THE EFFECTS OF STIMULUS AND RESPONSE CONCRETENESS ON THE ACQUISITION AND RETRIEVAL OF PAIRED-ASSOCIATES

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Paired-associates composed of one concrete noun (C) and one abstract noun (A) were presented to Ss in either CA or AC order and tested using either C or A noun as recall cue. This experiment replicated Lockhart's (1969b) design and extended his recall measure to include rating and rating latency measures at presentation and recall. In agreement with Lockhart, concrete nouns produced superior recall when used as test cue; this effect was independent of the concrete noun's position in the pair at presentation.

Test cue effects were also found in increased number of intrusions, and prolonged rating latencies for intrusions and omissions to C cues. The results were interpreted as inconsistent with Paivio's (1969) conceptual peg hypothesis which attributes concreteness effects to the concrete noun's superior capacity to prime and cue imaginal mediators. The results were interpreted as indicating quantitative rather than qualitative (imaginal) differences between concrete and abstract nouns.

ACKNOWLEDGMENTS

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INTRODUCTION

In a traditional paired-associate (PA) learning experiment, the S is required to learn an association between two words. The S may be said to have learned the association when he can recall one word of a pair when only the other is shown. The presentation of the word pair is usually termed the acquisition phase. In this phase, the pair may be encoded in some form and made available in storage. The test for recall of one member of the pair (usually the right-hand member), when cued by the other member of the pair (usually the left-hand member), is generally termed the retrieval phase. In this phase the information about the pair may be decoded and made accessible for report. A mediation hypothesis would suggest that part of the encoding process in PA learning involves finding a mediator or link to join the two words together and that it is this link which enables one member of the word pair to elicit the other member of the word pair in the decoding process.

The symbolic processes which serve to mediate in PA learning have been explained in terms of verbal associations (e.g., the associative probability hypothesis, Underwood and Schulz, 1960) and in terms of nonverbal imagery (e.g., the conceptual peg hypothesis, Paivio, 1965). The associative probability hypothesis suggests that the more associations a particular member of the pair has, the higher the probability that an associative mediator can be found common to both members. The mediating association could be either a word, an image, or both but Underwood and Schulz emphasize verbal processes.

The associative probability hypothesis introduces a logical inconsistency termed the "interference paradox". Although a greater number of word associations ensures that good potential mediators are available, it also provides more opportunity for response competition. Interference of this sort would be expected to lead to a performance decrement with a large number of response intrusions.

In order to account for the high probability of correct recall that is usually found with highly meaningful words, the effective mediators are usually considered as "protectors" of the associative bond. Jenkins (1961, pp. 74-75) suggests that a factor as important as number of

possible mediators would be the quality of the mediators since bizarre imaginal or verbal associations probably serve more effectively to oppose interference from competing responses.

Paivio's conceptual peg hypothesis emphasizes the image arousing value of nouns in just this way. Thus, he emphasized the difference in quality of the associates rather than quantity of associations as is stressed by the associative probability hypothesis. Paivio (1969) states through his conceptual peg hypothesis that in PA learning tasks "the stimulus member of a pair of nouns serves as a 'conceptual' peg to which its associate is hooked during learning trials, when stimulus and response members are presented together, and from which the response member can be retrieved on recall trials when the stimulus member is presented alone" (p. 244). Imagery is assumed to serve a mediating function and "the ease of learning the stimulus-response association depends partly on the image-arousing capacity of the individual nouns and of the stimulus member in particular" (p. 244).

In elaborating the conceptual peg hypothesis, Paivio has coordinated the supposed mediational function of image arousal to a concrete-abstract dimension of word meaning. Paivio, Yuille, and Madigan (1968) have reported that

nouns rated as highly concrete are also given high imagery ratings, and somewhat more verbal associates than are abstract nouns. Concrete words usually refer to objects in the environment which can be directly sensed. Thus this class is generally restricted to concrete nouns such as frog, house, and army. Abstract words refer to concepts which cannot be directly sensed. Included in this class are abstract nouns such as virtue, confidence, and fantasy.

Paivio tested his conceptual peg hypothesis in a PA learning experiment with 16 noun-noun pairs using the four types of pairs representing each combination of noun concreteness-abstractness. Paivio (1965) found that the difficulty of learning the different types of pairs was ordered from least to most difficult in the following way: concrete noun-concrete noun (CC), concrete noun-abstract noun (CA), abstract noun-concrete noun (AC), and abstract noun-abstract noun (AA). As the conceptual peg hypothesis would predict, the higher the concreteness value of both stimulus and response members, the higher the probability of correct recall. With mixed pairs of nouns (CA and AC), the effect is greater if the concrete noun is on the stimulus side of the pair.

The conceptual peg hypothesis attributes part of the greater ease in learning CA pairs to the superior capacity

of the C stimulus member to elicit the mediating image when the C member appears alone at time of testing. Paivio also implies that the presence of the C member on the left "primes" a stronger CA bond than would occur for the AC bond with the C member on the right. Since Paivio always tested the CA pairs with C as cue and the AC pairs with A as cue, his experimental paradigm cannot distinguish the effects on recall due to the order of presentation from the effects due to the concreteness of the test cue.

Lockhart (1969a,b) reported several experiments using adjective-noun and noun-noun pairs which were designed to separate the effects due to order of presentation from those due to the member of the pair used as a cue for retrieval. He presented pairs in both CA and AC orders, and in addition to testing recall of CA pairs with the C member and AC pairs with the A members (c.f., Paivio, 1965), he also tested each presentation order with what is conventionally the response member of each pair. Therefore a particular mixed pair was experimentally treated in four ways: CA presentation order, tested with C (CA/C); CA presentation order, tested with A (CA/A); AC presentation order, tested with C (AC/C); AC presentation order tested with A (AC/A). Lockhart (1969b) found that presentation order (CA or AC) had no effect on recall of the word pairs, but that significantly more

correct responses were reported when the C member was the recall cue than when the A member was the recall cue. This finding was obtained regardless of whether the A member of the pair was an adjective or an abstract noun derived from the adjective. Therefore, Lockhart concluded that the effect of concrete nouns was due to retrieval asymmetry rather than to associative asymmetry of the type where the CA bond could be stronger than the AC bond.

One limitation of Lockhart's (1969a,b) experiment was his use of empirically undefined abstract materials. Although Lockhart's concrete nouns had been rated as highly concrete by Ss (Spreen and Schulz, 1966), his adjectives and adjective-derived nouns had never, in fact, been judged or rated as abstract. Thus, Lockhart never demonstrated that his abstract words met the operational definition of abstractness. In addition, his adjective-derived nouns differed in other ways from the abstract nouns used by Paivio. Lockhart's nouns contained more acoustic and spelling similarity (e.g., ending "ness") than would be found in a set of ramdomly selected abstract nouns. Therefore, some question remains as to whether Lockhart's results would be replicable when concrete nouns are paired with unequivocally abstract stimulus materials.

Lockhart's conclusions were based on frequency of

correct responses and intrusions as his only dependent measure. Marshall's (1967) evidence would suggest, however, that measures taken at presentation of the word pair may reflect differences in encoding as a function of presentation order. Marshall analyzed the high frequency responses resulting from continued association to abstract nouns and pairs of abstract nouns. He found that number of high frequency associates common to both a stimulus word and a pair containing that stimulus word depended in part upon the position in the pair of the word. Therefore, measures taken at presentation or more sensitive recall measures could reflect a presentation order effect not detected by Lockhart's recall measure.

Ratings of associative strength could be obtained at presentation of the word pair to provide more information about the effect of the position of the concrete noun on associative processes. Arbuckle and Cuddy (1969) have reported that Ss can predict with a fairly high level of reliability at presentation of the word pair, the probability that they will recall that item correctly. Paivio (1969) has implied that the superior recall of CA pairs over AC pairs is due to the formation of stronger mediational links when the C member is presented on the left. Therefore, from Arbuckle and Cuddy's results, the stronger mediating links

resulting from a CA presentation order should be detectable at presentation and given higher ratings of associative strength than should AC noun pairs.

Latency of associative strength ratings could reflect different rates of acquisition for CA and AC pairs. Paivio's theory assumes that forward associations predominate in the formation of mediational links in PA learning. He implies (Paivio, 1969) that the images and verbal associations provided by the C noun in the CA order are evoked more quickly than the mainly verbal associations provided by the A nouns in the AC order. If this implication is valid and further if the latency of the rating response reflects the time required to find mediators, then shorter latencies should be obtained for ratings of CA noun pairs than AC noun pairs, regardless of the rating response given.

In addition to the dichotomous information provided by the recall measure of correct responses and intrusions collected by Lockhart (1969b), other potentially more sensitive measures of recall could clarify the role of concreteness in PA learning. In particular, confidence rating and response latency measures have been found to be increasingly useful in investigations of PA learning. Both measures provide graduated information about response characteristics within the categories of correct and

incorrect responses.

Confidence ratings taken at recall would be helpful with respect to the effect of concreteness on the discriminability of correct responses from intrusions. Lockhart (1969b) found that a significantly larger number of intrusions were made to the C cue than to the A cue. A response-conditional signal detection analysis of the results of a subsequent experiment (Lockhart, 1969a) yielded *d*'s that were higher for the adjective-cued recall. Lockhart interpreted this finding as indicating that discrimination of correct responses from incorrect responses was superior for adjective-cuing than for noun-cuing. However, Lockhart obtained confidence ratings under conditions of forced responding and thus was not able to determine whether concreteness affects discrimination of correct responses from intrusions, or whether the effect was primarily due to the larger number of response omissions to the A cue under free responding.

The latency of the rating response in the test phase could reflect the assumed differences between associative processes using images from those using verbal mediators. This measure would estimate the time required by the *S* to make a response and to rate his confidence in its

correctness. From a consideration of Paivio's conceptual peg hypothesis, one would expect that the faster and stronger images primed by a CA presentation order, and most effectively elicited by the C cue at recall, would lead to the shortest response latency for responses given in the CA/C condition. Lockhart suggested that at retrieval, correct responses were more likely to a C cue than to an A cue because the mediating images were more closely tied to the concrete member of the pair. Therefore, both Paivio's and Lockhart's interpretations would predict an ordering of response latencies, at least for correct responses from shortest latencies for the CA/C condition, to intermediate latencies for CA/A and AC/C, and longest latencies for AC/A combination of presentation order and test cue.

The present study was essentially an extension of Lockhart's (1969b) experiment. The concrete and abstract nouns used as stimulus materials were selected from those receiving extreme ratings of concreteness according to norms published by Paivio, Yuille and Madigan (1968). The major purpose was to establish the generality of Lockhart's findings and conclusions with respect to the role of concreteness in PA learning and to expand these findings and conclusions by obtaining rating and latency measures at time of presentation of the word pair and at time of testing for recall.

METHOD

Subjects

The Ss were 14 female and 26 male Sir George Williams University undergraduate summer students whose services were solicited in the university cafeteria. All Ss reported English as being their mother tongue and indicated no previous experience in psychological experiments. The Ss were unsystematically assigned to one of the four word pair study-test conditions with the only restriction being the maintenance of an equal number of Ss in each group.

