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ABSTRACT

Subjects in an independent groups free learning experiment recalled list of low- or high-arousal words, matched for imagery and frequency and exposed randomly for 3 seconds and 9 seconds. Extrapolating neural consolidation theory to previous work on serial position effects led to the predictions that (1) arousal facilitates primacy; (2) arousal inhibits recency; (3) arousal facilitates primacy increasingly with a longer exposure time; (4) arousal inhibits recency less with a longer exposure time. It was also predicted that (5) increased exposure time facilitates primacy. Although arousal significantly facilitated recall over both exposure times, none of the predictions were supported. Several analyses suggested that the arousal effect was not a function of differential clustering within list types. The results were interpreted as consistent with the claim that word arousal facilitates recall primarily through an increase in autonomic, but not necessarily cortical, arousal. (Author)

FREE RECALL OF DIFFERENTIALLY AROUSING WORDS

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Two of the most recent reviews of the effect of arousal upon memory have presented conflicting evidence regarding the question of whether arousal inhibits or facilitates short-term retention (Weiner, 1966; Berlyne, 1967.) There seems to be substantial agreement from the studies reviewed that arousal facilitates long-term retention.

The equivocal nature of the research into the effect of arousal upon short-term retention has made it difficult to assess the validity of arousal theory. Much of the more recent work (cf. Berlyne, 1967) has employed Hebb's (1955) theory of reverberating neural circuits to explain the memorial effect of arousal. The 'action decrement' theory of Walker (1958) as summarized by Walker and Tarte (1963) provides one of the best descriptions of the above phenomena:

> "(1) The occurrence of any psychological event, such as an effort to learn an item of a paired-associate list, sets up an active perseverative trace process which persists for a considerable period of time. (2) The perseverative process has two important dynamic characteristics: (a) permanent memory is laid down during this active phase in a gradual fashion: (b) during the active period, there is a degree of temporary inhibition of recall, i.e., action decrement (this negative bias against repetition serves to protect the consolidating trace against disruption). (3) High arousal during the associative process wil result in a more intensely active process. The more intense activity will result in greater ultimate memory but greater temporary inhibition against recall" (p. 113).

Some of the arousal research in the area of verbal learning has employed emotionally toned words as a means of inducing arousal in recall experiments. In several studies high-arousal words have been recalled better than low-arousal words over the short-term (Schonpflug & Beike, 1964; Maltzman, Kantor & Langdon, 1966; Osborne 1972.) However, other studies using differentially

arousing lists of words have shown arousal to inhibit short-term recall (Kleinsmith & Kaplan 1963; Walker & Tarte, 1963).

Farley (1969) used the same words as Walker and Tarte (1963) in a free recall paradigm. The aim was to avoid the problem of presenting the arousal inducing words both at learning and recall as is the case in a paired-associate paradigm. Farley found that arousal facilitated recall over both the short (1.5 min.) and long-term (3 days).

The purpose of the present study is an attempt to clarify the contradictory findings regarding the effect of arousal upon retention by extrapolating arousal theory (cf. Walker, 1958) to a free recall paradigm as used by Glanzer and Cunitz (1966). These authors suggested that serial position curves are a function of primary and secondary memories by demonstrating that additional exposure time facilitates primacy while delay of recall inhibits recency.

If the passage of time is intimately involved in serial position effects and the effect of arousal upon recall, the following predictions can be made on the basis of neural consolidation theory: (i) Arousal facilitates primacy, (ii)arousal inhibits recency, (iii)arousal facilitates primacy increasingly with a longer exposure time. (iv)arousal inhibits recency less with a longer exposure time. Additionally, in accordance with Glanzer and Cunitz's findings it was hypothesized that (v) increased exposure time facilitates primacy.

Method

Design A 2 x 2 factorial independent groups design was used with Ss being randomly assigned to conditions. The factors were (a) low and high-arousing

Words (b) exposure times of 3 sec. and 9 sec. per word.

