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Perceptual chunking of symbols in memory span

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Memory span for strings nine symbols in length ranging from two through nine different symbols per string was examined with repeated measures. Strings were sequentially exposed on a memory drum for 3 sec each; subjects recorded recall when the exposure interval elapsed. Memory span of symbol strings decreased as the number of different symbols composing the strings increased. Amount remembered was also a function of mode of output. Errors in recall indicated that perceptual overlap of symbol features was responsible for confusion errors. When symbols were rotated, confusions became within-symbol rather than between-symbol errors; between-symbol chunking was disrupted by loading individual symbol channels with within-symbol information. Systematic between-symbol chunking suggested that perceptual chunks are formed prior to output; error data revealed a distinct weakening of between-symbol associations when subjects had within-symbol priming information during output.

Myer and O'Connell (1972a) studied memory span of symbol strings as a function of length and composition of the strings and found that memory span decreased as length increased or as number of different symbols composing the string increased. A questionnaire supported the interpretation that perceptual mechanisms were used to store strings. Since perception was an important dimension of encoding, a post hoc inspection of symbols was conducted. Many symbols were systematically confused with other symbols, but since symbols had not been equated for total occurrences in strings, the distribution of confusion errors for each symbol, rather than total incidence of such errors, was noted.

If no idiosyncratic perceptual mechanisms had been involved, memory errors should have been randomly and rectangularly distributed over the remaining eight symbols for each misrepresented symbol. But they were not. Subjects mistaking asterisks recorded crosses as the modal error; circles were misrepresented most frequently as semicircles; diamond errors were mostly accounted for by triangles and vice versa; and upside-down T and slash confusions accounted for 42% of the errors made involving these two symbols (both are components of the asterisk symbol). The data showed that confused symbols tended to be confused with the same incorrect symbol in all within-string repetitions. All this evidence indicated perceptual confusions.

A subsequent experiment (Myer & O'Connell, 1972b) investigated these perceptual learning mechansims. Myer and O'Connell (1972a) had previously used perception of symbol strings in which the specific symbols were always in a constant and conventional orientation, so as to allow verbal codification to mediate storage and produce consistency among between-symbol errors. Myer and O'Connell (1972b) used three conditions of strings: symbols in conventional (C) rotation; symbols in constant rotation throughout the list but altered (A) from conventional by 90-deg clockwise rotation; and strings composed of all possible 90-deg rotations (V) of the symbols; in V all rotational alterations were equally represented. Refer to Figure 1.

The design measured between-groups differences in memory span and perceptual confusions. In C symbols had available verbal labels. In A five were altered and subjects attended more to perceptual features, since verbal labels were not as effective in encoding. In V perceptual mechanisms were necessary to discriminate within-symbol rotations.

C had more between-symbol errors than A, while both C and A had more than V. Memory span was directly related to errors: the more confusions obtained, the higher the level of memory.

The rotation served to increase attention to perceptual features from C to A to V. In V the greatest feature learning occurred (Gibson & Gibson, 1955) because subjects had to attend to varying symbols. The chunking in V was within-symbol, whereas between-symbol chunking occurred in C (Myer & O'Connell, 1972a). Rotation throughout C forced within-symbol organization, whereas in C and A between-symbol chunks yielded errors.

In C, highest memory span was obtained for learning conventional symbols with available verbal labels. A had intermediate amounts of feature learning and verbal mediators and was in between the other groups on errors and memory span. In V verbal mediators were not effective, feature learning loaded the information capacity, and memory span decreased.

The study validated that the feature-learning strategy was primed by rotation, that between-symbol errors and feature learning were inversely related, and that symbol memory span was directly related to verbal codability.

The present study concerned perceptual mechanisms involved in memory; do subjects store in between-symbol or within-symbol chunks during input, or is this a retrieval strategy during output? An extension of the Myer and O'Connell (1972b) design and procedure was required.

C-RECALL was identical to C in Myer and O'Connell (1972b). Symbols were constantly in conventional rotation (Figure 1). Output required written reproduction. Results were expected to support the previous study: memory span would be high due to effective verbal labels and errors would be systematic due to perceptual feature overlap in symbols.

C-RECOG-9 viewed the same list as C-RECALL. Output was a recognition task that required the subjects to choose the correct symbol for each of the nine units of the string from a pool containing the nine symbols of Condition C in Figure 1. If errors were the same for C-RECOG-9 as for C-RECALL, then mode of output was not significant and between-symbol chunking apparently occurred prior to output. If errors were more evenly distributed in C-RECOG-9 than in C-RECALL, the recognition task aided the subjects in discriminating between symbols and inhibited between-symbol chunking, which could be regarded as an output mechanism.

