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THE EFFECTS OF CHUNK MEMBER UNLEARNING ON RECALL OF OTHER CHUNK MEMBERS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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FIELDS OF STUDY

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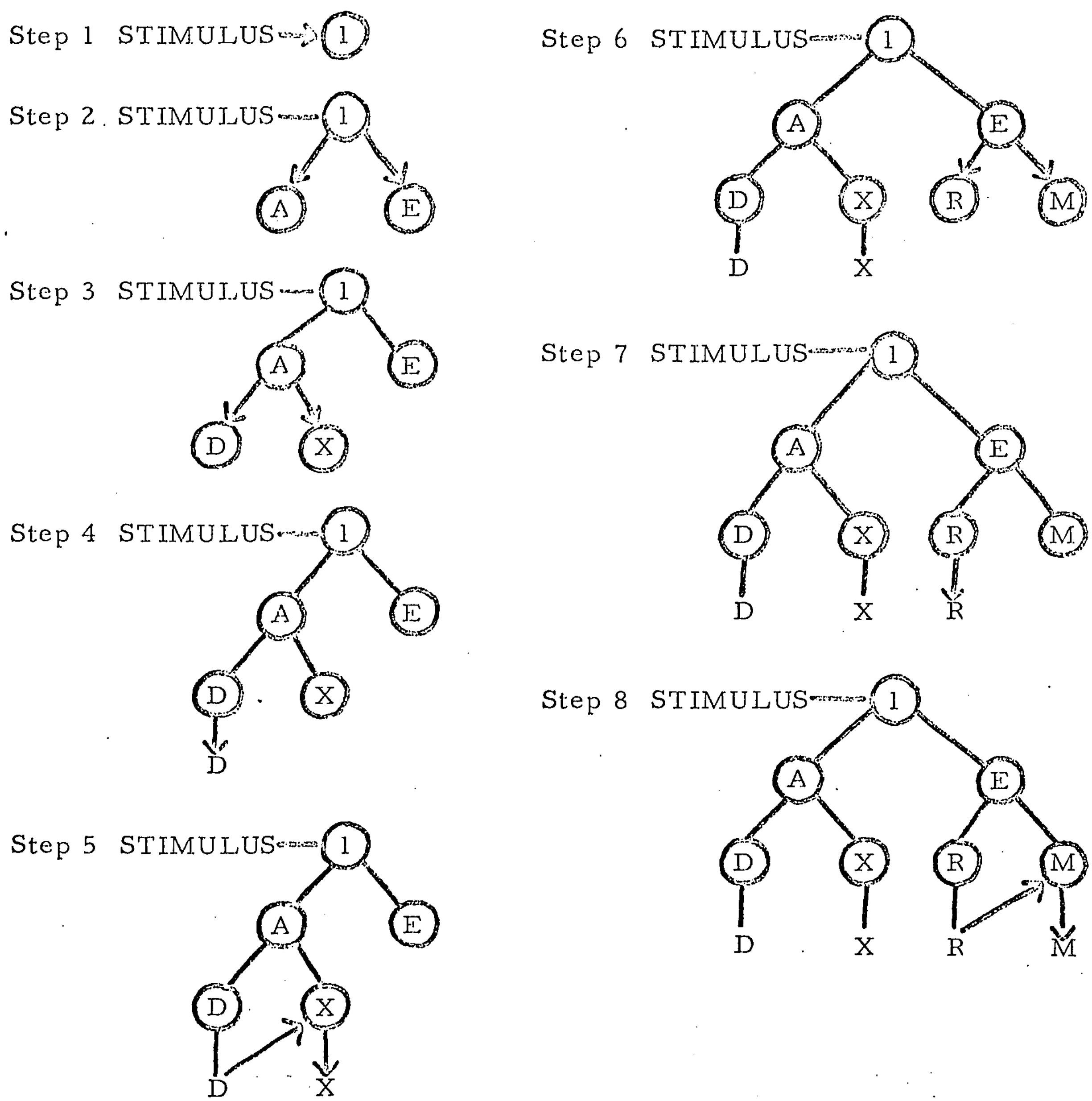
Johnson's (1966) decoding-operation model proposes a way in which subjects (Ss) learn to recall a response during learning. The model assumes that Ss divide the elements of a response into groups or chunks (Miller, 1956), each chunk being remembered by a single code or mnemonic device. The model further assumes that chunks are organized into higher-order chunks (i.e., chunks of chunks) and at the top of the chunk hierarchy one code represents the entire response. When the stimulus is presented, the model assumes that Ss recall the code representing the entire response. Ss then decode down through the chunk hierarchy translating each of the codes into its components, storing all but the first component in short term memory (STM), while the first component is decoded into its components. If, when a code is decoded into its components, the first component is a nonreducible response element, it is produced overtly, and S then retrieves the next element from STM and produces it overtly.

