Delay of auditory input in "simultaneous" auditory and visual short-term memory*

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In an attempt to facilitate visual recall when material is presented under bisensory simultaneous conditions (i.e., visual and auditory stimuli are presented together), auditory material was delayed up to ¼ sec relative to the onset of the visual material. Visual recall, however, remained stable across the auditory delays, suggesting a limitation in the visual system beyond that associated with the simultaneous occurrence of auditory material.

Previous short-term memory experiments have consistently demonstrated superior auditory recall over visual recall with alphanumeric material (Dornbush, 1968; Margrain, 1967). This difference is most obvious in bisensory situations involving the simultaneous presentation of different stimuli in both auditory and visual modalities. Further, when rate of presentation is varied, the two modalities operate independently of each other. That is, bisensorily, the visual and auditory curves are similar to those curves obtained when each modality is stimulated separately; the typical decrement in auditory recall is obtained with decreasing or slowing rate, whereas visual recall increases with decreasing rate.

Less clearcut, however, is the explanation for these differences in auditory and visual recall. The most popular explanation concerns itself with the nature of rehearsal—specifically, the translation of visual items into auditory items. Both auditory and visual stimuli are thought to be transformed into auditory subvocalizations (Broadbent, 1963; Wickelgren, 1965). However, auditory material when subvocalized is auditory; visual material when subvocalized must be transformed or translated into auditory subvocalizations. Thus, it is possible that items are lost in the translation of the visual material, particularly at the fastest rates. However, as the interval between successive visual items increases (i.e., as the

rate slows), there is increased opportunity, which approaches the auditory level, to translate and rehearse the visual materials. It is also probable that auditory material is processed first so that when visual material is finally attended to and subvocalized, this may be done from a fading trace.

Several attempts have been made to alter the shape of the visual curve and the amount recalled in that modality. For example, one such attempt involved "shadowing" or vocalization at presentation of one of the two modalities (Dornbush, 1968); another attempt directed S's attention to one modality rather than the other (Dornbush, 1969, 1970). None of these manipulations have been overwhelmingly successful in achieving their aim.

In the above manipulations, S's task or set was altered; in the present experiment, in yet another attempt to increase visual recall, the stimulus material was altered. More specifically, the onset of auditory items was delayed relative to the onset of visual items. It was thought that this procedure might allow the visual materials to be processed first and thereby allow for the more complex processing procedures associated with that modality. Thus, three auditory "delay" intervals were employed: auditory stimuli were presented (1) simultaneously, i.e., zero frames, (2) .125 sec, i.e., three frames, and (3) .250 sec, i.e., six frames after the onset of the visual stimuli.

METHOD

Subjects

One hundred and seventy-four undergraduates in introductory psychology courses served as Ss. There were 58 Ss in each of the three delay groups.

Apparatus and Materials

Materials were presented on 16-mm film (24 frames/second) with synchronous sound track by means of a Bell and Howell projector. Speech recordings were spliced into the film so that each utterance of a stimulus item commenced within the first half frame of its associated visual stimulus (± 21 msec) for the "0-delay" group. For the other two delay groups, the total sound track was shifted the appropriate number of frames: three for the .125-sec delay and six for the .250-sec delay.

Visual materials were made by Letraset instant black letters, exposed singly on white 8½ x 11 in. cards, which were then filmed and appropriately edited. The interstimulus and interlist intervals for visually presented material consisted of clear leader slightly less bright than the stimulus sequence, thus minimizing the negative afterimage.

An attempt was made to balance the intensity of the materials on the two channels by subjective judgments of equality. However, it seemed that the intensities might not be the crucial variable so long as the material was clearly and easily discriminable (Margrain, 1967; Sperling, 1963).

The stimulus materials consisted entirely of digits. Where items had to be employed twice, this was done within rather than across modalities. Each list contained six items. There were 18 pairs of lists (36 lists), 6 pairs of lists at each of three rates of presentation.

Visual items were presented for .5 sec (12 frames); the auditory items averaged 10 frames or .42 sec in duration. The three rates employed were: (1) one pair/.5 sec, no interstimulus interval (fast); (2) one pair/second, .5-sec interstimulus interval (medium); and (3) one pair/2 sec, 1.5-sec interstimulus interval (slow). There was a