Word Lists. Two lists of twenty words each were selected from a list of 925 nouns (Paivio et al., 1968) so that the lists differed maximally on arousal but were equated for mean imagery and frequency (Thorndike-Lorge, 1944). The words were chosen for arousal on an a priori basis by the E but were subsequently rated for arousal on a seven point scale, using a procedure similar to that of Paivio et al. (1968), by 218 volunteers from an introductory Educational Psychology course at the University of Alberta. Almost without exception the ratings supported the earlier judgement of the E. Table 1 shows the arousal, imagery and frequency levels of the two lists. Both lists had relatively high imagery but low frequency levels.

Insert Table 1 about here

Procedure. All Ss were presented with a 20 page booklet with one word centered on each page. A blank page covered the first word. The booklets were approximately 8" x 2 1/2" in size. The same 40 random list orders, but with the appropriate words, were presented to Ss in each of the four conditions. The assignment of Ss to groups was also random. The four experimental conditions were run in groups as Ss appeared for the experiment. Before the experimental task all Ss were presented with a practice list of 20 relatively neutral, high frequency words and read the following instructions:

"This is a memory experiment. You will be given a booklet of 20 pages with one word on each page. Every time you hear a 'beep' on the tape, turn one page of the booklet and study the word on that page. After you have looked at all the words write down as many as you can recall on the sheet provided.

Place your booklet face down before starting recall. Remember, there are 20 words to recall. Do not turn the pages until you hear the 'beep'." A maximum of 3 min. was permitted for recall. Familiarity with page turning was an important result of this exercise. The procedure was repeated using the experimental materials.

Subjects. The Ss were 160 students from the University of Alberta who were paid $2 for participating.

Results and Discussion

The scoring criteria were the same as those used by Glanzer and Cunitz (1966). A two way analysis of variance (Arousal x Exposure time) was performed on the recall data. There were significant main effects for both factors. High-arousal words were recalled more than low-arousal words, $F(1,156) = 16.8$ $p < .001$. Words exposed for 9 sec. were recalled more than words exposed for 3 sec., $F(1,156) = 45.1$, $p < .001$. There was no interaction between these two factors.

Figure 1 shows the serial position curves for recall data in the four conditions. The lack of an interaction between arousal and exposure time is evident in the fairly uniform facilitation of recall by arousal over both exposure times. The serial position data appeared to be cleanest and most apparent over the first and last six items so these data for each S were analyzed in an Arousal x Exposure time x Serial position analysis of variance. These data confirmed the findings of the initial analysis. There was a significant arousal effect, $F(1,156) = 5.9$, $p < .02$; a significant exposure time effect, $F(1,156) = 27.9$, $p < .001$, and a significant serial position effect, $F(1,156) = 12.4$, $p < .001$. As can be seen from Figure 1, primacy was greater than recency for all conditions. There were no significant interactions.

Insert Figure 1 about here

Inspection of the words in Table 1 indicates reason to expect some associative and/or categorical clustering within the recall data. If this occured more often within the high-arousal than the low-arousal list it would be difficult to determine whether the facilitation of recall was caused by arousal or clustering. However, if this was a significant factor within a randomized design it should have distorted serial position curves. The curves in Figure 1, although noisy in parts, do not appear to be unusual.

In order to check upon the effect of clustering in the recall data it was hypothesized that a significant difference in the degree of clustering within low and high-arousal lists would produce markedly different structures when the recall scores of the two types of words were subjected to a principal components analysis and varimax rotation (Kaiser, 1958). Recall data were collapsed over exposure times for this purpose to produce low and high-arousal recall. Subsequent varimax rotations and eigen values are shown in Table 2. Using a criterion of an eigen value of one produced a nine factor solution accounting for 69% of the variance in each case. The eigen values of the respective components were also very close. This result suggests that clustering within either list was not significantly different and thus not responsible for the superior recall of high-arousal words. In addition Kuder-Richardson coefficients of internal consistency for low-arousal (.50) and high-arousal (.54) suggested no significant difference in the degree of clustering within the two sets of data.