The model is illustrated in Figure 1. In step 1, the stimulus elicits the code which represents the entire response. In step 2, the code is decoded into its components, which in the illustration are codes A and E. In step 3, code E is held in STM, while code A is decoded into its components, which are nonreducible response elements D and X. In step 4, element X is held in STM, while element D is produced overtly. In step 5, S retrieves X from STM and produces it overtly.

Figure 1

An Illustration of the Decoding-Operation Model



In step 6, code E is retrived from STM and decoded into its components, which are nonreducible response elements R and M. In step 7, S holds element M in STM, while R is produced overtly. In step 8, element M is retrived from STM and produced overtly.

One implication of the decoding-operation model is that more decoding operations occur at the transition between the stimulus and first response element (i.e., the zero transition) and at the transitions between chunks than at the transitions between elements of the same chunk. If it is assumed that Ss terminate their response attempt whenever they become uncertain, and the likelihood of becoming uncertain is a function of the number of decoding operations at a transition, the model can make certain predictions. First, the probability of terminating should be higher at zero and between-chunk transitions than at within-chunk transitions. Second, the probability of terminating at a zero transition should be a function of the number of chunks within the response. Third, the probability of terminating at a between-chunk transition should be a function of the number of chunk members in the chunk which follows the transition.

The above predictions were tested in a set of studies by Johnson (1966). Ss learned paired associates in which the stimuli were single digits and each response consisted of two or more groups of letters (e.g., DHQ MZ). A blank space appeared between each group. Johnson assumed that Ss would use the blank spaces as a way of dividing a response into chunks, and the data supported the assumption. According to the decoding-operation model, the probability of terminating should be higher at the zero and blank space transitions than at transitions between letters of the same group. Second, the probability of terminating at the zero transition should be a function of the number of chunks within the response. Third, the probability of terminating at a chunk boundary should be a function of the number of letters in the chunk which follows the transition. All predictions were supported.

A second implication of the decoding-operation model is that within a chunk the code is associated directly with each of its chunk members. No associations between chunk members are assumed. The model would predict that if a chunk member was submitted to unlearning using a retroactive inhibition (RI) technique, recall of the other chunk members should not be effected.

Some support for the above prediction is found in an unpublished (RI) study by Johnson (personal communication). Experimental Ss learned paired-associate lists with digits as stimuli and letter sequences as responses (e.g., 2-DHQ MPZ TFL). The Ss then learned a second and similar list (e.g., 2 DXQ MPR TFL). Then, Ss recalled both sets of responses using the modified-modified-free-recall (MMFR) technique. It should be noted that some chunks had a single letter which changed from first to second list (e.g., DHQ to DXQ), while other chunks remained unchanged (e.g., TFL). Johnson assumed that for changed chunks the first-list code would be unlearned during second-list learning.

According to the decoding-operation model, the changed chunk unlearning should not effect recall of the unchanged chunks.

The results for recall of first-list responses on the MMFR were as follows. First, it appeared that the codes for changed chunks were unlearned during second-list learning; experimental Ss could not recall unchanged letters from changed chunks as well as a control group which had not learned the second list. Second, the changed letter also was unlearned during second-list learning; experimental Ss could not recall the changed letters as well as the unchanged letters from the changed chunks. Third, unlearning of changed chunk codes did not effect recall of unchanged chunks codes; experimental and control Ss did not differ significantly in their recall of letters from unchanged chunks.

