steeper for the non-overlapping (new) words relative to the overlapping (old) words.

Twum (1994) pointed out that after TBI, survivors lose the ability to organize. He reasoned that if the person does not organize effectively then he or she should not experience the same negative transfer of learning in the part-whole learning paradigm that is commonly reported with college students. His results with TBI survivors showed that overlapping list-learning produced positive transfer on the second list for overlapping words. An example of this finding is presented in Figure 1b which was obtained with TBI participants (Parente, DeMatt, Johnson, Jennings, & Silver, 2011). These participants learned overlapping words significantly better relative to non-overlapping words. This result has been consistently replicated in several studies (Twum, 1994; Wilbur, Silver, & Parente, 2007; Parente et al., 2011).

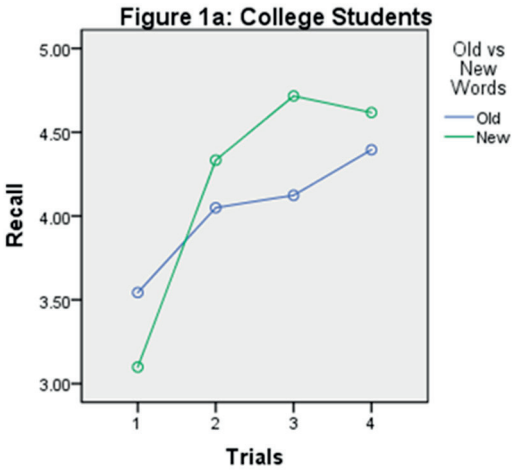

Figure 1a. Part/whole learning of overlapping word lists with college students (Nickerson, 2013)

Figure 1b. Part/whole learning of overlapping word lists with TBI survivors (Parente et al., 2011)

Although Twum's (1994) result has been replicated several times, it is unclear exactly what aspects of memory are affected. Twum reported only data related to total recall of words over a 12 item study/test sequence for an experimental and a control condition. However, his data collection procedure involved several other measures of recall that were never reported. In addition to the two standard conditions, his study included another experimental condition in which the participants were told of the relationship between the two lists. This condition was included because Novinski (1972) had found that with college students, the usual negative transfer of learning effect disappeared when the participants in the overlapping list condition were made aware of the relationship between the lists. It is therefore reasonable to suggest that this manipulation would produce even greater positive transfer when the participants were TBI survivors. Twum's data collection also included another condition that has never been part of any published overlapping list study; specifically, a group in which the participants did not receive any first list training.

Twum's scoring procedure was originally proposed by Buschke (1974). The Buschke Selective Reminding Task (BSRT) breaks down total recall into several different measures: Short-term retrieval, Long-term storage, Long-term retrieval, and Consistent long term retrieval. Short-term retrieval refers to the person's reliance on short-term retention for recall. Long-term storage refers to the transfer of the words from short to long-term memory. Both Long-Term Retrieval and Consistent Long-Term Retrieval measure consistent word retrieval over trials.

2. Methodology

The purpose of this experiment was to determine the effect of overlapping list learning on these various aspects of memory with participants who had experienced a TBI. This study analyzed Twum's unpublished data and focused on the various recall measures that were available from the BSRT procedure that Twum did not include in his original interpretation of the results. The analysis included a comparison of overlapping word recall for the Experimental group relative to a *traditional control* condition in which there was no overlapping of the first and second word lists. The Experimental groups were either *uninformed*, i.e., these participants learned overlapping lists but were not informed of the overlap between them; or the participants were *informed*, i.e., they were told that the two lists overlapped. The *traditional control* participants were told that there was no overlap of the words. Participants in the *no-pretraining* group learned the same second-list words without having any first-list exposure or practice. All participants had endured a TBI. Their

demographics are described in detail in Twum's original article (Twum, 1994).

This was a multivariate design in which the various measures of performance were derived from the BSRT. The aim of this study was to compare the overlapping list conditions (*informed* and *uninformed*) relative to the the control conditions (*traditional* and *no-pre-training*). It was hypothesized that the overlapping list conditions would perform better on the various BSRT measures relative to the controls. It was also hypothesized that prior exposure to the task (first-list learning in the *traditional control* condition) would produce better recall relative to the *no-pretraining* condition. The *informed* condition was expected to show superior recall relative to the *uninformed* condition. These hypotheses were predicted for all measures of long-term memory. The *traditional* control and *no-pretraining* conditions were predicted to demonstrate more reliance on short-term retention relative to the overlapping list conditions. Because the TBI participants in the *informed* and *uninformed* conditions learned overlapping lists, their learning would not be hindered by organizational interference; they would already have stored the overlapping list words in long-term memory and they would, therefore, be less dependent on short-term retention as they learned the words across the study/test sequence.

