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CONTEXTUAL INTERFERENCE:

ISSUES OF SIMILARITY, SCHEDULING, AND RANGE FACTORS

BY

CAM O'DONNELL

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ABSTRACT

Three experiments were conducted studying issues of contextual interference (CI). Experiment 1 investigated the issue of item similarity and how such a manipulation might increase the level of CI when learning a list of movement patterns. Concomitantly, the issue of learning type (stimulus learning vs motor learning) was investigated. The results from experiment 1 supported the notion that within list item similarity affected the level of CI in a manner that as similarity increased, so did CI. This finding supports the theoretical hypothesis forwarded by Battig (1979) known as the variable and multiple encoding hypothesis. The secondary issue of learning type, was answered in the affirmative for the motor learning type. The second experiment investigated the potential for additive affects of two variable manipulations of CI. Namely, item similarity as tested in experiment 1, and concurrently, item scheduling (blocked and random practice schedules) as observed in previous experiments. The results of experiment 2 illustrated a positive additive effect between the two variable manipulations. The third experiment investigated the potential for additive effects of a temporal schedule manipulation, massing and distributing practice, with item scheduling, blocked and random practice schedules. This manipulation was studied with the intent to isolate whether the same factors that have been observed to cause range effects, were in part responsible for the inferior acquisition performance observed in traditional CI experiments. The results support the conclusion that inferior acquisition performances are in part due to the massing the practice of randomly presented trials. Distributing practice eliminates inferior acquisition performance for randomly presented trials but at the cost of inferior retention performance.

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LIST OF ABBREVIATIONS

CI - Contextual Interference

V&M - Variable and Multiple

F&R - Forgetting and Reconstruction

PSAT - Pattern Segment Accuracy Technique

v-m - visual motor

ITI - Intertrial interval

VCF - Visual Comparative Feedback

UANOVA - Analysis of Variance

SNK - Student Newman-Keuls

LSD - Least Squared Differences

Pre - Pre-test

Acq - Acquisition

Ret - Retention

B - Blocked

R - Random

Introduction

Contextual Interference (CI) has its history in the verbal learning paradigm described by Lachman, Lachman, and Butterfield (1979). The pioneer of the term 'contextual interference' was William F. Battig whose interest in studying transfer effects eventually brought him to the discovery that interference during learning actually leads to facilitative effects in memory. Battig utilized the paired associate learning paradigm and observed transfer effects through the performance of a second task as a measure of inferred learning of a primary task (Battig 1965, 1966, 1966b, 1966c, 1966d, 1972).

Battig, among others, studied how various manipulations affected the learning of verbal lists. He observed (as early as Johnson 1964) a peculiarity related to the relationship between interference and facilitation. Battig (1966) observed that when intra-list interference was high, due to high levels of item similarity in a list, an associated inter-list facilitation resulted. The observation of interference, leading to facilitation, was somewhat unexpected as interference was not generally associated with facilitation in the manner described above. Subsequent research substantiated these previous observations and led Battig to conclude that intra-task interference led to inter-task facilitation (Battig 1972).

Battig theorized that the inter-task facilitation was caused by the subject's need for greater 'variable and multiple encoding' when presented with a list of highly similar items (Battig 1966, 1972, 1979). The increase of variable and multiple processing results in more distinctive representations and elaborate retrieval routes for recall (Battig 1966, 1972, 1979). Functionally, Battig predicted that in cases where variable and multiple processing was increased the following relationships would result: inferior acquisition performance, superior delayed retention, superior delayed transfer to similar tasks, and superior retention and transfer when the context of these tasks are changed (Battig 1972, 1979).

Battig, possibly influenced by the likes of Craik and Tulving (1975) and Lockhart, Craik and Jacoby (1976) with respect to their 'levels of processing' framework, expanded his concept of human memory (Battig 1979). One reason for extending the limiting factor of interference beyond that of 'intra-task interference' was to acknowledge the contribution of Bransford's (Bransford, Franks, Morris and Stein 1979) notion that the variety of the contextual factors that occur during the learning experience (acquisition) greatly affects the nature of the memory representation (retention or transferability) (Bransford et al. 1979). In order to incorporate the contextual factors with intra-task similarity as a potential co-variate, Battig (1979) created a new and broader term, *contextual interference*. The new term combined intra-task interference, which arose from within list item similarity, with the newly observed factors such as list presentation context. Presentation context refers to the way in which lists are presented (scheduling).

Broadening the definition of contextual interference to include a contextual factor, such as list presentation context, provided Battig with alternative methods by which the level of interference could be manipulated. Battig (1979) observed different retention scores when he manipulated the relative presentation context of two identical lists, thus maintaining a constant level of item similarity, and concluded that context was responsible for the observed differences. He concluded that other factors such as presentation context must concomitantly affect the level of multiple and variable processing and ultimately the distinctive and elaborate nature of the representations. Battig concluded that CI, regardless of how it was achieved, affected a similar underlying learning mechanism. External manipulations such as presentation scheduling (blocked vs random) or list item similarity (low vs high) both affect the level of variable and multiple encoding in the manner described above.

To summarize, contextual interference has been demonstrated both empirically and reliably in experiments using the verbal report procedures.

Shea and Morgan (1979), interested in the generalization of the contextual interference effect, were the first to translate Battig's conclusions into the motor learning literature. Shea and Morgan (1979) not only devised a motor task to test the predictions of the contextual interference principles but also adopted the theoretical explanations put forth by Battig and his contemporaries. Shea and Morgan (1979) chose to control contextual interference through the manipulation of list presentation context (i.e. presentation style - blocked and random scheduling) while maintaining a constant level of intra-list similarity. This was accomplished through the use of identical list items in both list presentations and through changing the context of the presented list items (movement patterns) in a blocked order (low-CI) or a random order(high-CI).

The subjects in Shea and Morgan's (1979) experiment were required to learn a set of three movement patterns presented in either a blocked order (low-CI) or in a random order (high-CI) condition. Retention and transfer were measured after a 10 minute or a 10 day delay. Shea and Morgan's (1979) experiment resulted in the high-CI group showing poor acquisition performance, but performing better than the low-CI group on the retention and transfer tests, notably when the context of the tests was changed from that of acquisition. Shea and Morgan's (1979) results are compatible with the predictions extrapolated from Battig's theoretical explanation. Their results seemed to bridge the gap between the verbal theory presented by Battig (1979) and the motor learning paradigm tested by Shea and Morgan (1979).

The contextual interference effect, as tested by variations in presentation context, has been frequently explored in the motor learning literature since the work of Shea and Morgan in 1979 (see Magill and Hall 1991 for review). When contextual interference is controlled by presentation context, blocked (low-CI) and random (high-CI) trial presentation schedules, virtually all the experiments have produced two consistent results. Firstly, when equated for the number of practice trials, acquisition performance is inferior for the randomly presented schedule (high-CI) when compared to the blocked presentation schedule (low-CI); and secondly, retention and transfer performance is superior for the randomly presented schedule (high-CI) when compared to the blocked presentation schedule (low-CI).

The above stated relationships have become synonymous with the term contextual interference in the motor learning literature. One striking observation, however, regarding the contextual interference research in the motor learning field, is that contextual interference has almost always been controlled through the use of presentation context and not list item similarity. The few papers devoted to list item similarity have failed to show any conclusive effect of item similarity on the level of interference (Shea and Zimney 1988; Gabriele et al. 1989 exp. 2; Wood and Ging 1991). These results are somewhat surprising given that Battig had effectively manipulated levels of contextual interference through changes in item similarity.

There are at least two possible reasons why the motor learning findings are not wholly supportive of Battig's predictions. First, there is the possibility that item similarity is not a factor that affects the learning of a motor skill, unlike the cognitive effects found by Battig (1966, 1972, 1979). Second, there is the possibility that item similarity has not been adequately controlled in the motor skill studies (Shea and Zimney 1988; Gabriele et al. 1989 exp. 2; Wood and Ging 1991) and therefore the issue of similarity has not been effectively tested.

Shea and Zimney (1988) manipulated item similarity in a multi-sequenced bar knock down experiment but failed to report the results of the similarity manipulations for the retention or transfer tests. The most likely reason for that omission was that the similarity manipulation was not a significant factor. Gabriele et al. (1989 exp. 2) utilizing an experimental paradigm similar to Shea et al. (1979, 1983, 1988), compared the effects of imagery practice with that of physical practice. They found no differences in retention performance for all the random groups (high-CI) when equated for physical practice (reported number of trials to acquisition), thereby calling into question the effectiveness of the imagery conditions to differentially affect memory processes.

The failure to establish different contextual conditions through the use of imagery casts doubt on the validity of using this manipulation to investigate variations in item similarity. Not withstanding the use of imagery to secure variations in similarity, the a priori definition established by Gabriele et al. (1989 exp. 2) (contrasting high and low levels of similarity) are arguably incongruent with Battig's definition of similarity. The observed condition of maximal similarity was in fact maximally dissimilar as defined by Battig (1965, 1966, 1966b, 1966c, 1966d, 1972). The result was a comparison of two conditions that were both maximally dissimilar relative to intra-list similarity.

Battig operationally defined intra-list similarity as lists of trigrams containing shared component letters in similar positions within the trigrams. If this concept were extrapolated to a movement item analogy, some shared movement parameters between patterns within a list must be adopted. Alternatively, there is no basis to expect that a shared cognitive concept such as highly similar semantic meaning (e.g. used by both Gabriele et al. 1989 exp. 2, and Wood and Ging 1991) would affect a motor movement.

Wood and Ging's (1991) manipulation of item similarity, like Gabriele et al (1989), does not appear to be congruent with Battig's definition of similarity. Thus it is not surprising that the use of a semantically defined level of similarity (the reported Z'ness of the patterns) failed to affect performance during movement acquisition and retention as expected by Wood and Ging (1991). In fact Wood and Ging's (1991) low similarity condition includes movement patterns that contained segments that were identical between items (indicating high similarity according to Battig) whereas the high similarity condition contained patterns where no segments were identical between items (indicating low similarity according to Battig) with respect to movement direction and extent. Interestingly, Wood and Ging's (1991) results show their low similarity condition inducing superior acquisition performance and better retention performance than their high similarity condition, a result which is contrary to any of the currently offered theoretical explanations. If one adopts the previously discussed interpretation of Battig's definition relative to movement patterns, Wood and Ging's (1991) results show weak support for Battig's predictions.

In summary, the current research regarding item similarity in the motor learning literature has yielded inconclusive results. The importance of the issue of item similarity as a control for contextual interference will become evident in the following discussion of theoretical alternatives to the variable and multiple processing (variable and multiple encoding hypothesis) explanation.

Theories and Predictions

What are the underlying mechanisms responsible for learning when contextual interference is increased? As reported previously, Shea and Morgan (1979) adopted Battig's theoretical explanation for the contextual interference effect. Shea and Morgan (1979) concluded that the results of manipulating presentation schedules were the following:

> ...[that] the random group was forced to use multiple processing strategies to optimize its performance during acquisition, whereas no such

> multiple processing was necessary for the blocked group. This greater elaboration led to better retention performance, especially when the context of performance was changed... (p. 186)

Increased levels of contextual interference required subjects to use multiple and variable processing strategies which resulted in more distinctive and elaborate representations of the to-be-remembered items.

Lee and Magill (1983, 1985) put forth an alternative explanation describing mechanisms that may be responsible for the inferior acquisition performance, superior retention and transfer performance found when conditions of high contextual interference where present. Lee and Magill (1983, 1985) forged a theory built on the ideas related to 'forgetting' as put forth by Jacoby (1978) and Cuddy and Jacoby (1982). Lee and Magill (1983, 1985) argued that in a case where contextual interference was manipulated through the use of blocked and random presentation schedules, the nature of the random schedule allowed subjects to forget elements of the motor program or action-plan when an intervening trial or trials separated two identical trials. Subjects are evidently forced to reconstruct the action-plan through more 'effortful processing' (Bransford et al. 1979) on each occasion when the preceding trial is not identical.

The underlying mechanism in Lee and Magill's theoretical explanation is the level of 'effortful processing' such that as effortful processing increases, a stronger memorial representation results (Lee and Magill 1983, 1985; Magill and Hall 1991). The blocked condition does not suffer from forgetting of the action-plan, as the action-plan is still active in STM from the previous trial. When reconstruction is not required, then effortful processing is not required, and so a poor memorial representation results. This explanation predicts acquisition performance and retention performance effects similar to that presented earlier (see Magill and Hall 1991 for review).

Both the variable and multiple encoding (V&M) hypotheses and the forgetting and reconstruction (F&R) hypotheses, while differing in their mechanistic explanations, predict similar sets of results. Both theoretical explanations predict that when contextual interference is increased, acquisition performance will be suppressed and that retention and transfer performance will be superior. When contextual interference is manipulated through the use of context scheduling, (ie. blocked and random presentation schedules) the results are consistent with both theoretical explanations (Magill and Hall 1991). Consequently, the manipulation of contextual interference through presentation scheduling alone cannot discriminate between the two opposing theoretical explanations of CI. Perhaps a change in experimental approach is required.

One approach that has gone relatively unnoticed throughout the brief history of the motor learning contextual interference research is the original manipulation of intra-list similarity. Only a few studies have attempted to manipulate contextual interference through variations of intra-list similarity. The results of these studies failed to generate any precise conclusions. That is unfortunate because the two theoretical explanations of CI hold different predictions about how the item similarity manipulation would affect the level of CI.

The two theoretical explanations offer different predictions relative to the influence of manipulating item similarity. The F&R hypothesis predicts that variations of item similarity will have <u>no</u> differential affect on the level of contextual interference. That is to say, highly similar items within a list <u>do not</u> cause greater forgetting than dissimilar items within a list. Contrary to this prediction, the V&M encoding hypothesis predicts that as item similarity increases, contextual interference increases. Item similarity therefore, can provide a differential test of the two competing theoretical explanations. Experiments 1 and 2 are aimed at studying the influence of item similarity on acquisition and retention performances.

The second issue presented here is the issue of explaining presentation scheduling results by way of the similar factors that have been observed to be present when range like effects occur. Wilberg (1990 personal communication) suggested that the inferior acquisition performances of the random schedule, observed in the motor learning literature, may be confounded by the same factors that have been observed during the presence of range like effects as described by Poulton (1979). There is a possibility that the underlying mechanisms that produce a central tendency to the movement range such as a the range-frequency effect (Parducci 1963, 1965) or an adaptation level (Helson 1947, 1948; Laab 1973), might also be present in the traditional randomly presented trials of CI.

Range effects such as over and\or undershooting a target, can occur when various factors are present in the learning context. Two such factors are the presentation scheduling of the trials and the relative timing between the presentation of the trials. When trials are massed, or presented in sets where the inter-trial interval (ITI) is less than the trial time, and presented in a random presentation schedule, range like effects can occur (Leuba 1892; Hollingworth 1910; Helson 1947, 1948; Ellson and Wheeler 1949; Parducci 1963, 1965; Laab 1973; Hall

1978; Poulton 1979). In the traditional motor learning contextual interference experiment the condition of the random presentation schedule usually resulted in massed trials and hence the possibility of range like results exists. When range like effects occur, the over and\or under shooting of target amplitudes, the performance becomes more errorful. In light of the possibility that range like effects may take place during the randomly presented schedule, the interpretation of common results such as inferior acquisition and superior retention and/or transfer performance becomes suspect. The results which traditionally have been explained in terms of increased contextual interference can alternatively be explained in terms of the factors associated with range like effects that are concomitantly present in the random schedule. Consequently, the third experiment in this thesis is devoted to the issue of the factors associated with range like effects.

In summary, three experimental issues relating to CI were examined. The following three experiments were developed to examine these issues. The first two experiments were designed to test the two competing theoretical explanations for the contextual interference effect utilizing the manipulation of item similarity to control the level of CI. The second experiment concomitantly studied the additive nature of item similarity and presentation scheduling as two factors that affect the level of CI. The third experiment was designed to investigate an alternative explanation for acquisition and retention effects found in traditionally high contextual interference situations, namely factors associated with range like effects observed when trials are massed and randomly presented.

