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IN VERBAL DISCRIMINATION LEARNING.

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PRE-EXPERIMENTAL WORD FREQUENCY AND IMAGERY

IN VERBAL DISCRIMINATION LEARNING

APPROVED BY

DISSERTATION COMMITTEE

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PRE-EXPERIMENTAL WORD FREQUENCY AND IMAGERY IN VERBAL DISCRIMINATION LEARNING

INTRODUCTION

The purpose of the present experiment was to investigate verbal discrimination (VD) learning as a function of word frequency and word imagery. In the VD learning task pairs of items are presented to the S who must learn which member of each pair has been arbitrarily designated by E as the right (R) item, the other member being the wrong (W) item. According to a theory proposed by Ekstrand, Wallace and Underwood (1966) Ss perform the task by discriminating frequency differences which accrue to the R and W items of each pair. An item gains frequency increments as a result of being seen, given as a response, or rehearsed. These subjective frequencies are referred to, respectively, as representational responses (RRs), pronunciation responses (PRs) and rehearsal-of-correct-alternative responses (RCRs). Right items build up frequency faster than W items, and Ss come to respond with that member of each pair which has the greater subjective frequency (Rule 1 strategy). Since frequency difference is posed as the major cue in VD learning, any manipulation which would reduce this frequency difference should increase the difficulty of the task. Conversely, any manipulation which would increase the frequency difference should decrease the difficulty of the task. And as an explanation of VD acquisition, frequency theory has received resounding support from numerous laboratories manipulating the various responses contributing to the frequency differential (e.g., Dominowski, 1966; Kanak, 1968; Kausler and Sardello, 1967).

The scope of the theory was clearly restricted to frequency units generated during a laboratory practice session. However, Ekstrand _et al._ also noted the possible role of pre-experimental item frequency as a variable in affecting intra-pair discrimination. They suggested the possibility of an inverse relation between pre-experimental frequency and the rate of VD learning with the basis for this hypothesized relation being a principle akin to Weber's Law of psychophysics. This analogy implies that pre-experimental frequency units function just as experimental units do and, hence, differential increments for W and R items on the latter are easier detected when the base level for pre-experimental frequency of the pair is low relative to when it is high. And furthermore, if intra-pair pre-experimental frequency is varied, _S_ starts the VD task with a potentially discriminative cue that differential increments in experimental frequency units to W and R items enchance or mitigate.

Skeen (1970) supported the Weber Law corollary when he varied frequency of stimulus material via free-recall training prior to VD acquisition training on a list mixed for inter-pair frequency. That is, within any given pair, items were equal in frequency, but between pairs, items varied in frequency level. A significant effect on trials to criterion was obtained on high and low frequency pairs due to faster learning of the low frequency pairs.

Lovelace (1969) and Underwood and Freund (1968) employed Rule 1 and Rule 2 (choose the least frequent item) paradigms constructed from words receiving differential familiarization pre-training and reported VD performance differences that are in line with frequency theory predictions and thus suggests frequency theory might be extended to include pre-experimental frequency.

Of more importance to the present study is Kausler and Farzanegan's (1969) finding that a list formed with intra-pair Thorndike-Lorge frequency differences can elicit a frequency strategy that will transfer to a second list. The immediate study focuses on single-list acquisition and extends the investigation to four intra-pair combinations of frequency to assess the additivity or nonadditivity of pre-experimental with experimental frequency accrual. If frequency units from the two sources do add, the two lists with intra-pair frequency differences should show initially fewer errors than the two lists having intra-pair homogeneity of frequency. Of the lists with intra-pair heterogeneity of frequency, the list having high W items should give progressively more errors over trials relative to the list with high R items. That is,a Rule 2 strategy initiated by pre-experimental frequency differences should become less and less efficient relative to a Rule 1 strategy if pre-experimental and experimental frequency units are indeed additive. And if this additivity occurs and the Weber Law principle is applicable, the list with pairs having both items low in pre-experimental frequency should be learned with fewer errors than the one high on this factor.

As for imagery, there is a resurging concern with this variable as a potent factor in verbal learning research. The occurrence of an image may be considered a part of the total response elicited by a stimulus and the stimulus attributes may be manipulated in such a fashion as to encourage or inhibit the arousal of an image. For example, some words and other symbols have more tangible referents than others, and as such, more readily bring such referents "to mind." Paivio, Yuille and Madigan (1968) had groups of Ss rate 925 nouns on a 1 to 7 scale for ease of eliciting an image. Subsequently, these norms have provided a means of manipulating word imagery for the purpose of observing the effect of imagery on various learning and recall processes.

It has long been known that images are excellent aids to memory and recently this has been studied experimentally. Paivio (1970) in a recent symposium on imagery in children concluded from his work on imagery in retention and PA learning that imagery is a more potent variable in verbal learning research than many of the other properties of materials that have been indexed to date (e.g., meaningfulness and frequency).

Ingison and Ekstrand (1970) were the first to report a study varying imagery (actually abstractness) in VD learning and they found no significant effect for a mixed-list design--both high and low imagery pairs (intra-pair homogeneity) at two levels of frequency (high and low). Paivio and Rowe (1970) varied (high and low pairs) imagery between lists while holding frequency and meaningfulness constant and found a strong facilitative effect for high imagery pairs. The present study combines two levels of imagery and two levels of frequency both inter- and intra-pairwise in a complete factorial design in order to determine if such a potent effect for imagery as observed by Paivio and Rowe (1970) might be due to imagery acting as a source of frequency.

Imagery may be considered a source of frequency analogous to implicit associative responses (IARs; Ekstrand, et al.) as suggested by Paivio and Rowe (1970). An IAR is some covert representation of a word (e.g., CAT) that occurs as part of the total reaction to a distinctly different stimulus referent (e.g., DOG). Ekstrand, et al. and others have shown that when IARs are manipulated as a source of frequency the difficulty of the list increases and decreases as predicted by frequency theory. And, although IARs are generally understood to mean verbal responses, they can be logically extended to include nonverbal (i.e., imaginal) reactions. Hence this study will assume imagery evoked by words selected to induce such a response (e.g., CIRCLE or CORNER) to be analogous to an IAR and should therefore possess all the properties of IARS in frequency theory.

METHOD

Lists. Due to the limited size of the normative word pool for frequency, imagery and meaningfulness, it was necessary to vary levels of one of the experimental factors within each list. Since research was available that revealed differential results when lists were mixed on frequency relative to those for unmixed lists, it was deemed best to have imagery serve in a mixed-list fashion and manipulate frequency only as a between-list factor.