3. RESULTS

3.1 Analysis of measures

We did not analyze the overall recall measure that was originally published by Twum (1994). We did analyze those measures that he did not derive from the BSRT. Figure 2: a,b,c,d shows the results for the Long-term Retrieval, Long-Term Storage, and Consistent Long-Term Recall, and Short-Term Retrieval measures. Initially, analysis of covariance was done to assess differences among those conditions that had a first-list learning condition, specifically, the *informed*, *uninformed* and the *traditional control* groups with the average of the training trial data used as a covariate. These analyses did not indicate any effect of the covariate. Therefore, analyses that follow were then computed with all four groups without the covariate. Specifically, several mixed-design analyses of variance were computed with one between-groups variable (*informed, uninformed, traditional control* and *no-pretraining*) and one within-subjects variables (Trials 1-12).

3.2 Recall datas

Figure 2: a,b,c,d, presents the recall data for the various BSRT measures across

trials. Analysis of the Long-Term Retrieval data presented in Figure 2a revealed an overall significant difference among the four conditions across the 12-trial sequence, $F(3,55) = 8.959$, $p < .05$, $\eta^2 = .324$, power = .99. The same overall differences occurred with the Long-Term Storage variable, $F(3,55) = 12.364$, $p < .05$, $\eta^2 = .398$, power = .99, and the Consistent Long-Term Recall variable, $F(3,55) = 2.85$, $p < .05$, $\eta^2 = .132$, power = .65. Individual planned comparisons computed on the data in these plots indicate that the *informed* and *uninformed* conditions demonstrated better long-term storage, long–term retrieval, and consistent long-term recall relative to the *traditional control* and relative to the *no-pretraining* condition. Further, the *no-pretraining* condition demonstrated significantly better long-term retrieval, long-term storage, and consistent long-term retrieval, relative to the *traditional control* condition. There were, however, no significant recall difference between the *informed* and *uninformed* conditions for any of these variables.

A different pattern of results emerged for the Short-Term Retrieval data presented in Figure 2d. The overall analysis of these data showed an overall significant difference among the groups, $F(3,55) = 6.646$, $p < .05$, $\eta^2 = .266$, power = .99. Individual planned comparisons indicated that the *traditional control* and *no-pretraining* conditions demonstrated significantly more short-term retrieval relative to the *informed* and *uninformed* conditions. The difference between the *traditional control* and *no-pretraining* condition was not significant nor was there a difference between the *informed* versus *uninformed* conditions.