Materials

Column 1 of Table 1 presents the 80 noun-noun pairs used in this experiment, alphabetically arranged in four blocks of 20 pairs each. These word pairs were chosen randomly with two restrictions from a pool of 462 pairs which had been generated by randomly pairing the 925 nouns scaled by Paivio, Yuille and Madigan (1968) as to rated concreteness (c), rated imagery (I), and production meaningfulness (m). These values on each of these scales for each member of each of the word pairs used in this experiment appear in Columns 2, 3, and 4, respectively, of Table 1. The first restriction in the choice of the 80 word pairs was that one member of the pair should have a

TABLE 1

DESCRIPTION OF VERBAL MATERIAL

	Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
					CA Order	AC Order
	(1)	(2)	(3)	(4)	(5)	(6)
Block 1	abode	6.31	5.07	6.64		
	fantasy	2.03	3.70	5.06	3	5
	apple	7.00	6.73	7.67		
	courtship	3.22	5.30	6.13	1	2
	army	6.55	6.53	6.88		
	outcome	2.80	2.40	4.24	1	1
	cattle	6.79	6.40	7.56		
	nonsense	1.90	3.07	4.12	4	5
	inhabitant	6.00	4.33	5.33		
	majority	3.48	3.63	5.48	1	1
	kerchief	6.82	5.23	6.48		
	heroism	2.26	4.17	5.84	1	2

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
moisture	6.24	5.20	6.72		
fun	2.45	5.23	5.50	3	3
monarch	6.40	6.20	6.92		
fault	2.87	2.83	4.80	3	3
musician	6.53	6.13	6.52		
competence	1.86	2.97	4.63	1	2
nephew	6.19	4.30	4.48		
comradeship	2.75	4.40	5.21	2	5
opium	6.44	4.60	5.88		
anger	1.70	4.87	5.83	1	2
person	6.51	5.83	5.68		
discipline	2.17	3.57	6.40	2	1
pupil	6.63	6.37	6.24		
hierarchy	2.73	5.13	4.48	2	2

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
sky	6.18	6.73	7.84		
magnitude	3.03	2.50	5.68	1	1
storeroom	6.73	5.87	6.52		
mind	2.60	3.03	5.88	1	1
thief	6.08	5.70	6.50		
opinion	2.29	3.23	4.96	3	3
thorn	6.87	6.33	6.44		
satire	2.33	3.37	5.64	1	1
ticket	7.00	6.20	7.21		
wistfulness	1.83	3.13	4.16	5	5
tripod	6.82	6.23	5.76		
hint	3.35	2.57	3.72	4	4
wigwam	6.83	6.23	5.88		
investigation	3.32	3.60	5.80	5	4

TABLE 1--Continued

	Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b] CA Order	Modal Difficulty Rating[b] AC Order
	(1)	(2)	(3)	(4)	(5)	(6)
Block 2	appliance	6.45	5.73	6.64		
	genius	2.76	4.27	5.50	3	3
	blossom	6.62	6.67	7.60		
	recognition	2.00	3.60	5.04	2	2
	clothing	6.63	6.17	7.08		
	suppression	2.35	2.83	3.89	1	4
	costume	6.12	5.80	6.19		
	fact	3.31	2.20	4.29	3	5
	flag	6.94	6.60	6.54		
	ingratitude	1.77	2.93	4.00	4	4
	forest	6.69	6.63	9.12		
	advice	2.08	3.13	5.39	3	5
	frog	6.96	6.73	6.56		
	confidence	1.52	3.40	4.17	1	4

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
girl	6.83	6.87	5.12		
amazement	2.18	4.47	4.50	2	2
infant	6.76	6.33	7.20		
engagement	3.46	4.70	5.76	2	2
mountain	7.00	6.77	7.58		
hardship	2.93	4.10	5.48	1	1
oats	6.90	6.07	7.16		
vacuum	3.87	4.77	5.94	5	5
piano	6.85	6.70	6.40		
illusion	2.03	3.53	4.67	4	3
pipe	6.90	6.43	6.20		
vigour	2.60	4.43	5.72	2	4
reptile	6.65	6.00	6.52		
attitude	1.83	2.77	5.60	4	3

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
skin	6.96	6.43	5.67		
emancipation	2.49	3.20	5.20	5	5
string	6.90	6.20	5.29		
madness	2.35	4.03	5.16	3	4
student	6.38	6.27	5.96		
style	3.18	3.83	5.84	3	2
suds	6.75	6.40	7.29		
betrayal	1.77	3.57	5.00	5	5
tomb	6.73	6.37	6.04		
victory	2.95	4.93	6.12	4	2
troops	6.69	6.13	7.54		
animosity	1.81	3.60	5.19	1	1

TABLE 1--Continued

	Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b] CA Order	Modal Difficulty Rating[b] AC Order
	(1)	(2)	(3)	(4)	(5)	(6)
Block 3	author	6.04	4.53	5.24		
	death	2.97	5.00	7.12	2	3
	bronze	6.59	6.17	6.19		
	elaboration	2.18	2.63	4.36	4	5
	child	6.87	6.50	7.04		
	inanity	2.36	1.83	2.16	5	4
	elbow	6.94	6.30	5.16		
	democracy	1.79	2.47	5.72	5	5
	fiord	6.69	5.70	6.48		
	gist	1.77	1.97	3.33	5	4
	fox	7.00	6.73	7.40		
	cleanness	3.63	4.77	5.64	3	3
	hammer	6.96	6.73	6.92		
	incident	3.00	2.90	4.16	2	3

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
house	6.93	6.67	6.83		
sensation	1.99	3.67	5.16	5	4
ink	6.87	6.37	6.96		
reflection	3.12	5.90	6.56	4	3
insect	6.80	6.10	6.32		
silence	3.09	4.10	5.82	2	3
invoice	6.14	5.17	6.28		
grief	1.86	4.70	6.32	4	5
jury	6.17	6.07	6.88		
promotion	3.56	3.33	5.56	3	4
meat	6.93	6.63	8.32		
homicide	3.81	4.17	6.24	2	2
missle	6.80	6.33	6.48		
freedom	1.98	3.83	6.36	1	1

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
palace	6.73	6.50	7.08		
ego	1.93	2.90	5.72	1	1
photograph	6.56	6.43	6.72		
profession	3.65	3.83	5.44	1	2
salad	6.83	6.53	7.20		
pledge	2.93	3.63	5.92	5	5
settler	6.07	5.40	6.48		
upkeep	2.50	3.07	4.76	3	4
tank	6.87	6.23	6.48		
misery	2.28	4.37	5.84	2	4
woman	6.63	6.70	6.40		
immunity	2.46	3.43	5.76	1	2

TABLE 1--Continued

	Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b] CA Order	Modal Difficulty Rating[b] AC Order
	(1)	(2)	(3)	(4)	(5)	(6)
Block 4	body	6.58	6.40	5.61		
	determination	1.66	3.57	4.64	3	5
	circle	6.00	6.23	4.88		
	figment	1.90	2.30	4.00	3	4
	cord	6.93	6.03	6.00		
	causality	3.75	2.90	4.38	4	3
	diamond	6.94	6.67	7.84		
	foible	3.07	2.20	2.60	5	5
	elephant	7.00	6.83	6.88		
	facility	2.20	2.73	4.64	4	3
	habitation	6.03	4.60	5.26		
	sentiment	1.83	3.57	4.88	1	4
	hoof	6.90	6.37	6.32		
	spirit	1.86	3.43	5.72	3	4

TABLE 1--Continued

Word Pair Order of Members:	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
Concrete Noun (C) Abstract Noun (A)				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
hospital	6.80	6.53	7.44		
necessity	1.97	3.00	5.92	1	1
inn	6.80	6.07	6.61		
interim	2.67	1.97	4.08	1	2
lemonade	6.93	6.50	7.13		
prayer	3.60	5.17	6.63	5	5
macaroni	7.00	6.47	6.00		
jealousy	1.77	4.72	4.88	4	4
market	6.08	6.13	7.04		
atrocity	2.38	3.67	4.17	5	3
noose	6.20	6.23	6.20		
management	3.69	3.90	5.68	2	4
nutmeg	6.87	5.37	5.60		
centennial	3.45	4.10	6.13	5	5

TABLE 1--Continued

Word Pair Order of Members: Concrete Noun (C) Abstract Noun (A)	Mean Concreteness Rating (c)[a]	Mean Imagery Rating (I)[a]	Mean Meaningfulness Value (m)[a]	Modal Difficulty Rating[b]	
				CA Order	AC Order
(1)	(2)	(3)	(4)	(5)	(6)
orchestra	6.55	6.77	6.76		
formation	3.76	3.87	4.92	2	2
oven	6.96	6.40	8.08		
competition	3.08	4.53	5.69	5	4
queen	6.38	6.57	7.36		
mischief	2.90	4.03	5.44	4	3
sultan	6.52	5.57	7.24		
onslaught	3.34	3.67	5.84	2	3
weapon	6.38	5.73	7.84		
ability	2.03	2.67	5.60	1	2
wine	6.96	6.60	7.54		
episode	3.91	3.37	5.32	2	3

a normative data obtained from Paivio, Yuille, & Madigan's publication of concreteness, imagery, and meaningfulness values for 925 nouns.

b pair modal difficulty ratings by 32 Ss, unpublished norms (S.G.W.U., Brace, 1969).

high c rating and the other member should have a low c rating. Since the pairs in Column 1 are all listed in their CA order, an examination of Column 2 shows that the first member (C) of each pair has a high c value in the extreme of Paivio, Yuille and Madigan's (1968) rating scale between 5.95 and 7.00 and the second member (A) of the pair has a low c value between 1.00 and 3.95. The imagery value (I), shown in Column 3, of each noun was determined by Paivio, Yuille, and Madigan (1968) by taking the mean of Ss' ratings of these nouns on a 7-point scale in terms of a word's "capacity" to arouse non-verbal images. The high correlation of .94 between c and I and the overlapping definitions suggest that these ratings probably reflect the same functional attribute. The meaningfulness (m) value in Column 4 was defined in terms of the mean number of written associations in 30 sec. and was allowed to co-vary with c and I in this experiment.

Column 5 of Table 1 shows the modal ratings on a 5-point scale from 1 (easy-to-learn) to 5 (difficult-to-learn) as given by an independent sample of 32 Sir George Williams University undergraduates to each word pair in its CA order. Column 6 shows the modal difficulty rating for the AC order. The correlation between the set of ratings for the word pairs in the CA order and the AC order

was +.76. This imperfect correlation was the source of the second restriction to the choice of the PAs for this experiment. Particular word pairs were selected so that there were approximately equal numbers of word pairs at each level of rated difficulty within the CA or AC pair orders and equal numbers of word pairs at each level of difficulty when the ratings of the word pairs in both the CA and AC groups were pooled.