Sixty-four items (four 16-pair lists) were selected from a pool of 925 nouns for which normative data are available on rated imagery (Paivio, Yuille & Madigan, 1968), production meaningfulness (Paivio, et al.) and frequency (Thorndike & Lorge, 1944). Thirty-two words were high (AA) and 32 low (9 or less) in frequency on the G rating of Thorndike-Lorge norms (see Appendix B). In each of the above categories, 16 words were high (6.03-6.87; $\bar{X}$=6.34) and 16 were low (2.13-3.87; $\bar{X}$=3.16) on imagery rating, with the mean rating for the norms being 4.97 on a 1 to 7 point scale. In the first list (HH; the first initial from this point on will always designate frequency or imagery rating of W items, and the second a rating on R items), all 16 of the R and W items were high in frequency (intra-pair homogeneity for frequency).

Within this and the remaining lists, 8 of the R and 8 of the W items were high in imagery value, with the remaining 8 words under each item function being low on imagery. The W and R items were paired so that there were 4 pairs each for high-high (HH), low-high (LH), high-low (HL) and low-low (LL) imagery combinations. (Any future reference to pairs according to the level of W and R item on frequency and imagery will be designated with frequency first and separated from imagery by a colon. For example, a pair with both items high on each factor will be designated, HH:HH.) The second list for frequency combination LH was made up of the same high frequency R items as List HH, but these were randomly paired (with restrictions to achieve the imagery combinations) with 16 low frequency W items. The third list, HL, was constructed with the 16 high frequency W items from List HH and 16 low frequency R items. List LL was formed by pairing W items from List LH with R items from List HL. Four additional lists were generated by making an item function change in List LH and HL. That is, W items from List LH became R items and the R items became W items in a new list that would now be high-low in frequency and constitute the HL list frequency of a second list set (b_2). Identical manipulations were performed on List HL of the first set (b_1) to give List LH of List Set b_2. The W and R items in these lists were combined in such a fashion as to generate two additional lists of HH and LL frequency. This last set of four lists was to control for any idiosyncrasies in W or R items that would affect acquisition.

A 3-way ANOVA on the meaningfulness rating for W and R items in the lists at the four levels of imagery combination gave Fs<1 except for the item function x imagery interaction which was also non-significant, $F(5,96)=1.94$, $p>.10$. This analysis assured that there was no confounding of the manipulated experimental factors with meaningfulness. The overall mean for meaningfulness of the 64 items was 4.19.

Subjects and design. The Ss were 96 volunteers (56 males and 40 females) from Introductory Psychology classes. The Ss had no prior experience with VD learning and were assigned one of the eight lists in random fashion according to their order of appearance at the lab. An independent randomization for lists was generated to insure that sex was evenly distributed across conditions. There were 7 males and 5 females run in each of the eight list conditions.

The design was a 4(List Frequency) x 2(List Set) x 2(Sex; unequal Ns) x 4(Imagery) factorial with the last factor constituting a within-subject measure.

Procedure. Each S was given conventional VD instructions which he paraphrased before demonstrating his understanding of the task by performing appropriately on several practice VD pairs (of medium value on imagery, frequency and meaningfulness) presented on 3x5 cards. Subject was not informed of the composition of the list in regards to the experimental factors. Each S was taken to a criterion of 2 errorless trials on the VD list, which was presented on a memory drum by the anticipation method at a 2(anticipation interval):2(feedback interval) sec rate with a 4 sec inter-trial interval. During the anticipation interval the items appeared in horizontal juxtaposition and S pronounced his selection. In the feedback interval the items appeared in the same manner but with the R item underlined.

There were four random orders for each list with left-right position of item function randomized under the restriction that R and W items appear an equal number of times in each position and no more than three consecutive times in the same position. Within the 4 random orders the R and W items of a given pair appeared twice on the left and twice on the right. No random order began with the same pair the last order ended with. Each random order began with a different imagery combination and no single imagery combination occurred more than twice in succession. The random order on which any S started was randomized with a restriction such that each order received this distinction at least once within each cell.

RESULTS AND DISCUSSION

In the 4x2x2x4 factorial analysis of variance on total errors (see Appendix D), the only significant between-group factor was the effect for List Frequency, $F(3,80)=22.61$, $p<.001$. The Fs for List Set and List Frequency x Sex interaction were at ps of >.20 and >.25 respectively. The main effect for Sex and remaining interactions gave Fs<1. An F max test on the significant List Frequency effect gave heterogeneity of variance for these four groups but since Box (1954) found the F-test to be robust to violations of the homogeneity assumption, this highly significant $F(p<.001)$ was accepted as revealing a real difference between group means. The means and standard deviations for each group were 12.00 and 4.71 (HL); 12.04 and 7.36 (LH); 26.50 and 11.31 (LL); 39.54 and 22.04 (HH). A Newman-Keuls test ($\alpha=.01$) showed HL=LH<LL<HH on errors to criterion (see Appendix E). The same factorial analysis on trials to criterion (see Appendix F) again showed lists to be the only significant effect, $F(3,80)=28.44$, $p<.001$.

The within-subject (Imagery) factor was also significant on total errors, $F(3,240)=4.69$, $p<.005$. Means and standard deviations for the four imagery combinations were 4.67 and 4.09 (HL); 5.82 and 5.11 (HH); 5.88 and 5.37

(LH); 6.14 and 5.86 (LL). The significant interactions for this within factor were List Frequency x Imagery, $F(9,240)=1.97$, $p<.05$; List Set x Imagery, $F(3,240)=3.50$, $p<.025$; List Frequency x List Set x Imagery, $F(9,24)=2.28$, $p<.025$; List Frequency x Sex x Imagery, $F(9,240)=2.01$, $p<.05$. The nonsignificant effects were for Sex x Imagery, $F(3,240)=1.39$, $p>.20$; List Set x Sex x Imagery, $F<1$; List Frequency x List Set x Sex x Imagery, $F(9,240)=1.52$, $p>.10$. In the trials to criterion analyses, imagery was again significant, $F(3,240)=4.40$, $p<.005$ as was the List Frequency x Imagery, $F(9,240)=2.44$, $p<.025$, List Set x Imagery, $F(3,240)=3.21$, $p<.025$ and List Frequency x List Set x Imagery, $F(9,240)=2.02$, $p<.05$.