The Unit of Analysis

Item similarity was used to alter the level of CI in the verbal learning situation. For example, Battig manipulated item similarity by holding constant specific letters in specific positions in CCC trigrams (Battig 1965, 1966, 1966b, 1966c, 1966d, 1972). Manipulating item similarity allowed lists of items (CCC trigrams) to be formed, contrasting unique items (low CI) in one list with similar items (high CI) in another list. To illustrate, a four item trigram list regarded as similar includes the items: BHK LRK BST BMK. These items are similar with respect to either the first or last position of the trigram between items within the list. Highly similar lists are shown to cause greater contextual interference than lists with four dissimilar trigrams (BHK LRM PZC YND). Battig (1966, 1972, 1979) explained the recall performance on such lists in terms of the need for more variable and multiple encoding. The result of increased encoding was more distinct representations of the list items in memory. The required increase in processing concomitantly resulted in more elaborate retrieval routes when these learned items required later recall (Battig 1966, 1972, 1979). Item similarity has been successfully manipulated in the verbal learning literature resulting in variable levels of CI. The task of translating this concept into the motor learning situation is essential because it distinguishes between the two previously presented theoretical explanations of CI.

Movement patterns have been traditionally used when studying CI in the motor learning literature. The movement patterns have predominantly consisted of three to four movement segments each with a specific direction and amplitude requirement. The patterns constructed from the movement segments, are joined in such a manner that two to three directional changes are required. These requirements dictate that the learning demands of the task be twofold. First, each movement amplitude and direction of the segments must be learned.[1] Second, the serial relationships or couplings between the movement segments must be learned. That is, once the motor

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[1] A question has been raised as to the motor demands of learning movement amplitudes and directions, relative to stimulus learning coupled with some general movement production mechanism. This issue is addressed in Experiment 1 by including two control conditions that receive the stimulus input only in the absence of motor output.

demands of the movement segment have been learned relative to the amplitude and direction, their relative spatial positions within the sequence must also be learned.

Learning the correct sequence is presumably based upon a cognitive rather than motor strategy. Either the motor aspects, direction and amplitude, or the cognitive elements, the serial relationships, of the movement patterns can be measured and studied. It is important to distinguish which of these two demands (or both) is being studied in the CI experiment as they represent two distinct areas.

The following experiments were designed to isolate the motor learning demands of performing a multi-segment movement pattern, particularly the learning of the segment amplitudes and directions, while minimizing the required learning of the serial relationships of the segments sequencing. This goal was accomplished by using the Pattern Segment Accuracy Technique (PSAT).

<u>The Pattern Segment Accuracy Technique (PSAT)</u>

In the following experiments, a technique known as the Pattern Segment Accuracy Technique (PSAT) was adopted to study the associated motor learning of movement patterns. A series of four segment movement patterns (to replace the trigram) was utilized to control the level of movement pattern similarity within a list. All the

Figure 1 Prototype Pattern.

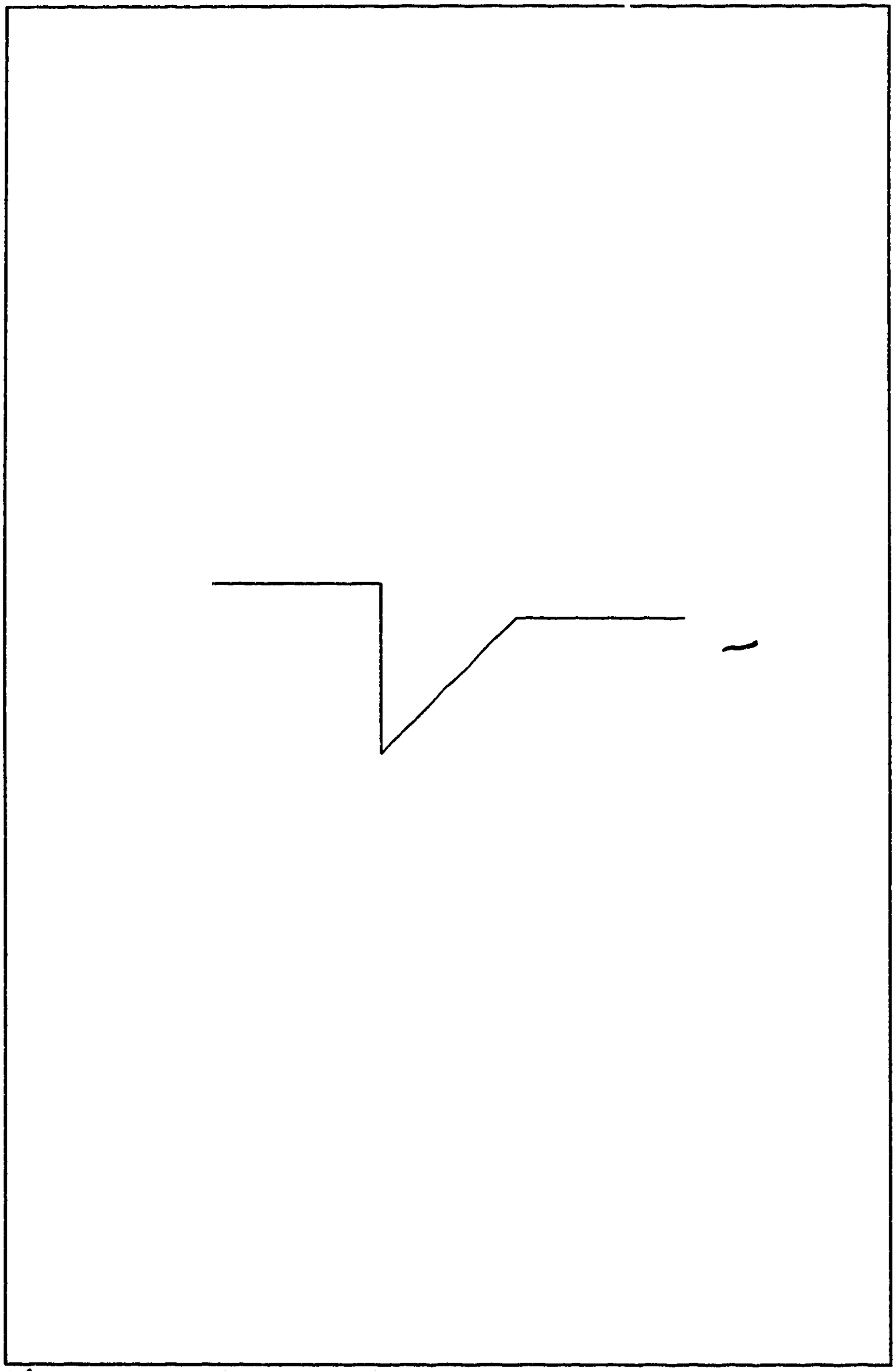

Figure 1 Prototype Pattern.

movement patterns maintained a common serial directional order, namely: right, down, 45 degrees up-right, and finally right again (see Figure 1). The prototye movement pattern was chosen to minimize learning of directional changes between patterns. Like the trigram, which is always reported in a serial left to right fashion with respect to the component letters, the movement patterns are always performed in the same direction as the prototype.

The experimental demands of learning the movement patterns now parallels the learning demands of the CCC trigram which was to learn the component letters (from a set of 21 possible consonants) and the associated relationships between the component letters. The subject's task using the PSAT paradigm was to learn the segment lengths (from a relatively unlimited set) and the associated relationships between those segments.

The level of similarity was manipulated by holding certain segment amplitudes within a pattern constant, and maintaining that constancy between patterns in the list. The PSAT procedure allowed pattern items within a list to be novel with respect to the segment amplitudes, or to share certain segment amplitude similarities. Consequently the PSAT procedure produces effects similar and likely congruent to what Battig achieved when he used CCC trigrams.

The dependent measure derived from the PSAT is the PSAT error score. It is obtained in the following way. The subject's response to a pattern is dissected into its four movement segments. Segment amplitudes from the original stimulus are then subtracted from the subject's produced segment amplitudes respectively, resulting in a negatively or positively signed error score for each segment. The signed error score indicates undershooting or overshooting respectively. The absolute values of each of the four segments are then summed to generate an overall pattern accuracy score (PSAT error score). The PSAT error score reflects the influence of all segment errors as they relate to the whole pattern. The PSAT error score was used as the dependent measure for all three experiments in this study.

A pilot study was conducted to ensure that the PSAT dependent measure would reflect learning. This goal was accomplished through a traditional CI paradigm using blocked and random scheduling of three movement patterns and observing acquisition and retention performance. The results indicated that the blocked acquisition performance was superior to the random acquisition performance and the random retention performance was superior to the blocked retention performance (see Appendix A). These results are congruent with the traditional contextual interference results and also support the contention that the PSAT error score is a valid measure of learning in this type of experimental design.

To summarize the functional affects of CI, three relationships are offered in their order of importance. The most important relationship to achieve relative to any CI experiment is evidence of a differential learning effect. This translates into an observed difference during retention between the high and low CI conditions such that the high CI condition out performs the low CI condition. This relationship indicates different levels of learning achieved during the acquisition phase of the experiment and is reflective of the CI manipulations. The next two relationships are supportive of, but not essential for a full explanation of CI.

The relationship between final acquisition performance and initial retention performance can indicate the level of learning maintenance. The high CI condition should maintain performance while the low CI condition will decline in performance. This relationship must be observed carefully as changes in procedures such as the removal of information feedback during retention testing can affect the relative nature of the scores. The third relationship to consider is the comparison of the high CI condition to the low CI condition during acquisition. The desired relationship should indicate the low CI condition performing better than the high CI condition. This relationship also must be viewed with caution as different learning demands can affect this relative relationship.

Experiment 1

The Effects of Item Similarity Manipulations on Contextual Interference

The main purpose of the first experiment was to test the predictions of the competing theoretical explanations for the Contextual Interference (CI) effect by investigating the issue of item similarity. Two levels of item similarity, similar visual-motor (v-m) and dissimilar visual-motor (v-m) were manipulated independently across acquisition and retention trials.

The F&R hypothesis supports the notion that item similarity *is not* a factor that should affect the level of CI. Advocates of the V&M hypothesis argue that item similarity should affect the level of CI in a direct manner such that as item similarity increases the level of CI also increases. Variations in the levels of CI translate into the following functional observations. Higher levels of CI cause performance during acquisition to be more errorful. Subsequently, retention performance for the higher CI condition will produce superior performance compared to the lower CI condition. These predictions are illustrated in Table 1.

Table 1

The Relationships of How the Level of Similarity Will Affect the Concurrent Level of Contextual Interference Forged from the Two Competing Hypothesis.

	Level of Similarity	Level of CI
Variable and Multiple Encoding Hypothesis	high	high
	low	low
Forgetting and Reconstruction Hypothesis	high	neutral
	low	neutral

A secondary issue, that of examining further whether the PSAT measure is one of motor learning, when compared to stimulus learning, was also investigated. The PSAT error score, indicative of some learning function, has arguably been questioned as to the nature of the learning it is in fact reflecting. To that end, the following predictions are offered. If the PSAT error score is a measure of stimulus learning only, then the retention scores for both v-m conditions should not be different than the associated control conditions (stimulus only). It is doubtful whether the stimulus alone can be responsible for the results if the v-m conditions lead to retention scores superior to the control conditions. Table 2 illustrates these predictions.

Table 2

Predictions of Retention Results for Stimulus Learning and Visual-Motor Learning Using the PSAT Error Score Measure.

	Control Conditions	Visual-Motor Conditions
Stimulus Learning	same	same
Visual-Motor Learning	inferior	superior

PSAT = Pattern Segment Accuracy Technique

Method

A traditional learning paradigm, in which groups practised under various conditions of visual and motor information, was adopted for this experiment. The result was four groups, two practising under conditions of visual-motor (v-m) information and two practising under conditions of vision only (control) information. The four groups were labelled Similar V-M, Dissimilar V-M, Similar Control, and Dissimilar Control respectively.

Subjects. Twenty-three volunteer subjects were assigned to one of four experimental conditions (8 subjects per visual-motor condition, 4 subjects to the similar control group and 3 subjects to the dissimilar control group).

Apparatus. The experimental stimuli and responses were presented and collected through the interface of a 20-Hz AT micro-computer using an AOC VGA Hi - resolution colour monitor and a SummaSketch II Professional digitizing tablet. The monitor resolution was set to 640(x) by 480(y) pixels with all stimulus lines presented in a 3 pixel wide format. The resolution of the digitizing tablet was configured to 10 lines per millimetre with a response collection rate of 50 reports per second. The data collected corresponded to x and y digital positions on the digitizing tablet. The monitor and digitized tablet were configured to a 1 to 1 mapping.

Subjects sat in a standard hight chair at a table that measured 73 centimetres from the floor to the top. The monitor was situated on the table approximately 75 centimetres in front of the subject and approximately at a viewing angle of 10 degrees below the horizontal gaze. The digitizing tablet was situated directly between the subject and the monitor and both were centred along the sagittal plane of the subject. The room lighting and temperature were held constant throughout the experiment.

Procedure. All groups received a full written (see Appendix B) and verbal explanation of the task followed by a single demonstration trial that served as a practice trial familiarizing them with the equipment and procedure. Subsequently, the visual-motor (v-m) groups proceeded with an acquisition phase of 30 experimental trials with visual comparative feedback (VCF), a 24 hour retention interval, and a retention phase. The two control groups received the same stimuli procedure as the visual-motor groups during acquisition but no response was required and subsequently no VCF was administered. The Similar V-M condition and the Similar Control condition received the list of similar patterns during the experiment. The Dissimilar V-M condition and Dissimilar Control condition received the list of dissimilar patterns during the experiment.

Each experimental trial commenced with a 500 msec long, clearly audible 500 Hz. tone. At that time a visual pattern appeared on the monitor for a duration of 5 seconds. Upon extinction of the visual pattern, the next visual pattern appeared for 5 seconds, until all 5 patterns had been presented. The visual-motor (v-m) groups received a visual response cue on the monitor ('Draw Figure n' where n was 1 to 5) prior to each attempt at drawing the cued pattern. The patterns were recalled in the same serial order that they were presented. The responses were self paced and drawn with the subject's preferred hand. Upon completion of all five responses, the subject pressed the space bar on the computer keyboard to end the trial. The two control groups were required to press the space bar after the fifth pattern presentation to end the trial.

During the acquisition phase of the experiment, VCF was shown to the subjects in the visual-motor conditions. The feedback was shown on the monitor for a duration of 3 seconds per item at the completion of all 5 reproductions. The VCF was administered in the form of a video reproduction of what the subject drew on the tablet along with the original pattern in contrasting colours so the subject could compare their output with the original pattern.

In all conditions the subjects controlled (self paced) the inter-trial interval (ITI) until all 30 experimental trials were completed.

Following a retention period of 24 hours, all subjects drew the 5 practised patterns in the same serial order in which they were presented during the acquisition phase of the experiment. Neither stimulus presentation nor VCF information was available to the subjects during the retention phase of the experiment. The subjects were required to make 3 attempts at the 5 pattern list.

Figures 2 and 3 illustrate the 5 similar and dissimilar patterns respectively. Bearing in mind Battig's definition of similarity discussed previously, similarity is defined as the measured relationship between items within a list. Two target patterns, pattern #3 and pattern #5 (Figure 2) were identical to pattern #8 and pattern #10 (Figure 3). The remaining patterns in both lists dictated the relative level of list similarity. The level of similarity was manipulated in the similar pattern list (Figure 2) by holding segment #2 (down) and segment #4 (right) constant between three of five patterns. The dissimilar pattern list (Figure 3) have different segment amplitudes in all positions. Only the target items were used in the comparisons of these two conditions.

Data and analysis. The dependent variable in this experiment was the PSAT error score. The PSAT error scores were calibrated to a 0.1mm level of precision.