Each word pair was typed in lower case letters in both its AC and CA order on white photographic paper, photographed, and the negatives mounted to yield 160 2-in. x 2-in. slides. Each member of every pair was also photographed and mounted so that each noun appeared alone on the left-hand side of the slide.

Apparatus

A Kodak Ektagraphic carousel projector presented the slides on a 21-in. x 13½-in. flashed opal screen at a letter size of ½-in. in height. On the table in front of S at the base of the screen was an 8-in. x 4-in. x 1-in. aluminum response panel which displayed five red buttons spaced 1 in. apart. To the left of the first button was the label "lo" and to the right of the last button was the label "hi". The buttons were numbered from 1 to 5 from left to right. Depression of any one of the buttons activated a corres-

ponding light on the control panel and stopped a Grason-Stadler Model 1200 Series 4-dial digital clock which was set to measure to 100th of a sec. Modular solid state programming equipment was wired to provide the following sequence: (a) the depression of a response button initiated a projector slide change and activated a solenoid; (b) the solenoid caused the onset of a Lafayette timer (Model VSI-E) and the closure of a tachistoscopic shutter covering the projector aperture; (c) the closed shutter blanked out the new slide which had moved into place; (d) the timer caused the shutter to open after an interval of 7.5 sec., allowing the new slide stimulus to appear on the screen, and (e) the onset of the stimulus was sensed by a photo-cell which reset the clocks until another cycle was initiated by S's response.

Data sheets providing an alphabetical listing of the particular AC and CA word pairs in each of the four treatment groups enabled the E to record the response data in an organized fashion since the slides were shuffled for each S before both the study trial and the test trial.

Experimental design

The experimental design is summarized in Table 2. The 80 pairs of nouns were divided as previously described into four blocks of 20 word pairs each. The 40 Ss were unsystematically assigned to one of four groups of ten Ss.

TABLE 2

EXPERIMENTAL DESIGN

		Blocks of noun pairs[a]			
		1	2	3	4
S groups					
(N=10)	1	CA/C	CA/A	AC/C	AC/A
(N=10)	2	CA/A	AC/C	AC/A	CA/C
(N=10)	3	AC/C	AC/A	CA/C	CA/A
(N=10)	4	AC/A	CA/C	CA/A	AC/C

[a]the four blocks of 20 word pairs are listed in Table 1.

For each group of Ss a different order of assignment of the presentation order-test cue combinations to word pair blocks was used. The assignment of experimental conditions to word pair blocks was counterbalanced across groups of Ss so that every word pair block was used with all four experimental conditions. The particular combinations of experimental conditions are shown in Table 2. Both the 80 word pairs and the 80 test cues were presented to Ss in a completely nonsystematic sequence as both sets of slides were shuffled prior to presentation to each S.

Procedure

The S, tested individually, was seated before the presentation screen and given standard PA instructions (Appendix I). He was specifically told to attempt to perceive the paired words "as going together to create a whole". He was instructed to rate the strength of the association so formed on a 5-point scale from 1, low association, to 5, high association. The S then viewed and rated the 80 word pairs. In the test phase, S was told to read the cue word aloud and to respond with the noun that had been previously paired with it. He was then asked to rate from 1 to 5 how sure he was that his overt response was correct. If he omitted a response he was instructed to say "don't know"

and press Button 1.

RESULTS

Acquisition Data

Ratings of associative strength

Upon presentation of each word pair, Ss assessed and rated the strength of the association between the members of the pair. Word pairs presented in the CA order received a mean rating of 2.66; AC order word pairs received a mean rating of 2.62. Analysis of variance indicated that these values were not significantly different, F (1,36)= .95, $p > .05$.

Latency of associative strength ratings

The mean latency of the associative strength ratings of word pairs presented in the CA order was 6.33 seconds and of word pairs presented in the AC order was 6.45 seconds. These means did not differ significantly, F (1,36)= 1.80, $p > .05$.

Recall Data

The recall data include the response itself, i.e. whether it was a correct response, an intrusion or an omission, the rating of confidence in the correctness of the response, and the latency of the confidence rating

measured from onset of the test slide.

Responses

Out of a total of 3,200 recall tests, 846 resulted in correct responses, 692 in intrusions and 1,662 in omissions. In the analyses which follow, these three categories of response are considered separately.

Correct responses. - The analysis of variance of correct responses is summarized in Table 3. The significant test cue effect was a consequence of the greater number of correct responses given to the C cue than to the A cue. Correct responses did not vary significantly as a result of the presentation order of the word pair (CA or AC), but the interaction of presentation order with recall cue significantly affected recall. The mean numbers of correct responses for each test cue are plotted as a function of presentation order in the left panel of Figure 1. Inspection of these means shows that both types of cue elicited more correct responses when they originally had been the left-hand member of the pair than when they had been the right-hand member.

The analysis of variance of correct responses also showed significant interactions between presentation order, test cue, and groups. These interactions could result either from bias in the assignment of noun pairs to blocks

TABLE 3

ANALYSIS OF VARIANCE OF NUMBER OF CORRECT RESPONSES AS A FUNCTION OF EXPERIMENTAL CONDITIONS

Source	df	MS	F
Subjects			
Groups (G)	3	13.408	0.29
Subjects within groups (S/G)	36	45.474	
Treatments			
Presentation order (P)	1	0.100	0.03
PxG	3	11.917	3.91*
PxS/G	36	3.046	
Test cue (T)	1	36.100	10.22**
TxG	3	3.417	0.97
TxS/G	36	3.532	
PxT	1	11.025	6.37*
PxTxG	3	5.042	2.91*
PxTxS/G	36	1.732	

*$p < .05$
**$p < .01$

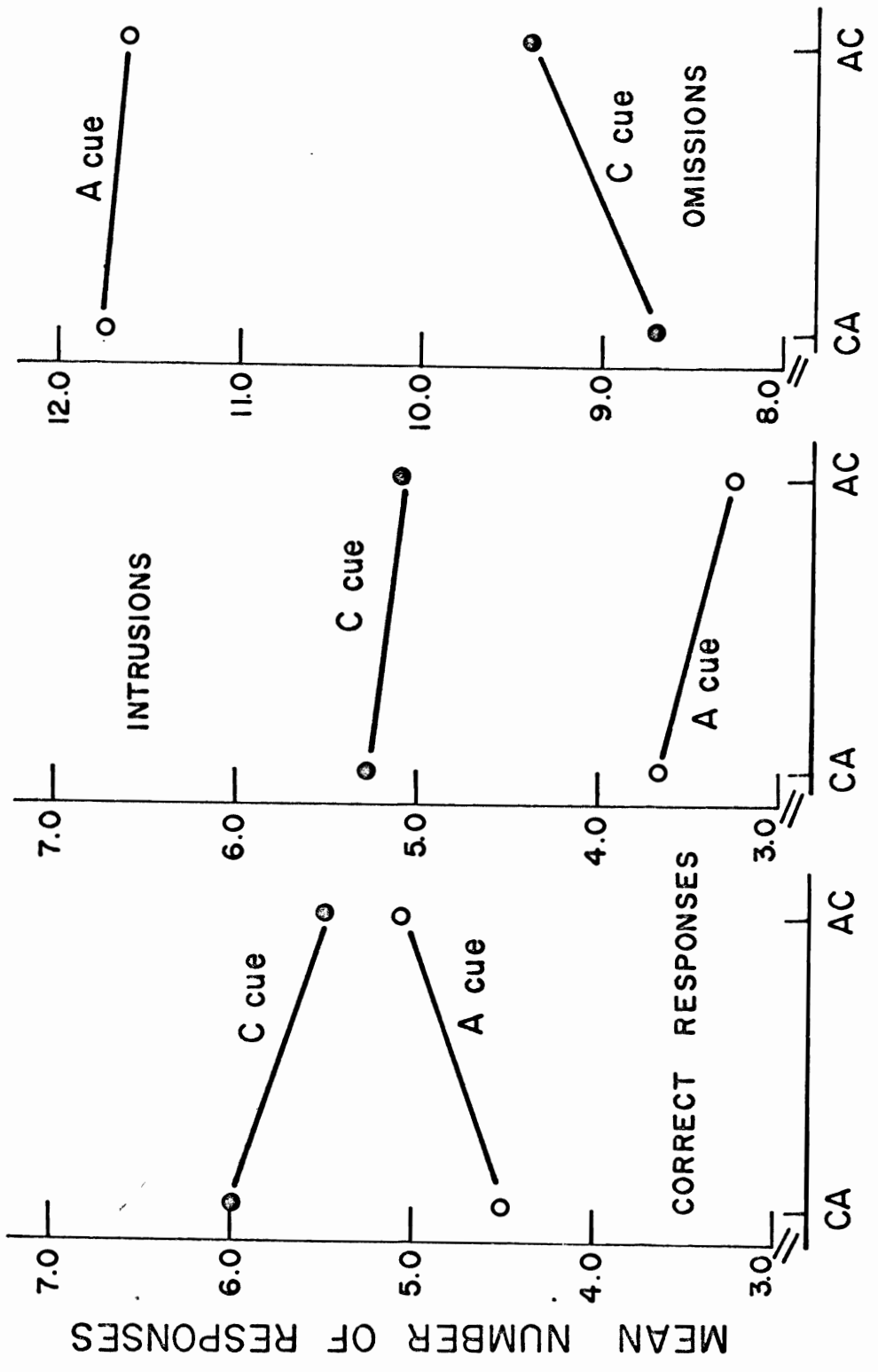

Fig. 1. Mean number of responses for each cue as a function of presentation order. The left panel shows correct responses, the center panel shows intrusions, and the right panel shows omissions.

or in the assignment of Ss to groups. In either case, it seems reasonable to attribute these effects to sampling error.

Intrusions. - The analysis of variance of intrusions summarized in Table 4 revealed a significant effect of test cue but no other significant main effects or interactions. In the center panel of Figure 1, the mean number of intrusions for the C cue can be seen to be greater than for the A cue, with no apparent differences across presentation order.

The intrusions were categorized as intralist intrustions if they had appeared in the set of noun pairs at presentation, or as extralist if they had not. Each extralist intrusion was also categorized as C or A, intralist intrusions having already been so classified. The majority of extralist intrusions appeared in the word list prepared by Paivio, Yuille, and Madigan (1968) and were classified accordingly. The remaining extralist items were judged by E as either concrete or abstract.