Simple effect analysis (Kirk, 1968) were run on the components of the two significant 3-way interactions in order to assess the generality of main effects for the experimental factors of List Frequency and Imagery and their interaction with each other. The simple main effects for List Frequency (Appendix G) demonstrated this variable to be highly significant at both List Sets (b_1 and b_2), for males (c_1) and females (c_2) and at all levels of Imagery (D), Fs with $p<.001$. The simple-simple main effects for this factor (Appendix H) gave significant Fs for all List Set-Imagery combinations and all but one Sex-Imagery cells. List Frequency for females at HL imagery gave an $F(3,320)=1.91$, $p>.10$ in contrast to $F(3,320)=6.49$, $p<.001$, for males at this level of imagery. If the null effect for females is not a Type II error, it could be that females are more sensitive to wrong-item imagery than males, thereby mitigating the effect for variation in frequency for females that is present for males.

The simple analysis on Sex suggests that the significant 3-way interaction involving this factor is largely restricted to one frequency-imagery combination. Appendix G shows no significant F for Sex at any level of imagery but does give Sex as significant at the HH frequency level. Appendix K shows a significant effect for Sex at only the HH:LL frequency--imagery combination. The means and standard deviations are 8.40 and 3.84 for females and 13.43 and 9.34 for males. This superiority for females may simply reflect a difference in intelligence for the two groups. Intelligence was not measured but one can make the case that college males differ widely in intelligence whereas only the more intelligent females attend college. Since there was no apparent external cue as to which item in the pairs of this cell was correct as a result of the intra-pair homogeneity of frequency and imagery, they should represent the most difficult pairs and did give significantly more errors as reflected in the Newman-Keuls analysis on List Frequency (Appendix E) and Imagery (Appendix M, LL was significantly different from only HL). Therefore, these pairs should be more sensitive to any systematic individual differences correlated with either imagery or frequency.

Tracing (Appendix G and I) the simple effects for List Set leads back to the same frequency-imagery cell discussed above in regard to the Sex factor. The basis for the significant 3-way interaction involving List Set may again be due to the relative difficulty in discrimination for these pairs. That is, Ss would be more sensitive to idiosyncracies in their content and hence the List Frequency x List Set x Imagery interaction.

Assuming the above attempts do somewhat negate the qualifying affect of the 3-way interactions, one can conclude that frequency theory can indeed be extended to include pre-experimental frequency units. The Newman-Keuls analysis showing List LH and HL to be learned with fewer errors than those with intra-pair homogeneity (List HH and List LL) supports the Rule 1 and

Rule 2 strategies, respectively, of frequency theory. The equality for errors on LH and HL is consistent with Kausler and Farzanegan (1969; their preliminary study) but inconsistent with the superiority of Rule 1 strategies reported in most transfer studies (e.g., Kanak & Dean, 1969). The fact that List LL was learned with fewer errors than List HH is in line with the Weber Law corollary. Therefore, it seems safe to conclude that pre-experimental frequency combinations of W and R items function in acquisition as frequency theory and the Weber Law corollary dictates for experimental frequency combinations.

The simple main analysis of Imagery on List Frequency (Appendix G) shows Imagery as significant only for VD pairs with high intra-pair homogeneity for frequency. So imagery as a within-list factor is a useful cue only when frequency level of the pair is high enough to reduce sensitivity to differential frequency accrual to W and R items. Combined with Ingison and Ekstrand's (1970) finding of no effect for frequency or imagery when both of these factors were manipulated within lists, it seems imagery may not act as another source for frequency but simply competes with frequency differential as a cue for acquisition. The present study does not conclude that frequency is a more important factor in VD acquisition since the within-list manipulation of imagery makes this an unfair comparison.

An additional group was run on an unmixed-list that was LL in frequency and LH on imagery. This group and the comparable pairs from List LL were combined in an analysis of variance (Appendix M) on errors to the base of opportunities for errors. This measure was necessary because of the difference in number of pertinent pairs for the two lists. The significant $F(1,40)= 37.76$, $p<.001$ for the two groups is due to the lower error rate on the unmixed list ($\overline{X}$=.151, SD=.049) relative to that on the LL:LH pairs in the mixed list (List LL) ($\overline{X}$=.259, SD=.073). These results, combined with Paivio and Rowe's (1970) strong effect for imagery (fewer errors on HH than LL imagery pairs with frequency held constant at 36.25 and 37.56 T-L frequency, respectively), suggest that imagery is indeed a potent factor in VD acquisition. But the present author would have to conclude that at least in a list mixed on imagery, this factor does not function consistently as a source of frequency to give the performance difference that frequency theory would predict.

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APPENDICES

Appendix A

Dissertation Prospectus

PRE-EXPERIMENTAL WORD FREQUENCY AND IMAGERY IN VERBAL DISCRIMINATION LEARNING

Although verbal discrimination (VD) learning has been of interest to investigators in the field of verbal learning for many years, it has only recently gained the popularity that is making research with the VD learning task competitive with that of the serial and paired-associate (PA) learning task in volume of monthly publications. The VD materials consist of lists of pairs of verbal units that have been randomly designated as wrong (W) and right (R) items by the experimenter. The S's task is to select and pronounce the R item during the initial exposure. Traditionally, immediately following this anticipation interval, the two items are again presented in juxtaposition with the R item underlined. The latter exposure serves as a feedback interval wherein the S is informed of the correctness of his selection. This recent surge in VD research followed and apparently resulted from a recent attempt to integrate the VD task into a theoretical system.

Ekstrand, Wallace and Underwood (1966) posed a theory to explain acquisition of a VD task and predict performance when various manipulations are made within such a task. The theory is based on the potential for differential subjective frequency to build up for the W and R items and serve as a stimulus cue for discriminating the R item of a VD pair. According to frequency theory there are four ways in which frequency units may build up: (a) by a representational response (RR)--reading or listening to both of the items when they are presented; (b) by a pronunciation response (PR)--choosing one of the items and pronouncing it; (c) by a rehearsal-of-the-correct-alternative response (RCR)--an implicit or explicit pronunciation of the correct item; and (d) in lists employing associatively related words, by an implicit associative response (IAR)--e.g., presentation of the word DOG elicits an IAR of CAT (or some other related item). Based on RRs and PRs above, a correct selection results in a 1:2 frequency ratio in favor of the R item, whereas an incorrect selection yields a 2:1 frequency ratio in favor of the W item. Based upon initial chance levels of responding, it would be impossible for the S to learn the list unless other mechanisms are invoked. Consequently, frequency theory assumes that S rehearses the R item (RCR) at least once during the feedback exposure. This last frequency addition provides a ratio of 1:3 in favor of R item when a correct choice is made and a 2:2 or chance when an incorrect choice is made. Hence, the VD list may be learned with these three sources providing frequency cues. Implicit associative responses enhance or depress this differential frequency cue depending on whether they are contained in the W or R items. Frequency theory (Ekstrand, et al., 1966) can be tested by manipulating any or all of these sources for frequency units.