The PSAT error data for the acquisition phase of the experiment were collapsed for the two target patterns (patterns #3 and #5 for the similar list and patterns #8 and #10 for the dissimilar list). Subsequently, the 30

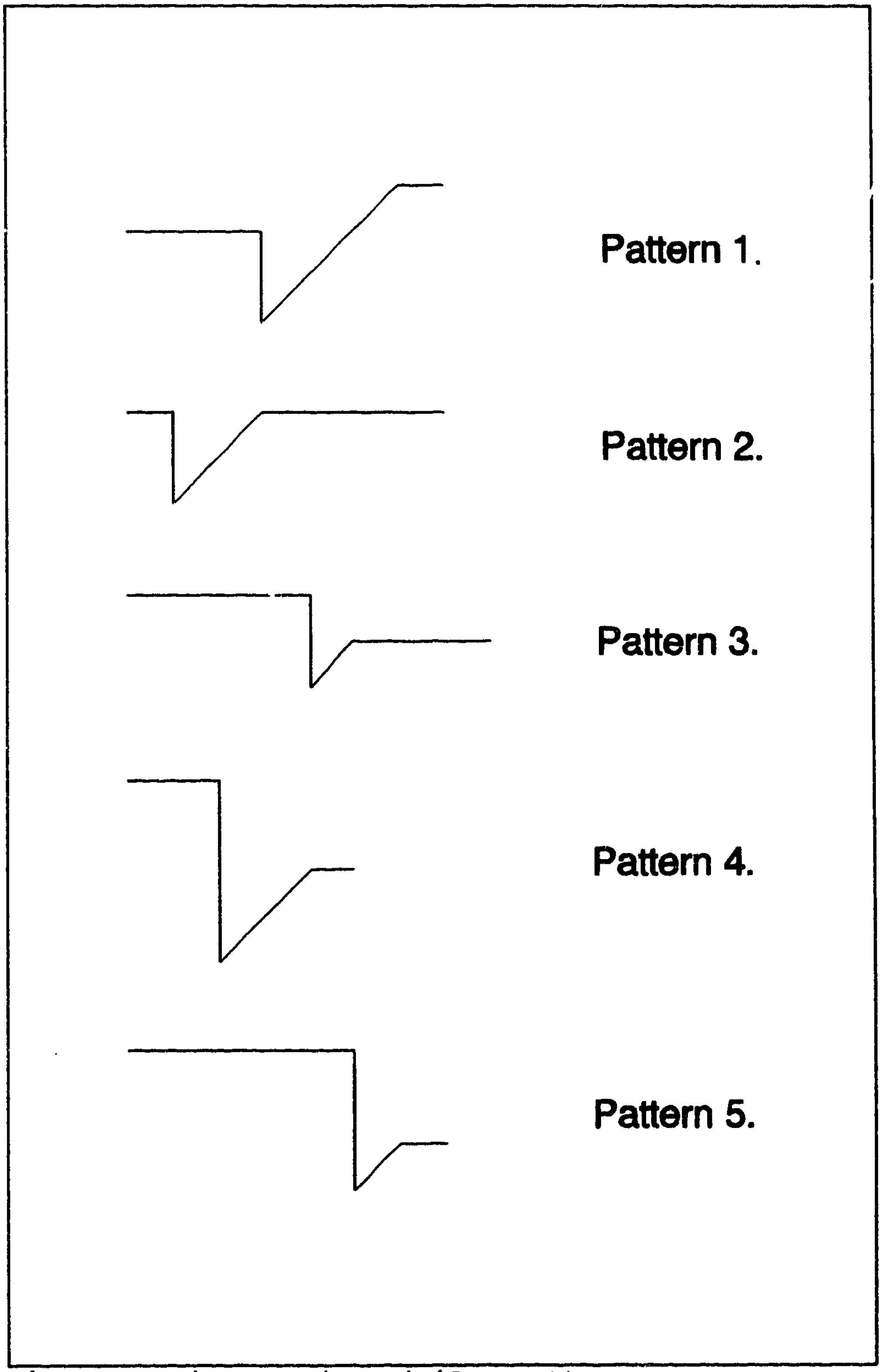

Figure 2 List of Five Similar Patterns.

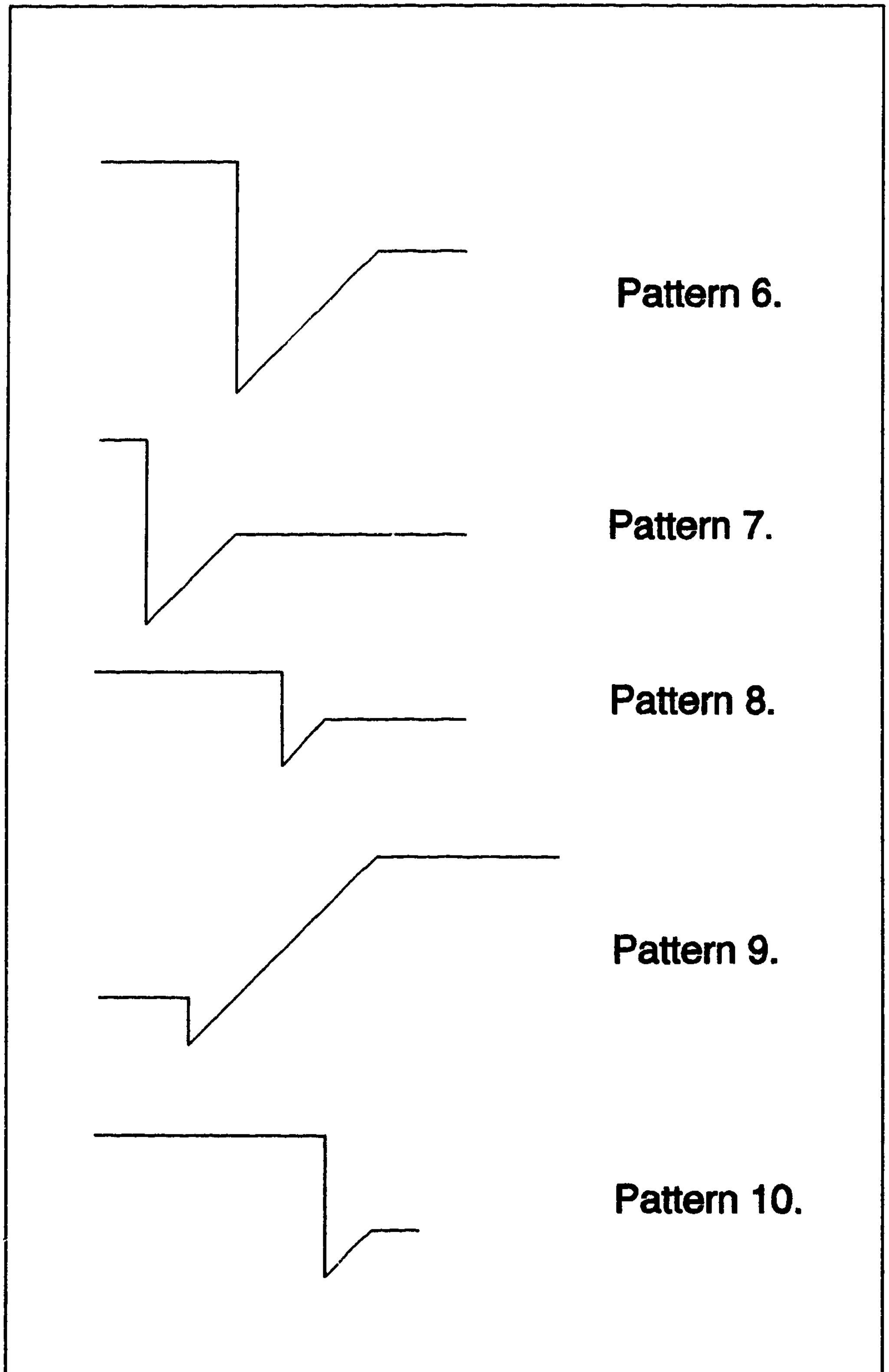

Figure 3 List of Five Dissimilar Patterns.

acquisition trials were collapsed into 10 blocks of 3 trials each resulting in 10 mean data scores for each subject. The retention data also were collapsed across trials (3) and patterns (2) resulting in 1 mean retention score. The mean PSAT error data underwent 3 separate analyses.

Analysis. The first analysis was a 2-way UANOVA trial block(10) x similar-dissimilar(2) and subsequent Student Newman-Keuls (SNK) post hoc tests on the v-m acquisition data. The second analysis, also a 2-way UANOVA, trial block(11) x similar-dissimilar(2) was followed by SNK post hoc tests on the v-m acquisition and retention data inclusive. A third 2-way UANOVA trial block (4) x similar-dissimilar-control (4) was calculated, followed by SNK post hoc tests on the first, second, and last blocks of acquisition for the v-m conditions and retention data for both the v-m and control conditions.

Results

Acquisition data. The results from the 2-way UANOVA are presented in Table 3. The mean values are recorded in Appendix C.

Table 3

Experiment 1. UANOVA Results for Acquisition Data.

Dependent Variable	F Ratio	M.S. Error	Probability
SimDis	0.14	114785	0.711
Blocks	47.17	27597	0.35E-35
SimDis * Blocks	3.18	27597	0.0017

SimDis = Similar-Dissimilar condition (2).

Blocks = Blocks of Trials (10).

The observed significant interaction (Figure 4) between the similar-dissimilar and the trial blocks conditions required post hoc analysis using SNK tests with alpha set at the .05 level. The SNK tests revealed a more accurate score for the dissimilar group in the first trial block, but no differences were found between the similar and dissimilar conditions at any other trial block comparison. There was significant improvement from trial block 1 to trial block 10 for both similar and dissimilar conditions.

Retention data. The results from the 2-way UANOVA are presented in Table 4.

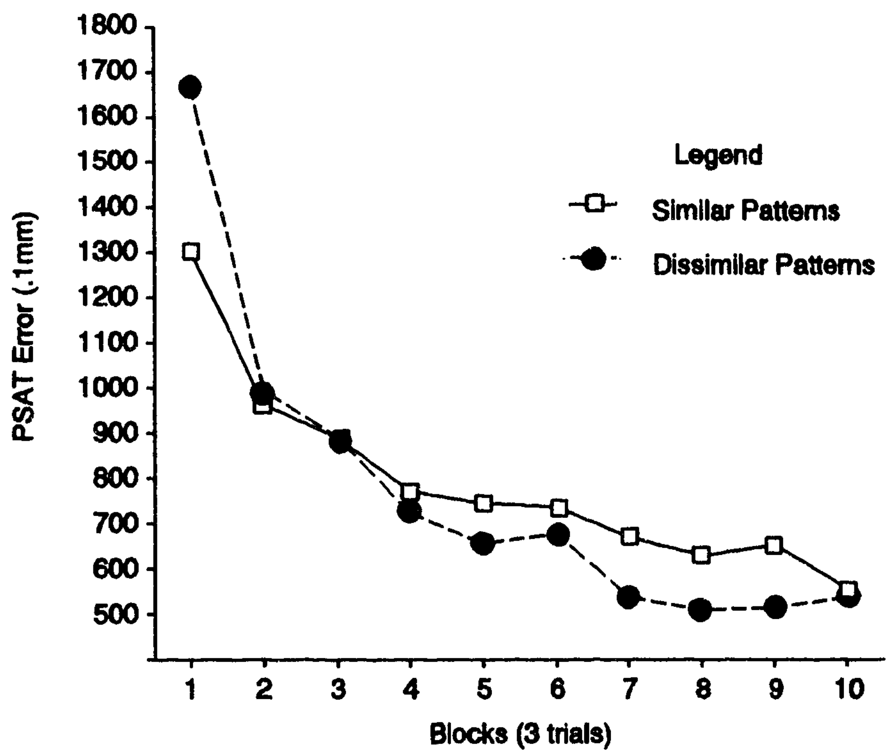

Figure 4. Acquisition Data for Experiment 1.

Table 4

Experiment 1. UANOVA Results for Acquisition and Retention Data.

Dependent Variable	F Ratio	M.S. Error	Probability
SimDis	0.10	103077	0.752
Blocks	43.23	27386	0.59E-37
SimDis * Blocks	4.95	27386	0.39E-5

SimDis = Similar-Dissimilar condition (2).

Blocks = Blocks of Trials (11).

The observed significant interaction (Figure 5) between the similar-dissimilar and the trial blocks conditions required post hoc analysis using the SNK tests with alpha set at the .05 level. The SNK tests revealed a more accurate score for the similar condition relative to the dissimilar condition for the retention data, concomitantly no difference was found with the last block of acquisition. The dissimilar retention data alternatively revealed a less accurate score than the last block of dissimilar acquisition. While both retention blocks revealed significantly better

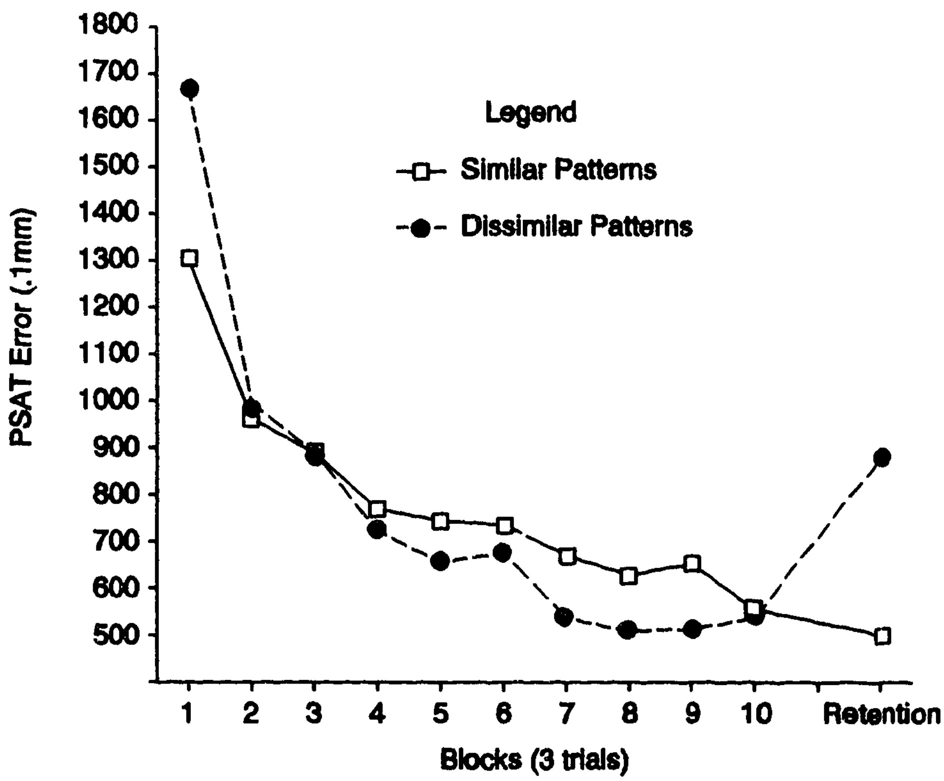

Figure 5. Acquisition and Retention Data for Experiment 1.

performance than the initial first block of acquisition, only the similar condition was better than the second block of acquisition. Also, the dissimilar retention block was not different from the second block of the dissimilar acquisition.

Control data. The results from the 2-way UANOVA are presented in Table 5.

Table 5

Experiment 1. UANOVA Results for the Retention Data Inclusive of the Control Conditions.

Dependent Variable	F Ratio	M.S. Error	Probability
SimDis	4.0	59566	0.023
Blocks	44.99	48504	0.481E-14
SimDis * Blocks	6.63	48504	0.201E-5

SimDis = Similar-Dissimilar condition (4).

Blocks = Blocks of Trials (Blocks 1,2,10, and 11).