C-RECOG-20 saw the same list as C-RECALL and C-RECOG-9. The recognition task required choosing the correct symbol for each of the nine units of the string from a pool containing the 20 symbols of V in Figure 1. If results indicated continued dominance of between-symbol chunks, then chunking occurred prior to output and mode (recall vs. recognition) was

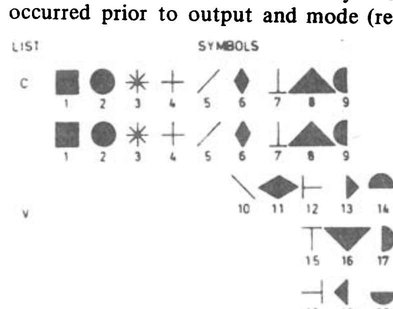

Figure 1. Code numbers and representations of the symbols.

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Table 1: Confusion Matrix C-RECALL

Actual Symbols*	Misrepresentations* 1	2	3	4	5	6	7	8	9	Totals
1	—	10	5	7	8	9	8	10	7	64
2	8	—	7	8	10	8	8	8	8	65
3	1	4	—	18	20	1	17	3	4	68
4	12	6	57	—	39	2	43	8	2	169
5	6	5	20	18	—	5	19	1	4	78
6	7	7	4	5	1	—	5	61	2	92
7	8	7	24	23	19	5	—	6	9	101
8	9	5	6	4	5	63	3	—	7	102
9	10	51	8	6	6	5	9	9	—	104
Totals	61	95	131	89	108	98	112	106	43	844

**Coded as in Figure 1.*

not significant. If errors were no longer systematic between-symbol associations, chunking could be an output process of decoding.

If C-RECOG-9 has between-symbol chunks present in output (suggesting chunks are formed prior to output) but C-RECOG-20 decreases between-symbol confusions, the chunking process is reversible if the subject has the appropriate priming during output: within-symbol information to break up between-symbol ties.

V-RECALL was like V in Myer and O'Connell (1972b). Symbols were equally represented in their various 90-deg rotations (as shown in Figure 1) and output required written reproduction.

V-RECOG-20 had the V-RECALL list. Output was similar to C-RECOG-20; symbol identity required recognition from the pool of 20 symbols. It was expected that V-RECOG-20, like V-RECALL, would not have between-symbol associations due to the information load in the within-symbol channels. If V-RECOG-20 was like V-RECALL, then output was not significant and the input rotation was successful in weakening between-symbol chunks.

METHOD

Design

Twelve subjects were in each group (C-RECALL, C-RECOG-9, C-RECOG-20, V-RECALL, V-RECOG-20). C had symbols in constant conventional rotation, while V had symbols represented in all possible 90-deg rotations. There were eight compositions that could occur in strings nine symbols in length; any particular string could be composed of two through nine different symbols. Eight strings of each composition were used to insure that symbol combinations were well represented in each composition. There were two analysis of variance models: the first was within the C conditions—string composition (two through nine different symbols) by string trials factor (eight repetitions of each composition) by output (RECALL, RECOG-9, RECOG-20); this analysis was an A by B by C factorial design with eight repeated measures on each of the A and B factors (Winer, 1962, pp. 319-337). The second analysis was between string composition by string trials by input (C, V) by output (RECALL, RECOG-20). This analysis was an A by B by C by D factorial design, again with repeated measures on the A and B factors.

Construction of the Symbol Strings and Lists

Nine symbols were used: asterisk (an X overlaid on a cross), circle, cross, diamond, semicircle, slash, square, triangle, and an upside-down T (Figure 1). Symbol height was approximately 5/16 in. These nine symbols were the same as those used in the Williams and Fish (1965) and Myer and O'Connell (1972a, b) studies.

All strings were nine symbols long and each symbol was centered in one of nine horizontally adjacent areas 10 cm square. Each separate string of 90 x 10 cm was transferred to memory drum tape by using nonreflective Scotch brand Magic Tape. Composition was varied from two different symbols per string to nine different symbols per string. Lists for each condition (C and V) contained 64 strings plus five introductory practice strings. The 64 experimental strings in each list were the eight repetitions from each of the eight compositions.

