Stimulus Encoding in A-B, A-D Transfer

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After A-B, A-D transfer learning with compound stimuli, subject-item protocols were categorized according to whether backward, response-to-stimulus recall resulted in B and D eliciting the exact same stimulus component (stay events) or entirely different stimulus components (switch events). Stay events were twice as frequent as switch events, and negative transfer relative to the A-B, C-D control paradigm occurred only for stay events.

In recent papers, Williams and Underwood (1970) and Postman and Stark (1971) have presented empirical arguments against the idea that in the second task in an A-B, A-D negative-transfer situation subjects will recode (change their functional perception of) the common stimulus in order to avoid transfer interference. Moreover, Schneider and Houston (1969) and Goggin and Martin (1970) have reported that subjects who were free to recode or not to recode tended to perform with subjects who were forced not to recode. These results clearly stand in opposition to the hypothesis that subjects will spontaneously recode a stimulus common to two incompatible behaviors (Martin, 1968).

On the other hand, Houston (1967, Experiment III) and Merryman and Merryman (1971) have presented evidence that does indicate spontaneous recoding, and Goggin and Martin (1970), Schneider and Houston (1969), and Weaver (1969) have reported that if, for whatever reason, the subject is prompted or coerced to recode the stimulus in second-task learning, he then suffers less negative transfer and less retroactive interference than if he had not recoded the stimulus.

The general picture thus seems to be that a given subject may or may not recode the stimulus, most likely not; but if he does, he then escapes transfer interference and retroactive interference to some degree. This general summary, however, is based on only weak evidence. In all relevant studies the evidence consists of comparisons of group means, which is to say that there has been no analytic recognition of the possibility that among subjects treated alike, some do one thing and others another, or that some stimuli but not others are recoded.

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Since a group mean for the A-B, A-D transfer paradigm may conceal a considerable array of distinguishable phenomena, the purposes of the present experiment and analyses were to find out to what extent subjects do or do not select a different stimulus component in the second task of that paradigm, to relate such flexibility or intransigence to transfer performance, and to discover how the component elements of a compound stimulus relate to each other after having served together in a negative-transfer situation.

The experiment was a 2 × 2 between-subjects factorial. One factor contrasted the two transfer paradigms A-B, A-D and A-B, C-D. The other contrasted two types of posttesting for what was remembered from the two tasks of the transfer paradigms. The stimuli were triads of high-frequency four-letter words, thus permitting the two posttests to entail either presenting the intact compound stimuli for response recall, *condition W* (for Whole), or presenting single components as stimuli for recall both of responses and of other stimulus components, *condition P* (for Parts). The condition P posttest was intended to reveal the amount of intracompound, intercomponent association formation during learning.

A subsequent posttest common to all subjects was a response-to-stimulus backward-recall test that was intended to permit classification of individual subject-item transfer events in the A-B, A-D paradigm into three categories: *stay events,* those where corresponding B and D responses elicited the exact same stimulus components; *switch events,* those where B and D elicited entirely different components; and *partial events,* those where B and D elicited incompletely overlapping component sets. The frequencies of these subject-item event categories should index the extent of stimulus recoding (switching). First-task (A-B) and second-task (A-D) performance on pairs within these categories, relative to an A-B, C-D control paradigm, should relate degree of negative transfer to mode of second-task stimulus encoding.

METHOD

— Subjects — The subjects were 64 undergraduate females enrolled in summer school in the University of Michigan. Sixteen were assigned to each of the four experimental conditions (two paradigms, A-B, A-D and A-B, C-D; two types of posttests, conditions W and P) in a mixed, disorderly fashion; that is, the four conditions were interleaved in their administration. Each subject was paid $1.50 for her participation, which required less than an hour.

— Materials — The learning materials were lists of nine paired associates. The stimuli were triads of unrelated common words, arranged in a fixed left-to-right order. The responses were single common words. There were two distinct sets of nine triads, and two distinct sets of nine single words. The two stimulus lists and the two response lists were combined in the four ways possible, and each of the four resulting paired-associate lists was used equally often in first- and second-list learning in both paradigms. Each list was arranged into nine different presentation orders so that each pair occurred in each presentation position equally often.