In the present study experimental Ss learned paired associates in the two lists. Digits were the stimuli and trigrams were the responses. The two lists were identical except in the second list the middle letter of the trigrams was changed. After second-list learning, Ss were tested using the MMFR technique. On the basis of the results from Johnson's RI study, it was assumed that the changed letter of first-list chunks would be unlearned during second-list learning. According to the decoding-operation model, the following prediction was made. Under conditions of code recall, the recall of unchanged letters from first-list chunks should not be effected. It is assumed the code is recalled where at least one chunk member has been recalled.

The present study had a second purpose. A study by Postman, Keppel and Stark (1965) indicated that where first and second-list responses were from the same class (e.g., bigrams) there is *more* unlearning of first-list responses than where the two sets of responses were from different classes (e.g., bigrams and adjectives). In the present study, it was hypothesized that if first and second-list chunks were unpronounceable trigrams (i.e., CCC's) there should be more unlearning of first-chunk codes and changed letters than if one set of chunks was unpronounceable trigrams (i.e., CCC's) and the other set was pronounceable trigrams (i.e., CVC's). It was assumed that unpronounceable trigrams are from the same class, while unpronounceable and pronounceable trigrams are from different classes. Code unlearning was measured by the number of times *S*s were not able to recall correctly any member of a chunk (i.e., a complete error), while changed letter unlearning was measured by the probability of recalling the changed letter given the recall of the code as evidenced by the recall of at least one unchanged letter.

METHOD

The conditions of the experiment may be viewed as three experiments, each of which involved an experimental and control group. The experimental groups learned two paired-associate lists in which the stimuli were single digits 1 to 5 and responses were unpronounceable (U) or pronounceable (P) trigrams (i.e., CCC's or CVC's). During learning Ss were required to pronounce each letter of the response. For one experimental group (U-U), the responses of both lists were unpronounceable; for a second group (P-U), first and second-list responses were pronounceable and unpronounceable, respectively; for a third group (U-P), first and second-list responses were unpronounceable and pronounceable, respectively. For each experimental group, each paired associate in the first list was nearly identical to a paired associate in the second list. Only the middle letters of the two paired-associate responses in each case were different.

The control group (c) in each experiment (U-Uc, P-Uc and U-Pc) learned the first list that was learned by the experimental group, and then performed a symbol cancellation task that matched the time required for the experimental group to learn the second list. For the symbol cancellation task, Ss were presented a series of symbols and numbers at the top of a sheet of paper. They were told that each symbol represented the number below it. The symbols were presented again further down the sheet in random order with each symbol being repeated a number of times. The Ss were asked to cross out each symbol and write below it the number which the symbol represented. The Ss were allowed to refer to the top of the sheet throughout the task.

After second-list learning, experimental Ss were required to recall both sets of responses using the MMFR technique. The Ss were supplied a sheet of paper on which the stimuli were listed. They were asked to supply the responses from both lists on two sets of three blanks. After they had written down the responses, they were asked to identify the list to which each response belonged. The control Ss were asked to supply the responses from the first list on one set of three blanks next to each stimulus. Unlimited time was given for the recall test.

All lists were learned to a criterion of one perfect trial. The lists were presented by the standard anticipation procedure at a 2 sec : 2 sec rate with a 2 sec intertrial interval.

Lists

Two first and second lists were used in each experiment. The responses from the lists are presented in Table 1. One-half of each experimental and control group learned one of the first lists, while the other half of each group learned the other first list. One-half of each experimental group learned one of the second lists, while the other half learned the other second list. The two first lists used for group P-U were identical to the two second lists used for group U-P. The two

TABLE 1

The Stimuli and Responses Used
in the Paired-Associate Lists

U-U Lists				P-U and U-P Lists			
1-RWL	1-RHL	1-ZGQ	1-ZTQ	1-CAZ	1-CPZ	1-DAQ	1-DHQ
2-CZK	2-CQK	2-RJM	2-RBM	2-NUK	2-NGK	2-TEP	2-TJP
3-DSX	3-DPX	3-KSW	3-KHW	3-BEX	3-BMX	3-GIZ	3-GMZ
4-MGB	4-MJB	4-CNP	4-CFP	4-WOQ	4-WSQ	4-CUX	4-CSX
5-NFV	5-NTV	5-DXV	5-DLV	5-JID	5-JFD	5-NOF	5-NLF

second lists used for the P-U group were identical to the two first lists used for the U-P group.