The theory has been supported when RRs are manipulated by varying the number of times a word appears (serves in more than one pair) as an R or W item (Ekstrand, et al.) and when a word serves as both an R and W item in different pairs (Kausler & Boka, 1968). Kausler and Sardello (1967) and Sardello and Kausler (1967) added support for the PR mechanism when they varied item pronunciation. Dominowski's (1966) report is in line with the theory's prediction about RCRs, as is Kanak's (1968) significant effect for rate of exposure--the implication being that more time allows for more RCRs to occur. Implicit associative responses manipulated in the R items have provided stronger support than IARs in W items (e.g., Ekstrand, et al.). So as an explanation of VD acquisition, frequency theory has received resounding support from numerous laboratories manipulating the various within-task sources for differential frequency buildup.

The question arises as to whether or not the VD frequency cue can be effective when it is learned outside of the immediate acquisition process. It has been shown that frequency theory can successfully predict the transfer effects from one VD list to another that employs some of the same items. In fact, Ekstrand, et al. originally postulated the frequency theory to account for the transfer data reported by Underwood, Jesse and Ekstrand (1964) and only then formalized their theory for VD acquisition.

In one of the earliest transfer studies, McClelland (1942) found positive transfer whenever the second list retained either the correct or incorrect items from list one paired with new items. This procedure and results were essentially replicated by Underwood, Jesse and Ekstrand (1964), although these authors fully informed the S concerning the nature of the second list.

Ekstrand, et al. proposed that, whenever the second list is characterized by R items from the first list paired with new W items (W1-R1, W2-R1), the S should initially respond by selecting the most frequent item (Rule 1). Whenever the W items of the two lists are identical, but paired with new R items in the second list (W1-R1, W1-R2), the S should now select the least frequent item (Rule 2). Positive transfer is therefore attributed to the utilization of the appropriate rule. Of course, the above predictions are relative to a control condition in which the second list is characterized by W and R items unrelated to list one (W1-R1, W2-R2; hereafter, only the second list notation will be used), thus neither rule is initially applicable on the transfer list. A strict interpretation of frequency theory predicts that, with continued practice on the W1-R2 list, the initial frequency difference in favor of the W item breaks down because of the more rapid accrual of frequency units to the R items. After several trials, the total number of frequency units to the W and R items becomes nearly equal and thus a deterioration in VD performance is expected, since neither rule can be successfully applied. A return to Rule 1 usage should follow.

A number of studies (Kausler & Dean, 1967; Kausler, Fulkerson & Eschenbrenner, 1967; Kanak & Dean, 1969) have failed to find positive transfer in the W1-R2 paradigm (Rule 2) when Ss are not aware of the nature of the second list. Since the W1-R2 paradigm is analogous to the classical paired-associate A-B, A-C negative transfer paradigm, the presence of negative transfer in the VD paradigm has been attributed to the associative interference from list one as PA research dictates (Kausler, et al., 1967). In support of this interpretation, Raskin, Boice, Rubel and Clark (1968) minimized associative interference by creating a second list in which the item function of List 1 W and R items was reversed--W items from list one became R items in list two and R items of list one became W items in list two. Such a list demands a Rule 2 strategy in the absence of associative interference since item pairings remain the same as in list one. These authors reported positive transfer even though the Ss were not informed about the relationship between the two lists.

Since several PA studies (e.g., Goulet & Barclay, 1965) have shown that forward associations are a more potent source of interference than backward associations and others (e.g., Kanak & Dean, 1969) have demonstrated that the W1-R2 and W2-R1 VD transfer paradigms are forward and backward associative interference paradigms, the contrasting consistently positive transfer effects of Rule 1 paradigms (e.g., Kausler & Dean, 1967; Kanak & Dean, 1969) and the inconsistent effects for Rule 2 paradigms (e.g., negative and positive cited above) seem readily resolved by appealing to the potential differential strength of associative interference.

Runquist and Freeman (1960, Exp. III), used familiarization training to manipulate the frequency of VD items prior to acquisition (syllables of 0% to 27% association value were seen and spelled 12 times). These authors found that when the items experienced in this training became R items (Rule 1), performance was better than when they became W items (Rule 2). Lovelace (1969), using similar (pronounced rather than spelled) familiarization training on meaningful words, found that differential familiarization on R and W items was initially beneficial, but more so when the R item received the greater (5 vs. 1 exposure) familiarization. When the reverse was true, there was a slower rate of improvement across trials than occurred in the former list or when items received equal familiarization or Ss were given familiarization on irrelevant items. These results, along with those of Wallace and Nappe (1970, using free-recall familiarization), suggest that subjective frequency differentials that build up from familiarization training are used by Ss in the same manner as those acquired in VD acquisition--to facilitate or hinder acquisition.

In these familiarization studies associative interference is not a factor and we see Rule 2 paradigms being learned with fewer trials and errors than a control. Further, Rule 1 paradigms are found to be more facilitative than Rule 2 paradigms, as frequency theory predicts.

Another way to vary frequency of W and R items is via frequency norms (e.g., those provided by Thorndike & Lorge, 1944). Kausler and Farzanegan's (1969) is the only study this writer is aware of that varied frequency within a pair (intra-pair heterogeneity) and it was a transfer study that failed to include sufficient lists or analyses to adequately surmise whether or not such pre-experimental frequencies affect performance in the same manner frequency theory predicts for experimental frequency buildup or as the above research has shown for frequencies in familiarization studies.

The ability to manipulate frequencies prior to VD acquisition suggests and makes readily testable a Weber Law corollary to frequency theory. Are Ss more sensitive to an intra-pair frequency change when the pair is initially at a low frequency level than when at a high level? The obvious manipulation is to equate frequency of the W and R item of any given pair but vary frequency level of VD pairs, either within or between lists.

With frequency varied via familiarization training, the results favor a Weber Law corollary (e.g., Berkowitz, 1968; Underwood & Freund, 1968; Lovelace, 1969; Wallace & Nappe, 1970), but the null (Keppel, 1966; Schulz & Hopkins, 1968, Exp. III; aural presentation) and directly opposite (Schulz & Hopkins, 1968, Exp. III; visual presentation) effects have also been reported.