The observed significant interaction (Figure 6) between the similar-dissimilar conditions and the trial blocks conditions required post hoc analysis using the SNK tests with alpha set to the .05 level. The SNK tests

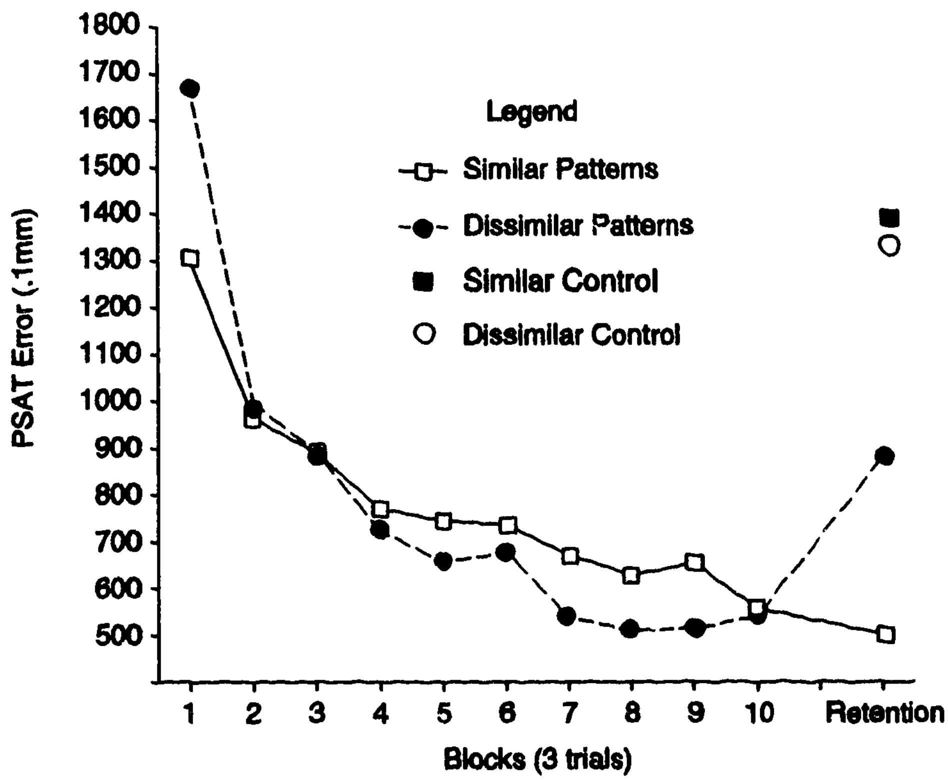

Figure 6 Acquisition and Retention Data for Visual-Motor Conditions and Retention Data for Control Conditions.

revealed differences between the v-m similar and similar control, and v-m dissimilar and dissimilar control conditions in a manner such that the control conditions performed with more error than the v-m conditions for the retention data. Both control retention scores performed no better than their counterpart v-m conditions when compared to the first block of acquisition practice.

Discussion

The results from the acquisition data analysis revealed one traditional and one non-traditional finding. As expected, both v-m groups showed improved performance as practice increased, as evidenced by the decrease in PSAT error scores as trial blocks increased. Unexpectedly, the acquisition performances of the two v-m conditions did not differ from one another. Traditionally, higher levels of CI have led to poorer performance during acquisition. The absence of a main effect and subsequent meaningful interaction for the similarity manipulation, raises the question whether the similarity manipulation functionally affected the level of CI in this experiment.

The observed interaction between the blocks factor and the similarity factor materialized from one significant pair-wise comparison, that being, the poorer performance of the dissimilar condition when compared to the similar condition in the first trial block. This difference is at present, unexplained.

The results from the analysis, including the retention score data, revealed two important findings. First, the comparisons of acquisition performances to retention performances indicated that the similarity manipulation affected the learning of the movement patterns. The performance for the similar group during retention was no different than the last block of acquisition while the performance for the dissimilar group was poorer than the last block of acquisition. The dissimilar group's retention performance was also the same as that of early practice performance (Block 2). Second, the comparison of the retention scores to each other indicate the benefits of practising similar patterns together during the acquisition phase of the experiment. The performance of the similar condition's retention score was superior to that of the dissimilar condition.

Together, these findings support one conclusion. Whatever processing mechanisms were activated during the acquisition phase for the similar condition in this experiment, induced a long term stable affect that was not evident for the dissimilar condition.

The retention results indicate a superior learning effect for the similar condition of visual-motor practice. The context surrounding the similarity conditions during practice led to differential retention performances, yet no interference was observed during acquisition. The inability of the similarity manipulation to affect performances during acquisition calls into question whether CI is responsible for the observed retention differences.

One explanation for the discordant acquisition results is the possibility that the presentation schedule used in this experiment was not effective in producing a significant level of CI. The use of identical presentation schedules for both the similar and dissimilar conditions may have been too subtle to reveal differential practice results. This observation is supported by the trend for superior performances observed for the dissimilar condition during acquisition that failed to reach statistical significance.

The secondary issue related to the nature of the learning was addressed using the results of the analysis inclusive of the control conditions. The results from the analysis including the control conditions revealed that vision only was not sufficient information to affect the learning of the movement patterns. The retention performances of both control conditions, which did not differ from each other, were inferior to their counterpart v-m retention performances. The retention scores for the control groups were also no different than the first trial block performances of their counterpart v-m conditions. Together, these results indicate that potential stimulus learning during acquisition, as measured by the control conditions, did not assist the subjects in performing the motor reproduction task during the retention phase of the experiment.

In summary, these results cast serious doubt on the idea that the information contained in the stimulus during acquisition is predominantly responsible for the learning of the motor ɔroduction task, when measured by the PSAT error scorɩ

riment 2

Effects of Item Similarity and
Presentation Scheduling on Contextual Interference

The purpose of the second experiment was to test the predictions of the competing theoretical explanations of contextual interference on the issues of item similarity and presentation scheduling.

The results from Experiment 1 indicated a positive learning effect from the manipulation of item similarity. However, the similarity manipulation failed to produce the anticipated set of acquisition data usually associated with differing levels of CI. The suggestion was made that the acquisition results, were in part, affected by some factor related to the presentation schedule.

Two different factors related to presentation style were manipulated in Experiment 2. These were the blocked and random schedules and the presentation of the VCF following every pattern reproduction. If these changes affect the level of CI during acquisition, separate and additive effects of presentation scheduling and item similarity should result.

Neither of the two theoretical explanation for CI make different predictions where presentation scheduling is concerned, yet supporters of the F&R hypothesis predict that item similarity is <u>not</u> a factor that would affect CI. Advocates of the V&M encoding hypothesis argue that item similarity would affect CI in a direct relationship. That is, as pattern similarity increases, so does CI. The manipulation of presentation scheduling and item similarity should alter the functional level of CI in the manner illustrated in Table 6.

Table 6

Predictions of Levels of CI Relative to Presentation Scheduling and Pattern Similarity for the Multiple and Variable Encoding Hypothesis and the Forgetting and Reconstruction Hypothesis.

Hypothesis	Similarity	Schedule	Level of CI
Multiple and Variable Encoding	high	random	highest
	high	blocked	intermediate
	low	random	intermediate
	low	blocked	lowest
Forgetting and Reconstruction	high	random	high
	high	blocked	low
	low	random	high
	low	blocked	low

Method

The level of CI was altered in this experiment by manipulating two variables. These were: presentation scheduling (random and blocked presentation order) and pattern item similarity as defined in Experiment 1. Four experimental groups emerged: dissimilar patterns presented in a blocked schedule (Blocked-Dissimilar), similar patterns presented in a blocked schedule (Blocked-Similar), dissimilar patterns presented in a random schedule (Random-Dissimilar) and similar patterns presented in a random schedule (Random-Similar).

Subjects. Thirty-two volunteer subjects were randomly assigned to 1 of 4 experimental conditions (8 subjects per condition). The 4 groups were labelled Blocked presentation - High similarity (Blocked-Similar), Blocked presentation - Low similarity (Blocked-Dissimilar), Random presentation - High similarity (Random-Similar), and Random presentation - Low similarity (Random-Dissimilar).

Apparatus. The same apparatus was used as described in Experiment 1.

Procedure. All groups received a full written (see Appendix B) and verbal explanation of the task followed by one demonstration trial. It served both as a practice and familiarization trial with the equipment and procedure. All groups received an acquisition phase

(Acq) of 75 trials (15 per pattern) of either 5 similar or 5 dissimilar patterns presented in either a Blocked (B) or Random (R) order. Each trial was followed immediately with visual comparative feedback (VCF). After a 24 hour retention interval all subjects performed the retention phase (Ret) requiring a colour cued recall of each pattern.

Each trial commenced with a clearly audible 500 Hz. tone for a duration of 500 msec. At that time a coloured visual pattern appeared on the colour monitor for a duration of 5 seconds. Upon extinction of the pattern, a visual response cue, presented in a colour identical to the stimulus pattern, cued the subject to reproduce the response (eg. after a red pattern, the visual cue "Draw red" was printed in red, cuing the subject to draw). The subject drew the pattern (self paced) on the digitizing tablet with the tablet's pen shaped probe. Upon completion, the subject pressed the space bar on the computer keyboard to end the trial.

During the acquisition phase, VCF was shown to the subject on the monitor device for a duration of 5 seconds. The VCF was given in the form of a reproduction of what the subject drew on the tablet (in a neutral colour - different from any pattern and the same for all feedback trials) along with the original pattern in its original colour so the subjects could compare their output with the original pattern. The VCF was given to all groups during the acquisition phase of the experiment. Each trial was separated by a two second inter-trial interval (ITI).

The retention phase of the experiment required the subjects to reproduce the 5 patterns in the absence of the presentation stimulus or the VCF. The subjects received 15 retention trials, 3 of each pattern. The response cue was the same as the response cue in the acquisition phase (eg. "Draw red" printed in red).

The patterns used in this experiment were the same as described in Experiment 1 (5 similar patterns shown in Figure 2, and 5 dissimilar patterns shown in Figure 3) with the exception that each pattern was now coloured in a pair-wise yoking between the similar and dissimilar conditions (patterns 1 and 6 were red, patterns 2 and 7 were blue, patterns 3 and 8 were green, patterns 4 and 9 were white and patterns 5 and 10 were grey). The same two identical target patterns (patterns 3 and 8, and patterns 5 and 10) were used to compare the similarity conditions.

Data and analysis. The dependent variable in this experiment was the PSAT error score. The PSAT error scores were calibrated to a 0.1mm level of precision.

The PSAT error data for the acquisition phase of the experiment was collapsed together for the same 2 target patterns as described in Experiment 1. Thirty acquisition trials (15 of each target pattern) were subsequently collapsed into 5 blocks of 3 trials each resulting in 5 mean data scores for each subject. The retention data was also collapsed across trials (3) and patterns (2) resulting in 1 mean retention score. Two separate analysis were calculated.

The first analysis was a 3-way ANOVA, trial block(5) x similar-dissimilar(2) x blocked-random(2) and subsequent Bon Ferroni planned comparison tests for the acquisition data. The second analysis was a 3-way ANOVA, trial block(6) x similar-dissimilar(2) x blocked-random(2) and subsequent Bon Ferroni planned comparison tests for the last block of the acquisition data and retention data inclusive.

Results

Acquisition data. The results from the 3-way UANOVA are presented in Table 7. The mean values are recorded in Appendix C.

Table 7

Experiment 2. UANOVA Results for Acquisition Data.

Dependent Variable	F Ratio	M.S. Error	Probability
SimDis	12.09	73715	0.0017
BlRan	12.38	73715	0.0015
Blocks	3.29	25556	0.0136
SimDis * BlRan	0.09	73715	0.769
SimDis * Blocks	1.52	25556	0.200
BlRan * Blocks	0.22	25556	0.926
SimDis * BlRan * Blocks	0.24	25556	0.918

SimDis = Similar-Dissimilar condition (2).

BlRan = Blocked-Random condition (2).

Blocks = Blocks of Trials (5).

Significant main effects for the three variable manipulations were obtained. No significant interactions were present. The means for the main effects are illustrated in Figures 7, 8 and 9 for blocks, similar-dissimilar patterns and blocked-random scheduling conditions respectively. The means for the 4

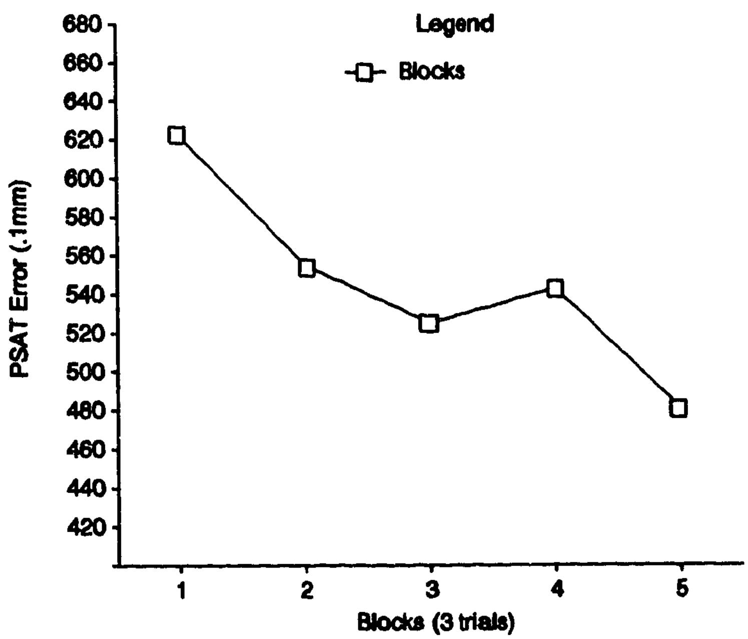

Figure 7 Experiment 2. Means from the Blocks Main Effect for Acquisition.

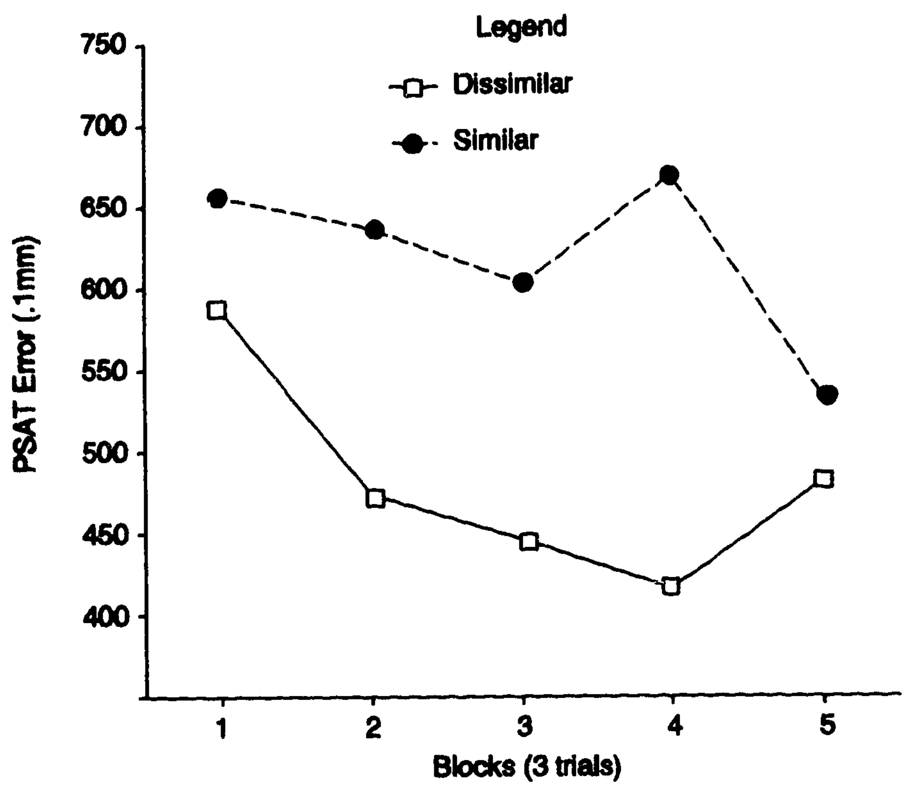

Figure 8 Experiment 2. Means from the Similar-Dissimilar Patterns Main Effect for Acquisition.