Table 1
Means and Standard Deviations for Delay by Modality by Order by Rate

		Means and Standard Deviations for Delay by Modality by Order by Rate											
		Auditory						Visual					
		First			Second			First			Second		
Modality	Order	F	M	S	F	M	S	F	M	S	F	M	S
Rate													
0-Sec Delay	Mean	3.83	3.61	3.57	3.48	2.84	3.11	1.92	2.06	2.52	1.13	1.24	1.36
	SD	1.32	1.27	1.41	1.35	1.38	1.29	1.20	1.31	.89	.87	1.07	1.19
.125-Sec Delay	Mean	3.97	3.50	3.09	3.10	2.92	2.87	1.94	2.26	2.11	1.27	1.35	1.40
	SD	1.16	1.12	1.38	1.31	1.25	1.30	1.19	1.01	1.31	.87	1.13	.98
.250-Sec Delay	Mean	3.48	3.29	3.19	2.83	2.57	2.41	1.93	2.29	2.40	1.08	1.09	1.10
	SD	1.28	1.31	1.32	1.28	1.09	1.20	.98	1.26	1.36	.82	1.16	.95

Table 2
Summary of Four-Way Analysis of Variance

Source	Source	DF	MS	F	p
Between Ss	747.94	123			
A ("Delay")	23.19	2	11.58	2.73	
Ss Within Groups	724.76	171	4.23		
Within Ss	3855.92	1914			
B (Modality)	1194.84	1	1194.84	256.40	.001
AB	11.42	2	5.71	1.22	
B x Ss Within Groups	797.12	171	4.66		
C (Order)	302.88	1	302.88	180.28	.001
AC	9.83	2	4.92	2.93	
C x Ss Within Groups	288.59	171	1.68		
D (Rate)	2.49	2	1.24	1.20	
AD	9.67	4	2.42	2.35	
D x Ss Within Groups	354.47	342	1.03		
BC	16.69	1	16.69	104.31	.001
ABC	.03	2	.02		
BC x Ss Within Groups	28.06	171	.16		
BD	41.47	2	20.74	34.00	.001
ABD	.87	4	.22		
BD x Ss Within Groups	206.94	342	.61		
CD	5.55	2	2.77	3.51	.05
ACD	1.37	4	.34		
CD x Ss Within Groups	271.85	342	.79		
BCD	2.03	2	1.01	1.14	
ABCD	6.39	4	1.59	1.80	
BCD x Ss Within Groups	303.35	342	.88		

20-sec interlist interval, with 15 sec for recall and a ready signal given 5 sec before the start of each list. All lists at one rate were presented before the lists at the other rates in the fast, medium, slow order.

Administration

Ss in each group were run as a group in a large auditorium with a projection booth. They were centrally seated so that no S viewed the screen at an extreme angle. All Ss were given general short-term memory instructions with emphasis placed on the necessity of correct serial order of items in written response. The word "auditory" or "visual," indicating the modality to be reported first was spoken immediately after the last item in each list; half of the lists were followed by "auditory" and half by "visual" in prearranged random order.

RESULTS

The data for each S for each sequence of six items were scored according to the accuracy of responses both in nature and location, i.e., the item had to be in its proper serial position; scores ranged from 0 to 6.

Average scores for each condition are shown in Table 1, from which all interactions and main effects can be reconstructed. A four-way analysis of variance was applied to the data and a summary is shown in Table 2.

It can be seen from Table 2 that the main effects of modality and order of report were significant: as typically obtained, more auditory items were recalled than visual, and the channel reported first was reported best. Additionally, the following interactions were significant: Order by Rate, Modality by Order, and Modality by Rate.

Most relevant to this experiment is the Modality by Rate interaction and the failure to alter its nature. That is, the decrease in auditory recall was obtained, while the visual recall increased with decreasing rate—the integrity of each modality was maintained. Further, none of the effects involving the delay variable were significant.

DISCUSSION

The results indicate that recall in the visual modality remains stable across the three delays; auditory recall, however, shows a tendency, though not significant, to decrease with greater delay of onset. This stability of visual recall and the failure to alter the shape of the curve suggests some limitation of the visual system beyond that associated with the simultaneous occurrence of auditory items. Such a suggestion gains support from visual-recall data (Dornbush, 1967) collected under ordinary short-term memory conditions (i.e., not bisensory).

More specifically, when each modality is tested separately, visual-recall performance with verbal material is significantly less than auditory recall and also differs as a function of rate of presentation. Other things being equal, there is no basis to expect that recall in the two modalities would not be similar. In fact, as mentioned, it is not.

Further support comes from "shadowing" experiments. Under bisensory conditions, when S is requested to "shadow" the visual materials, the amount recalled increases, though not to the auditory level, but again the shape of the visual curve as a function of rate of presentation does not change (Dornbush, 1968).

Thus, it would seem that there is some limitation in the system, which could be a learned phenomenon or peculiar to the modality, which is of primary relevance. Recall is then further limited by the simultaneous occurrence of auditory items. Importantly, however, the simultaneous occurrence of auditory material does not cause S to alter the manner in which he processes or stores visual material. Rather, the characteristics of visual recall, i.e., greater recall with slower rate, are present in the bisensory situation.

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