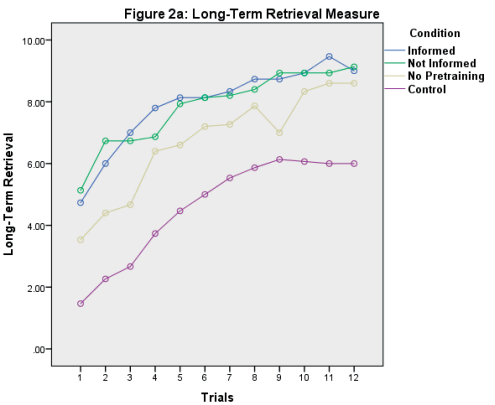

Figure 2a. Long-term retrieval of second-list words

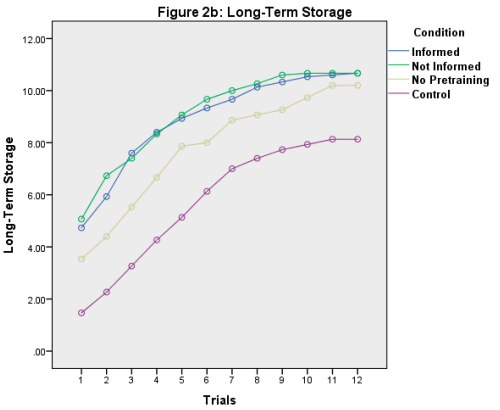

Figure 2b. Long-term storage of second-list words

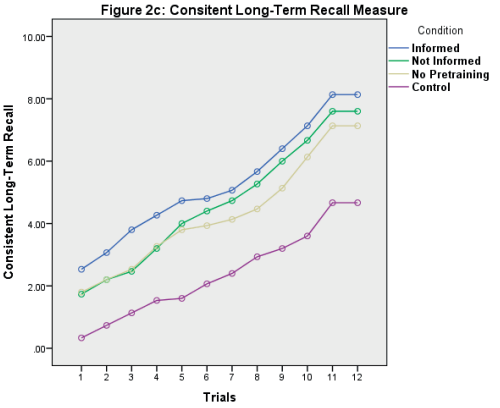

Figure 2c. Consistent long-term recall of second word lists

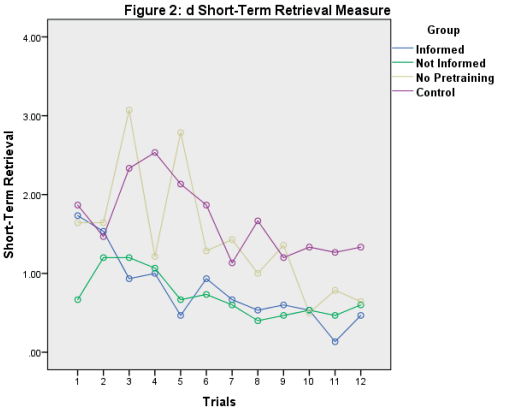

Figure 2d. Short-term retrieval of second word lists

It was hypothesized that prior exposure to the task (first-list learning in the *traditional control* condition) would produce better recall relative to the *no-pretraining* condition. In addition, the *informed* condition was expected to show superior recall relative to the *uninformed* condition. Neither of these hypotheses was supported with any of the long-term memory measures. The analyses did support the hypothesis that participants in the *no-pretraining* and *traditional control* conditions would demonstrate significantly more reliance on short-term memory relative to the overlapping list conditions.

4. Discussion

These results are consistent with findings originally reported by Twum (1994) and later replicated by Wilbur et al. (2007) and Parente et al. (2011). The enhanced performance for participants in the overlapping list conditions relative to the *no pre-training* and *traditional control* conditions in this experiment was consistent across all measures of long-term memory. At the same time, these experiments also raise several curiosities that will require replication and study. In addition, the results lead to several practical suggestions for enhancing performance in situations that involve part-whole transfer.

4.1 Consistencies

This experiment replicates a series of recently published results that show positive transfer of learning with TBI survivors (Parente et al., 2011; Wilbur et al., 2007). Specifically, these studies indicate that TBI survivors who initially learn half of a larger list of words demonstrate positive transfer when learning a second overlapping list relative to conditions where participants initially learn unrelated word lists. The positive transfer occurs regardless of whether the learner is aware or unaware of the relationship between the part list and the whole list. This positive transfer occurs across several different measures of long-term storage, retrieval, and recall. Although these findings are intuitively reasonable, they stand in stark contrast to those obtained in college student studies that consistently show the opposite effect, i.e., negative transfer of learning. The result is also consistent with the notion that persons with TBI do not organize effectively; their lack of organization of the part-list does not conflict with their ability to organize the whole-list. The results suggest that TBI survivors benefit from frequency of exposure to the overlapping list elements without any of the organizational interference.

4.2 Curiosities

The negative transfer of learning typically found in overlapping list experiments with college students (Tulving, 1966) is manifested when the slope of the learning curve for the overlapping list condition is significantly less relative to the non-overlapping list condition. These slope differences are assumed to demonstrate differences in learning. The significant effect among groups in this study however, involved differences in performance, not slopes. The participants benefitted from frequency of exposure to the overlapping words but did not seem to experience conflicting organizational interference that limited their change in performance with practice.

These results showed that the *no pre-training* condition recalled more words overall on the second list relative to the *traditional control*. This finding suggests that some portion of the transfer differences 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 (Johansson, Berglund, & Rönnbäck, 2009); therefore, it is reasonable to suggest that the improved recall of words in the *no pre-training* condition was due in part to the mental fatigue that developed in the *traditional control* group. For the experimental groups, however, learning half the words initially made the second list-learning task easier, which allowed them to overcome the effects of mental fatigue.

It was also curious that there were no significant differences between the *informed* and *uninformed* 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. Her explanation of the finding was that the informed students were able to use their knowledge of the relationship between the lists to maintain their first-list organization when learning the overlapping words in the larger 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.

4.3 Implications

This experiment, along with others, suggests that the part-whole recall paradigm can be used as a diagnostic tool. For example, Parente, et al., (2011) and Wilbur et al. (2007) suggested that a whole-whole-list paradigm can be used to diagnose organizational deficits with individuals who have experienced

a TBI. This procedure includes learning two lists with the same number of words in each list. However, the second list contains half of the first-list words. A clinician simply plots the second-list old and new word recall separately for an individual patient, and then inspects the plot for negative or positive transfer of the old words. Negative transfer would suggest that the person did subjectively organize the old words during first-list learning; the organization interfered with learning of the same words on the second list. Positive transfer of the old words would suggest that the person did not subjectively organize the words during first-list learning but did benefit from frequency of exposure to half of the words during first list learning. No transfer suggests that the person did not notice the overlapping words and therefore did not experience any organizational interference or benefit from exposure frequency.

4.4 Applications

These results suggest that part-whole learning provides an 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, Bladdeley, Evans, and Shiel (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 first-list materials so that the organization carries over to the second task. He facilitated positive transfer by providing categorized a word list during first list learning and maintaining the old words in their categories in the second task. Positive transfer also occurred when the organizational categories, but not the original words, were maintained from part to whole. His results suggest 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.

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