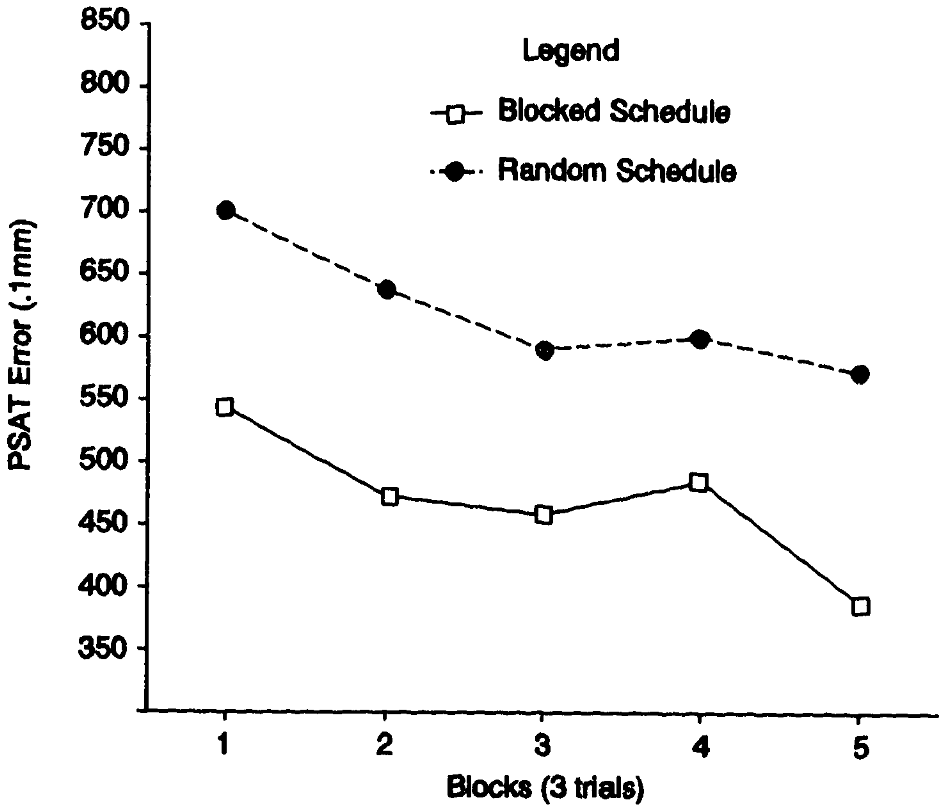

Figure 9 Experiment 2. Means for the Blocked-Random Schedule Main Effect for Acquisition.

experimental groups are illustrated in Figure 10, as these best illustrate the groups results relative to the discussion of the Bon Ferroni ($\alpha < .05$) planned comparisons. The least squared differences (LSD) results (Table 8) revealed superior performance for the blocked-dissimilar condition relative to the random-dissimilar condition. The performance of the blocked-similar condition when compared to the random-similar condition approached significance. Concomitantly, both dissimilar conditions performance relative to their counterpart similar conditions, compared at the level of scheduling, approached but failed to reach significance.

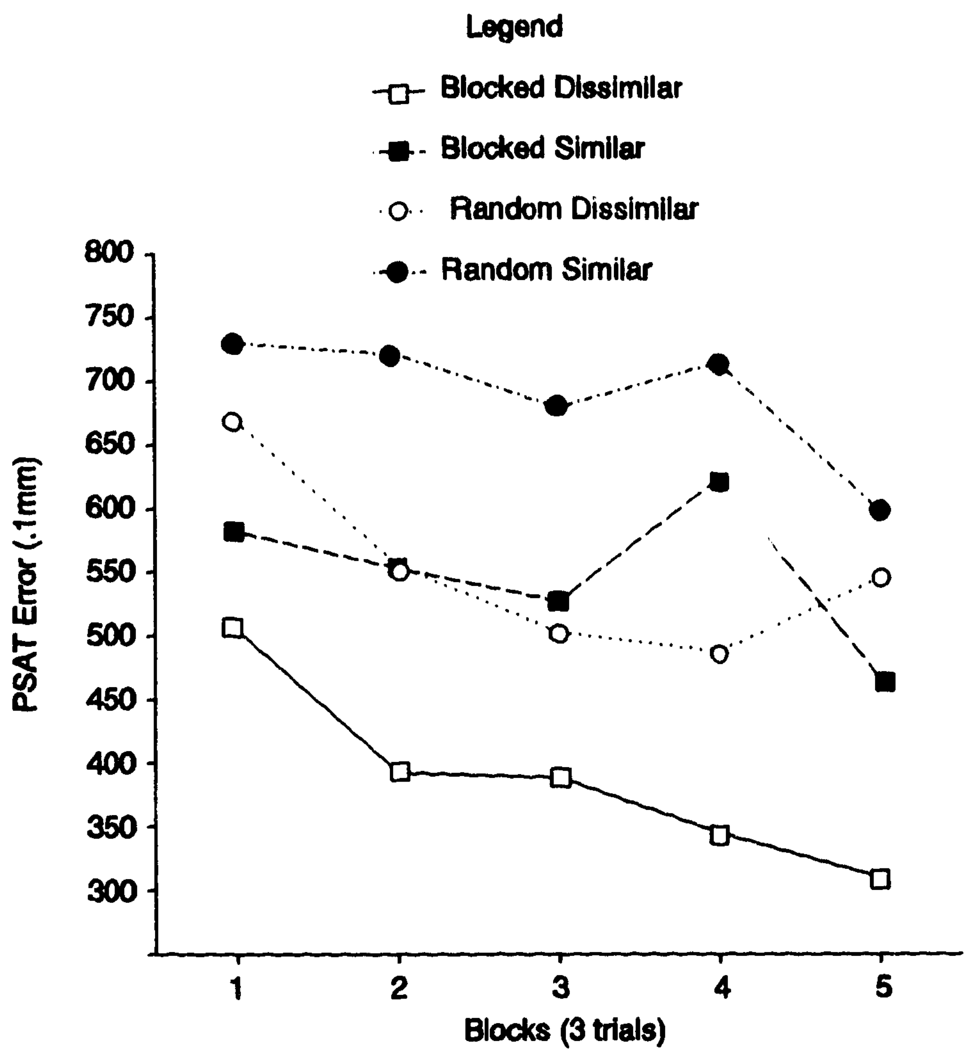

Figure 10 Experiment 2. Means from the Blocked-Dissimilar, Blocked-Similar, Random-Dissimilar, and Random-Similar Conditions for Acquisition.

Table 8

Experiment 2. Bon Ferroni Planned Multiple Comparisons for Similar-Dissimilar by Blocked-Random Conditions.

		Dissimilar Blocked	Similar Blocked	Dissimilar Random	Similar Random
Blocked	Dissimilar				
	Re Diff				
	Obs Diff				
Blocked	Similar				
	Re Diff	162.06			
	Obs Diff	162.00			
Random	Dissimilar				
	Re Diff	162.06			
	Obs Diff	163.77 *			
Random	Similar				
	Re Diff		162.06	162.06	
	Obs Diff		138.35	136.57	

Re Diff = Required Difference

Obs Diff = Observed Difference

* = $\alpha < .05$

Retention data. The results from the 3-way UANOVA are presented in Table 9.

Table 9

Experiment 2. UANOVA Results for Acquisition and Retention Data.

Dependent Variable	F Ratio	M.S. Error	Probability
SimDis	4.15	72698	0.0512
BlRan	0.04	72698	0.835
Blocks	46.10	35610	0.58E-27
SimDis * BlRan	0.29	72698	0.595
SimDis * Blocks	7.48	35610	0.30E-5
BlRan * Blocks	27.65	35610	0.17E-13
SimDis * BlRan * Blocks	0.23	35610	0.951

SimDis = Similar-Dissimilar condition (2).

BlRan = Blocked-Random condition (2).

Blocks = Blocks of Trials (6).

The analysis revealed 2, two-way interactions. They were the similar-dissimilar patterns by trial blocks interaction and the blocked-random schedule by trial blocks interaction. Both interactions required post hoc analysis using SNK tests ($\alpha < .05$). The means are illustrated in Figures 11 and 12 respectively.

The post hoc analysis of the similar-dissimilar patterns by trial blocks interaction revealed inferior performance for both the similar and dissimilar conditions in retention relative to the last block of acquisition. The two retention scores were not different from each other.

The post hoc analysis of the blocked-random schedule by trial blocks interaction revealed inferior performance in retention relative to the last block of acquisition for the blocked condition only. Subjects in the random condition performed no differently in retention when compared to the last block of acquisition, but performed better than subjects in the blocked retention score.

The means for the four experimental groups are shown in Figure 13, as these best illustrate the groups' results relative to the discussion of the Bon Ferroni ($\alpha < .05$) planned comparisons. The LSD results revealed inferior performances for all groups from the last block of acquisition to the retention trials with the exception of the random-similar condition which did not differ. Subjects in the random-similar group out performed both their counterparts in the random-dissimilar and blocked-similar groups during retention. The random-dissimilar

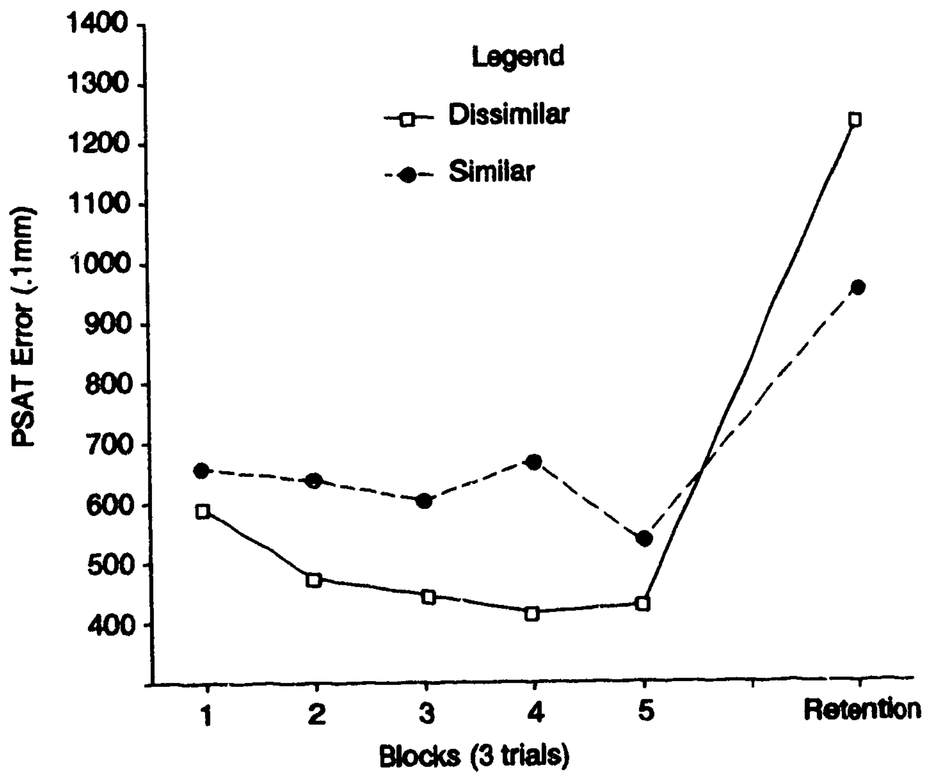

Figure 11 Experiment 2. Means from the Similar-Dissimilar Patterns by Trial Blocks Interaction for Acquisition and Retention.

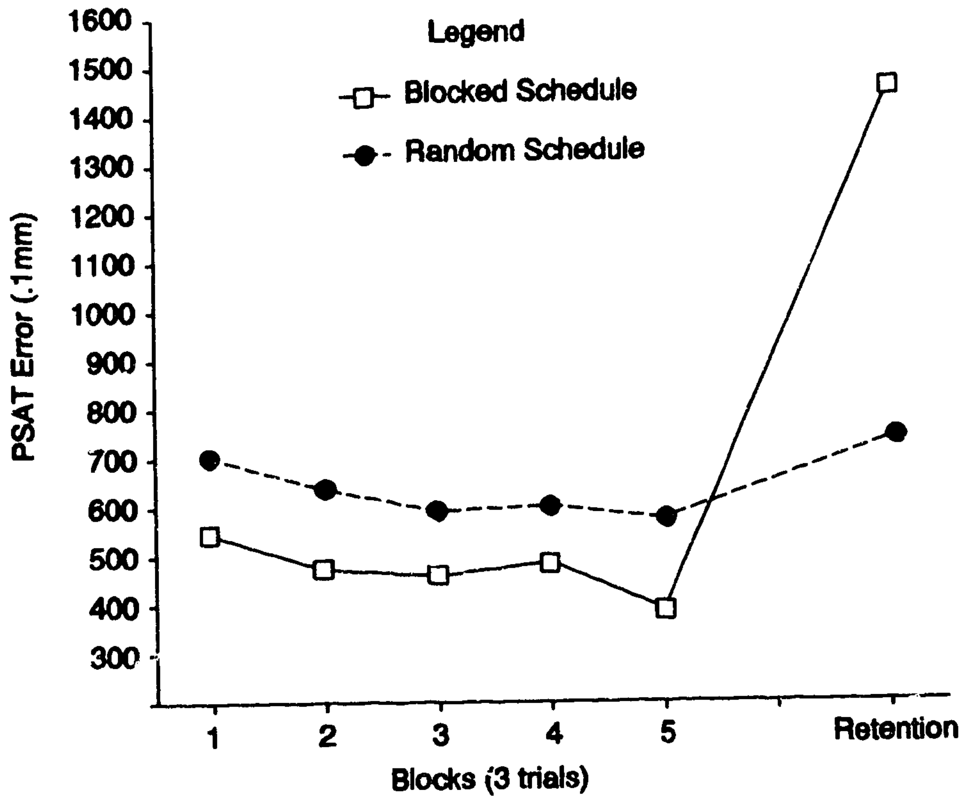

Figure 12 Experiment 2. Means from the Blocked-Random Schedule by Trial Blocks Interaction for Acquisition and Retention.

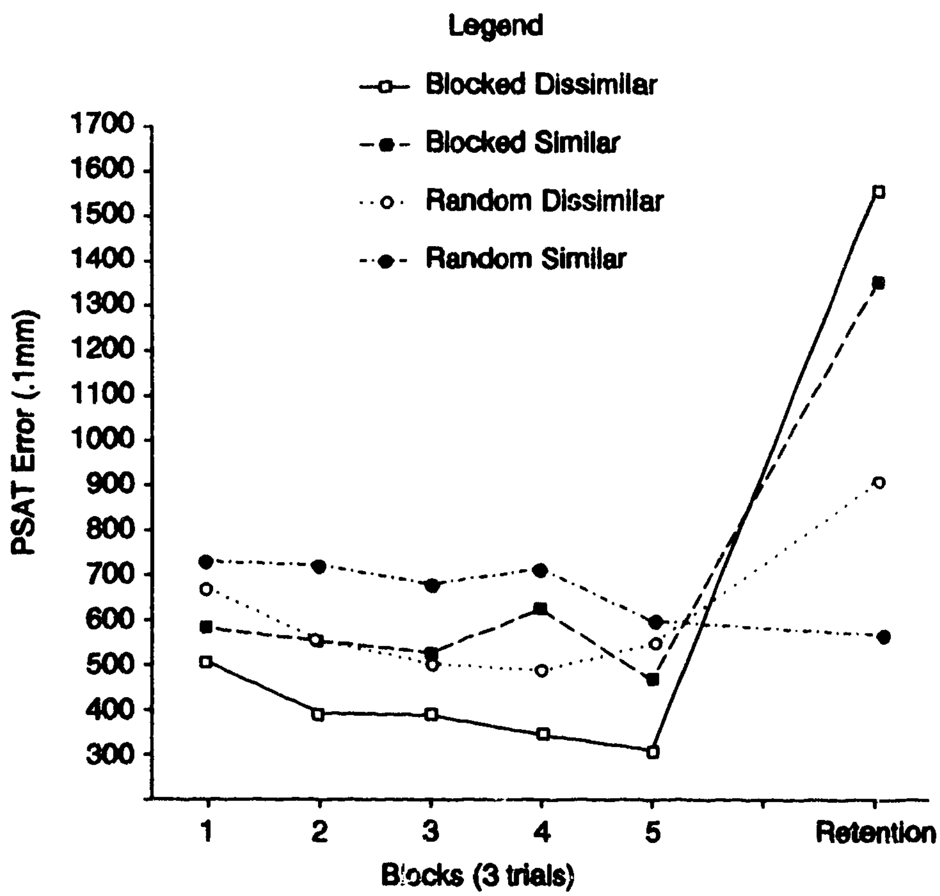

Figure 13 Experiment 2. Means from the Blocked-Dissimilar, Blocked-Similar, Random-Dissimilar, and Random-Similar Conditions for Acquisition and Retention.

group was superior to the blocked-dissimilar group in retention. The blocked-dissimilar group did not differ from the blocked-similar group in retention.