An attempt was made to equate, as nearly as possible, the responses of the lists on association value. The association values for the CCC's were taken from the Witmer norms cited in Underwood and Schulze (1960), while the association values for the CVC's were taken from Archer (1960). To control for intralist similarity, no letter was repeated within any list. The association values for four of the five responses for the two U-U first lists were between 40.5% and 29.5%, while the association values for four of the five responses for the two second U-U lists were between 38.5% and 24.5%. For one of the responses in each of the first and second U-U lists, an association value could not be obtained. These responses were selected from Appendix F of Underwood and Schulze (1960) on the basis of their relatively low letter to letter association values. For these responses, the mean number of <u>S</u>s which gave the second letter as an associate to the first letter was 4.5, and the mean number of <u>S</u>s which gave the third letter as an associate to the first and second letter was 3.5. The association values for the two P-U first lists, thus the two U-P second lists, were between 32.4% and 37.6%. The values for the two P-U second lists, thus the two U-P first lists, were between 33.0% and 34.0%.

Subjects

The Ss were 120 introductory psychology students at the Ohio State University. An equal number of Ss were assigned in alternating order to each of the three experimental and control groups.

RESULTS

First-list learning

The mean number of trials to criterion for U-U, P-U, U-P, U-Uc, P-Uc, and U-Pc was 27.20, 14.65, 18.35, 23.50, 15.70, and 23.05, $F(5, 114)=5.18$, $p < .05$. The mean number of errors to criterion for U-U, P-U, U-P, U-Uc, P-Uc, and U-Pc was 75.35, 38.35, 51.30, 63.60, 40.15, and 61.30, $F(5, 114)=4.65$, $p < .05$. Duncan's (Edwards, 1960) multiple range test was used to determine which of the differences between the means on the two measures of first-list performance were significant at the .05 level. Groups U-U, U-Uc, and U-Pc were not significantly different from each other on either measure; groups P-U and P-Uc were not significantly different from each other on either measure; groups U-U and U-P were significantly different from each other on both measures; groups U-U, U-Uc, and U-Pc were significantly different from P-U and P-Uc on both measures. For the most part, groups learning unpronounceable trigrams took a significantly greater number of trials to reach criterion and had a significantly greater number of errors to criterion. It appears that where CCC's and CVC's are nearly equated on association value, the CCC's are still more difficult to learn. These results are in accord with those obtained by Underwood and Schulze (1960).

Second-list learning

The mean number of trials to criterion for U-U, P-U, and U-P was 10.20, 15.35, and 7.55, *F*(2,57)=27.44, *p*<.05. The mean number of errors to criterion for U-U, P-U, and U-P was 24.25, 39.65, and 15.65, *F*(2,57)=9.10, *p*<.05. Duncan's (Edwards, 1960) multiple range test was used to determine which of the differences between means on the two measures of second-list performance were significant at the .05 level. Group P-U took a significantly greater number of trials to reach criterion than group U-P and had a significantly greater number of errors to criterion than group U-P. This result supports the generalization made earlier that where CCC's and CVC's are nearly equated on association value, the CCC's are still more difficult to learn. Group P-U also took a significantly greater number of trials to reach criterion than group U-U and had a significantly greater number of errors to criterion than group U-U. It could be that where first and second-list responses are CCC's, the set to give CCC's which is learned during first-list learning facilitates second-list learning. Group U-P and U-U did not differ significantly from each other.

Recall

The recall of first-list responses for the three experimental and control groups is presented in Table 2. The results include the mean number of complete errors, the probability of recalling a changed letter given the recall of the code (rows two and three) and the probability of recalling either the first unchanged letter or the second unchanged letter