The two lists of stimulus triads were: LOAF ARCH SAND, RICE CHIP MOON, ZONE TASK VIEW, FUND KNEE DOVE, BATH NAIL PORT, HEAP FIST COAT, CARE LUCK SONG, SHOP MODE YARD, TOWN BEAM ROOT; and GLUE OATH CORD, VINE PATH GOAL, BIRD TIME SKIN, SPOT CAVE RING, FLAG DESK GOWN, VEST WIRE SEED, DEBT TUBE LIME, CODE FROG WOOL, WARD HOOD BAND. The two lists of response words were: TANK, HORN, PAGE, MASK, CANE, LAKE, BOOT, GRIN, YEAR; and ROSE, DUKE, LACE, WHIP, JOKE, GAME, FIRE, PALM, SALT. The orders given are the orders of stimulus-response pairing.

For posttesting of what was remembered from first- and second-list learning, several booklets were prepared. For the *A-B, A-D* paradigm under *condition W,* the nine compound A stimuli appeared singly on separate pages with two blank spaces (one above the other) for the B and D responses. Each of the nine stimuli appeared three times in the 27-page booklet, but no particular stimulus appeared for the second (or third) time until every other stimulus had appeared once (or twice). The subjects wrote their response recalls in the blanks.

For the *A-B, C-D* paradigm under *condition W,* the nine compound A stimuli and the nine compound C stimuli appeared once each in an 18-page booklet that was otherwise identical to the test booklets for condition W under the A-B, A-D paradigm. The subjects wrote their response recalls in one or the other of the two blanks provided with each stimulus.

For the *A-B, A-D* paradigm under *condition P,* each single-word component of each compound stimulus appeared singly on a page with two positional blanks for the two missing stimulus components and, to the right, two blanks (one above the other) for the B and D responses. Over the first nine pages, one component from each of the nine compound stimuli was presented, three each from positions 1, 2, and 3. The second and third nine pages tested the remaining two component positions of each compound stimulus. The subjects filled in all blanks, both for missing stimulus components and for responses, as best they could.

For the *A-B, C-D* paradigm under *condition P,* each of the three components of each of the 18 stimuli (nine As, nine Cs) appeared once in a 54-page booklet, again with positional blanks for the two missing stimulus components and a pair of blanks for the missing response.

Finally, a booklet common to *all* conditions was prepared. Each of the nine B and nine D responses appeared singly on a page and to the right. To the left were three positional blanks for the three stimulus components. The pages with B and D responses were intermixed randomly except that at least one other response intervened between the appearances of B and D responses with a common stimulus. The subjects wrote in what they could recall of the stimuli.

— Procedure — Each paired-associate list was learned by the anticipation procedure at a 2:2:4-sec rate to a criterion of one perfect recitation. The lists were presented visually by a Stowe memory drum. Approximately 1 min intervened between the first and second tasks, just enough time for second-task instructions.

At the end of second-list learning there was a 10-min delay before posttesting began. This interval was occupied by a sentence-parsing task. Each subject then worked her way through the first (condition P or W) booklet at her own pace, whereupon she was given the second (backward recall) booklet, through which she again worked at her own pace.

RESULTS

Learning and transfer

Mean trials to criterion (excluding the initial inspection trial and the final, criterion trial) on the first list are posted on the left in Table 1 for each of the four combinations of paradigm and posttest condition. The $F(1,60)$ statistics for paradigm, posttest condition, and their interaction were .06, .40, and .06 respectively. The corresponding mean trials to criterion on the second list are posted on the right in Table 1, and the corresponding $F(1,60)$ statistics were 2.11, .73, and .60. A Type I error probability of .10 requires an F value of 2.79.

Using trials to criterion on the first list as a control variable for subject differences in learning ability, covariance analysis of second-list performance yielded $F(1,61) = 3.08, .05 < p < .10$, for the paradigm effect. Thus on the basis of comparison of group means, negative transfer in the A-B, A-D paradigm relative to the A-B, C-D control paradigm was not observed, or perhaps with only marginal likelihood under the covariance analysis.

Backward recall and transfer

In the backward-recall test, all nine B and all nine D responses were presented and the subject attempted to recall the corresponding stimulus to each. In the A-B, A-D paradigm, for every B response there was a D response with the same nominal learning stimulus. Collapsing conditions W and P, there were (9 pairs, 32 subjects) 288 such B and D pairs. For

Table 1. Mean trials to criterion

Paradigm	List 1	List 2
A-B, A-D		
Condition W	12.6	8.4
Condition P	11.2	6.5
A-B, C-D		
Condition W	12.6	4.9
Condition P	14.0	7.4

each of these, the pair members might elicit the exact same stimulus components (e.g., $B \rightarrow A_1A_2$ and $D \rightarrow A_1A_2$), entirely nonoverlapping sets of stimulus elements (e.g., $B \rightarrow A_1$ and $D \rightarrow A_2A_3$), or partially overlapping component sets (e.g., $B \rightarrow A_1A_2$ and $D \rightarrow A_2A_3$, or $B \rightarrow A_1A_3$ and $D \rightarrow A_3$), where A_i is the stimulus component in the ith position for $i = 1, 2, 3$.