Discussion

The results from the acquisition data analysis revealed that the groups as a whole improved their performance with practice.

The observed main effect for presentation scheduling indicates an expected superior performance for the two blocked conditions when compared to the two random conditions. The planned comparisons for the blocked vs random conditions revealed significant differences for only the Blocked-Dissimilar and the Random-Dissimilar comparison (see Table 9). Unexpectedly, the Blocked-Similar and Random-Similar comparison failed to reach significance. While the result failed significance, the comparison was relatively close and in the predicted ordinal direction.

The main effect for pattern similarity indicates that the two similar conditions performed poorer than the two dissimilar conditions during acquisition. Both planned comparisons for the individual dissimilar and similar conditions failed statistically to reveal significant differences. As with the failed schedule comparison, both similarity comparisons approached significance and were in the predicted direction (see

Table 9).

The data, when graphed as separate experimental conditions (Figure 10), appears to illustrate an additive effect when presentation scheduling is coupled with item similarity. Unfortunately the visual representation was not confirmed statistically.

The apparent discordant results for the similarity factor as evidenced by the similarity main effect, seems to be contrary to results from Experiment 1. The presentation of the VCF, which was changed in Experiment 2 to follow every individual pattern presentation and response, may be responsible for the observed differences between the similarity conditions' results.

In summary, both treatments affected the level of CI observed through the acquisition performances as evidenced by the significant main effects. Although the statistical support is weak there appears to be an additive effect of the two treatment conditions during the acquisition phase of the experiment as illustrated in Figure 10.

The retention performances confirm the different levels of CI observed during the acquisition phase of the experiment. The significant interactions between both the trial blocks factor with the similarity factor and with the presentation schedule must be viewed with caution. Both interactions represent collapsed factor data and not the individual conditions of practice. It will benefit the discussion to focus on the planned comparisons of the actual conditions relative to the retention data and the last block of acquisition data.

The Random-Similar condition was unique in the fact that the retention score preserved the same level of performance as the last block of acquisition. The other conditions failed to maintain their respective performance levels. The retention performance comparisons revealed the best performance for the Random-Similar condition, supporting the hypotheses that the highest level of CI must have been present during the acquisition phase for this condition. The Random-Dissimilar condition performed poorer than the Random-Similar condition indicating the benefits of the similar trial type when a random practice schedule was used during acquisition. The result was an improved retention score for the similar condition. Subjects in the two blocked conditions performed similarly (statistically) and poorer than those in the random-dissimilar condition.

These findings, in part, illustrate variable levels of CI associated with the two factors manipulated during the acquisition phase of the experiment. Taken together, the two random groups outperformed the two blocked groups, and the random-similar group outperformed the random-dissimilar group.

The set of retention results provide partial support for both the F&R and the V&M hypotheses. The blocked-random schedule manipulation had the most consistent effect on the subject's retention performance which supports the F&R hypotheses. Alternatively, the superior performance by the subjects in the Random-Similar condition and three different levels of retention performance support the contentions of the V&M encoding hypotheses.

In summary, the acquisition performance, graphically, conforms to the additive predictions made from the V&M encoding hypothesis. The retention scores also support the contention of an additive effect, as illustrated by the three different levels of retention performance. Concurrently, the retention performances illustrate the dominant effect of presentation scheduling which adds support to the F&R hypothesis. Taken together, item similarity and presentation scheduling can functionally affect the level of CI in a direction consistent with the V&M encoding hypothesis.

Results from Experiments 1 and 2 have provided evidence that at least two variable manipulations can affect the level of CI. Likely many other contextual factors can affect the levels of CI as well. The next experiment departs from the issue of item similarity and studies the issue of a specific temporal manipulation, massing and distributing presentation schedules.

Experiment 3

The Study of Massing and Distributing Trials Factors Associated with Range Like Effects

The purpose of the third experiment was to investigate whether or not the same factors that produce range like effects were also responsible for the inferior acquisition performance associated with a randomly presented schedule. Concurrently, this experiment investigated the long term effect of these same factors.

When subjects are randomly exposed to the full 'range' of movements in a movement set, a tendency develops in which long movements become foreshortened and short movements are elongated. This tendency, named the range effect, develops progressively as a function of trials and is often considered as a contaminant to performance excellence. The tendency to produce range-like behaviour can be suppressed by blocking the movement trials, hence the range effect is most often measured as the difference in one's performance on random and blocked trials.

When using movement production protocol, such as the PSAT or other multi-segment movement paradigms, range effects, as described above, are not directly observable effects. The present experiment is not designed to observe or measure range effects within lists of practiced movement patterns. This experiment is intended to investigate the factors that have been shown to be present when range effects are observed in linear positioning paradigms (Hall and Wilberg, 1978).

Because of the presentation method of inducing CI, those factors that produce range-like effects on performance are also those that are present during the acquisition phase of the traditional CI experiment. Two such factors are the random nature of the presentation order and the massed nature of the presentation timing (Leuba 1892; Hollingworth 1910; Helson 1947, 1948; Parducci 1963, 1965; Laab 1973; Hall 1977; Poulton 1980).

Presentation timing (massing or distributing) is defined as the time to perform a trial or block of trials when compared to the time between trials (intertrial interval - ITI) or blocks of trials (Poulton 1980). If the ITI exceeds the trial time, the schedule is termed: distributed. When the ITI is shorter than the trial time, the schedule is termed: massed. Trials can be massed and/or distributed either within or between practice blocks.

Traditional CI experiments have commonly used conditions of massed practice with both random and blocked presentation schedules. Attributing the poor random practice results to high levels of CI may be erroneous as this condition may be influenced by range-like effects.

In this third experiment, presentation timing was manipulated concomitantly with presentation scheduling such that the scheduling factor may be observed when the potential for range effects is both present (massed) and absent (distributed).

Neither the V&M encoding hypothesis nor the F&R hypothesis offer predictions related to the issue of massed and distributed practice schedules. The predictions offered here speak directly to the interpretation of the CI effect itself. Range like effects gained through massing and random scheduling may affect either acquisition performance alone or both acquisition and retention performances together depending on whether ranging is limited to a short term performance oriented effect or to a deeper learning effect. Table 10 illustrates a potential set of results if range factors influence either acquisition or acquisition and retention performance.

Table 10

Predictions for Acquisition and Retention Results if Range Factors Affects Either Acquisition Only or Acquisition and Retention Performances Together.

Conditions	Acq. Only		Acq. and Ret.	
	Acq. Perform.	Ret. Perform.	Acq. Perform.	Ret. Perform.
Massed-Random	poor	good	poor	best
Massed-Blocked	good	poor	good	poor
Distributed-Random	good	good	good	good
Distributed-Blocked	good	poor	good	worst

If range factors *do not* affect the acquisition or retention performances, Table 11 best illustrates the relative relationships between ranging and CI.

Table 11

Predictions for Acquisition and Retention Results if Ranging Has No Functional Affect on Performance.

Conditions	Acquisition Perf.	Retention Perf.
Massed-Random	poor	good
Massed-Blocked	good	poor
Distributed-Random	poor	good
Distributed-Blocked	good	poor

Methods

Four experimental groups emerge when presentation scheduling is crossed with presentation timing. These are; massed practice with a random presentation (M-R), massed practice with a blocked presentation (M-B), distributed practice with a random presentation (D-R), and distributed practice with a blocked presentation (D-B).

Only one condition has the opportunity to evoke range type effects, that being the massed-random condition (M-R). The two blocked conditions do not have the opportunity to range due to the nature of the repetition of the identical trials. Similarly, the two distributed conditions do not have the opportunity to range due to the intermittency of this style of presentation.

Subjects. Thirty-two volunteer subjects were randomly assigned to one of 4 experimental conditions (8 subjects per condition). The 4 groups were labelled: Massed practice - Random presentation (M-R), Massed practice - Blocked presentation (M-B), Distributed practice - Random presentation (D-R), and Distributed practice - Blocked presentation (D-B).

Apparatus. The same apparatus and task was used as described in Experiment 1.

Procedure. All groups received a full written and verbal explanation of the task followed by one demonstration trial that served as a practice trial and familiarized them with the equipment and procedure. The experiment was presented in three phases. First, a pretest phase (Pre), consisting of one trial of each of the three patterns (patterns Red, Yellow, and Green, see Figure 14) was completed. Second, an acquisition phase (Acq) consisting of 45 trials (15 of each pattern), was administered in either a blocked or random presentation schedule and was either massed in one 45 trial session or distributed across three sessions of 15 trials per session. The massed trial conditions had an ITI of 2

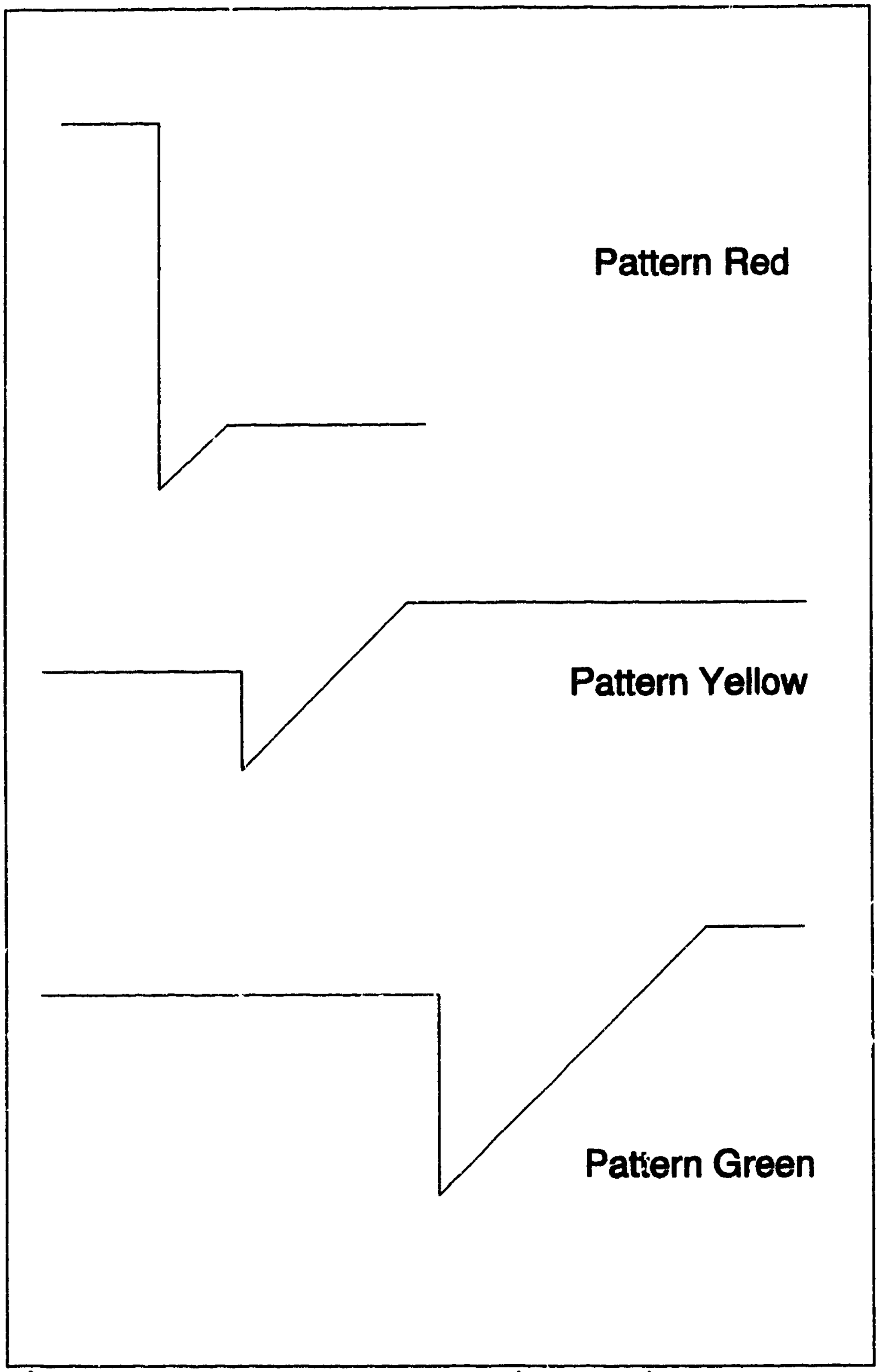

Figure 14 Three Patterns Used in Experiment 3.

seconds. The distributed trial conditions had a 15 second ITI as well as 24 hour interval between sessions. All acquisition trials were performed with visual comparative feedback (VCF) following each trial. A 24 hour retention interval followed the last trial of acquisition practice for all groups. Subsequently a retention phase (Ret) consisting of one trial of each pattern was administered similar to that described in the pre test phase but in the absence of a visual stimulus.

Each trial commenced with a clearly audible 500 Hz tone for a duration of 500 msec. At that time a coloured visual pattern appeared on the monitor for a duration of 3 seconds. Upon extinction of the pattern, a second 500 Hz. tone for a duration of 500 msec. sounded cuing the subject to reproduce the response. The subject drew the pattern (self paced) on the digitized tablet with the pen shaped probe. Upon completion, the subject pressed the space bar on the computer keyboard to end the trial.

During the acquisition phase, VCF was shown to the subject on the monitor for a duration of 5 seconds. The VCF was given in the form of a reproduction of what the subject drew on the tablet in a neutral colour (different from any pattern and the same for all feedback trials) along with the original pattern in its original colour. The subjects could then compare their output with the original pattern. The VCF was given to all groups during the acquisition phase of the experiment.

The retention phase of the experiment required the subjects to reproduce the three patterns in the absence of the presentation stimulus or the VCF. The subjects received 3 retention trials (1 of each pattern) in a serial recall order. The response cue for the retention phase was the same as the response cue in the acquisition phase.

The 3 patterns used in this experiment were held constant for all 4 conditions of practice.

Data and analysis. The dependent variable in this experiment was the PSAT error score. The PSAT error scores were calibrated to a .1mm level of precision.

The PSAT error data for the acquisition phase of the experiment was collapsed together for the 3 target patterns. Forty-five acquisition trials (15 of each target pattern) were subsequently collapsed into 5 blocks of 3 trials each resulting in 5 mean data scores for each subject. The acquisition and retention data was also collapsed across trials (1) and patterns (3) resulting in one mean retention score. Three separate analysis were run on the data.

The first analysis was a 3-way UANOVA, trial block(5) x massed-distributed(2) x blocked-random(2) and Bon Ferroni planned comparisons. The second analysis was also a 3-way UANOVA, trial block(6) x massed-distributed(2) x blocked-random(2) and Bon Ferroni planned comparisons for the acquisition data and retention data inclusive. The third analysis was also a 3-way UANOVA, trial block(7) x massed-distributed(2) x blocked-random(2) and subsequent post hoc SNK tests for the pre-test data, acquisition data and retention data inclusive.

Results

Acquisition data. The results from the 3-way UANOVA are presented in Table 12. The mean values are tabulated in Appendix C.

Table 12

Experiment 3. UANOVA Results for Acquisition Data.

Dependent Variable	F Ratio	M.S. Error	Probability
MasDis	0.04	39306	0.8418
BlRan	20.56	39306	0.0001
Blocks	12.15	7609	0.31E-7
MasDis * BlRan	4.97	39306	0.0340
MasDis * Blocks	1.53	7609	0.1970
BlRan * Blocks	0.31	7609	0.8686
MasDis * BlRan * Blocks	2.21	7609	0.0725

MasDis = Massed-Distributed condition (2).

BlRan = Blocked-Random condition (2).

Blocks = Blocks of Trials (5).