An analysis of variance containing the categories of intrusions as factors is summarized in Table 5. The analysis was performed on response frequencies pooled across Ss within each group because frequencies for individual Ss resulted in extremely skewed distributions. Examination of Table 5 shows the signifcant test cue effect

TABLE 4

ANALYSIS OF VARIANCE OF NUMBER OF INTRUSIONS
AS A FUNCTION OF EXPERIMENTAL CONDITIONS

Source	df	MS	F
Subjects			
Groups (G)	3	27.150	0.92
Subjects within groups (S/G)	36	29.504	
Treatments			
Presentation order (P)	1	4.225	1.33
PxG	3	5.842	1.83
PxS/G	36	3.188	
Test cue (T)	1	112.225	27.72***
TxG	3	3.842	0.95
TxS/G	36	4.049	
PxT	1	0.400	0.19
PxTxG	3	3.450	1.62
PxTxS/G	36	2.132	

***$p < .001$

TABLE 5

ANALYSIS OF VARIANCE OF FREQUENCY OF INTRUSIONS CLASSIFIED AS INTRALIST OR EXTRALIST (INTRUSION SOURCE) AND AS C OR A (CONCRETENESS OF INTRUSION) AS A FUNCTION OF EXPERIMENTAL CONDITIONS

Source		df	MS	F
Groups (G)		3	33.458	
Treatments				
Presentation order	(P)	1	9.000	0.45
Test cue	(T)	1	272.250	13.52**
Intrusion source	(I)	1	156.250	7.76**
Concreteness of intrusion	(C)	1	132.250	6.57*
PxT		1	0.000	0.00
PxI		1	12.250	0.61
PxC		1	4.000	0.20
TxI		1	144.000	7.15*
TxC		1	1024.000	50.86**
IxC		1	400.000	19.87**
PxTxI		1	25.000	1.24
PxTxC		1	6.250	0.31
PxIxC		1	1.000	0.05
TxIxC		1	9.000	0.45
PxTxIxC		1	16.000	0.79
Error		45	20.134	

*$P < .05$
**$P < .01$

TABLE 6

MEAN NUMBER OF INTRUSIONS AS A FUNCTION OF TEST CUE AND INTRUSION SOURCE, AS A FUNCTION OF CONCRETENESS OF INTRUSION AND INTRUSION SOURCE, AND AS A FUNCTION OF CONCRETENESS OF INTRUSION AND TEST CUE

Intrusion Source	Test Cue C	Test Cue A
Intralist	4.875	4.425
Extralist	4.825	1.975

Intrusion Source	Concreteness of Intrusion C	Concreteness of Intrusion A
Intralist	5.075	4.220
Extralist	1.825	4.975

Concreteness of Intrusion	Test Cue C	Test Cue A
C	2.675	4.220
A	7.025	2.175

TABLE 7

ANALYSIS OF VARIANCE OF NUMBER OF OMISSIONS
AS A FUNCTION OF EXPERIMENTAL CONDITIONS

Source	df	MS	F
Subjects			
Groups (G)	3	5.758	0.12
Subjects within groups (S/G)	36	50.089	
Treatments			
Presentation order (P)	1	3.025	0.98
PxG	3	3.425	1.11
PxS/G	36	3.089	
Test cue (T)	1	275.625	44.38***
TxG	3	5.425	0.87
TxS/G	36	6.211	
PxT	1	7.225	2.26
PxTxG	3	0.425	0.13
PxTxS/G	36	3.194	

***$p < .001$

previously noted. The significant effect of source of intrusion reflects the fact that the number of intralist intrusions (372) was greater than the number of extralist intrusions (272). The significant difference of the concreteness of intrusion was a consequence of the larger number of A intrusions (368) than C intrusions (276). Three significant interactions are shown in Table 5. The mean numbers of intrusions per S for these interactions are shown in Table 6. Table 6 shows that the interaction between test cue and intrusion source resulted from the small number of extralist intrusions to the A cue. The interaction between concreteness of intrusion and intrusion source reflects the relative infrequency with which C nouns from outside the presentation list were used as intrusions. Finally, the interaction between test cue and concreteness of intrusion shows that Ss tended to give A intrusions to C cues and C intrusions to A cues.

Omissions. - Table 7 summarizes the analysis of variance for omissions. These results, presented for completeness, are the mirror image of the sum of the correct responses and intrusions. The effect of test cue was significant with the number of omissions being greater to the A cue than to the C cue, as shown in the

right panel of Figure 1.

Confidence ratings

Each response given in the experiment had a confidence rating associated with it. The individual S's ratings for each category of response were analyzed separately. The overall mean rating for correct responses was 4.45, for intrusions 2.83, and, of course, for omissions, was 1.00. The relative magnitude of the difference between the means for correct responses and intrusions precludes any need for statistical demonstration that the difference is significant. The omissions were all rated as 1 and since they do not provide any meaningful confidence ratings, they will not be considered further in this section.

Correct responses. - An analysis of variance of the mean confidence ratings for correct responses, presented in Table 8, yielded no significant effects of presentation order, recall cue, or the interaction between presentation order and recall cue. Examination of the left panel of Figure 2 shows that correct responses to the C cue received slightly higher ratings than those to the A cue if the word pair had been presented in the CA order but lower ratings if the word pair had been presented in the AC order.

Figure 3 displays frequency distributions of the

TABLE 8

ANALYSIS OF VARIANCE OF THE MEAN CONFIDENCE RATINGS ASSOCIATED WITH CORRECT RESPONSES AS A FUNCTION OF EXPERIMENTAL CONDITIONS

Source	df	MS	F
Subjects			
Groups (G)	3	0.521454	0.86
Subjects within groups (S/G)	36	0.607472	
Treatments			
Presentation order (P)	1	0.206841	0.88
PxG	3	0.076367	0.32
PxS/G	36	0.235556	
Test cue (T)	1	0.277269	1.20
TxG	3	0.094271	0.41
TxS/G	36	0.231000	
PxT	1	0.729795	3.72
PxTxG	3	0.103890	0.53
PxTxS/G	36	0.195944	

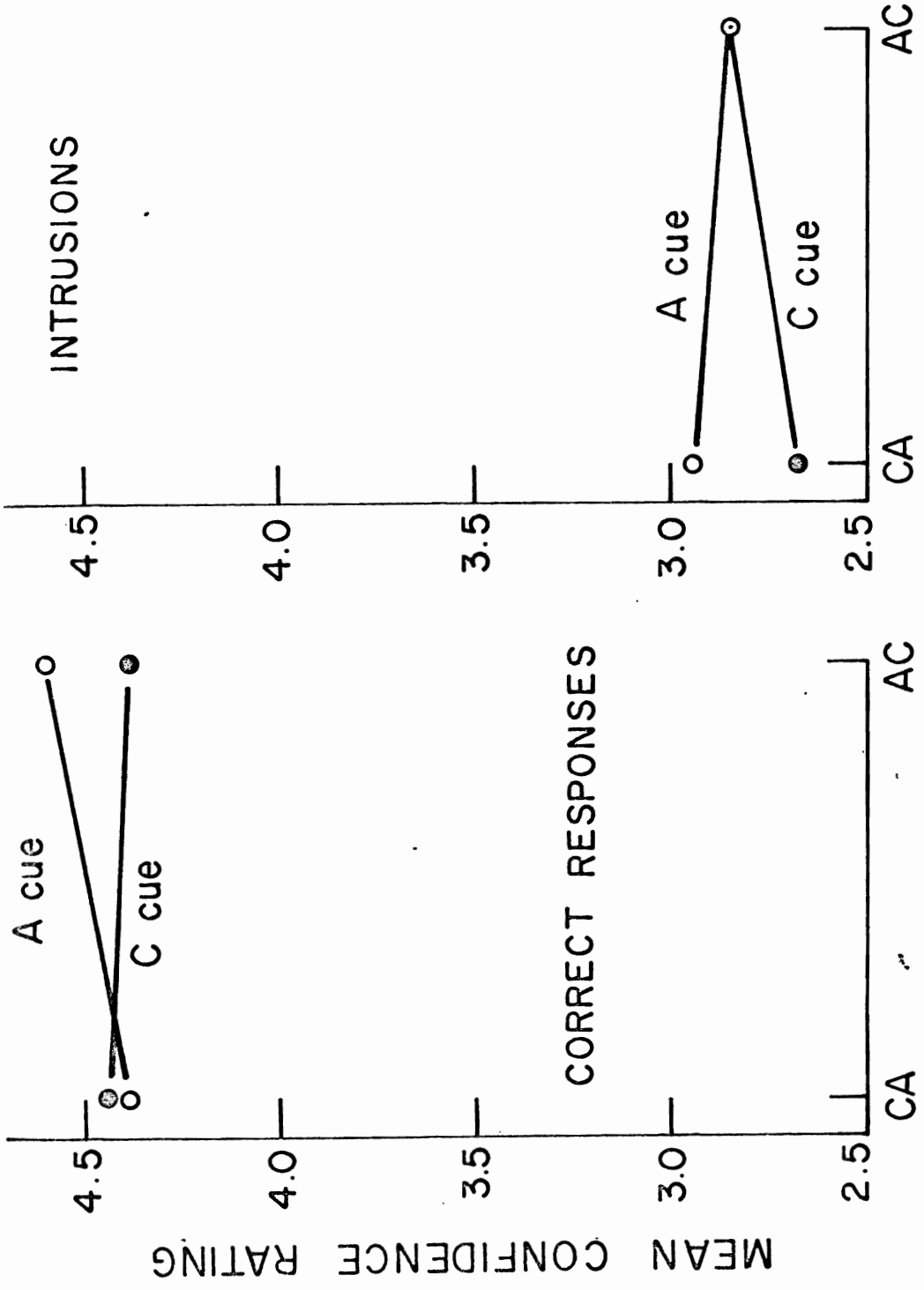

Fig. 2. Mean confidence ratings for each cue as a function of presentation order. The left panel shows correct responses and the right panel shows intrusions.