The results are even more equivocal when studies varying inter-pair frequency pre-experimentally are considered (e.g., Skeen, 1970, supports corollary while Ingison and Ekstrand, 1970, do not). Some cursory support is offered by a developmental study (Deichmann, Speltz & Kausler, 1970) that found an inverse relationship between age and intentional VD learning from the fourth to sixth grade level and again (Exp. II) from third to sixth. In other words, different frequency levels for items was inferred from an organismic variable--age and/or school grade.

Imagery

Historically, the focus of research on imagery was primarily on the processes and contents of images, on the description of images, and on the classification of people into imaginal types. Now, however, the bulk of such research is concerned with the ways images influence other processes, especially memory. This research has employed three general operational methodologies. The first being manipulation of stimulus attributes which are designed to encourage or to inhibit the arousal of an image. For example, some words and other symbols have more tangible referents than other stimuli, and, as such, more readily bring the referents "to mind." Paivio, Yuille and Madigan (1968) had groups of Ss rate 925 nouns on a 1-7 scale according to their ease of eliciting an image. Subsequently, these norms have provided a means of manipulating word imagery for the purpose of observing the effect of imagery on various learning and recall processes. A second method is to instruct Ss concerning the use of imagery (e.g., "form a mental image of the stimuli"). And last, Ss can be selected according to symbolic habits or skills. The latter is made possible via batteries of spatial-ability and other imagery tests.

It has long been known that images are excellent aids to memory and recently this has been studied experimentally. The effects of imagery on retention are greatly reduced as the learning-recall interval increases (Paivio, 1963, 1965). In addition, Paivio (1968) has shown that, in paired associate (PA) learning, noun imagery is a more potent determinant of learning difficulty than other properties of materials that have been indexed to date (e.g., meaningfulness and frequency). This effect of imagery results primarily from manipulation of the characteristics of the stimulus items as opposed to response items (e.g., Paivio, 1969).

Ingison and Ekstrand (1970) were the first to report a study varying imagery (actually abstractness) in VD learning and they found no significant effect for a mixed-list design--both high and low imagery pairs (intra-pair homogeneity) at two levels of frequency (high and low). In another VD study, Paivio and Rowe (1970) varied (high and low pairs) imagery between lists while holding frequency and meaningfulness constant and found a strong facilitative effect for high imagery pairs. On the basis of this one study, it appears that imagery is as potent a variable in VD learning as in PA learning and retention.

The Present Experiment

This study attacks two of the questions raised by the above review. First, how do pre-experimental frequency differences affect VD learning? Many of the contradictions in the data may be explained by lack of proper controls. For example, Postman's (1964) study varied frequency but allowed meaningfulness to co-vary with this factor. And up until the studies by Ingison and Ekstrand (1970) and Paivio and Rowe (1970), no one controlled for imagery. In addition, there is only one study (Kausler & Frazanegan, 1969) that varied intrapair-pre-experimental frequency and they did not employ all R-W frequency combinations. Secondly, what role does imagery play in VD learning and how does it interact with experimental and pre-experimental frequency? Knowledge of effects for imagery in VD learning may prove important to the theoretical understanding of imagery effects in other tasks as well as being of interest in its own right. But the primary interest here is: What does it do to frequency theory predictions?

Since frequency theory has been strongly supported in studies manipulating the VD task, in familiarization training and in VD transfer, the present study used this theory and the research investigating this theory as a model for predicting and explaining acquisition of VD lists wherein pre-experimental frequency and imagery are manipulated.

Although the Thorndike and Lorge (1944) norms are based solely on the frequency of occurrence of words in several popular publications, one can assume that the relative differential frequencies with which these words have been heard and spoken are also reflected by these norms. Therefore, the above norms can be used to vary the initial frequency level of RRs, PRs and RCRs for W and R items in a VD list.

As for imagery, it can be interpreted as a fractional part of the total reaction to a given stimulus. And, although IARs are generally understood to mean verbal responses, they can be logically extended to include nonverbal (i.e., imaginal) reactions as suggested by Paivio and Rowe (1970). Hence, this study will assume imagery evoked by viewing or hearing words to be analogous to an IAR and, therefore, assume all the properties of IARs in frequency theory.

The present study attempts to answer the above two questions by combining W and R items at two levels (high and low) of pre-experimental frequency (Thorndike & Lorge, 1944) and imagery (Paivio, Yuille & Madigan, 1968) in a complete factorial design that equates all cells for meaningfulness. The predictions follow from the model: (a) When intra-pair frequency is varied the pairs will be mastered with fewer errors than pairs equated on frequency due to the initial availability of Rule 1 and Rule 2 strategies for the former pairs. (b) Lists favoring a Rule 1 strategy will be learned with fewer errors than those favoring a Rule 2 strategy because of the increasing inefficiency of the latter during acquisition. (c) Lists with low base level (lowest frequency level represented in the pair) frequency will be learned with fewer errors than ones with high base levels due to the Weber Law corollary. (d) High imagery items will hinder acquisition when they are W items and facilitate when they are R items by enhancing or attenuating, respectively, the differential frequency cue.

Method

Lists. Due to the limited size of the word pool it was necessary to vary levels of one of the experimental factors within each list. Since more research was available that revealed different results when lists were mixed on frequency to those for unmixed lists, it was deemed best to have imagery serve in a mixed-list fashion and manipulate frequency as a between-list factor.

Sixty-four items for four 16-pair lists were selected from a pool of 925 nouns for which normative data on rated imagery, production meaningfulness and frequency are available. Thirty-two of the words were high (AA) and 32 low (9 or less) in frequency, according to the G rating of Thorndike-Lorge (1944) norms. In each of the above categories, 16 words were high (6.03-6.87; $\bar{X}$=6.34) and 16 were low (2.13-3.87; $\bar{X}$=3.16) on imagery rating, with the mean rating for the norms being 4.97. In the first list HH all 16 of the R and W items are high on frequency (intra-pair homogeneity for frequency). Within this and the remaining lists 8 of the R and 8 of the W items are high on imagery with the remaining 8 words under each item function being low on imagery. These W and R items are paired so that there are 4 pairs each for high-high (HH), low-high (LH), low-low (LL) and high-low (HL) imagery combinations. The second list LH was made up of the same high frequency R items as List HH, but these were paired with 16 low frequency W items. List LL was constructed with the 16 low frequency W items from List LH and 16 low frequency R items. List HL was formed by pairing W items from List HH with R items from List LL. Four additional lists were generated by making an item function change in List LH and HL. That is, W items from List LH became R items and the R items became W items in a new list that would now be high-low in frequency and constitute the HL list frequency of a second list set (b_2). Identical manipulations were performed of List HL of the first set (b_1) to give List LH of list set b_2. The W and R items in these lists were combined in such a fashion as to generate two additional lists of HH and LL frequency. This last set of four lists was to control for any idiosyncrasies in W or R items that would affect acquisition.