A significant interaction between the massed-distributed and blocked-random manipulations was observed. A significant main effect for the trial blocks condition was also obtained. The means for the blocks main effect is illustrated in Figure 15. The means for the 4 experimental groups are illustrated in Figure 16, as these best illustrate the groups results relative to

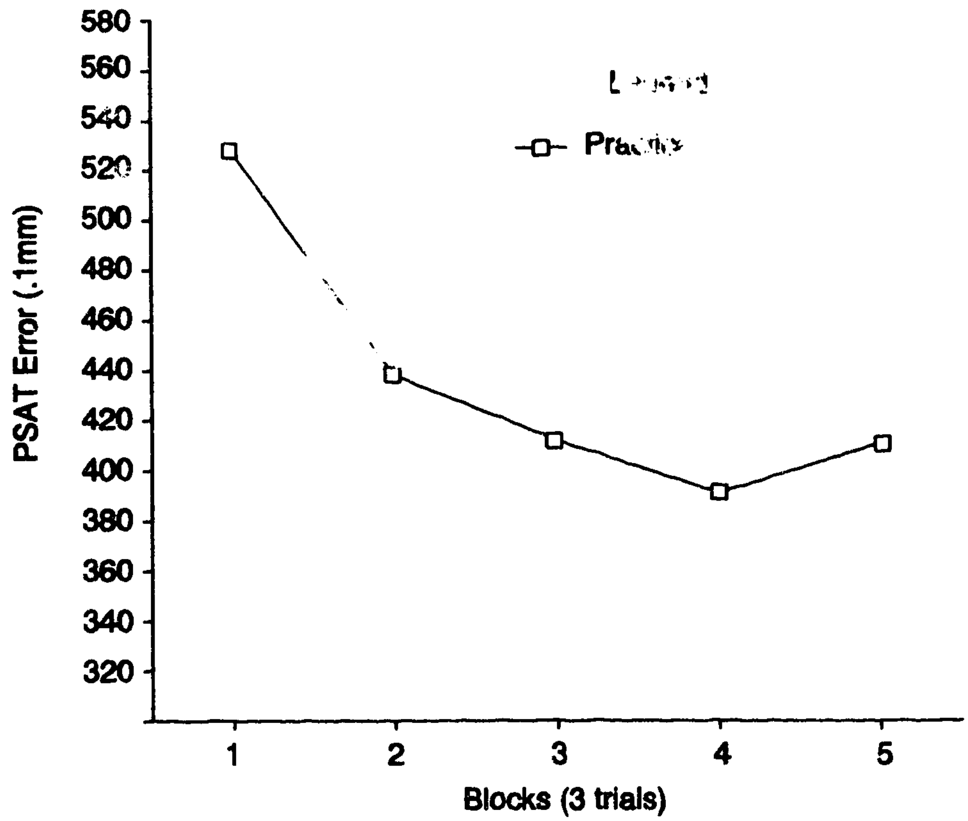

Figure 15 Experiment 3. Means for the Blocks Main Effect for Acquisition.

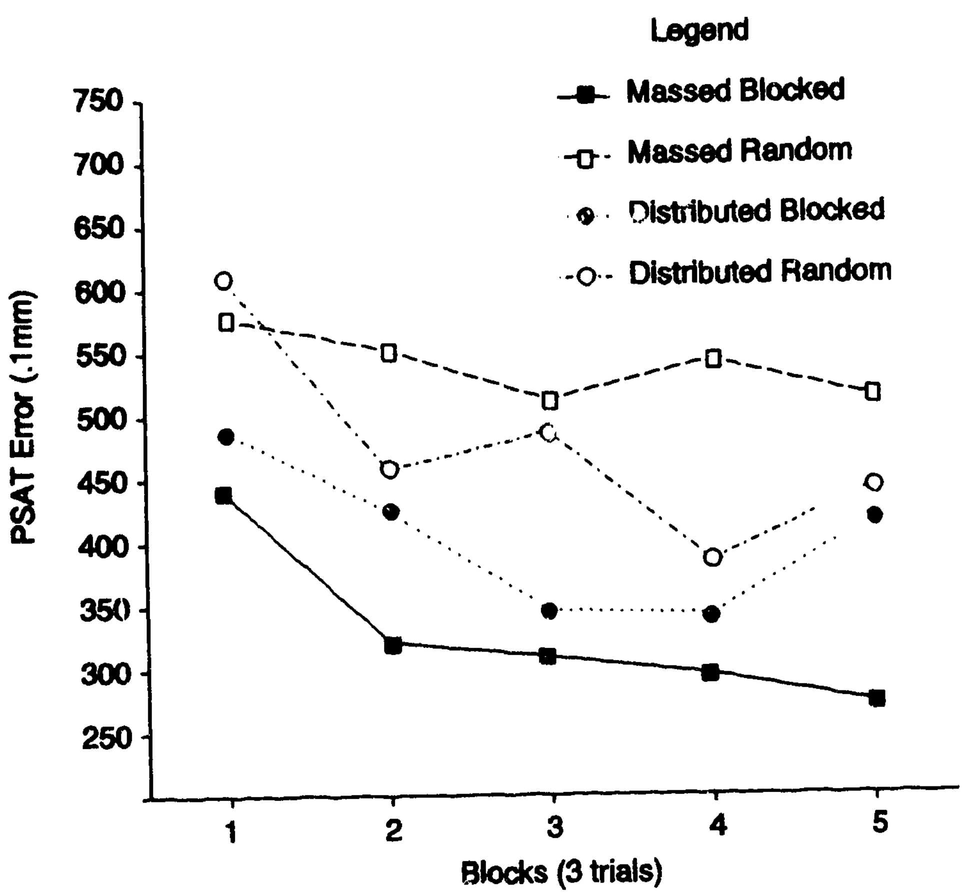

Figure 16 Experiment 3. Means for the Massed-Blocked, Massed-Random, Distributed-Blocked, and Distributed-Random Conditions for Acquisition.

the discussion of the Bon Ferroni planned comparisons of the significant interaction. The Bon Ferroni planned comparisons had significance set at $\alpha < .05$. The least squared differences (LSD) results (Table 13) revealed superior performance for the massed-blocked condition relative to the massed-random condition. The distributed-blocked condition was no different than the distributed-random condition.

Table 13

Experiment 3. Bon Ferroni Planned Multiple Comparisons for Massed-Distributed by Blocked-Random Conditions.

	Massed Blocked	Distrib Blocked	Massed Random	Distrib Random
Blocked Massed				
Re Diff				
Obs Diff				
Blocked Distributed				
Re Diff	105.00			
Obs Diff	76.17			
Random Massed				
Re Diff	105.00			
Obs Diff	212.00*			
Random Distributed				
Re Diff		105.00	105.00	
Obs Diff		72.27	63.55	

Re Diff = Required Difference

Obs Diff = Observed Difference

* = $\alpha < .05$

<u>Retention data.</u> The results from the 3-way UANOVA are presented in Table 14.

Table 14

<u>Experiment 3. UANOVA Results for Acquisition and Retention Data.</u>

Dependent Variable	F Ratio	M.S. Error	Probability
MasDis	5.79	53042	0.0229
BlRan	2.10	53042	0.1584
Blocks	13.53	15927	0.90E-10
MasDis * BlRan	8.16	53042	0.0080
MasDis * Blocks	16.95	15927	0.45E-12
BlRan * Blocks	26.73	15927	0.63E-14
MasDis * BlRan * Blocks	2.74	15927	0.0215

MasDis = Massed-Distributed condition (2).

BlRan = Blocked-Random condition (2).

Blocks = Blocks of Trials (6).

The analysis revealed a significant three-way, blocked-random by massed-distributed by trial blocks interaction, illustrated in Figure 17. The interaction required Bon Ferroni planned comparisons with

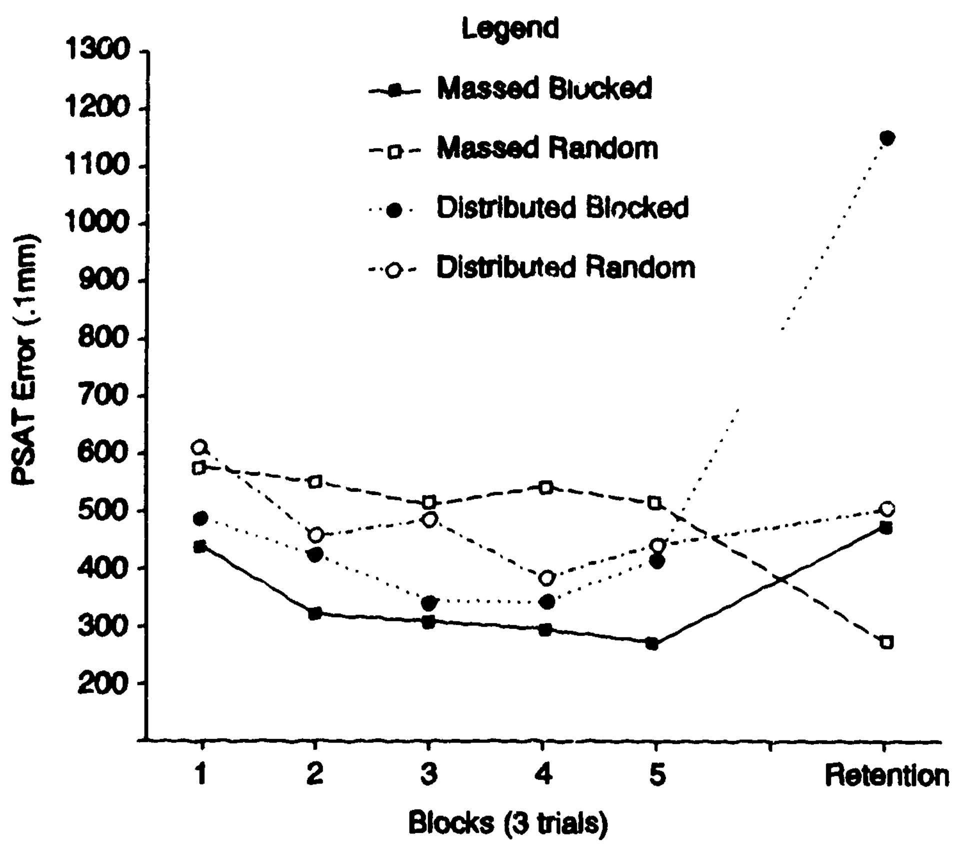

Figure 17 Experiment 3. Means for the Massed-Blocked, Massed-Random, Distributed-Blocked, and Distributed-Random Conditions for Acquisition and Retention.

significance set at $\alpha < .05$.

The planned comparisons (Table 15) revealed superior retention performances for both random conditions compared the blocked conditions relative to massed or distributed practice. Subjects in the two blocked conditions performed worse during retention compared to the last block of acquisition while those in the random conditions performed no worse than the last block of acquisition. Subjects in the massed-random condition performed significantly better during retention than the last block of acquisition.

Table 15

<u>Experiment 3. Bon Ferroni Planned Multiple Comparisons for Massed-Distributed by Blocked-Random Conditions by Blocks of Practice.</u>

	Retent Massed Blocked	Retent Distrib Blocked	Retent Massed Random	Retent Distrib Random
Blocked Massed Retent				
Re Diff			199.44	
Obs Diff			201.25*	
Blocked Distrib Retent				
Re Diff				199.44
Obs Diff				642.00*
Blocked Massed Block 5				
Re Diff	168.87			
Obs Diff	203.37*			
Blocked Distrib Block 5				
Re Diff		168.87		
Obs Diff		728.25*		
Random Massed Block 5				
Re Diff			168.87	
Obs Diff			239.12*	
Random Distrib Block 5				
Re Diff				168.87
Obs Diff				59.75

* = $\alpha < .05$

Pre-test data. The results from the 3-way UANOVA are presented in Table 16.

Table 16

Experiment 3. UANOVA Results for Pre-Test, Acquisition and Retention Data.

Dependent Variable	F Ratio	M.S. Error	Probability
MasDis	6.58	61240	0.0159
BlRan	1.98	61240	0.1702
Blocks	23.70	18743	0.11E-14
MasDis * BlRan	5.40	61240	0.0276
MasDis * Blocks	12.07	18743	0.29E-10
BlRan * Blocks	18.93	18743	0.82E-14
MasDis * BlRan * Blocks	2.92	18743	0.0098

MasDis = Massed-Distributed condition (2).

BlRan = Blocked-Random condition (2).

Blocks = Blocks of Trials (6).

The analysis revealed a significant three-way, blocked-random by massed-distributed by trial blocks interaction, illustrated in Figure 18. The interaction was subsequently analyzed using Student Neuman Kuels

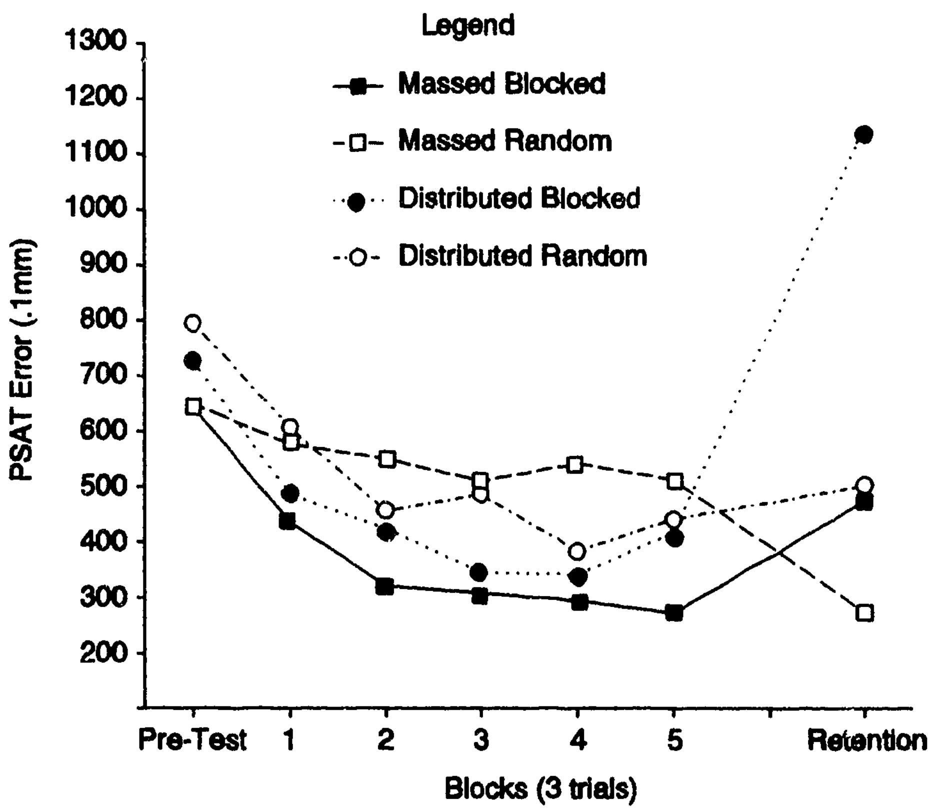

Figure 18 Experiment 3. Means for the Massed-Blocked, Massed-Random, Distributed-Blocked, and Distributed-Random Conditions for Pre-Test, Acquisition and Retention.

(SNK) post hoc pairwise tests with significance set at $\alpha < .05$. The results from the post hoc analysis are shown in Table 17.

Table 17

Experiment 3. Student Newman Keuls Multiple Comparisons for the Massed-Blocked by Blocked-Random by Trial Blocks Interaction for the Pre-Test Analysis.

Blocked Massed Pre				
Re Diff	223.28			
Obs Diff	168.87			
Blocked Distrib Pre				
Re Diff		162.13		
Obs Diff		417.75*		
Random Massed Pre				
Re Diff			252.92	
Obs Diff			375.25*	
Random Distrib Pre				
Re Diff				223.28
Obs Diff				292.75*
	Retent Massed Blocked	Retent Distrib Blocked	Retent Massed Random	Retent Distrib Random

* = $\alpha < .05$

The results from the SNK tests indicate that subjects in the two random conditions performed better during retention than during the pre-test. Subjects in the two blocked conditions performed no better during retention than during the pre-test. None of the pre-test scores differed from each other during the pre-test phase of the experiment.

Discussion

The results from the acquisition data analysis uncovered that the groups as a whole improved their performance with practice.

The results from the analysis of the acquisition performances show that massing and distributing practice schedules can differentially affect the level of contextual interference. The massed group, traditionally used in the CI literature, illustrates a typical superior performance for the blocked condition when compared to the random group. The failure of the distributed conditions, random vs blocked, to show separation during practice supports the hypotheses that massing of trials is integral to inducing the traditional interference observed in the CI literature.