Insert Table 2 about here

The question of relative clustering on the low and high-arousal word lists was further investigated by applying a recently developed test for the comparative assessment of multivariate association within independent samples (Hakstian, Osborne, and Skakun, 1974). The degree of multivariate association for low and high-arousal words was not significantly different, $W(2,158) = 1.06$. $p > .50$.

It was also hypothesized that the extent of differential clustering within the low and high-arousal lists should be indirectly reflected in the correlation of input with output order for the recall data. Table 4 shows the correlation of input and output order for each of the words used in the two lists for the two retention levels.

Insert Table 4 about here

To the extent that clustering occurred it should have produced lower correlations for the words involved. There appears to be no obvious difference in the number of lower coefficients for either low or high-arousal words. In fact the mean correlation coefficients for either list at both time intervals were not significantly different. The high-arousal words, policeman and revolver, had low correlations ($r < .10$) suggesting some clustering over the 3 sec. exposure time. However, the correlations for the same words were not as low over a 9 sec. exposure time. In fact, for high-arousal words in general low input-output correlations over 3 sec. were not repeated over 9 sec. This argues against clustering if one considers that greater exposure time probably allows more time for subjective organization.

The fact that there were slightly more lower correlations over 9 sec. than 3 sec. for both high and low-arousal words suggests that more

clustering took place over the longer exposure time. The low-arousal word list had more low correlations with an increase in exposure time. This was contrary to the suggestion of differential clustering in favor of the high-arousal list. In the low-arousal word list, jelly and toast appeared as a possible cluster with low correlations over 9 sec. Consistency of low correlations across exposure times was evident only for low-arousal words. The words appliance, caravan and harp had low stable correlations across both exposure times.

Although indirect, the input-output correlations for low and high-arousal words recalled produced no significant evidence of differential clustering within the low or high-arousal word lists.

Table 3 shows the mean percent recall scores for Arousal x Exposure time x Serial position. Although high-arousal primacy was greater than low-arousal primacy for both 3 sec. and 9 sec. exposure times the differences were not significant. These results failed to confirm hypotheses 1 and 2. Hypothesis 3 failed to gain support also. The superiority of high-arousal primacy over low-arousal primacy decreased with an increase in exposure time. This was probably due to the additional time available for rehearsal for both list types.

Insert Table 3 about here

Hypothesis 4 was also negatived by the fact that arousal facilitated recency as well as primacy. The failure to confirm the above hypotheses suggests that the facilitation of recall in this study is explicable in terms other than the neural consolidation hypothesis of arousal inhibiting short-term memory, unless the retention intervals involved were not short

enough. However, they were well within the limits of intervals used in other studies where arousal inhibited short-term recall (cf. Berlyne, 1967).

The collapsing of arousal conditions over exposure times showed that an increase in exposure time almost doubled the superiority of primacy over recency (5.6%, 11.0%). However, this finding was not statistically significant and may have been partly a function of a one trial forward recall strategy rather than the type of effect recorded by Glanzer and Cunitz (1966) where a repeated measures design was employed.

The use of a one trial procedure may also have been responsible for some of the variability shown in the serial position curves.

The failure to confirm the predictions based upon neural consolidation theory suggests that the facilitation of recall by word-arousal in this study is a function of autonomic rather than cortical arousal. The present author (Osborne, 1973) has shown that rated word-arousal correlated ($r = .37$) with Neuroticism but not with Extraversion, (a known correlate of cortical arousal). It seems that the emotionally engendered by words can affect retention without necessarily producing an increase in cortical arousal sufficient to inhibit memory.

The uniform facilitation of recall by arousal for both of the exposure times used in this experiment suggests that arousal does not necessarily inhibit short-term recall. This is consistent with some of the studies cited earlier.

The presence of a stronger primacy than recency effect for all conditions is uncharacteristic of free recall studies (cf. Hall, 1971, p. 182). This is probably a result of the S having only one learning trial. As Paivio (1971, p. 227) points out, in a multiple learning trial free

recall experiment a stronger primacy effect on trial one yields to a stronger recency effect on trial two. This is attributed to the S initially adopting a forward recall strategy then changing to backward recall on subsequent trials to produce a stronger recency effect. This appears to be the probable reason for greater primacy in the present study.