Eight groups of symbol combinations were randomly picked for each of the compositions with two constraints: no repetitions of any entire combination (except for Composition 8, for which there was only one mathematical combination possible, since all nine symbols were always used in a string nine symbols long, requiring nine different symbols); all symbols were used before any symbol already used in a combination was repeated. Ordering of symbols within strings was determined randomly without replacement from the combinations.

The strings and their order were the same for the C and V lists. In the V list the symbol rotation was varied randomly without replacement. The symbols and their rotations are represented in Figure 1.

The order with the 64 strings was random, with one constraint. A string from each of the eight compositions occurred before any composition repeated a string.

Procedure

The experimental apparatus was a Stowe memory drum and the two lists. Subjects were seated 15 in. from the drum. Instructions read by each subject required written reproductive recall of what was "just seen"; symbols were to be recorded by drawing the symbols in their correct positions within strings. Subjects received data sheets providing 69 sets of nine blank adjacent boxes (each 10 cm square).

Strings were presented sequentially, one at a time, for 3 sec and the subjects had 12 sec to record recall. A mirror was used by the experimenter to insure that recall was not commenced until each string disappeared from view.

Subjects

Sixty undergraduates voluntarily served as subjects. They were enrolled in general psychology courses at Saint Louis University and were naive to memory studies.

RESULTS AND DISCUSSION OF ERRORS

Tables 1, 2, 3, 4, and 5 account for errors. A correct symbol had to be correctly identified and in correct rotation.

Matrix C-RECALL

Asterisk misrepresentations as cross, slash, and upside-down T accounted for disproportionate errors. The cross distribution is skewed to slash, upside-down T, and asterisk. Errors involving the slash were mostly due to asterisk, cross, and upside-down T. Upside-down T errors were most likely to be asterisk, cross, or slash. The cross, slash, and upside-down T, along with their multiple embodiment in the asterisk symbol, apparently form a pool of features from which the subject chooses. Only when the stimulus pool consists of a single symbol could it be predicted that intersymbol confusions would not be systematic. Diamond errors were accounted for by triangles, and vice versa. This supports the "chunking" prediction, since a triangle is a perceptual feature of the diamond. Semicircles were most often mistaken as a circle. The semicircle is a feature of the circle and the two symbols occupy the same perceptual pool of features. The semicircle is a verbal and conceptual derivative of the circle. Note that the dependency of the semicircle on the circle is more unidirectional than other symbol interrelationships.

It is appropriate to distinguish between confusion errors and intrusion errors. An error was called a confusion error when the correct symbol was not recorded and one of the other eight symbols was recalled in the rotation in which it was represented for that particular condition. An error was called an intrusion error when the correct symbol was not recorded in its correct rotation and one of the other eight symbols was recalled in a rotation not represented in the condition, or the correct symbol was recorded but in an incorrect rotation. There were no intrusion errors in Condition C-RECALL. Results from this group further supported previous studies (Myer & O'Connell, 1972a,b). Errors in symbol identity were systematic due to perceptual overlap between features embodied in multiple symbols.

Matrix C-RECOG-9

Cross, slash, and upside-down T accounted for a disproportionate number of asterisk errors. Cross errors were mostly due to asterisk, slash, and upside-down T. The slash formed a skewed distribution accounted for by asterisk, cross, and upside-down T. The T confusions revealed errors involving asterisk, cross, and slash. A disproportionate number of confusions occurred among symbols sharing perceptual features. The diamond was mostly misrepresented as the triangle; mistaken triangles were represented as diamonds. Circles accounted for the majority of semicircle errors. There were no intrusion errors in C-RECOG-9. Errors were due to overlap of features common to multiple symbols. Output was not significant, since the one difference between C-RECALL and C-RECOG-9 was output. Apparently between-symbol chunking occurred prior to input, providing the symbols in the recognition task did not inhibit between-symbol chunking.

Matrix C-RECOG-20

A difference can be found in the asterisk data: in C-RECOG-20 the cross, slash, and upside-down T accounted for 45.7% of the errors (C-RECALL, 80.9%; C-RECOG-9, 88.8%). Cross had asterisk, slash, and upside-down T accounting for 54.5% of the errors (C-RECALL, 82.3%; C-RECOG-9, 85.1%). The drops are striking; C-RECOG-20 has weakened between-symbol association strength. Asterisk, cross, and T accounted for 47.4% of the slash errors (C-RECALL, 73.1%; C-RECOG-9, 81.1%). The diamond had 24.0% triangle misrepresentations (C-RECALL, 66.3%; C-RECOG-9, 76.8%). The slash, cross, and asterisk accounted for 56.8% of upside-down T errors (C-RECALL, 65.3%; C-RECOG-9, 72.1%). Triangle had diamond accounting for 24.5% of errors in C-RECOG-20 (C-RECALL, 61.7%; C-RECOG-9, 71.9%). The semicircle errors had circles accounting for 24.4% (C-RECALL, 49.0%; C-RECOG-9, 67.3%).