TABLE 2

Recall of First-List Responses for the Experimental and Control Groups

	U-U	U-Uc	P-U	P-Uc	U-P	U-Pc
Complete Errors	2.35	.60	1.85	.05	2.65	.10
p(C/UC-1)	.80	.99	.82	.98	.93	.99
p(C/UC-2)	.79	.99	.81	.99	.95	.98
p(UC-1/C)	1.00	1.00	1.00	1.00	.94	.99
p(UC-1/UC-2)	.94	1.00	1.00	.99	.88	.98
p(UC-2/C)	.97	1.00	.98	.95	.94	.99
p(UC-2/UC-1)	.90	.99	.95	.95	.89	.99

given the recall of the code (rows four, five, six, and seven). There are two measures for the probability of recalling a changed letter given the code: the probability of recalling the changed letter given either the recall of the first unchanged letter (p[C/UC-1]) or the recall of the second unchanged letter (p[C/UC-2]). There are four measures for the probability of recalling an unchanged letter given the code: the probability of recalling the first unchanged letter given either the recall of the changed letter (p[UC-1/C]) or the recall of the second unchanged letter (p[UC-1/UC-2]) and the probability of recalling the second unchanged letter given either the recall of the changed letter (p[UC-2/C]) or the recall of the first unchanged letter (p[UC-2/UC-1]).

It was assumed that the measure of code unlearning would be the number of times Ss were not able to recall correctly any member of a chunk, while the measure of changed letter unlearning would be the probability of recalling a changed letter given the recall of the code (p[C/UC-1] and p[C/UC-2]). On the basis of these assumptions, it appears that there was code unlearning for all three experimental groups. Each of the experimental groups had a significantly greater number of complete errors than its control group (for U-U and U-Uc, $t(38)=3.54$, $p < .05$; for P-U and P-Uc, $t(38)=4.09$, $p < .05$; for U-P and U-Pc, $t(38)=5.57$, $p < .05$). It appears also that there was changed letter unlearning for group U-U and P-U. Given the recall of either the first or second unchanged letter, both U-U and P-U recalled a significantly fewer number of changed letters than their controls (for U-U and U-Uc on p[C/UC-1], $t(34)=2.74$, $p<.05$; for U-U and U-Uc on p[C/UC-2], $t(35)=2.69$, $p<.05$; for P-U and P-Uc on p[C/UC-1], $t(36)=2.92$, $p<.05$; for P-U and P-Uc on p[C/UC-2], $t(36)=3.63$, $p<.05$). For group U-P, the probability of recalling the changed letter was less than the control but the difference was not significant (for U-P and U-Pc on p[C/UC-1], $t(33)=1.79$, $p>.05$; for U-P and U-Pc on p[C/UC-2], $t(34)=1.07$, $p>.05$).

It also was hypothesized that there would be more code and changed letter unlearning where first and second-list responses were unpronounceable trigrams than where one set of responses was unpronounceable and the other set was pronounceable. The hypothesis was based on the assumption that unpronounceable trigrams are from the same class, while unpronounceable and pronounceable trigrams are from different classes. The results of the present study do not support the above hypothesis. The results relevant to this hypothesis are presented in Table 3. For complete errors, p(C/UC-1) and p(C/UC-2), the difference between U-U and U-Uc was not significantly different from the difference between P-U and P-Uc (for complete errors, $t(38)=.07$, $p>.05$; for p[C/UC-1], $t(32)=.36$, $p>.05$; for p[C/UC-2], $t(29)=.25$, $p>.05$). For complete errors, p(C/UC-1) and p(C/UC-2), the difference between U-U and U-Uc was not significantly different from the difference between U-P and U-Pc (for complete errors, $t(38)=1.17$, $p>.05$; for p[C/UC-1], $t(29)=1.21$, $p>.05$; for p[C/UC-2], $t(27)=1.63$, $p>.05$). For complete errors and p(C/UC-1), the difference

TABLE 3

The Difference between Experimental-Control Differences in the Recall of First-List Responses

	(U-U - U-Uc)	(P-U - P-Uc)	(U-P - U-Pc)
Complete Errors	1.75	1.80	2.55
p(C/UC-1)	-.19	-.16	-.06
p(C/UC-2)	-.20	-.18	-.03
p(UC-1/C)	.00	.00	-.05
p(UC-1/UC-2)	-.06	.01	-.10
p(UC-2/C)	-.03	.03	-.05
p(UC-2/UC-1)	-.09	.00	-.09

between P-U and P-Uc was not significantly different from the difference between U-P and U-Pc (for complete errors, $t(31)=1.19$, $p > .05$; for p[C/UC-1], $t(31)=1.17$, $p > .05$). For p(C/UC-2), the difference between P-U and P-Uc was significantly greater than the difference between U-P and U-Pc, $t(32)=2.27$, $p < .05$.