Of the 288 B and D pairs, 72 resulted in B and D eliciting entirely nonoverlapping stimulus components. These 72 events were switch events in terms of our target problem, the problem of stimulus recoding in transfer. There were 136 stay events, those in which B and D elicited the exact same stimulus components, and 16 partial events. In the interest of completeness, there were also 54 events where either B or D elicited at least one stimulus component but the other did not, and 10 events where neither B nor D elicited any stimulus component.

For each of the 72 switch events, the 16 partial events, and the 136 stay events, we can count the number of errors incurred during first-list (A-B) learning and during second-list (A-D) learning. Figure 1 shows the mean errors per subject-item on the two lists for each of the three event types. Individual subjects contributed varyingly often to the switch, partial, and stay categories, hence no statistical test for the obvious interaction between event category and list is available. At any rate, stay events entailed more errors in second-list learning than did switch events. The partial category fell halfway between.

As Figure 1 shows, the mean errors per switch event were 6.00 in A-B learning (first list) and 2.39 in A-D learning (second list); also, the mean errors over all 288 subject-item events in the control paradigm, collapsed over conditions W and P, were 6.19 for A-B learning and 2.54 for C-D learning. Thus, the A-B, C-D control results corresponded almost exactly with the A-B, A-D switch results.

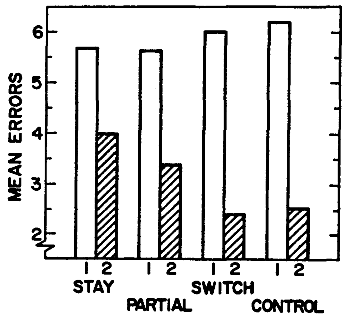

Fig. 1. Mean errors on lists 1 and 2 for stay, partial, and switch events in A-B, A-D and for control events in A-B, C-D

Each subject herself was then classified as a *switch subject,* if of her nine B and D pairs the number that were switches was at least two greater than both the number that were stays and the number that were partials, or as a *stay subject,* if, similarly, the number that were stays exceeded by two both the number that were switches and the number that were partials. All other subjects were considered inconsistent. This categorization yielded 7 switch subjects and 18 stay subjects. Table 2, the top two rows, shows the mean number of pairs (out of nine possible) that were switch, partial, and stay events for these two categories of subjects. Clearly, switch subjects switched on most (5.7) of their nine pairs and stay subjects stayed on most (also 5.7) of their nine pairs. (The rows do not sum to 9 because, as has been noted, for some subjects some B and D pairs were not classifiable as either switch, partial, or stay events.)

On the right in Table 2, still in the top two rows, are posted the mean trials to criterion (not counting the initial inspection trial or the final, criterion trial) on the first (A-B) and second (A-D) lists for the 7 switch and the 18 stay subjects. An analysis of variance of this 2 × 2 subtable yielded $F(1, 23) = .02$ for the switch/stay contrast; $F(1, 23) = 11.98$, $p < .01$, for the difference between the first and second list; and $F(1, 23) = 5.09$, $p < .05$, for the target interaction. In the bottom row of Table 2 are the corresponding learning data for the 32 A-B, C-D control subjects. Evidently, the switch subjects performed like the A-B, C-D control subjects; negative transfer was peculiar to the stay subjects.

Condition W posttest

After learning the second list, and after a 10-min delay, all subjects in condition W were presented with each intact compound stimulus and asked to recall the corresponding response(s). Each stimulus was presented three times. At present we shall consider only the results of the first presentation. The mean numbers of B and D responses recalled out of nine possible are shown in Table 3. Relative to the A-B, C-D control paradigm, the A-B, A-D paradigm suffered an 18% loss of B responses (1.62 items) and a 5% loss of D responses (.44 items). A paradigm-by-

Table 2. Recoding and learning performance for stay, switch, and control subjects

		Stimulus-coding event			Trials to criterion	
Subjects	*N*	Switch	Partial	Stay	List 1	List 2
Stay	18	.6	.5	5.7	12.8	10.1
Switch	7	5.7	.2	.7	15.9	6.3
Control	32				13.3	6.2

Table 3. Recall of B and D responses under condition W

Paradigm	Response B	Response D
A-B, A-D	7.19	8.50
A-B, C-D	8.81	8.94

response analysis of variance gave $F(1, 30) = 14.92, p < .001$, for the paradigm contrast; $F(1, 30) = 9.72, p < .01$, for the response contrast (B versus D); and $F(1, 30) = 6.65, p < .05$, for their interaction. With the reservation that scores from the A-B, C-D paradigm contributed but limited variance to the two error mean squares because of a ceiling effect, we may conclude that the A-B, A-D paradigm produced retroactive interference.