For C-RECOG-20 the between-symbol chunks were weakened. These chunks were present in C-RECOG-9 output, which suggests that perceptual chunks are formed prior to output. Since C-RECOG-20 showed a significant decrease in confusions, the chunking was reversible if the subject had appropriate priming during output: presentation of within-symbol information to break up the between-symbol ties.

Matrix V-RECALL

There were no extra-symbol intrusion errors made by the V conditions since all symbol rotations were represented; errors were confusions when another symbol was recorded, and intrusions were the correct symbol in an incorrect rotation.

The circle had 22 errors as semicircles, indicating that the circle-semicircle relationship was strongest under V. This result was also obtained by Myer and O'Connell (1972b). The circle storage capacity had no more load under V than under C, since a circle was the same in all rotations; apparently, when the subjects saw a varying semicircle, the confusion of semicircles for the circle was facilitated. In C-RECALL, C-RECOG-9, and C-RECOG-20, the circle accounted for 49.0%, 67.3%, and 24.4% of semicircle errors, respectively. In V-RECALL the circle accounted for 11.2%. It was predicted that within-symbol feature learning in V would decrease between-symbol confusions, since within-symbol substitutions would occur. The excess of semicircle errors made in V-RECALL was due to within-symbol semicircle errors; the confusion errors between semicircle and circle were substantially decreased.

The asterisk had T, slash, and cross accounting for 56.3% errors. The reduction was due to within-symbol chunking. The cross had asterisk, slash, and T accounting for 75.9% errors. The slash and semicircle data support the idea that rotation primes within-symbol feature learning and inhibits between-symbol confusions. Fewer slash confusions occurred in V-RECALL than in C-RECALL, C-RECOG-9, or C-RECOG-20. The T confusions were fewer than committed in C conditions. V-RECALL triangles accounted for 24.9% of diamond errors, and diamonds accounted for only 6.4% of triangle errors; thus, a weakening in the diamond-triangle relationship. Symbol rotation yielded evidence that intersymbol associations are inhibited when intrasymbol associations are built up.

Table 2: Confusion Matrix C-RECOG-9

Actual Symbols*	Misrepresentations* 1	2	3	4	5	6	7	8	9	Totals
1	—	11	7	9	5	8	9	12	8	69
2	9	—	7	9	8	11	10	11	9	74
3	0	2	—	21	35	2	15	2	3	80
4	7	3	49	—	45	3	37	6	4	154
5	3	4	32	26	—	6	28	4	3	106
6	3	2	3	4	2	—	4	73	4	95
7	4	6	25	28	22	7	—	4	8	104
8	8	4	2		3	59	2	—	4	82
9	8	70	6	3	1	4	5	7	—	104
Totals	42	102	131	100	121	100	110	119	43	868

*Coded as in Figure 1.

Table 3: Confusion Matrix C-RECOG-20

Actual Symbols*	Misrepresentations* 1	2	3	4	5	6	7	8	9	Totals
1	—	12	9	8	5	11	7	14	9	75
2	9	—	6	5	7	15	9	13	15	79
3	8	6	—	12	10	10	15	9	11	81
4	14	11	18	—	20	8	24	10	9	114
5	9	12	17	14	—	10	15	9	11	97
6	14	18	9	7	11	—	7	24	10	100
7	9	7	17	15	18		—	10	12	88
8	10	13	9	9	11	27	15	—	16	110
9	14	21	8	6	7	16		14	—	86
Totals	87	100	93	76	89	97	92	103	93	830

*Coded as in Figure 1.