An implication of this hypothesis is that categorical clustering may have been minimized if Ss were concentrating on a forward recall strategy. The correlation of input and output order shown in Table however is more consistent with a retrieval strategy of recalling the more recently presented items first and the earlier presented items later. This apparent conflict may be the result of Ss basically employing a recency - primacy retrieval strategy modified by a tendency towards forwards recall.

The facilitation of recall by arousal in this study, whilst controlling the word attributes of frequency and imagery, suggests that word-arousal is a word attribute which can affect memory in a way not readily explicable in terms of neural consolidation theory. The position for consolidation theory could possibly be rescued if one hypothesized that the levels of arousal employed in the two lists were low and moderate. By invoking the Hebbian notion (Hebb, 1955) of an inverted U shaped function between arousal and performance it can be claimed that the increase in arousal was optimal and therefore produced uniform facilitation across the two exposure times.

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TABLE 1

Word Attribute Values for High and Low Arousal Word Lists

High Arousal				Low Arousal			
	Arousal	Imagery	Frequency		Arousal	Imagery	Frequency
skull	4.46	6.47	13	ankle	3.54	6.77	21
alcohol	4.97	6.47	15	banner	3.34	5.93	23
noose	4.59	6.23	2	beverage	4.15	5.87	8
morgue	4.78	6.63	2	appliance	2.83	5.73	7
bosom	5.00	6.57	27	caravan	3.64	5.83	7
jail	4.58	6.43	22	bungalow	3.75	6.13	8
snake	4.94	6.90	28	fiord	3.62	5.70	2
agony	5.24	5.43	24	hamlet	3.64	5.87	15
bacteria	3.52	5.33	8	utensil	2.77	5.47	8
disaster	5.43	5.10	23	harp	4.04	6.60	20
glutton	4.32	5.77	2	hurdle	3.86	6.33	2
volcano	5.31	6.63	14	instructor	3.79	5.70	8
drunkard	4.56	5.38	5	jelly	3.19	6.40	19
hurricane	5.52	5.97	7	juggler	3.64	6.10	1
avalanche	5.54	6.27	4	leaflet	2.50	5.47	7
panic	5.46	5.33	19	cigar	3.41	6.80	16
revolver	5.06	6.70	9	settler	3.09	5.40	20
ghost	5.00	5.37	2	speaker	3.47	5.67	25
brute	4.60	5.17	14	toast	3.53	6.57	20
policeman	4.55	6.70	22	tank	3.60	6.23	19
$\bar{X}$	4.87	6.04	13.09		3.47	6.02	12.80
S.D.	.49	.61	9.03		.42	.43	7.72

TABLE 2

Varimax Rotated Matrices for

Low and High-Arousal Words (Decimals omitted)