A 3-way ANOVA on the meaningfulness rating for W and R items in all 4 lists at the 4 imagery combinations gave $\underline{F}s<1$ except for the function x imagery interaction, $\underline{F}(3,96)=1.94$, $\underline{p}>.10$.

Subjects and design. The Ss will be 80 volunteers (40 males and 40 females), from Introductory Psychology classes at the University of Oklahoma, having no prior experience with VD learning. Each S will practice on one of the 8 lists as determined by randomization within sex, with the restriction that all list conditions contain n Ss before any receive n+1. An effort will be made to have consecutive Ss alternate in sex.

The design will be a 4(List Frequency) x 2(List Sets) x 2(Sex) x 4(Imagery) factorial on errors with the last factor constituting repeated measures.

Procedure. Every S will be given conventional VD instructions that he will paraphrase before demonstrating his understanding of the task by performing appropriately on several VD pairs (of medium value on I, F, and m) presented on 3x5 cards. Subject will not be informed of the composition of the list in regards to the experimental factors. Each S will be taken to criterion of 2 errorless trials on his list, which will be presented on a memory drum in anticipation fashion at a 2(anticipation interval):2(feedback interval) sec rate with a 4 sec inter-trial interval. During the anticipation interval the items will appear in horizontal juxtaposition and S will pronounce one of them. In feedback the items appear in the same manner, but with R item underlined.

There are four random orders for each list with left-right position of item function randomized, with the restriction that R and W items appear an equal number of times in each position and no more than three consecutive times in the same position. Other restrictions are that no random order will begin with the pair the last order ended with, each random order begins with a different imagery combination, within the 4 random orders the R and W items of a given pair appear twice on the left and twice on the right, and no single imagery combination will occur more than twice in succession. The random order on which any S starts will be randomized, with the restriction that each order receive this distinction at least once in each cell.

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Appendix B

Word Lists

Set b_1

FREQUENCY

IMAGERY	HH		LH		LL		HL	
	W(high)	R(high)	W(low)	R(high)	W(low)	R(low)	W(high)	R(low)
HH	dress	circle	hairpin	circle	hairpin	brassiere	dress	brassiere
	letter	corner	bungalow	corner	bungalow	bouquet	letter	bouquet
	gentleman	newspaper	honeycomb	newspaper	honeycomb	timepiece	gentleman	timepiece
	girl	mother	tweezers	mother	tweezers	juggler	girl	juggler
LH	amount	rock	bivouac	rock	bivouac	pianist	amount	pianist
	cost	lip	semester	lip	semester	hurdles	cost	hurdle
	honor	iron	deduction	iron	deduction	macaroni	honor	macaroni
	opinion	village	perception	village	perception	microscope	opinion	microscope
LL	knowledge	answer	subtraction	answer	blasphemy	exclusion	knowledge	exclusion
	thought	effort	antitoxin	effort	antitoxin	animosity	thought	animosity
	trouble	mind	blasphemy	mind	subtraction	afterlife	trouble	afterlife
	method	hour	anecdote	hour	anecdote	adversity	method	adversity
HL	hall	hope	goblet	hope	goblet	creator	hall	creator
	square	length	tripod	length	tripod	aptitude	square	aptitude
	officer	idea	wigwam	idea	wigwam	feudalism	officer	feudalism
	chief	soul	noose	soul	noose	ego	chief	ego

Word Lists

Set b_2

FREQUENCY

IMAGERY	HH W(high)	HH R(low)	LH W(low)	LH R(high)	LL W(low)	LL R(low)	HL W(high)	HL R(low)
HH	circle	dress	pianist	dress	brassiere	hairpin	iron	hairpin
	corner	letter	bouquet	letter	bouquet	bungalow	corner	bungalow
	newspaper	gentleman	timepiece	gentleman	timepiece	honeycomb	newspaper	honeycomb
	mother	girl	juggler	girl	juggler	tweezers	mother	tweezers
LH	hope	hall	creator	hall	creator	goblet	hope	goblet
	length	square	aptitude	square	aptitude	tripod	length	tripod
	idea	office	afterlife	office	feudalism	wigwam	idea	wigwam
	soul	opinion	ego	opinion	ego	noose	soul	noose
LL	answer	knowledge	exclusion	knowledge	exclusion	blasphemy	answer	blasphemy
	effort	thought	animosity	thought	animosity	antitoxin	effort	antitoxin
	mind	trouble	feudalism	trouble	afterlife	subtraction	mind	subtraction
	hour	method	adversity	method	adversity	anecdote	hour	anecdote
HL	rock	amount	brassiere	amount	pianist	bivouac	rock	bivouac
	lip	cost	hurdle	cost	hurdle	semester	lip	semester
	iron	honor	macaroni	honor	macaroni	deduction	circle	deduction
	village	chief	microscope	chief	microscope	perception	village	perception

Appendix C

Instructions

In the window of this memory drum, pairs of familiar words will be presented at two-second intervals (for example, RUN BOX). One of the words in each pair has been arbitrarily designated as "right," and the other as "wrong." Each pair will be exposed twice, for two seconds each time, before a new pair appears. Your task is to learn to recognize and pronounce the word designated as "right" during the first exposure of each pair. The second exposure, in which the "right" word will be underlined (for example, RUN BOX), will inform you whether or not your selection was correct.

There are 16 different pairs in the list. Each time through the 16 pairs constitutes a "trial." Asterisks will appear in the window within the four-second interval between trials to cue you that a new trial will follow in two seconds. The 16 pairs of words are rearranged in four different orders so that the position and order of "right" and "wrong" words will vary within and between trials. Your first trial will be a "guessing" trial-- guess which word you think is "right" during the first exposure of each pair. You will continue the trials until two trials are completed with no mistakes. Remember to respond aloud during the first exposure of each pair and remain silent on the second exposure. To clarify any questions, we will first practice on a few words unrelated to the formal learning task.