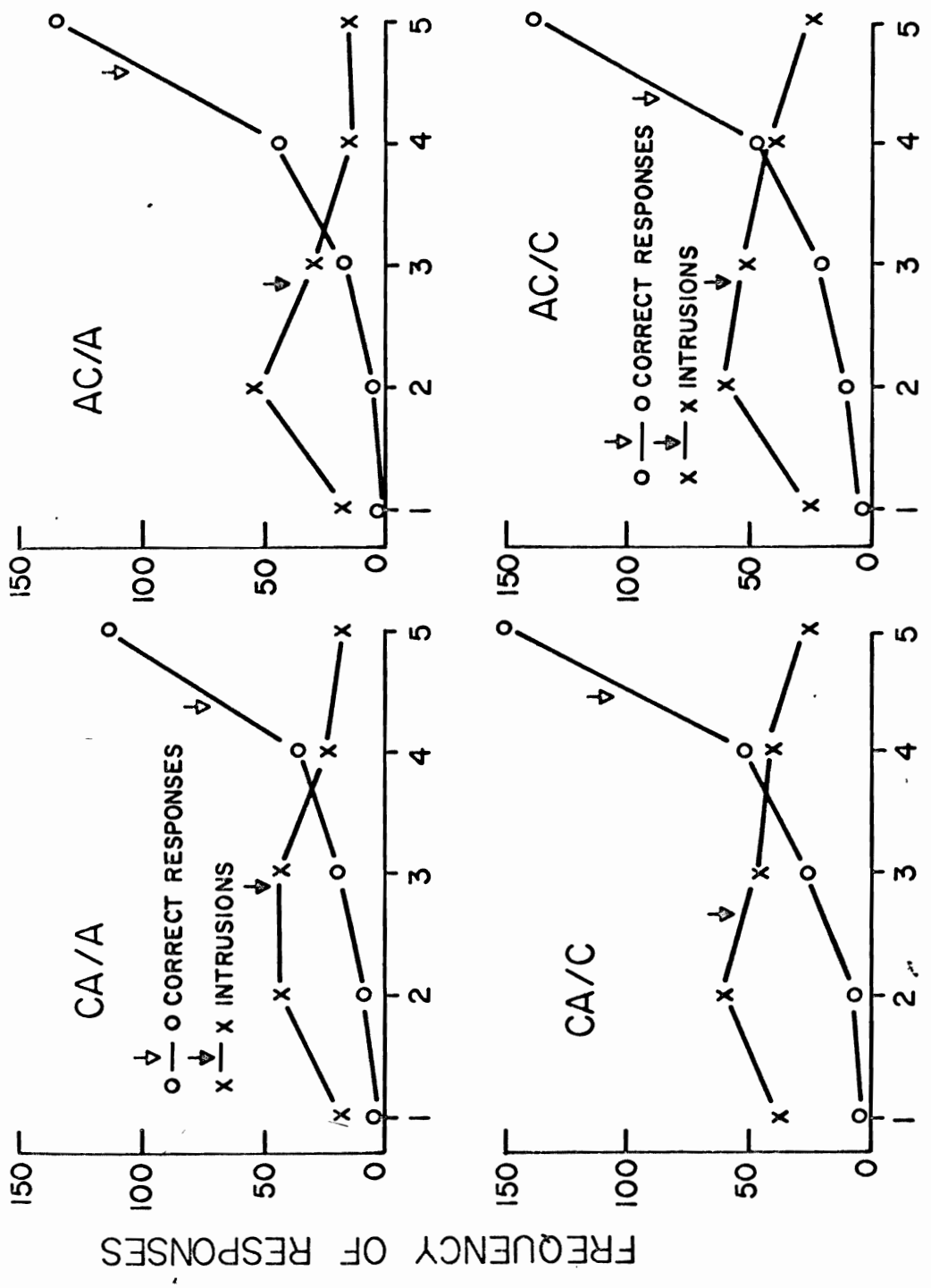

Fig. 3. Frequency distributions of confidence ratings for correct responses and intrusions. The upper panels show distributions for presentation orders tested with the A cue and the lower panels show presentation orders tested with the C cue. The left panels show the CA presentation order and the right panels show the AC presentation order. The arrows indicate the mean confidence ratings.

ratings for the correct responses given under each combination of presentation order and test cue. The mean ratings of Figure 2 are indicated by arrows in Figure 3. The highest frequency of high confidence ratings occurred to responses given in the AC/A and CA/C conditions.

An analysis of variance of the confidence rating frequencies is summarized in Table 9. The error term was calculated from the between-group variance since the cell frequencies were too small for a between-subjects analysis. Examination of this table indicated a highly reliable increase in frequency of rating with an increase in rating category. The significant test cue effect simply reflects the superior recall to the C cue. Neither presentation order nor any of the interactions were significant.

Intrusions. - As may be seen from Table 10, an analysis of variance performed on the mean confidence ratings of the intrusions indicated no significant effects of the experimental conditions or their interactions. The right panel of Figure 2 shows mean confidence ratings of the intrusions made to each combination of presentation order and test cue. Examination of Figure 2 indicates only minor differences in the mean confidence ratings across experimental conditions. It may be noted, however, that

TABLE 9

ANALYSIS OF VARIANCE OF FREQUENCY OF CORRECT RESPONSES AS A FUNCTION OF ASSOCIATED CONFIDENCE RATING CATEGORY

Source	df	MS	F
Groups (G)	3	26.817	
Treatments			
Presentation order (P)	1	0.200	0.02
Test cue (T)	1	72.200	6.58*
Confidence rating (C)	4	2946.169	268.66**
PxT	1	22.050	2.01
PxC	4	2.480	0.23
TxC	4	14.792	1.35
PxTxC	4	15.958	1.46
Error	57	10.966	

*$p < .05$
**$p < .01$

TABLE 10

ANALYSIS OF VARIANCE OF MEAN CONFIDENCE RATINGS ASSOCIATED WITH INTRUSIONS

Source	df	MS	F
Subjects			
Groups (G)	3	1.011221	0.50
Subjects within groups (S/G)	36	2.028528	
Treatments			
Presentation order (P)	1	0.076656	0.15
PxG	3	0.060276	0.12
PxS/G	36	0.499388	
Test cue (T)	1	0.744465	1.66
TxG	3	0.275577	0.62
TxS/G	36	0.447583	
PxT	1	0.739634	1.89
PxTxG	3	0.349860	0.90
PxTxS/G	36	0.390556	

the mean confidence rating for intrusions in the CA/A condition is higher than for the CA/C condition.

Figure 3 displays frequency distributions of confidence ratings given to intrusions made under each experimental condition. The number of ratings decreased from rating category 2 to rating category 5. For each presentation order and test cue combination, frequency of ratings of 1 was uniformly depressed in respect to the frequency of 2 ratings.

An analysis of variance summarized in Table 11 shows this variation across rating categories to be significant. The test cue effect has been previously noted. The error term reflects the between-group variation, since the analysis was based on frequencies pooled across Ss within groups.

Speed of confidence ratings

The speed of the confidence rating was defined as the reciprocal of the time in seconds elapsed from onset of the cue for recall to the pressing of the chosen rating button by the S. The overall mean speed for correct responses was 0.213, for intrusions 0.115, and for omissions 0.155. The relative magnitude of the differences between these means makes statistical analysis superfluous.

TABLE 11

ANALYSIS OF VARIANCE OF FREQUENCY OF INTRUSIONS AS A FUNCTION OF ASSOCIATED CONFIDENCE RATING CATEGORY

Source	df	MS	F
Groups (G)	3	54.300	
Treatments			
Presentation order (P)	1	8.450	0.49
Test cue (T)	1	224.450	13.11**
Confidence rating (C)	4	186.112	10.87**
PxT	1	0.800	0.05
PxC	4	5.010	0.29
TxC	4	6.080	0.35
PxTxC	4	10.750	0.63
Error	57	17.120	

**$p < .01$

Correct responses. - The analysis of variance of speeds of rating correct responses, summarized in Table 12, yielded no significant effects of the experimental variables. The mean speeds, shown in the left panel of Figure 4, were high for all experimental conditions.

Intrusions. - Analysis of variance of rating speeds of intrusions yielded a significant test cue effect, as shown in Table 13. Examination of the center panel of Figure 4 indicates that intrusions to the A cue were rated more quickly than were intrusions to the C cue. No other differences among experimental conditions were significant.

Omissions. - The speeds of the confidence rating responses, shown in the right panel of Figure 4, also contained a significant cue effect, as may be noted in Table 14. Again, mean confidence rating speeds were greater to the A cue than to the C cues. No other differences were significant.

Relationships among recall measures

Because the frequency distribution of confidence ratings was so highly skewed for correct responses, the mean latency of confidence rating for each rating category was determined for each group of Ss for each category of response. Analyses of variance were performed on these means using the between-groups variance as an estimate of error.

TABLE 12

ANALYSIS OF VARIANCE OF MEAN SPEED OF CONFIDENCE RATING FOR CORRECT RESPONSES

Source	df	MS	F
Subjects			
Groups (G)	3	0.010900	1.03
Subjects within groups (S/G)	36	0.010583	
Treatments			
Presentation order (P)	1	0.000598	0.22
PxG	3	0.007511	2.82
PxS/G	36	0.002667	
Test cue (T)	1	0.000026	0.02
TxG	3	0.002147	1.27
TxS/G	36	0.001694	
PxT	1	0.000485	0.16
PxTxG	3	0.001883	0.64
PxTxS/G	36	0.002944	

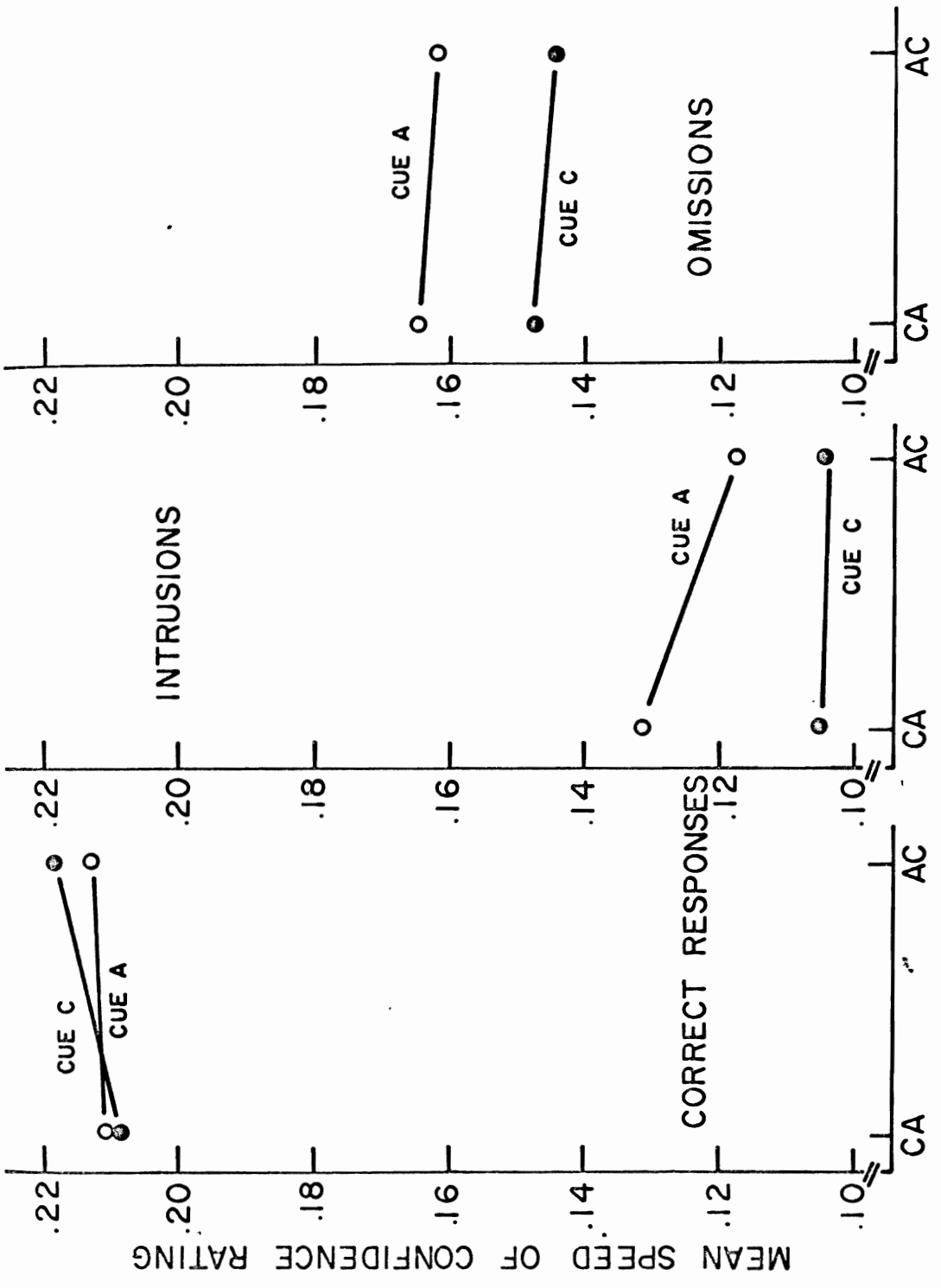

Fig. 4. Mean speed of confidence rating for each cue as a function of presentation order. The left panel shows correct responses, the center panel shows intrusions, and the right panel shows omissions.