The results from the retention performances indicate some interesting departures from the traditional CI findings. First, the observation of the traditional CI conditions of massed practice, both random and blocked conditions, evoked a typical set of CI results relative to retention scores. The superior performance of subjects in the random condition relative to the blocked condition and the traditional decrement in performance for the blocked group relative to the last block of acquisition support this claim. The departure from traditional findings lies in the fact that the random group performed significantly better during retention than any time during acquisition. This finding can be partially explained since the contextual factors associated with acquisition are no longer present during the retention testing and therefore the interference associated with the prior performance has been released leading to better scores during the retention testing.

The second departure from traditional CI results is the failure to show contextual factors interfering with performance during acquisition for the distributed groups. This finding may foreshadow that the learning mechanisms underlying contextual manipulations were not affected during practice. The retention scores reveal another interpretation. The traditional retention performances associated with CI, stated previously, support an explanation that an underlying learning mechanism had been activated. Together with the acquisition performances of the distributed groups, a new interpretation of how learning mechanisms are activated during blocked and random practice can be questioned.

The data does not provide a clear picture relative to question of how range factors affect the traditional high CI condition. The massed-random condition was not significantly poorer than the distributed-random condition even though the trend is apparent visually. Concomitantly, the failure of the distributed group to show functional differences relative to the contextual factors during acquisition, can not be held in support or refute of the presence of any underlying mechanisms that might be associated with range like effects. The retention results lend mild support to the hypotheses that range factors do not affect the conditions of practice relative to the learning potential.

One observation that is relatively clear from this data is that the temporal variations associated with practice schedules dramatically affect the performances during both the acquisition phase and the retention phase of learning.

The retention results illustrate an interesting set of data, pointing to the possibility of some additive function existing between the two variable manipulations. The massed random condition prevailed as the best overall learning performance while the blocked distributed group showed the worst performance. The two mixed conditions were intermediately located between the previous two mentioned conditions. The interpretation of additivity between these manipulations, again like Experiment 2, questions whether more than one underlying mechanism is present during the acquisition phase of the experiment. Further speculation on the concept of separation and additivity of effect must wait on the outcome of future experiments.

General Discussion

The three separate experiments coupled with the reported pilot study (see Appendix A) have illustrated the use of the pattern segment accuracy technique (PSAT) as a useful measurement for the study of motor learning. Each experiment, using a traditional acquisition and retention learning paradigm, used the PSAT error score as a dependent measure and successfully reflected both acquisition effects and retention effects similar to previously reported CI experiments.

The observed learning effects reflect the activation of a motor learning mechanism rather than only a stimulus learning mechanism. The failure of the stimulus only control conditions to induce the same learning level as the visual-motor conditions in Experiment 1 supports the notion that the learning effects are related to the motor demands of the task rather than the stimulus demands of the task. This finding strengthens the support for using this measuring technique to reflect specific motor learning phenomenon rather than a general stimulus learning phenomenon. To date, this differentiation has not been tested empirically in other studies and therefore any assumed motor learning has been made by speculation only. The results from Experiment 1 have secured the observed learning phenomenon to be of a motor origin.

The original manipulation of CI used in the verbal literature, item similarity, has never been shown to functionally affect CI in the motor learning domain (Shea and Zimney 1988; Gabriele et al. 1989 exp. 2; Wood and Ging 1991). For reasons discussed in the introduction, it remains unclear why this manipulation has not been effectively tested in the motor learning field. It also remains unclear why one major theoretical explanation, the F&R hypothesis, has made no provision in its explanation of CI effects, for such a well documented effect found in the related field of verbal learning. The evidence provided from Experiments 1 and 2, has shown that the manipulation of item similarity has dramatically affected the level of CI in the motor learning task tested here.

In Experiment 1, subjects that practised a list of highly similar patterns produced superior retention performances when compared to subjects that practised a list of dissimilar patterns. This indicates an effective manipulation of the level of CI. The F&R hypothesis while failing to predict such an outcome can not explain the high similarity groups superior retention performance by way of either a forgetting or reconstruction mechanisms. Both the high and low similarity groups practised under identical presentation schedules thus ruling out the possibility of different presentation formats being responsible for different rates of forgetting. The conclusion is made that whatever forgetting and reconstruction requirements needed for one practice condition must also be the needed for the other condition. The V&M encoding hypothesis predicts a set of results that are similar to those observed in the retention performances by way of more variable and multiple encoding that is required when a list of highly similar patterns are practised together in the same list.

Further support for the V&M encoding hypothesis, relative to the manipulation of item similarity, was gained in experiment 2 when the similarity manipulation produced superior retention performances for the highly similar groups. The change in presentation style and feedback from a total list presentation used in Experiment 1, to a single pattern presentation style and feedback used in Experiment 2 did not affect the resultant effect of the similarity manipulation observed in the retention results. Concomitantly, the tentative main effect during acquisition in Experiment 1 (supported by a frequency count parametric statistic) was realized statistically in Experiment 2. The presence of variable levels of CI, due to the item similarity manipulation, suggests that the manner in which practice feedback is administered dramatically affected the performance during the trials when feedback was present. The different presentation and feedback formats have provided a stronger reflection of the similarity manipulation when feedback was presented following every reproduction attempt. The change in presentation feedback format has partially masked the performance effects during acquisition but not during retention. This observation indicates a need for reinterpretation of acquisition performance differences and how they speak to the level of CI. Perhaps acquisition performance is a reflection of the feedback schedule and not the level of CI. This possibility should be examined at a later time.

Evidence gained from Experiments 1 and 2 supports the claim that item similarity and presentation scheduling both affect the levels of CI. The results of Experiment 2 illustrated that these two contextual factors are both separate and additive. The performances by subjects in the combined highest CI condition, random presentation of similar patterns, reflected the poorest acquisition performance and the best retention performance. Concomitantly, the combined lowest CI condition, blocked presentation of dissimilar patterns, illustrated the best acquisition performance and the poorest retention performance. The randomly presented dissimilar patterns, while not differing from the blocked presentation of the similar patterns during acquisition did show superior retention performances from the combined lowest CI condition and poorer performance than the highest CI condition. This gradient of performance during retention indicates the resultant effects of variable levels of CI induced during practice.

The nature of the single pattern and feedback presentation scheduling, typical of most CI experiments and used in Experiment 2, has shown that the more dominant CI effects are elicited from the presentation schedule. Of the two contextual factors, the random nature of the presentation schedule had more marked effects on retention performances than did the similar nature of the practised patterns. The finding suggests that when this type of pattern presentation and feedback format is used, the presentation scheduling plays a more dominant role relative to the level of CI produced during practice.

The results from Experiments 1 and 2 solidify the argument that more than presentation scheduling can affect the level of CI. Battig (1972,1979) concluded that many contextual factors during practice can affect the acquisition and retention performances, indicating learning of verbal material. The evidence presented here has expanded the list of factors affecting CI in the motor domain to at least two. The third experiment in this study investigated yet another potential factor that may affect the level of CI or at least some underlying mechanism of learning. The factor of schedule timing or massing and distributing of practice trials has been shown to greatly affect the performance and learning of movement patterns.

Lee and Genovese (1988, 1989) studied the effects of massing and distributing practice trials for both discrete and continuous tasks. Their findings relative to massing and distributing practice of discrete tasks indicates that while no differences were apparent during acquisition, the massed groups retention scores out performed that of the distributed group. The results from Experiment 3 in the present study support the general conclusion that massed practice results in retention scores superior to that of distributed practice.

The further division of practice scheduling into blocked and random presentations has further revealed an additive form of the learning phenomenon. Massed practice, when tested for long term retention, may benefit especially when presented in a random format; but massed practice (when blocked) is not any better than distributed practice (when random) when tested for the same learning phenomenon. The distributed blocked format was the poorest format when long term learning was measured by a retention test. If CI is proposed to be the underlying factor responsible for activating some learning mechanism when blocked and random presentation schedules are used, the relative timing of these schedules must also be considered. The results from Experiment 3 show that blocked and random schedules are affected by massing and distributing the schedules both for acquisition performance and retention performances.

The evidence presented here does not contradict the findings of Lee and Genovese (1989) but furthers the delineation of how scheduling manipulations affect the performance and learning of discrete motor tasks.

In conclusion, a number of issues related to motor learning and specifically CI have been investigated in the three experiments presented here. First, the PSAT error score has been successfully defended as being a secure dependent measure for motor learning. Second, the issue of whether item similarity can affect the level of CI in a motor learning task has been answered in the affirmative. Third, an additive nature of item similarity and presentation scheduling as evidenced by retention performances of mixed conditions has been shown. Forth, the effects of massing and distributing trials has indicated how ITI can radically affect the CI factors associated with presentation scheduling especially during acquisition. Fifth, observing the additive effects uncovered in Experiments 2 and 3, lead to the potential for investigation of whether more than one mechanism underlays the learning phenomenon associated with CI.

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Appendix A.

Pilot Study Using the PSAT

The pilot study was conducted to ensure that the PSAT error score reflected learning when used in a traditional contextual interference paradigm. The same apparatus and procedures were used as reported in the accompanied experiments.

Two groups (blocked (B) and random (R) received a schedule of identical patterns in a pre-test, acquisition, and retention format. The pretest and retention phases consisted of one attempt at each pattern with no visual comparative feedback (VCF). The acquisition phase consisted of 45 trials (15 of each pattern) each trial followed by 5 seconds of VCF. A ten minute filled interval followed acquisition and preceded retention.

The results of the UANOVA for the acquisition phase data indicated main effects for both trials ($p < .01$) and groups ($p < .01$). The UANOVA and subsequent post-hoc tests (SNK, $\alpha < .05$) for the inclusion of the pre-test and retention phases indicated that the retention scores for the R schedule group were less errorful than either the pre-test or acquisition phases of the experiment. The B schdule group did not reveal any differences between the acquisition and retention phases of the experiment. The means for the B and R schedule groups are shown in Figure 19.

The results of the pilot study have shown general

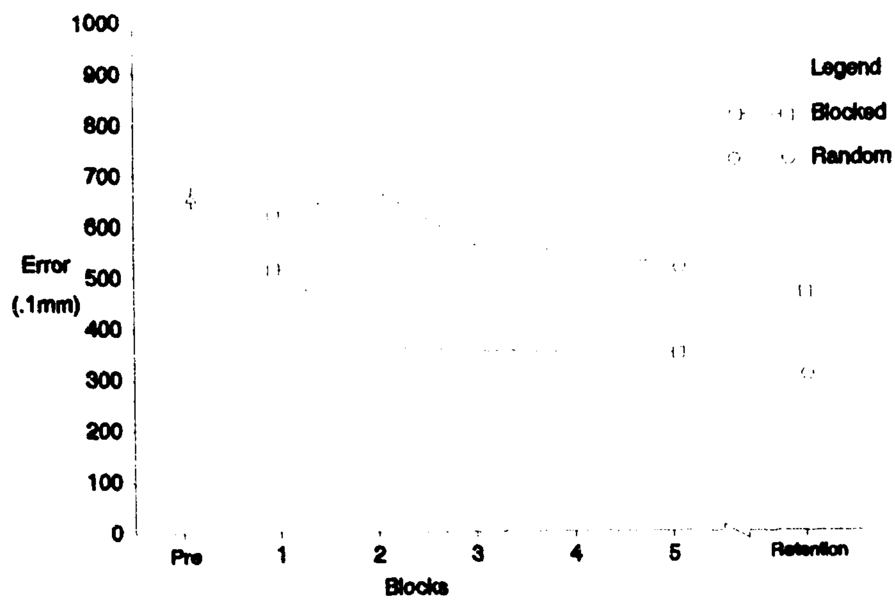

Figure 1 Pilot Study. Blocked and Random Presentation Schedule Effects Across Trial Blocks.

support for using the PSAT error score as a dependent measure for learning as evidenced using the contextual interference paradigm.

Appendix B.

Written Explanations for Subjects and Consent Forms

Written Explanations for Demonstration Trial.

Each subject received a copy of the consent form found in this Appendix as well as signing and relinquishing another copy to the experimenter. After reading and signing the consent form each subject performed one practice trial.

The following description appeared on the color monitor at the beginning of each experimental session. All subjects in all experiments received the same demonstration trial. This written explanation was accompanied with a verbal explanation and manual demonstration by the experimenter.

"Instructional Pattern and Demonstration.

All patterns used in this experiment will follow one basic rule. Each pattern will have 4 separate directional movements, in a certain order: 1) right 2) down 3) diagonal up-right and finally 4) right again. The following will serve as an example and practice trial.

A white stimulus pattern will appear for 5 seconds. When it extinguishes, reproduce the pattern on the tablet while depressing the pen tip. Make sure to hesitate at the end of each movement segment. When completed, hit the space bar and wait for the result. To clear the screen hit any key."

Following the demonstration trial, the subjects were verbally informed of the various presentation formats to be undertaken relative to the particular condition they were assigned.

Consent Form for Human Research in the Human Motor Performance Laboratory

Project Title: Contextual Interference - Similarity Study # 1.

Principle Investigator: Cam O'Donnell 403-436-3569 or 492-1039

Experimental Rationale: This experiment is designed to test the learning ability of human subjects in a specified task. The task requires subjects to view a visually presented two-dimensional figure (stimulus) on a computer screen, followed by an attempt to draw the figure on a digitized tablet (response). The subject will receive 3 trials as a pretest, followed by 45 trials with information feedback, followed by a 24 hour delay and lastly 3 retention trials.

The subjects will be assigned a personal "subject number" that will be kept confidential and known only to the subject and the experimenter, in keeping with the "Confidentiality and Anonymity" section of the 1990 University Policy Related to Ethics in Human Research (page 6 lines 253-261). In accordance to the policy, the data attained by this study, may be used by only the principle investigator while maintaining the anonymity and confidentiality of all subjects.

The subject will be required to volunteer approximately 1 hour in a two session visit with the right to "**Withdraw from the experiment at any time without consequences**".

There are no known side effects related to this type of experimental procedure.

Subject's Signature for consent ______________________

Witness ______________________

Date ______________________

Subject's Initials for receiving copy of concent form _____

Investigator's Signature ______________________

Appendix C.

Mean Score Values for All Three Experiments

(All mean values reported in .1mm)

Mean Values for Experiment 1.

Means for Interaction Terms Used in Figure 4, 5, and 6.

Trial Block	Mean Value (.1mm)			
	Condition			
	Similar V-M	Dis V-M	Similar Con	Dis Con
1	1303	1671	-	-
2	963	[illegible]95	-	-
3	890	892	-	-
4	771	723	-	-
5	745	657	-	-
6	737	677	-	-
7	671	538	-	-
8	629	510	-	-
9	653	515	-	-
10	557	538	-	-
Retention	503	877	1370	1330

Mean Values for Experiment 2.

Means for Trials Main Effect Used in Figure 7.

Trial Block	Mean Value (.1mm)
1	622
2	555
3	525
4	543
5	481

Means for Interaction Terms Used in Figure 8, 9, 11, and 12.

Trial Block	Mean Value (.1mm)			
	Condition			
	Dissimilar	Similar	Blocked	Random
1	587	656	543	700
2	474	637	473	638
3	446	603	458	591
4	416	669	485	601
5	428	533	389	573
Retention	1224	953	1442	735

<u>Means for Interaction Terms Used in Figures 10 and 13.</u>

Trial Block	Mean Value (.1mm)			
	Condition			
	Blocked-Dis	Random-Dis	Blocked-Sim	Random-Sim
1	505	582	669	730
2	393	553	555	721
3	389	527	503	680
4	345	624	488	715
5	310	467	546	599
Retention	1546	1337	902	569

Mean Values for Experiment 3.

Means for Trials Main Effect Used in Figure 15.

Trial Block	Mean Value
1	527
2	438
3	412
4	391
5	411

Means for Interaction Terms Used in Figures 16, 17, and 18.

Trial Block	Mean Value			
	Condition			
	Massed-Blocked	Dist-Blocked	Massed-Random	Dist-Random
Pre-test	644	726	649	795
1	437	487	577	607
2	321	424	551	457
3	309	345	511	486
4	295	342	542	384
5	272	416	513	442
Retention	475	1144	274	502