Table 4: Confusion Matrix V-RECALL

Actual Symbols*	Misrepresentations* 1	2	3	4	5	10	6	11	7	12	15	18	8	13	16	19	9	14	17	20	Totals
1	—	10	5	9	8	6	10	0	0	2	4	1	6	2	2	1	1	0	3	2	72
2	11	—	6	4	8	5	2	0	3	0	2	0	5	0	0	1	9	3	10	0	69
3	4	14	—	8	17	1	1	0	2	0	9	3	6	0	0	4	2	0	0	0	71
4	14	5	27	—	14	2	1	0	11	1	31	2	7	0	0	0	1	0	0	0	116
5	4	5	8	5	—	42	0	0	3	0	0	0	2	0	0	0	1	0	0	0	70
10	3	4	9	1	44	—	1	0	5	0	2	0	2	0	0	0	1	0	3	0	75
6	4	4	5	0	2	0	—	21	0	0	0	0	15	0	0	1	0	0	0	0	52
11	5	8	3	1	1	0	91	—	1	0	3	0	27	2	3	4	1	2	5	0	157
7	0	1	3	5	0	0	0	0	—	8	29	3	1	2	0	0	1	0	0	0	53
12	2	3	1	3	2	1	3	0	3	—	43	8	1	0	0	0	2	0	1	0	73
15	0	1	2	0	4	1	0	0	6	8	—	9	0	0	0	0	0	0	1	0	32
18	3	2	1	0	0	1	1	0	8	6	14	—	1	0	0	0	1	0	1	0	39
8	3	4	1	2	0	0	3	0	0	0	2	0	—	12	5	4	0	0	0	0	36
13	2	1	1	3	2	0	4	1	1	0	1	0	33	—	21	14	0	0	1	0	85
16	4	3	2	1	1	0	4	1	2	0	1	1	12	18	—	4	1	1	2	0	58
19	1	2	1	2	2	0	2	1	3	1	1	1	38	9	3	—	1	0	1	0	69
9	2	6	3	1	3	0	1	0	2	0	1	0	2	0	1	1	—	9	27	15	74
14	4	8	4	2	1	0	0	0	2	2	1	1	0	0	0	1	11	—	14	26	77
17	1	9	2	1	0	2	1	1	2	0	1	1	0	0	0	2	12	9	—	11	55
20	0	5	3	2	0	0	0	0	3	0	0	0	1	0	1	1	10	10	8	—	44
Totals	67	95	87	50	109	61	125	25	57	28	145	30	159	45	36	38	55	34	77	54	1377

*Coded as in Figure 1.

Table 5: Confusion Matrix V-RECOG-20

Actual Symbols*	Misrepresentations* 1	2	3	4	5	10	6	11	7	12	15	18	8	13	16	19	9	14	17	20	Totals
1	—	12	3	8	10	7	9	0	3	1	2	0	8	3	1	0	3	0	2	1	73
2	10	—	8	6	7	5	1	0	2	1	1	1	6	1	0	1	10	2	5	0	67
3	8	9	—	9	15	2	3	1	5	2	8	1	4	2	3	2	2	2	2	2	82
4	8	7	22	—	12	5	3	2	9	3	20	5	9	1	1	1	3	0	3	0	114
5	8	6	9	7	—	52	0	0	5	0	4	0	3	0	1	0	2	0	2	1	100
10	4	7	8	2	49	—	1	0	6	0	3	0	4	0	0	0	2	0	1	0	87
6	6	5	2	1	2	1	—	33	0	0	1	0	14	0	2	0	0	0	0	0	67
11	8	4	5	2	3	1	87	—	2	1	4	0	22	1	1	1	1	0	1	0	144
7	1	2	2	7	3	2	1	0	—	11	35	10	2	1	0	0	2	0	0	0	79
12	3	1	2	2	1	0	3	0	9	—	54	14	3	0	0	0	2	0	1	1	96
15	3	2	2	4	5	1	2	0	18	17	—	10	1	1	1	1	2	0	1	0	71
18	2	2	4	6	8	0	0	0	12	10	18	—	1	0	0	0	3	0	0	0	66
8	5	3	2	2	0	0	5	1	0	0	4	0	—	18	9	7	1	0	0	0	57
13	4	2	2	1	2	0	3	0	3	0	3	1	44	—	20	18	1	0	1	0	105
16	3	3	4	2	2	0	5	0	2	1	0	0	31	21	—	8	2	0	0	0	84
19	2	2	2	2	2	0	3	0	2	1	1	1	25	13	4	—	1	0	0	0	61
9	3	5	2	2	3	0	1	0	2	2	2	1	2	0	1	1	—	11	23	18	79
14	3	10	3	2	1	0	1	0	3	3	5	1	1	1	1	0	14	—	16	28	93
17	2	5	2	2	2	0	2	0	2	0	1	0	1	0	1	0	17	13	—	14	64
20	4	8	1	2	3	0	1	0	1	0	3	0	1	1	1	1	15	11	7	—	60
Totals	87	95	85	69	130	76	131	37	86	53	169	45	182	64	47	41	83	39	65	65	1649