TABLE 13

ANALYSIS OF VARIANCE OF MEAN SPEED OF CONFIDENCE RATING FOR INTRUSIONS

Source	df	MS	F
Subjects			
Groups (G)	3	0.001419	0.32
Subjects within groups (S/G)	36	0.004417	
Treatments			
Presentation order (P)	1	0.002223	1.60
PxG	3	0.000363	0.26
PxS/G	36	0.001389	
Test cue (T)	1	0.015962	15.53**
TxG	3	0.001238	1.20
TxS/G	36	0.001028	
PxT	1	0.001442	0.89
PxTxG	3	0.001257	0.78
PxTxS/G	36	0.001611	

**$p < .01$

TABLE 14

ANALYSIS OF VARIANCE OF MEAN SPEED OF CONFIDENCE RATING FOR OMISSIONS

Source	df	MS	F
Subjects			
Groups (G)	3	0.023983	0.87
Subjects within groups (S/G)	36	0.027472	
Treatments			
Presentation order (P)	1	0.000584	1.40
PxG	3	0.000377	0.91
PxS/G	36	0.000417	
Test cue (T)	1	0.011522	11.85**
TxG	3	0.001600	1.65
TxS/G	36	0.000972	
PxT	1	0.000052	0.08
PxTxG	3	0.000094	0.14
PxTxS/G	36	0.000667	

**$p < .01$

Correct responses. - Since the Ss of one group contributed no ratings of 1 or 2 for correct responses, only categories 3 to 5 were included in this analysis, summarized in Table 15. The only significant effect, that of rating category, can be seen in Figure 5 where mean latencies decrease monotonically across rating category.

Intrusions. - The analysis of variance of the mean latencies of confidence ratings as a function of rating category is summarized in Table 16. Examination of the results of the analysis shows the significant effect of test cue on mean latencies previously noted and a significant effect of confidence rating category. Two cells of the analysis were empty because of the failure of one group to give any ratings of 1 for two experimental conditions. The missing mean latencies were replaced with the mean of the other three values and the error degrees of freedom were reduced appropriately. The mean latencies, which also appear in Figure 5, were a monotonically decreasing function of confidence rating category.

Relations between measures taken at presentation and measures taken at recall

Word pairs were classified according to the three dependent measures of associative strength ratings, latency of rating response, and performance at recall (i.e., whether

TABLE 15

ANALYSIS OF VARIANCE OF MEAN LATENCIES OF CONFIDENCE RATING FOR CORRECT RESPONSES AS A FUNCTION OF CONFIDENCE RATING CATEGORY

Source	df	MS	F
Groups (G)	3	4.265295	
Treatments			
Presentation order (P)	1	0.359219	0.15
Test cue (T)	1	0.523754	0.21
Confidence rating (C)	2	37.081034	14.98**
PxT	1	1.346675	0.54
PxC	2	0.691382	0.28
TxC	2	1.095536	0.44
PxTxC	2	1.265046	0.51
Error	33	2.476054	

**$P < .01$

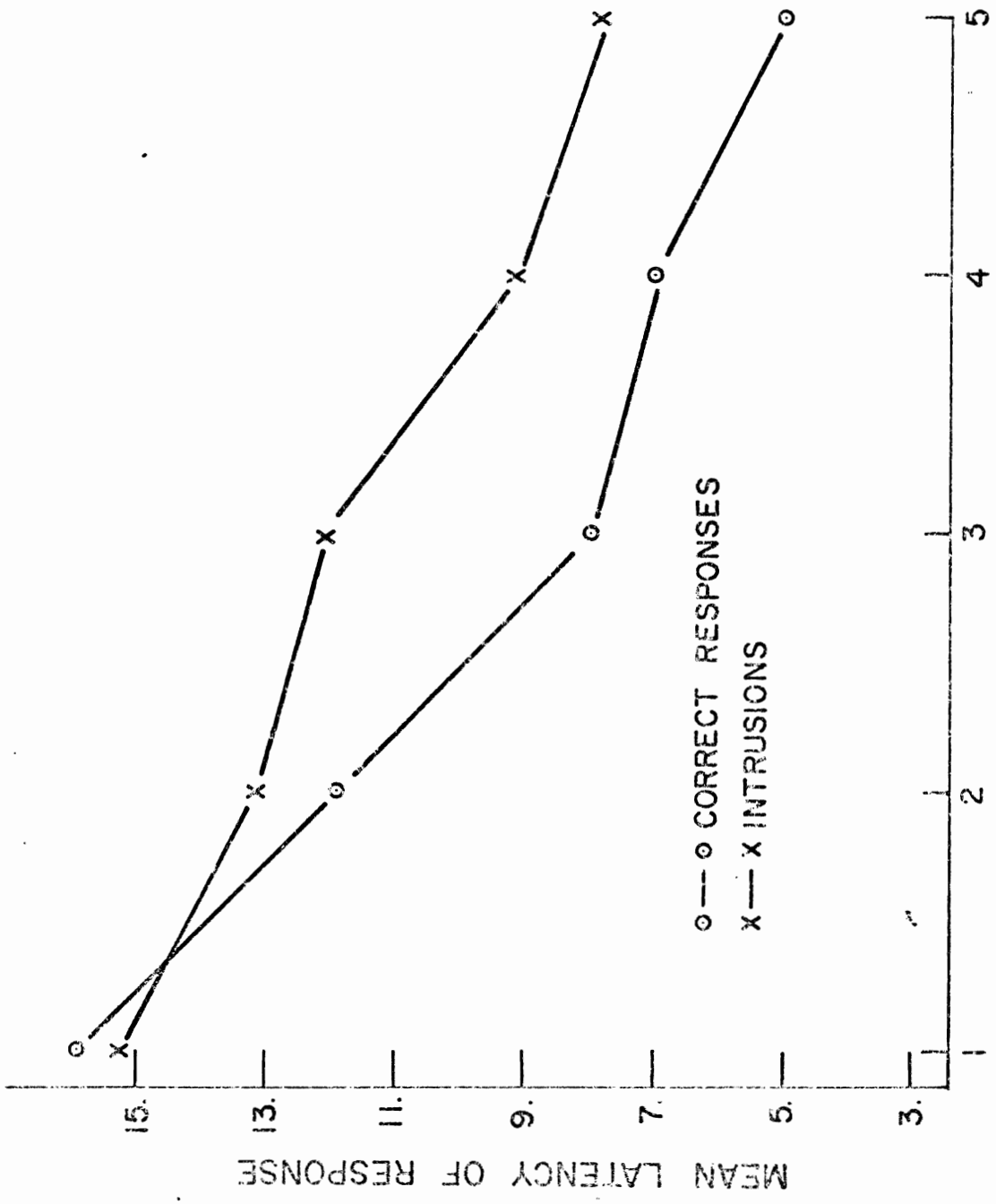

Fig. 5. Mean latency in seconds of confidence ratings for correct responses and intrusions shown as a function of the confidence rating category.

TABLE 16

ANALYSIS OF VARIANCE OF MEAN LATENCIES OF CONFIDENCE RATING FOR INTRUSIONS AS A FUNCTION OF CONFIDENCE RATING CATEGORY

Source	df	MS	F
Groups (G)	3	10.3759	
Treatments			
Presentation order (P)	1	0.8419	0.14
Test cue (T)	1	31.9400	5.32*
Confidence rating (C)	4	156.4608	26.06**
PxT	1	16.7253	2.79
PxC	4	3.8964	0.65
TxC	4	3.3032	0.55
PxTxC	4	2.8284	0.47
Error	55	6.0047	

*$P < .05$
**$P < .01$

the word pair received a correct response, an intrusion, or an omission at time of testing). These three classifications were related in various ways in order to assess more completely the effects of the independent variable of presentation order.

Relations between measures of noun pair associative strength ratings and the response given at recall

In order to assess the relation between associative strength rating and response at recall, and the effect of presentation order of the pair on this relation, a particular method of classification for analysis of variance was employed. Within the independent variable of presentation order each word pair was doubly classified for each S according to its associative strength rating and the nature of the response made to its test cue. Then, separately for each group of Ss and for each set of CA and AC pairs in each rating category, the proportion of word pairs with subsequent correct responses, intrusions, and omissions, respectively, was determined. Analyses of variance were performed on these proportions using the between-group variation as the estimate of error.

The analysis of variance performed on proportions of word pairs responded to correctly at recall is summarized in Table 17. Presentation order had no effect on the distribution of the mean proportions across rating categories. The significant source of variation of associative strength rating represents differences in

TABLE 17

ANALYSIS OF VARIANCE OF PROPORTIONS OF NOUN PAIRS IN EACH ASSOCIATIVE STRENGTH RATING CATEGORY WHOSE RESPONSES AT RECALL WERE CORRECT

Source	df	MS	F
Groups (G)	3	0.069828	
Treatments			
Presentation order (P)	1	0.000932	0.11
Associative strength rating (A)	4	0.180191	21.78**
PxA	4	0.003152	0.38
Error	27	0.008273	

**$P < .01$

the mean proportions across rating categories. As may be seen from Figure 6, the mean proportions of the word pairs that were responded to correctly at recall, increase across associative strength rating categories.

The distribution across rating categories of the mean proportions of word pairs that received intrusions at recall did not differ significantly as an effect of presentation order. This can be seen in Figure 6 and in the analysis of variance summarized in Table 18. The distribution of mean proportions across rating categories was generally flat.

Those word pairs whose recall responses were omissions formed the major proportion of word pairs given an associative strength rating of 1. Presentation order had no effect on mean proportions or on the distribution of mean proportions across rating categories. The analysis of variance presented in Table 19 shows a significant effect of associative strength rating. As can be seen in Figure 6, this effect is a consequence of the significant decrease in the mean proportions across rating categories.