Appendix D

Summary Table for the 4x2x2x4 Mixed Analysis of Variance for Errors to Criterion

Source	SS	df	MS	F	p
Between Ss	7297.75	95			
Lists (A)	3156.26	3	1052.09	22.61	<.001
List Sets (B)	66.66	1	66.66	1.43	>.20
Sex (C)	9.53	1	9.53	<1	
A x B	102.15	3	34.05	<1	
A x C	154.53	3	51.51	1.11	>.25
B x C	31.64	1	31.64	<1	
A x B x C	54.23	3	18.08	<1	
Ss within Gp.					
Error (between)	3722.74	80	46.53		
Within Ss	2999.75	288			
Imagery (D)	124.46	3	41.49	4.69	<.005
A x D	156.60	9	17.40	1.97	<.05
B x D	92.91	3	30.97	3.50	<.025
C x D	36.97	3	12.32	1.39	>.20
A x B x D	181.78	9	20.20	2.28	<.025
A x C x D	159.91	9	17.77	2.01	<.05
B x C x D	2.89	3	.96	<1	
A x B x C x D	121.02	9	13.45	1.52	>.10
D x Ss within Gp.					
Error within	2123.21	240	8.85		

Appendix E

Summary Table for Newman-Keuls

Errors for List Frequency

	$\bar{X}_{HL}$	$\bar{X}_{LH}$	$\bar{X}_{LL}$	$\bar{X}_{HH}$
$\bar{X}_{HL}$=12.00	--	.04	14.50*	27.54*
$\bar{X}_{LH}$=12.04		--	14.46*	27.50*
$\bar{X}_{LL}$=26.50			--	13.04*
$\bar{X}_{HH}$=39.54				--

MS error = 46.53

*p<.01

Appendix F

Summary Table for the 4x2x2x4 Mixed Analysis of Variance for Trials to Criterion

Source	SS	df	MS	*F*	*p*
Between *Ss*	2581.93	95			
Lists (A)	1258.89	3	419.63	28.44	<.001
List Sets (B)	27.62	1	27.62	1.87	>.10
Sex (C)	2.59	1	2.59	<1	
AB	43.23	3	14.41	<1	
AC	51.45	3	17.15	1.16	>.25
BC	2.13	1	2.13	<1	
ABC	15.27	3	5.09	<1	
Ss within Gp.					
Error (between)	1180.75	80	14.75		
Within *Ss*	1585.75	288			
Imagery(D)	65.21	3	21.75	4.40	<.005
AD	108.95	9	12.10	2.44	<.025
BD	47.70	3	15.90	3.21	<.025
CD	14.66	3	4.88	<1	
ABD	90.23	9	10.02	2.02	<.05
ACD	26.17	9	2.90	<1	
BCD	15.12	3	5.04	1.02	>.25
ABCD	31.48	9	3.49	<1	
D x *Ss* within GP.					
Error (within)	1186.23	240	4.94		

Appendix G

Analysis of Variance Table for the Simple Main Effects on Errors

Source					
Between subjects					
Between A at b_1	2009.39	3	669.80	36.66	<.001
Between A at b_2	1249.02	3	416.34	22.79	<.001
Between A at c_1	25.05.47	3	835.16	45.71	<.001
Between A at c_2	805.32	3	268.44	14.69	<.001
Between A at d_1	933.87	3	311.29	17.04	<.001
Between A at d_2	826.36	3	275.45	15.08	<.001
Between A at d_3	373.92	3	124.64	6.82	<.001
Between A at d_4	1178.71	3	392.90	21.51	<.001
Between B at a_1	123.76	1	123.76	6.77	<.01
Between B at a_2	5.51	1	5.51	<1	
Between B at a_3	37.50	1	37.50	2.05	>.10
Between B at a_4	2.04	1	2.04	<1	
Between B at d_1	5.51	1	5.51	<1	
Between B at d_2	.84	1	.84	<1	
Between B at d_3	8.17	1	8.17	<1	
Between B at d_4	147.04	1	145.04	7.94	<.005
Between C at a_1	47.86	1	47.86	2.62	>.10
Between C at a_2	30.29	1	30.29	1.66	>.10
Between C at a_3	13.88	1	13.88	<1	
Between C at a_4	72.04	1	72.04	3.94	<.05

Appendix G (Continued)

Source	SS	df	MS	F	p
Between C at d_1	25.55	1	25.55	1.40	>.20
Between C at d_2	8.49	1	8.49	<1	
Between C at d_3	.30	1	.30	<1	
Between C at d_4	12.14	1	12.14	<1	
Within cell Error (pooled)	5845.95	320	18.27		
Within subjects					
Between D at a_1	203.28	3	67.76	7.66	<.001
Between D at a_2	22.45	3	7.48	<1	
Between D at a_3	1.75	3	.58	<1	
Between D at a_4	53.58	3	17.86	2.02	>.10
Between D at b_1	146.68	3	48.89	5.52	<.005
Between D at b_2	70.68	3	23.56	2.66	<.05
Between D at c_1	107.26	3	35.75	4.04	<.025
Between D at c_2	54.17	3	18.06	2.04	>.10
D x Ss within Gp. Error (within)	2123.21	240	8.85		

Appendix H

Analysis of Variance Table for the Simple Simple Main Effects for List Frequency (A) on List Set (B) and Imagery (D) and on Sex (C) and D on Errors

Source	SS	df	MS	F	p
Between subject					
Between A at b_1d_1	568.41	3	189.47	10.26	<.001
Between A at b_1d_2	325.06	3	108.35	5.93	<.001
Between A at b_1d_3	221.75	3	73.92	4.04	<.01
Between A at b_1d_4	1088.91	3	362.97	19.87	<.001
Between A at b_2d_1	401.73	3	133.91	7.23	<.001
Between A at b_2d_2	566.00	3	188.67	10.33	<.001
Between A at b_2d_3	171.41	3	57.14	3.13	<.025
Between A at b_2d_4	253.50	3	84.50	4.62	<.005
Between A at c_1d_1	732.36	3	244.12	13.36	<.001
Between A at c_1d_2	473.29	3	157.76	8.63	<.001
Between A at c_1d_3	355.86	3	118.62	6.49	<.001
Between A at c_1d_4	1141.77	3	380.59	20.83	<.001
Between A at c_2d_1	237.68	3	79.23	4.34	<.005
Between A at c_2d_2	394.28	3	131.43	7.19	<.001
Between A at c_2d_3	104.60	3	34.87	1.91	>.10
Between A at c_2d_4	187.48	3	62.49	3.42	<.025
Within Cell Error (pooled)	5845.95	320	18.27		

Appendix I

Analysis of Variance Table for the Simple Simple Main Effects for List Set (B) on List Frequency (A) and Imagery (D) on Errors