	Factors								
	I	II	III	IV	V	VI	VII	VIII	IX
Eigen Value	2.57	1.90	1.62	1.57	1.44	1.34	1.21	1.12	1.03
Low-Arousal Words									
ankle	76	07	13	04	02	01	07	04	10
banner	34	21	22	35	41	17	17	07	02
beverage	16	36	37	22	10	05	19	04	40
appliance	12	10	11	03	03	19	00	84	04
caravan	09	01	01	08	81	06	07	04	22
bungalow	16	06	57	06	38	11	15	13	21
fiord	06	18	29	23	09	30	11	53	14
hamlet	05	04	00	88	05	04	02	07	10
utensil	66	13	07	03	02	17	16	27	22
harp	17	18	64	40	01	00	25	07	03
hurdle	33	41	04	05	55	03	14	35	13
instructor	33	39	01	37	25	27	26	00	25
jelly	23	11	24	39	12	12	54	09	04
juggler	10	11	03	13	13	05	05	03	88
leaflet	67	02	00	07	09	35	10	20	09
cigar	11	08	65	22	17	00	06	13	06
settler	10	68	04	02	23	35	08	02	05
speaker	09	05	04	02	01	86	13	08	01
toast	05	09	09	07	06	17	84	01	03
tank	23	78	06	05	11	21	12	02	06
Eigen Value	2.44	1.94	1.66	1.60	1.38	1.33	1.23	1.15	1.03
High-Arousal Words									
skull	03	06	14	03	00	06	89	02	02
alcohol	12	76	07	02	02	13	02	02	05
noose	65	13	15	35	18	13	05	11	19
morgue	69	23	01	18	05	05	10	19	18
bosom	03	08	75	09	13	02	08	19	25
jail	16	03	04	10	14	14	17	28	69
snake	16	08	27	08	73	09	05	09	09
agony	22	02	23	15	67	05	00	00	03
bacteria	23	15	00	25	38	12	35	54	09
disaster	00	01	10	15	12	04	07	79	03
glutton	28	09	41	00	34	11	45	18	09
volcano	15	05	13	72	09	16	04	15	00
drunkard	10	70	22	02	15	08	17	17	18
hurricane	03	03	00	06	04	84	09	06	10
avalanche	14	69	03	09	08	06	02	16	26
panic	03	20	08	05	00	67	08	20	18
revolver	75	23	14	02	25	16	19	00	11
ghost	08	02	04	09	04	32	33	22	61
brute	10	02	76	12	15	05	08	09	34
policeman	16	02	16	81	11	12	02	02	00

TABLE 3

Mean Per Cent Recall Scores for Arousal x Exposure Time x Serial Position

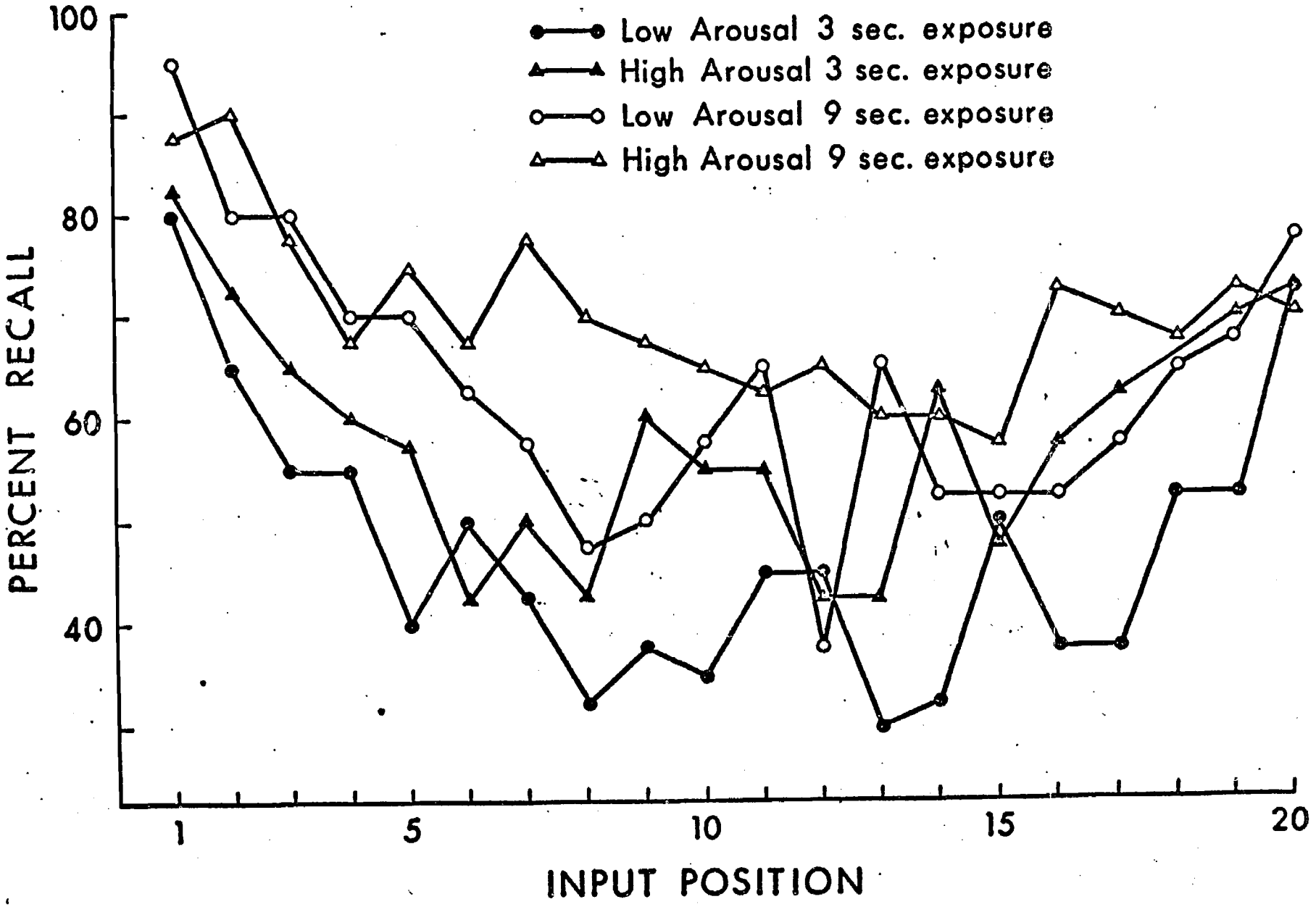
Exposure Time	Primacy		Recency	
	Low-Arousal	High-Arousal	Low-Arousal	High-Arousal
3 sec.	57.5	63.7	50.0	60.0
9 sec.	75.8	77.5	62.0	69.3