Finally, it was hypothesized that if a changed letter was unlearned, recall of the unchanged letters, given the recall of the code, should not be effected. The hypothesis was derived from Johnson's (1966) decoding-operation model which assumes that within a chunk the code is associated directly with each of its chunk members, (i.e., no interitem associations). The results from the present study support the above hypothesis. For the two groups where the changed letter was unlearned (U-U and P-U), the recall of the unchanged letters under conditions of code recall was not effected. That is, for p(UC-1/C), p(UC-1/UC-2), p(UC-2/C) and UC-2/UC-1), U-U and P-U did not differ significantly from their controls (for U-U and U-Uc on p[UC-1/C], $t(34)=.00$, $p > .05$; for U-U and U-Uc on p[UC-1/UC-2], $t(35)=1.11$, $p > .05$; for U-U and U-Uc on p[UC-2/C], $t(34)=1.13$, $p > .05$; for U-U and U-Uc on p[UC-2/UC-1], $t(34)=1.43$, $p > .05$; for P-U and P-Uc on p[UC-1/C], $t(36)=.00$, $p > .05$; for P-U and P-Uc on p[UC-1/UC-2], $t(36)=.92$, $p > .05$; for P-U and P-Uc on p[UC-2/C], $t(36)=1.15$, $p > .05$; for P-U and P-Uc on p[UC-2/UC-1], $t(36)=.98$, $p > .05$).

One other point should be made about the recall results of the present study. There were a relatively large number of calls where experimental Ss did not attempt to recall any member of a first-list chunk (i. e., a complete omission). The mean number of complete omissions for U-U, P-U, and U-P was 2.1, 1.8, and 1.65. It could be that on some of these complete omissions Ss were able to recall the code and first unchanged letter, but they were uncertain about the changed letter and second unchanged letter. This possibility could have occurred if two assumptions are made. First, contrary to the decoding-operation model, it could be that in some cases the code of a chunk is associated only with the first unchanged letter, the first unchanged letter is associated with the changed letter, and the changed letter is associated with the second unchanged letter (chaining hypothesis). According to the chaining hypothesis, where Ss are uncertain of the changed letter, they also should be uncertain of the second unchanged letter. Second, it could be that when Ss were uncertain of the changed and second unchanged letter, they withheld overt recall of the entire chunk, the result being a complete omission.

EXPERIMENT II

It was noted in the first experiment of the present study that there were a relatively large number of calls where Ss did not attempt to recall any member of a chunk. It was suggested that on some of the complete omissions Ss may be able to recall the code and the first unchanged letter. The purpose of the present study is to test that hypothesis.

Experimental Ss learned paired-associates (e.g., 2-DHQ) in a first list, learned paired-associates (e.g., 2-DXQ) in a second list, then recalled both sets of responses using the MMFR technique. After Ss indicated that they were finished with the MMFR, they were required to guess on blank spaces where they had not attempted to recall a letter. According to the above hypothesis, under conditions of guessing the probability of recalling the second unchanged letter, given the first unchanged letter, should be less for the experimental than for the control group. On the basis of the results from the first experiment, it was expected that experimental and control Ss would not differ significantly on the regular MMFR in their recall of the second unchanged letter given the first unchanged letter.

METHOD

The second experiment of the present study consisted of an experimental and control group. The experimental and control groups were treated in almost exactly the same manner as the U-U groups in the first experiment. One-half of the experimental group learned one of the first and second lists that was learned by the U-U group, while the other half of the experimental group learned the other first and second list. One-half of the control group learned one of the first lists, while the other half learned the other first list.

After second-list learning, experimental Ss recalled both sets of responses using the MMFR technique. As described earlier, Ss were supplied a sheet of paper on which the stimuli were listed. Ss were asked to supply the responses from both lists on two sets of three blanks next to each stimulus. After Ss had written down their responses, they were asked to identify the list to which each response belonged. The control group was asked to supply the responses from the first list on one set of three blanks next to each stimulus. Unlimited time was given for the recall test. After Ss indicated that they were finished with the recall test, they were given a different colored pen and asked to guess on blanks where they had not attempted to supply a letter.