The reason for the 10-min delay between second-list learning and posttesting was to see if posttest performance on the D responses in the A-B, A-D paradigm could be appreciably lowered from the ceiling of nine correct responses. This obviously did not happen. Moreover, the smallness of the amount of retroactive interference against the B responses (1.62 items) may in part be due to spontaneous recovery, although over the two succeeding retests with the stimuli the increase in likelihood of a B response was very slight.

Three matters: First, we cannot seriously make anything of the fact that in these tests we observed the joint probability of recalling both B and D to be

$$P(\text{B} \,\&\, \text{D}) = .750$$

while the corresponding expected joint probability under the independence hypothesis is

$$P(\text{B})P(\text{D}) = .754 ;$$

this because unconditional $P(\text{D})$ is rather high, .944. Second, we do not present the results of the two succeeding retests with the stimuli because they show, except for a very minor trend (spontaneous recovery of the B responses), exactly what is shown in Table 3. Third, we cannot defensibly partition these posttest results into the earlier switch, partial, and stay categories because there are not enough data to go around for a reliable inference.

Condition P posttest

Previous reports (Wichawut and Martin, 1970; Martin, 1971) have indicated that if A is the compound stimulus $\{A_1A_2A_3\}$ and if B is the response, then if only A_i is presented and the subject is asked to recall all missing elements (stimulus components A_j and A_k and response B), neither of the not-presented stimulus components (A_j, A_k) can be recalled unless response B is recalled. Under the condition P posttest of the present experiment, the individual stimulus components were presented singly and the subject asked to supply the two not-presented components and the appropriate response(s). Consider first the results of this test under the A-B, A-D transfer paradigm.

Each time an A_1 component was presented, the subject either did or did not recall at least one of the two responses, B or D. Either way, we can count the number of times that at least one of the two components A_2 and A_3 was recalled. We can proceed similarly for presentations of A_2 and A_3. Table 4 shows the frequency of recall of at least one of the two not-presented components, A_j and A_k, given that either B or D was recalled (Yes column) and given that neither B nor D was recalled (No column), according to whether $i = 1$, 2, or 3 (the rows). Under each entry, in parentheses, is the frequency of the response category (Yes, No) for the particular stimulus component presented; these total 144 for each row because there were (9 compound stimuli, 16 subjects) 144 tests at each component position.

Clearly, if A_i elicited neither B nor D (the No column), then subjects could not recall either A_j or A_k. The overall probability of recalling either A_j or A_k given no response recall was .005. On the other hand, if either B or D was recalled (the Yes column), then subjects recalled at least one of the other, not-presented stimulus components with overall probability .172.

A similar analysis can be made of the condition P posttest results under the A-B, C-D control paradigm. These are posted in Table 5. For a given

Table 4. Frequency of recall of A_j or A_k when A_i was presented in the A-B, A-D paradigm, conditional on recall of B or D (also, frequency of recall of either B or D when A_i was presented alone)

Stimulus component presented	Response recall	
	Yes	No
A_1	12	0
	(66)	(78)
A_2	16	1
	(47)	(97)
A_3	12	0
	(119)	(25)

presented stimulus component, failure to recall the appropriate response precluded recall of either of the other two not-presented stimulus components; or rather, out of 545 occasions when the response was not recalled, only 3 involved also the recall of either or both of the missing stimulus components, which gives a probability of .006. On the other hand, given that the response was recalled, the overall probability of recall of at least one of the two not-presented stimulus components was .312 for A_i and .157 for C_i.