TABLE 4

Input-Output Correlations for Low and

High-Arousal Words Recalled

Low Arousal Words	Exposure Times 3 sec.	9 sec.	High Arousal Words	Exposure Times 3 sec.	9 sec.
ankle	.01	-.27	skull	-.31	.07
banner	-.41	.02	alcohol	.04	.14
beverage	-.66	-.12	noose	-.36	-.29
appliance	-.05	.02	morgue	-.27	.33
caravan	-.08	.00	bosom	-.26	.07
bungalow	-.08	-.19	jail	-.16	-.14
fiord	.04	-.14	snake	-.07	.37
hamlet	.14	-.17	agony	-.12	-.28
utensil	-.34	-.27	bacteria	-.13	.01
harp	.01	.00	disaster	-.22	.32
hurdle	-.34	.34	glutton	.14	.37
instructor	-.33	-.03	volcano	-.18	-.40
jelly	-.16	-.05	drunkard	-.37	-.28
juggler	-.35	.09	hurricane	-.20	.09
leaflet	-.34	-.01	avalanche	-.22	.12
cigar	-.15	.08	panic	-.60	.14
settler	-.40	-.33	revolver	-.08	-.12
speaker	.24	.31	ghost	-.11	.27
toast	-.48	-.07	brute	-.27	.09
tank	-.22	-.01	policeman	.03	.23
$\bar{X}$	-.23	-.08		-.20	.14


Low Arousal 3 sec. exposure
High Arousal 3 sec. exposure
Low Arousal 9 sec. exposure
High Arousal 9 sec. exposure
PERCENT RECALL
100
80
60
40
1
5
10
15
20
INPUT POSITION

Abstract

Subjects in an independent groups free learning experiment recalled lists of low or high-arousal words, matched for imagery and frequency and exposed randomly for 3 sec. and 9 sec. Extrapolating neural consolidation theory to previous work on serial position effects led to the predictions that (i) arousal facilitates primacy (ii) arousal inhibits recency (iii) arousal facilitates primacy increasingly with a longer exposure time, (iv) arousal inhibits recency less with a longer exposure time. It was also predicted that (v) increased exposure time facilitates primacy. Although arousal significantly facilitated recall over both exposure times none of the predictions were supported. Several analyses suggested that the arousal effect was not a function of differential clustering within list types. The results were interpreted as consistent with the claim that word-arousal facilitates recall primarily through an increase in autonomic, but not necessarily cortical, arousal.