Subjects

Both the experimental and control group consisted of 8 introductory psychology students at the Ohio State University and 12 nonintroductory psychology students at the Ohio State University.

RESULTS

First and second-list learning

The mean number of trials to criterion on the first-list for the experimental and control groups was 32.5 and 25.6, $t(38)=1.08$, $p > .05$. The mean number of errors to criterion on the first-list for the experimental and control groups was 88.65 and 71.85, $t(38)=1.01$, $p > .05$. The mean number of trials to criterion on the second-list for the experimental group was 13.5, while the mean number of errors to criterion on the second-list for the experimental group was 25.6.

Recall

The mean recall scores for the first-list performance on the regular MMFR, and under conditions of guessing, are presented in Table 4. The results include the mean number of complete errors, the two measures for the probability of recalling the changed letter given the code (p[C/UC-1] and p[C/UC-2]) and the four measures for the probability of recalling an unchanged letter given the code (p[UC-1/C], p[UC-1/UC-2], p[UC-2/C] and p[UC-2/UC-1]).

Recall of first-list responses on the regular MMFR was examined first. As can be seen in Table 4, the experimental Ss had a significantly greater number of complete errors than the control group, $t(38)=3.92$,

TABLE 4

Recall of First-List Responses for the
Experimental (E) and Control (C) Group

	E (MMFR)	C (MMFR)	E (Guessing)	C (Guessing)
Complete Errors	1.20	.00	.65	.00
p(C/UC-1)	.67	.96	.63	.96
p(C/UC-2)	.83	.99	.77	.99
p(UC-1/C)	.95	.98	.95	.98
p(UC-1/UC-2)	.95	.98	.94	.98
p(UC-2/C)	.88	1.00	.90	1.00
p(UC-2/UC-1)	.75	.96	.75	.96

$p < .05$. Given the recall of either the first or second unchanged letter, experimental Ss recalled significantly fewer changed letters than the control group (for p[C/UC-1], $t(35)=4.56$, $p < .05$; for p[C/UC-2], $t(34)=2.53$, $p < .05$). Given the recall of either the changed letter or the second unchanged letter, experimental and control Ss did not differ significantly in their recall of the first unchanged letter (for p[UC-1/C], $t(34)=.80$, $p > .05$; for p[UC-1/UC-2], $t(34)=.70$, $p > .05$). Given the recall of the changed letter, experimental and control Ss did not differ significantly in their recall of the second unchanged letter, $t(34)=1.85$, $p > .05$. The above results are in accord with those obtained in the first experiment of the present study. Given the recall of the first unchanged letter, experimental Ss recalled significantly fewer second unchanged letters than the control group, $t(34)=2.53$, $p < .05$. That result is not in accord with the results obtained in the first experiment and does not support the assumption made by Johnson's (1966) decoding-operation model that within a chunk the code is associated directly with each chunk member. However, the result does support the chaining hypothesis.

The recall of first-list responses under conditions guessing were in accord with those obtained on the regular MMFR. Experimental Ss had a significantly greater number of complete errors than the control group, $t(38)=2.77$, $p < .05$. Given recall of either the first or second unchanged letter, experimental Ss recalled a significantly fewer number of changed letters than the control group (for p[C/UC-1], $t(37)=4.93$, $p<.05$; for p[C/UC-2], $t(36)=3.40$, $p<.05$). Given recall of either the changed letter or second unchanged letter, experimental and control Ss did not differ significantly in their recall of the first unchanged letter (for p[UC-1/C], $t(36)=.85$, $p>.05$; for p[UC-1/UC-2], $t(36)=1.02$, $p>.05$). Given the recall of the changed letter, experimental and control Ss did not differ significantly in their recall of the second unchanged letter, $t(36)=1.74$, $p>.05$. Given the recall of the first unchanged letter, experimental Ss recalled significantly fewer second unchanged letters than the control group, $t(35)=2.90$, $p<.05$. Again, the results are in accord with the chaining hypothesis.