**Coded as in Figure 1.*

Matrix V-RECOG-20

Data again indicated that the circle-semicircle relationship was strongest under V; regarding the semicircle-circle association, the circle accounted for less than 10%. Intrasymbol feature learning had decreased systematic intersymbol confusions. As in V-RECALL, the T, slash, and cross did not account for asterisk errors as strongly as in C-RECALL or C-RECOG-9. The information load of T and slash was loaded with within-symbol variations. The slash provided evidence that rotation increased within-symbol feature learning. The cross, asterisk, and T accounted for 23.5% slash errors (73.1% of C-RECALL and 81.1% of C-RECOG-9). T had 15.9% errors associated with asterisk, slash, and cross (C-RECALL, 65.3%; C-RECOG-9, 72.1%). An evident decrease in between-symbol chunking can be noted. The diamond-triangle association was weakened. In V-RECOG-20 triangles accounted for 19.4% diamond errors (C-RECALL, 66.3%; C-RECOG-9, 76.8%). Triangles had 218 intrasymbol mistakes. Once again rotation inhibited between-symbol associations by building up within-symbol information. In V-RECOG-20 diamonds accounted for 6% of triangle errors (C-RECALL, 61.7%; C-RECOG-9, 71.9%; C-RECOG-20, 24.5%). V-RECOG-20 data was close to V-RECALL (6.4%). The V-RECOG-20 group, like V-RECALL, did not exhibit between-symbol associations due to the information load on within-symbol channels. Since V-RECOG-20 was like V-RECALL in reducing between-symbol chunks, it was the rotation of the V input that was significant and mode of output was not a contributor.

RESULTS AND DISCUSSION OF MEMORY SPAN

All five conditions were scored for memory span; results are shown in Table 6. A conservative F test was used (df = 1/n) to determine statistical significance (Winer, 1962) since the design was repeated measures.

As different symbols/string increased, memory span suffered. Symbol memory span does not approach seven (Myer & O'Connell, 1972b). Subjects do not have readily available strategies to deal with sequential nonverbal stimuli; the memory limit is around four or five symbols.

Table 6: Memory Span Scores for Compositions and Conditions (Mean Number of Symbols Recalled)*

	Condition				
Composition†	C-RECALL	C-RECOG-9	C-RECOG-20	V-RECALL	V-RECOG-20
2	6.03	5.94	6.05	5.02	4.66
3	3.75	3.79	4.19	3.68	3.70
4	3.74	3.85	3.79	3.29	3.11
5	3.33	3.49	3.47	3.19	2.94
6	3.10	3.41	3.41	3.08	2.99
7	3.16	3.29	3.34	2.95	3.07
8	3.28	3.70	3.36	3.16	3.00
9	3.44	3.28	3.37	3.04	3.05

**df = 95 for each cell* †*Number of different symbols/string*

Two analyses of variance were performed. The 3 by 8 by 8 repeated measures analysis showed no significant main effect of output [$F(1,2) = 1$, n.s.] with list C (C-RECALL, C-RECOG-9, C-RECOG-20). Quantitatively a subject has the same memory span regardless of output method. The main effect of string composition [$F(1,7) = 49.38$, $p < .005$] reached very high significance. The Williams and Fish (1965) and Myer and O'Connell (1972a, b) studies showed significant decreasing memory as number of different symbols per string increased.

The trials main effect [$F(1,7) = 5$, $p < .05$] was also significant; this practice decrement was not confounding nor unexpected (Myer & O'Connell, 1972b). Since position and spacing of repeated symbols were not controlled variables, much variability was contributed due to the spacing of repeated symbols within strings.

The two-way interaction of Compositions by Trials was significant [$F(1,49) = 10.34$, $p < .005$]; no other interaction effects were significant.

The second analysis of variance was an 8 by 8 by 2 by 2 repeated measures analysis. Again string composition reached high significance [$F(1,7) = 13.09$, $p < .005$], with memory lowered as symbols/string increased. The trials measure, [$F(1,7) = 116.92$] was also again significant ($p < .005$). The Compositions by Trials interaction reached significance [$F(1,49) = 10.63$, $p < .005$].

Mode of input (C vs. V) was not significant [$F(1,1) = 1$, n. s.] but mode of output (RECALL vs. RECOG-20) was significant [$F(1,1) = 13.26$, $p < .005$]. The amount the subject remembered was not a function of which list he saw (C or V) but was influenced by aids to recall available during output. Output interacted significantly ($p < .05$) with the trials factor [$F(1,7) = 4.78$].

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