Relations among word pair associative strength rating, latency of rating and the response given at recall

For this analysis, the mean latency of rating of CA and AC word pairs in each rating category was determined

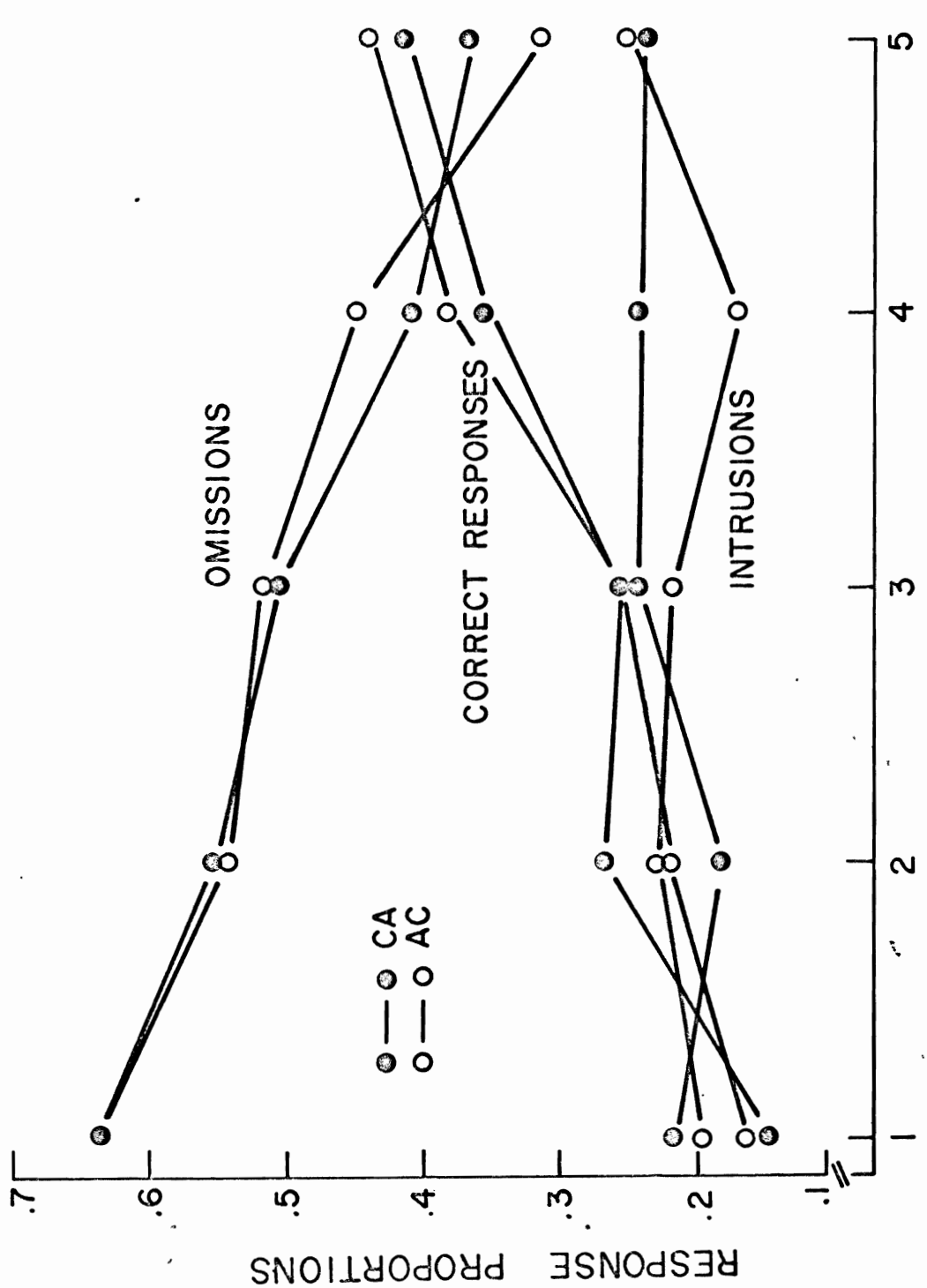

Fig. 6. Proportion of the total number of word pairs for each associative strength rating, that resulted in correct responses, intrusions, and omissions. The proportions were calculated separately for CA and AC presentation orders.

TABLE 18

ANALYSIS OF VARIANCE OF PROPORTIONS OF NOUN PAIRS IN EACH ASSOCIATIVE STRENGTH RATING CATEGORY WHOSE RESPONSES AT RECALL WERE INTRUSIONS

Source	df	MS	F
Groups (G)	3	0.030466	
Treatments			
Presentation order (P)	1	0.001711	0.31
Associative strength rating (A)	4	0.005497	0.99
PxA	4	0.007531	1.35
Error	27	0.005566	

TABLE 19

ANALYSIS OF VARIANCE OF PROPORTIONS OF NOUN PAIRS IN EACH ASSOCIATIVE STRENGTH RATING CATEGORY WHOSE RESPONSES AT RECALL WERE OMISSIONS

Source	df	MS	F
Groups (G)	3	0.013266	
Treatments			
Presentation order (P)	4	0.000003	0.00
Associative strength rating (A)	1	0.207278	24.66**
PxA	4	0.004805	0.57
Error	27	0.008404	

**$P < .01$

separately for word pairs receiving correct responses, intrusions and omissions at recall. Table 20 summarizes the between-groups analysis of variance performed on these means. This table shows that presentation order had no significant effects on the mean latencies either alone or in interaction. Mean latencies differed in relation to subsequent recall and varied significantly across rating categories. The effects are depicted in Figure 7 where latency may be seen to vary as an inverted U across rating categories. The significant effect of type of response was largely due to the fact that relatively longer latencies of associative strength ratings were associated with pairs which were subsequently correctly recalled.

In conclusion, measures taken at presentation of the word pairs seem to be related to each other and to performance at recall in regular and reliable ways. However, presentation order was shown to have no effect upon these relationships.

DISCUSSION

The order of presentation of word pairs (CA or AC) as a single source of variation had no effect on any of the dependent measures taken in this experiment. The

TABLE 20

ANALYSIS OF VARIANCE OF MEAN LATENCIES OF ASSOCIATIVE STRENGTH RATINGS IN EACH RATING CATEGORY OF NOUN PAIRS WHOSE RESPONSES AT RECALL WERE CORRECT, INTRUSIONS AND OMISSIONS

Source	df	MS	F
Groups (G)	3	2.16721	
Treatments			
Presentation order (P)	1	0.53738	0.74
Type of response (R)	2	4.30300	5.95**
Associative strength rating (A)	4	18.56282	25.67**
PxR	2	0.72375	1.00
PxA	4	0.28947	0.40
RxA	8	0.83723	1.16
PxRxA	8	0.26872	0.37
Error	87	0.72300	

**$P < .01$

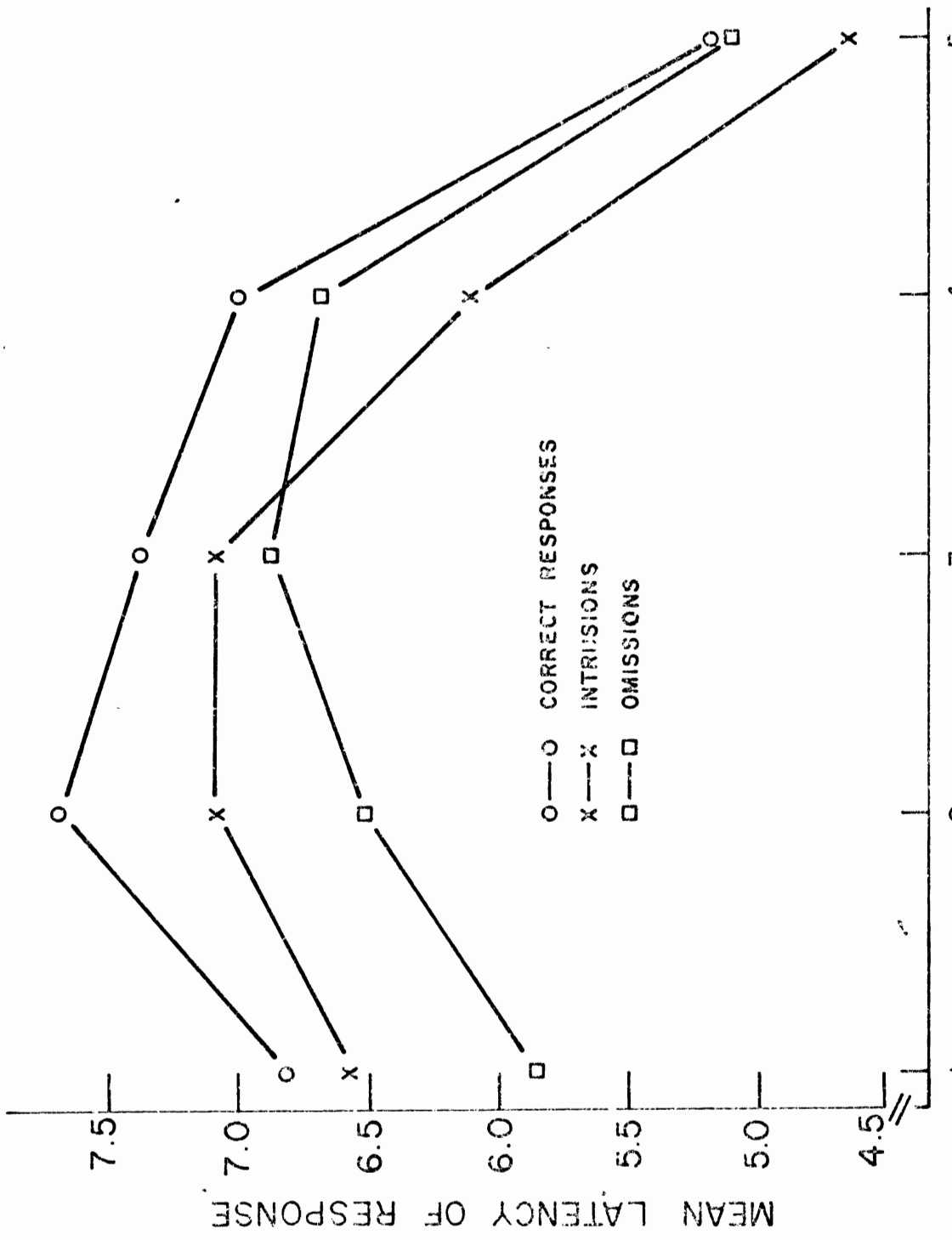

Fig. 7. Mean latency in seconds of associative strength ratings as a function of rating category for word pairs whose responses at recall were correct, intrusions, or omissions.

ratings of associative strength of word pairs during acquisition showed the same predictive relation to recall performance as that found by Arbuckle and Cuddy (1969). However, the associative strength ratings did not significantly differentiate between the CA and AC noun pair orders. Correctly recalled word pairs in every rating category were rated significantly more slowly than were those word pairs incorrectly recalled. Again, the presentation order of the noun pairs had no significant effect upon this relationship. Thus, no evidence was provided in this experiment to support predictions from Paivio's (1969) conceptual peg hypothesis that a C noun in the stimulus position leads to stronger associative links between C and A words than does a C noun in the response position. This lack of a presentation order effect agrees with the findings of Lockhart (1969b). The use of unequivocally abstract stimulus materials in the present experiment provides generality to the conclusion that the effect of concreteness is independent of the left-to-right reading order in which the pair is presented. Therefore, it would seem that Paivio must abandon his emphasis on forward associations in explaining the effects of concreteness via mediating imagery.