The results of the present experiment indicate that on the regular MMFR experimental Ss recalled a significantly fewer number of second unchanged letters given the first unchanged letter than did the controls. The same result was found under conditions of guessing. If Ss did withhold on the MMFR, the experimental-control difference in p(UC-2/UC-1) should have been greater under conditions of guessing than on the regular MMFR. That expectation was not confirmed. The probability of recalling the second unchanged letter, given the first unchanged letter, for the experimental and control group was .75 and .96 on the MMFR and .75 and .96 under conditions of guessing. One possible explanation for that finding might be that in the present experiment where Ss were able to covertly recall the code and second unchanged letter, they did not withhold. The above explanation has some support in that there were a smaller number of complete omissions in the second experiment than there were in the first experiment. The mean number of complete omissions for group U-U in the first experiment was 2.1, while the mean number of complete omissions for the experimental group in the second experiment was 1.1.

DISCUSSION

It was hypothesized in the present study that there would be more code and changed letter unlearning where first and second list responses are CCC's than where one set of responses are CCC's and the other set are CVC's. It was assumed that CCC's are from the same response class, while CCC's and CVC's are from different response classes. The hypothesis was not supported. For complete errors, p(C/UC-1) and p(C/UC-2), the difference between U-U and U-Uc was not significantly different from the difference between P-U and P-Uc or the difference between U-P and U-Pc. One explanation for this finding could be that since Ss had to pronounce each letter of the CVC's during learning, they may have perceived the CVC's as being unpronounceable, thus from the same response class as the CCC's.

It was also hypothesized that where a chunk member is unlearned recall of the other chunk members should not be effected. The hypothesis was supported in the first experiment. For p(UC-1/C), p(UC-1/UC-2), p(UC-2/C) and p(UC-2/UC-1), groups U-U and P-U did not differ significantly from their controls. The results support Johnson's (1966) decoding-operation model which assumes that within a chunk the code is associated directly with each chunk member, while no associations are formed between chunk members. The hypothesis was not supported in the second study, however. For p(UC-1/C), p(UC-1/UC-2) and p(UC-2/C), the experimental and control group did not differ significantly. However, for p(UC-2/UC-1) the experimental group was significantly less than the control group. The results support the chaining hypothesis which assumes that within a chunk the code is associated with the first chunk member, the first chunk member is associated with the second chunk member, and so on. One explanation for the discrepancy between the findings of the first and second experiment could be as follows. First, there was a greater chance that Ss in the second experiment had participated in a verbal-learning experiment prior to the present study. The introductory psychology students in the second experiment were required to participate in more experiments than the introductory students in the first experiment, and the nonintroductory psychology students in the second experiment had already taken an introductory psychology course. Second, it could be that Ss with more experience at verbal-learning tasks tend to learn a chunk more in the way specified by the chaining hypothesis. One way to test the above set of assumptions is as follows. Experimental Ss learn paired-associates (e.g., 2-DHQ) in a first list, learn paired-associates (e.g., 2-DXQ) in a second list, learn paired-associates (e.g., 2-DMQ) in a third list, then recall the responses from the three lists using the MMFR technique. On the MMFR, there should be a larger difference between the experimental and control group in p(UC-2/UC-1) for second-list responses than for first-list responses.

It was noted that there were a relatively large number of complete omissions in the first experiment. It was hypothesized that where a complete omission occurs Ss may be able to covertly recall the code and first unchanged letter. The hypothesis was not supported. For p(UC-2/UC-1), the experimental-control difference was no greater under conditions of guessing than on the regular MMFR. One explanation for that finding may be that Ss in the second experiment did not withhold recall of the first unchanged letter. This explanation was supported by the fact that there were a smaller number of complete omissions in the second experiment. It could be that the tendency not to withhold in the second experiment was again due to second experiment Ss having more experience at verbal-learning tasks.

In conclusion, the results of the present study indicate that a member of a chunk can be unlearned. On the MMFR, group U-U and P-U in the first experiment and the experimental group in the second experiment recalled significantly fewer changed letters under conditions of code recall than the control groups. The results, unfortunately, are ambiguous about the effects of chunk-member unlearning on the recall of other chunk members. One experiment indicated that the other chunk members were not effected, while the other experiment indicated that the other chunk members were effected. One explanation for the conflicting results could be that as experience with verbal-learning tasks increases, the way in which Ss learn a chunk changes.

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