Source	SS	df	MS	F	*p*
Between subjects					
Between B at a_1d_1	32.67	1	32.67	1.79	>.10
Between B at a_1d_2	16.67	1	16.67	<1	
Between B at a_1d_3	18.38	1	18.38	1.01	>.25
Between B at a_1d_4	266.67	1	266.67	14.60	<.001
Between B at a_2d_1	.04	1	.04	<1	
Between B at a_2d_2	20.17	1	20.17	1.10	>.25
Between B at a_2d_3	.38	1	.38	<1	
Between B at a_2d_4	1.04	1	1.04	<1	
Between B at a_3d_1	2.04	1	2.04	<1	
Between B at a_3d_2	26.04	1	26.04	1.42	>.10
Between B at a_3d_3	6.00	1	6.00	<1	
Between B at a_3d_4	10.67	1	10.67	<1	
Between B at a_4d_1	7.04	1	7.04	<1	
Between B at a_4d_2	2.67	1	2.67	<1	
Between B at a_4d_3	2.67	1	2.67	<1	
Between B at a_4d_3	30.38	1	30.38	1.66	>.10
Within Cell Error (pooled)	5845.95	320	18.27		

Appendix I (Continued)

Source	SS	df	MS	F	p
Within subjects					
Between D at a_1b_1	273.73	3	91.25	10.31	<.001
Between D at a_1b_2	140.17	3	46.72	15.24	<.001
Between D at a_2b_1	1.40	3	.47	<1	
Between D at a_2b_2	37.17	3	12.39	4.13	<.01
Between D at a_3b_1	2.25	3	.75	<1	
Between D at a_3b_2	6.75	3	2.25	<1	
Between D at a_4b_1	64.06	3	21.35	7.12	<.001
Between D at a_4b_2	30.23	3	10.08	3.36	<.025
D x Ss within Gp. Error (within)	2123.21	240	8.85		

Appendix J

Analysis of Variance Table for the Simple Interaction Effects in the List Frequency (A) x List Set (B) x Imagery (D) Interaction on Errors

Source	SS	df	MS	F	*p*
Between subjects					
AB at d_1	36.27	3	12.09	<1	
AB at d_2	64.70	3	21.56	1.18	>.25
AB at d_3	19.26	3	6.42	<1	
AB at d_4	163.71	3	54.57	2.99	<.05
Within Cell Error (pooled)	5845.76	320	18.27		
Within subject					
AD at b_1	194.76	9	21.64	12.79	<.001
AD at b_2	143.63	9	15.96	1.80	<.10>.05
BD at a_1	210.61	3	70.20	7.93	<.001
BD at a_2	16.11	3	5.37	<1	
BD at a_3	7.25	3	2.42	<1	
BD at a_4	40.71	3	13.57	1.53	>.20
ABD	181.78	9	20.20	2.28	<.05
D x *Ss* within Gp. Error (within)	2123.21	240	8.85		

Appendix K

Analysis of Variance Table for the Simple Simple Main Effects of Sex (C) on List Frequency (A) and Imagery (D) on Errors

Source	SS	df	MS	F	p
Between subjects					
Between C at a_1d_1	35.22	1	35.22	1.93	>.10
Between C at a_1d_2	20.12	1	20.12	1.10	>.25
Between C at a_1d_3	.06	1	.06	<1	
Between C at a_1d_4	147.50	1	147.50	8.07	<.001
Between C at a_2d_1	1.81	1	1.81	<1	
Between C at a_2d_2	5.50	1	5.50	<1	
Between C at a_2d_3	19.81	1	19.81	1.08	>.25
Between C at a_2d_4	8.20	1	8.20	<1	
Between C at a_3d_1	.34	1	.34	<1	
Between C at a_3d_2	8.60	1	8.60	<1	
Between C at a_3d_3	6.17	1	6.17	<1	
Between C at a_3d_4	6.88	1	6.88	<1	
Between C at a_4d_1	24.34	1	24.34	1.33	>.20
Between C at a_4d_2	15.47	1	15.47	<1	
Between C at a_4d_3	60.80	1	60.80	3.33	<.10>.05
Between C at a_4d_4	.09	1	.09	<1	
Within Cell Error (pooled)	5845.95	320	18.27		

Appendix K (Continued)

Source	SS	df	MS	F	p
Within subjects					
Between D at a_1c_1	266.62	3	88.87	10.04	<.001
Between D at a_1c_2	91.70	3	30.57	3.45	<.025
Between D at a_2c_1	19.21	3	6.40	<1	
Between D at a_2c_2	8.28	3	2.76	<1	
Between D at a_3c_1	5.36	3	1.79	<1	
Between D at a_3c_2	4.50	3	1.50	<1	
Between D at a_4c_1	13.86	3	4.62	<1	
Between D at a_4c_2	68.40	3	22.80	2.58	<.10>.50
D x Ss within Gp. Error (within)	2123.21	240	8.85		

Appendix L

Analysis of Variance Table for the Simple Interaction Effects in the List Frequency (A) x Sex (C) x Imagery (D) Interaction on Errors

Source	SS	df	MS	F	p
Between subjects					
AC at d_1	36.16	3	12.05	<1	
AC at d_2	41.21	3	13.74	<1	
AC at d_3	86.55	3	28.85	1.58	>.10
AC at d_4	150.54	3	50.18	2.75	<.05
Within Cell Error (pooled)	5845.95	320	18.27		
Within subjects					
AD at c_1	197.80	9	21.98	2.48	<.01
AD at c_2	118.71	9	13.19	1.49	>.10
CD at a_1	155.04	3	51.68	5.84	<.001
CD at a_2	5.03	3	1.68	<1	
CD at a_3	8.11	3	2.70	<1	
CD at a_4	28.68	3	9.56	1.08	>.25
ACD	159.91	9	17.77	2.01	<.05
D x Ss within Gp. Error (within)	2123.21	240	8.85		

Appendix M

Source	SS	df	MS	F	p
Groups (A)	.1397	1	.1397	37.76	<.001
Set (B)	.0009	1	.0009	<1	
Sex (C)	.0134	1	.0134	3.62	<.10>.05
AB	.0015	1	.0015	<1	
AC	.0111	1	.0111	3.00	<.10>.05
BC	.0001	1	.0001	<1	
ABC	.0026	1	.0026	<1	
Error	.1497	40	.0037		

Appendix N

Summary Table for Newman-Keuls Analysis
on Errors for Imagery

	$\bar{X}_{HL}$	$\bar{X}_{LH}$	$\bar{X}_{HH}$	$\bar{X}_{LL}$
$\bar{X}_{HL}$=4.67	--	1.15*	1.21*	1.47*
$\bar{X}_{LH}$=5.82		--	.06	.32
$\bar{X}_{HH}$=5.88			--	.26
$\bar{X}_{LL}$=6.14				--

*p .01

MS error = 8.85