DISCUSSION

In terms of group means, the present experiment failed to produce statistically significant negative transfer in the A-B, A-D paradigm. This is shown in Table 1 and the accompanying analyses. The backward, response-to-stimulus recall data were then analyzed in such a way as to partition the 288 A-B, A-D subject-item events into three classes: that where B and D elicited the exact same stimulus components (stay events), that where they elicited completely different components (switch events), and that involving partial overlap in the components they elicited (partial events). By this analysis, and in terms of errors during first- and second-list learning, switch events yielded zero transfer relative to the A-B, C-D control paradigm, stay events yielded clear negative transfer, and partial events fell midway between (Figure 1). Thus, the ordinary group means

Table 5. Frequency of recall of A_j or A_k and C_j or C_k when A_i or C_i was presented in the A-B, C-D paradigm, conditional on recall of B or D (also, frequency of recall of B or D when A_i or C_i was presented alone)

Stimulus component presented	Response recall	
	Yes	No
A_1	15	1
	(48)	(96)
A_2	18	1
	(31)	(113)
A_3	20	1
	(87)	(57)
C_1	8	0
	(41)	(103)
C_2	7	0
	(23)	(121)
C_3	9	0
	(89)	(55)

of Table 1 conceal the important fact that whether or not negative transfer is observed in the A-B, A-D paradigm depends closely on whether or not for a given stimulus the subject retains or alters in second-list learning the first-list encoding of that stimulus.

This result may at first seem marred by its reliance on the backward, response-to-stimulus posttest. Since a posttest is indeed a posttest, one may have reason to suspect its relevance to what happened earlier as the subject shifted from the first to the second list. At present, the best evidence to allay this suspicion is the fact that the switch results shown in Figure 1 match those for the A-B, C-D control paradigm, where switching was forced on the subjects by definition of the paradigm. Moreover, one should feel satisfied that negative transfer occurred for stay events, since 'staying' is what theorists have always meant by the A-B, A-D paradigm.

The results shown in Table 2 are basically redundant with those shown in Figure 1. They were introduced to show that subjects who operated primarily in the switch or in the stay mode differed in how much negative transfer they experienced. It might be noted, however, that the 18 stay and the 7 switch subjects were not, on the average, completely consistent over the nine pairs. In fact, there were 7 subjects who could not be classified in either category — they switched and stayed on about equal numbers of their pairs.

A rather startling upshot of these results is what they mean for the transfer literature, which rests largely on stay events, or rather on those pairs for which subjects decide on a stay strategy. One wonders how many of the experimental variables known to affect the amount of negative transfer observable in the A-B, A-D paradigm are variables that do no more than influence the likelihood of stay versus switch encoding strategies. A corollary of this observation is that suddenly the (undoubtedly many) unpublished transfer studies that 'failed' might now be of great value.

At the beginning of this report we remarked that in experiments where some subjects were forced to recode the nominal stimulus (switch) and others were prevented from recoding (stay), those who were free to go either way tended to perform with those who were prevented from recoding (Schneider and Houston, 1969; Goggin and Martin, 1970). This result on preferred strategy receives analytic confirmation in our data. The frequencies for the stay, partial, and switch events shown in Figure 1 were 136, 16, and 72 respectively. And as can be seen in the second column of Table 2, the number of subjects classified as stay subjects was 18, while the number of switch subjects was only 7.

Wichawut and Martin (1970) and Martin (1971) have reported that if, after learning, stimulus component A_i is presented and recall of the missing components A_j and A_k and response B is requested, neither of the missing stimulus components (A_j, A_k) can be recalled unless response B is recalled. This result was twice replicated here, in the two lists of the A-B, C-D paradigm (see Table 5). We cannot say, however, that the result has been generalized, because the lists used here were of largely the same type as those used earlier. A new finding is that the phenomenon holds also in the A-B, A-D transfer paradigm, where the same nominal stimulus recurs in the second list (see Table 4).

Earlier, Martin (1971) had interpreted such results to mean that associations do not form among stimulus components during a learning task. This interpretation involved concluding from the data that a subject could not recall a not-presented stimulus component except by mediation through the response term. The data in question do not, however, distinguish between this interpretation and an alternative one. Suppose a subject has associated component A_i with response B. If he then turns his attention to component A_j, he will associate A_j both with response B and with component A_i. Thus if A_j has not been attended to, A_j will elicit neither A_i nor the response B in a recall test; if A_j was indeed attended to, it will elicit both A_i and B. A specially designed experiment will be required to decide between the alternative hypotheses. The present data, however, categorically deny that an intercomponent $A_i \rightarrow A_j$ association can form in the absence of, or prior to, the $A_j \rightarrow$ B association.

In sum, subjects seem to prefer to retain in second-list learning the functional stimulus encoding they settled upon during first-list learning, even though such a strategy leads them into transfer interference. There exists, however, the phenomenon of stimulus recoding. Whether transfer in the A-B, A-D paradigm is zero or negative relative to the A-B, C-D paradigm depends on whether the subject recodes or does not recode the nominal stimulus common to the two responses. The conditions that determine which coding strategy will be used are not known. At any rate, group statistics average over these two strategies and accordingly reflect only their relative frequencies both between and within subjects.

Notes

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