In contrast to the failure of presentation order alone to produce significant effects on any of the dependent measures, the concreteness of the test cue produced significant effects on several measures taken at recall. Cuing recall with the C noun produced a greater number of correct responses and intrusions, fewer omissions, and significantly longer latencies of confidence ratings for intrusions and omissions. However, there were no apparent differences in means and distributions of confidence ratings of correct responses and intrusions or in latencies of confidence ratings of correct responses as a result of the test cue used. The recall data were thus consistent with Lockhart's (1969b) findings of retrieval asymmetry for both correct responses and intrusions to the C cue. The present data, obtained with more sensitive recall measures and unambiguously abstract stimulus materials, firmly supports the conclusion that recall is dependent upon the concreteness of the test cue.

The only significant interaction of presentation order and test cue was in the number of correct responses. The number of correct responses given to each test cue varied significantly with the presentation order of the pair. However, this significant interaction did not seem

to be related to any qualitative or quantitative differences between CA and AC bonds. Rather, it appeared to result from the fact that forward associations (CA/C and AC/A) were recalled better than corresponding backward associations (AC/C and CA/A).

This interaction between presentation order and test cue was surprising in view of Lockhart's (1969b) failure to obtain a similar interaction. Both Lockhart's and the present experiments met the conditions laid down by Murdock (1966) for producing backward associations equal to forward associations. One procedural difference between Lockhart's and the present experiment might account for the difference in results: in the present experiment the recall cue was always presented on the left regardless of whether it was the right- or the left-hand member of the pair. If the shift in position of the right-hand member reduced its discriminability as a test cue, poorer performance in terms of correct responses would result for shifted cues and thus for backward associations (CA/A and AC/C). The confidence ratings contained some evidence of reduced discriminability for the responses in the CA/A and AC/C experimental conditions. As was shown in Figure 3, the mean ratings for correct responses and intrusions differed less for the CA/A and

AC/C conditions, indicating reduced discriminability, than they did for the CA/C and AC/A conditions, indicating greater discriminability.

The present experiment not only supported Lockhart's (1969a,b) general finding of a higher frequency of intrusions for C cues than for A cues, but also his particular finding of a proportionately higher frequency of extralist intrusions for C cues than for A cues. Lockhart reported equal numbers of extralist and intralist intrusions for adjective cues, but a proportionately greater number of extralist relative to intralist intrusions to the C cue. The present experiment reported significantly fewer extralist intrusions than intralist intrusions to A cues but equal numbers of extralist and intralist intrusions to the C cue. In spite of this apparent difference, the pattern of both sets of results is similar in showing that the C cue received proportionately more extralist intrusions than did the A cue. This suggests that, while possibilities for intralist response confusions for C cues are about equal to those for A cues, strong a priori C noun associations lead to many more extralist intrusions for the C cue. The A cue would seem to have fewer extralist possibilities for strong associations which might lead to intrusions.

Unlike Lockhart's (1969a) finding of superior discriminability with forced responding between correct responses and intrusions to the A cue, the results obtained by free responding in the present experiment showed no differences in the means and distributions of confidence ratings to correct responses and intrusions. If the greater number of omissions to the A cue under conditions of free responding become intrusions, rated 1, under conditions of forced responding, the number of incorrect responses rated 1, would be greater for the A cue than for the C cue. Therefore the results of Lockhart (1969a) and of the present experiment are not inconsistent and suggest that the criterion for decisions such as when to respond and the correctness of the response is the same for both A and C cues, but that the A cue more frequently provides too little information to warrant a response.

The latency of the confidence rating response contributed additional information concerning the effects of concreteness in PA learning. Since the means and distributions of the confidence rating values did not differ between C- and A-cued responses, it seems reasonable to assume that any differences in the latencies of these ratings reflect differences in the search time for responses

to C and A cues. In addition, the effect on latencies of using the C cue was the same for a search ending in an intrusion as it was for a search ending in an omission, where no overt confidence rating decision was required. Therefore, differences between confidence rating latencies for C-cued and A-cued responses were assumed to reflect a prolonged search time for C-cued searches ending in intrusions and omissions.

If the previous assumptions are correct, the following conclusions might be drawn from the results of the present experiment:

(a) the superior recall to the C cue reflects mediators that are in some sense stronger in linking C nouns to A nouns than in linking A nouns to C nouns;

(b) the greater number of intrusions, in particular, extralist intrusions, to the C cue reflects <u>a priori</u> associations that are in some sense stronger for the C cue than for the A cue;

(c) lack of differences in means and distributions of confidence ratings between the C-cued and A-cued correct responses and intrusions indicates no differences in discriminability

between correct responses and intrusions to C and A cues;

(d) lack of differences in latency of confidence rating for correct responses to C and A cues reflects equal search time for C- and A-cued correct responses;

(e) the longer latency of confidence ratings for intrusions and omissions to the C cue indicates a longer search time for C-cued intrusions and omissions.

The results upon which these conclusions are based would not have been predicted from Paivio's conceptual peg hypothesis. Paivio assumes that imaginal mediators are more effective than verbal mediators and attempts to explain better learning for C nouns by the fact that images occur with higher frequency and shorter latency for C nouns than for A nouns (Paivio, Yuille, and Madigan, 1968). If images are more effective mediators, the probability of a correct response would be higher for pairs linked by an image than for pairs linked by a verbal mediator. Paivio suggests that CA pairs are more likely to be imaginally encoded than AC pairs because of the position of the C noun. Both Lockhart's (1969) and the present findings have been unable to show an effect of

presentation order on the probability of correct responses. However, if imaginal mediators are predominantly selected for both AC and CA pairs, regardless of the position of the C noun, superior recall to the C cue could be explained in terms of the superior ability of the C noun to arouse the mediating image so selected.

Although superior recall for the C cue could be explained in this way, other results of the present experiment still could not be explained by mediating imagery. The mediating image should be aroused more quickly and more effectively by the C noun than by the A noun. However, the present results show that latency of rating of correct responses is no different for C and A nouns. In addition, the concept of stronger mediators produced by images, as hypothesized by Paivio, should lead to a higher frequency of high confidence ratings for correct responses to the C cue. This prediction was not supported by the findings of the present experiment. Therefore, even if Paivio's conceptual peg hypothesis were modified to predict predominantly imaginal mediators for both AC and CA pairs, an interpretation in terms of superior speed and strength of arousal of imaginal mediators still cannot account for all the effects of concreteness demonstrated in the present experiment.

Therefore, some mechanism other than mediating imagery must be proposed to account for superior recall to the C noun. It would seem that this mechanism must include a principle whereby the mediator is in some way more strongly linked to the C noun. One possible hypothesis is that the mediator has a higher probability of being in the sample of associations to the C cue at recall than to the A cue. This could occur if the associations to the C cue were more reliable than those to the A cue. Possibly the set of associations elicited by the C cue at recall contains a higher degree of overlap with the associations elicited at presentation than does the set elicited by the A cue. This kind of hypothesis is reminiscent of Martin's (1968) variable encoding hypothesis. The higher probability of sampling the mediator directly predicts the higher probability of correct responses to the C cue. Since no assumptions are made by a reliability hypothesis concerning the relative speed or quality of the association from the C or A cue to the mediator, the lack of differences in confidence ratings or latencies of confidence ratings for C- and A-cued correct responses could be explained.

If it could further be assumed that because there are more associations to the C cue, more associations are

examined in the search for the mediator at presentation and recall (c.f., the interference paradox of the associative probability hypothesis, Underwood and Schulz, 1960), both the higher frequency of response intrusions and longer latency of confidence ratings to intrusions and omissions could be explained.

An alternative possibility to the assumption that C cues have more reliable associations is provided by the findings of Marshall (1967). Marshall found that the high frequency responses to one member (the dominant member) of a pair of abstract nouns overlapped to a greater degree with the high frequency responses to the pair than did the high frequency responses to the other member of the pair (the subdominant member). If the C member of the mixed noun pair tends to be dominant with respect to the A member, the mediator chosen from the high frequency responses to the pair has a higher probability of also being a high frequency response to the C cue. Thus the mediator has a higher probability of being sampled when the C cue is used at recall than when the A cue is used. Therefore, with the assumption of a dominant C member, the present data could be explained in the same way as they are with an assumption of a higher reliability of the set of associations to the C noun.

One advantage of the assumptions necessary to the present interpretation is that they are directly testable. One disadvantage of theoretical interpretations dependent upon qualitative differences in the independent variable is that the concepts tend to be too poorly defined to permit direct experimental verification. It would seem advisable to exhaustively examine all possibilities of quantitative differences in the concreteness of nouns such as number and reliability of associations prior to invoking qualitative explanatory concepts such as imagery.

APPENDIX I

Instructions read to every S

There are two parts to this experiment. In the first part of this experiment you will be shown a series of paired words, one pair at a time, on the translucent screen in front of you. As soon as a pair appears on the screen you are to say the two words out loud so that I can hear you. For example, if the two words appearing on the screen are CALIFORNIA and AMIABLE you will say "CALIFORNIA" "AMIABLE", reading the words from left to right. Your task in this experiment is to associate the two words in your mind, that is, to perceive them as going together to create a whole, so that if I said "CALIFORNIA" to you, you would be able to tell me that the word "AMIABLE" completed the pair; or if I said "AMIABLE" to you, you would be able to tell me that the word "CALIFORNIA" completed the pair. You are then to rate how strongly you have been able to link the two words in your mind by pressing one of the five buttons on the table in front of you. The buttons, as you see, are numbered from one to five. Pressing button number

one indicates that the pair of words is weakly associated in your mind, while pressing button number five indicates the association is very strong, with the other buttons indicating degrees of strength in between. Feel free to use the entire range of numbers from one to five; at the same time, don't be concerned about how often you use a particular number as long as it is your true judgment. Work fairly quickly, but do not be careless in your ratings. When you press a button, the image on the screen will disappear, and a new pair of words will take its place ten seconds later. You will repeat the process I have just described for each of the 80 pairs of words as they appear on the screen.

Any Questions?

In the second part of the experiment you will be shown, in random order, one word from each of the 80 pairs which you have just seen. These single words will be projected one at a time on the screen, and for each word shown you are to say out loud first the word on the screen and then the word which you think was originally paired with it. You should then press one of the buttons numbered from one to five, this time to indicate how certain you are that your answer or response word is the correct one, from one, indicating not very certain, to five, indicating that you

are very certain. If you are sure you don't know, say "DON'T KNOW" and press button 1. When you press a button, the image on the screen will disappear, and a new word will take its place ten seconds later. You will repeat the process I have just described for each of the 80 words as they appear on the screen.

Any Questions?

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