Journal of Experimental Psychology
1970, Vol. 83, No. 1, 32–39

RETROACTIVE INTERFERENCE IN SHORT-TERM RECOGNITION MEMORY FOR PITCH [1]

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The present studies were carried out to investigate the effects of different retroactive stimuli on pitch discrimination in a short-term recognition memory task. Tones, Gaussian noise, and "blank" stimuli were employed in the retroactive (interference) interval. The effects of different stimuli in the interference interval are highly dependent on the strategies of *S*. Tones or noise in the interference (I) interval produce more forgetting than blank I intervals. This result cannot be attributed to the fact that *S*s may have rehearsed or hummed the tone during the blank I interval. Therefore, the decrease in accuracy of perceptual memory over time with filled I intervals was attributed to interference rather than decay. A storage-forgetting model of perceptual memory described the quantitative results accurately.

Discrimination performance can be studied by a matching procedure (Sorkin, 1962) in which the task of *S* is simply to state, after two successive signal presentations, whether the signals were the same or different. An extension of this paradigm is the psychophysical method sometimes called "delayed paired comparison." In this task, the standard (S) and comparison (C) stimuli are not presented in immediate temporal succession, and the interval separating the S and C presentations is the interference (I) interval. Therefore, both discrimination and recognition memory are involved in the "delayed comparison" task. Also, if the I interval is relatively short, we can say that the task is a short-term recognition memory (STRM) experiment. This method has been employed successfully in the study of nonverbal or perceptual memory (Kinchla & Smyzer, 1967; Wickelgren, 1966b).

The present study investigated pitch discrimination in an STRM task employing different stimuli in the I interval. First, the results were used to test a storage-forgetting model of perceptual memory. Second, the parameter values of the model under the different I stimulus conditions were employed to indicate whether forgetting in the present task was due to decay or interference of the memory trace.

Previous to Wickelgren's (1966b) study of STRM for pitch, *E*s usually employed "higher" and "lower" response alternatives and used the difference limen (DL) as a measure of performance (Woodworth & Schlosberg, 1954, Ch. 8). Experiments on delayed comparison of pitch have shown that pitch discrimination usually decreases as the duration of the I interval is increased (Bachem, 1954; Wolfe, 1886). For example, Harris (1952) found no decrease in accuracy with a .1- to 1-sec. increase in the duration of the I interval. However, he found an overall linear increase in the DL with increases of 3, 7, and 15 sec. in the I interval. The decrease in accuracy over time is reflected by the increase in the DL. Other early studies of memory for pitch either give insufficient information concerning the decrease in the accuracy of memory over time or show such variability that the exact nature of the forgetting curve is difficult to discern (Koester, 1945; Postman, 1946).

Studies finding no decrease in pitch discrimination with increases in the I interval have employed only one S stimulus (i.e.,

[1] This research was supported in part by a National Aeronautics and Space Administration Predoctoral Fellowship Grant NSG(T)-137 awarded to the author at the University of Massachusetts. The author is grateful to his advisor, John Moore, and the members of his dissertation committee, Jerry Myers and Stanley Moss, for their helpful contributions throughout all phases of this study.

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Anderson, 1914; Irwin, 1937). As pointed out by Harris (1952), long-term memory (LTM) for the S tone would increase over training and could possibly eliminate any STM deficit caused by increasing the I interval. Therefore, studies of STRM should try to reduce any LTM for the S stimulus by employing a sufficient number of different S stimuli.

The experimental evidence to date indicates that STRM for pitch decreases with increases in the I interval duration. However, the nature of the forgetting process over time is not known since the effect of different retroactive stimuli on memory for pitch has not been investigated. That is, studies of memory for pitch have usually employed an empty or blank interval as the I interval. Wickelgren (1966b), investigating STRM for pitch, did present a tone during the I interval, but one assumed to be psychophysically distinct from the S and C tones. Thus, decreases in STRM of the S tone with increases in the duration of the I tone could hopefully be attributed to a relatively pure decay effect. The results indicated that when the value d', from the theory of signal detection, is used as a measure of trace strength, an exponential decrease in STRM over time seemed to describe the data accurately.

It seems likely that STRM for pitch over time would be highly dependent upon the I interval stimulus. For example, the amount of retroactive interference found in memory for letters is positively related to the phonemic similarity of the interfering letters to the letters to be recalled (Wickelgren, 1966a). Therefore, the present study attempted to assess the decrease in accuracy of recognition memory for pitch while varying the psychophysical similarity of the I stimulus to the S and C tones. The present experiments employed Gaussian noise or tones in the I interval as well as "blank" intervals. Furthermore, the I tones employed differed with respect to their psychophysical similarity to the S and C tones. That is, I tones were used that differed from the S tone by as little as 10 Hz. and as much as 90 Hz. A highly distinctive I tone (90-Hz. difference) was also used in the Wickelgren (1966b) study, in which forgetting might be attributed to a relatively pure decay effect, free of interference.

It is possible that a psychophysically distinctive stimulus in the I interval does not justify the assumption that the observed decrease in memory over time is due to a pure decay effect. The results of the present study may indicate that the decrease of memory for pitch depends on the I stimulus, even though it is psychophysically different from the S and C tones. For example, the rate of forgetting may be larger for an I tone that is 90 Hz. higher than the S tone than one 50 Hz. higher than the S tone. The size of the step in hertz of the S to I tone may affect both pitch discrimination and forgetting. The view of recognition memory presented here is that this step is an important factor in STRM for pitch.

A storage-forgetting model.—At first glance, a theory of STRM for pitch based on consolidation, generalization, and decay of memory strength seems sufficient to describe the results of the proposed experiments (e.g., Wickelgren, 1966b). This theory postulates that presentation of an S tone increases not only the strength of a memory trace of that tone, but also psychophysically similar tones as well. The increase in strength or consolidation of the memory traces of the similar tones is positively related to the psychophysical similarity of the tones to the S tone. Also, the trace strength increases with increases in the tone duration. This assumption is similar to Wickelgren's (1966b) assumption of linear consolidation during presentation of the S tone.

During the I tone interval, Wickelgren (1966b, 1969) proposes a pure exponential decay process of S tone memory strength since he assumes that the I stimulus is not affecting the memory trace of the S tone. According to this decay assumption, the rate of forgetting over time should be independent of the I stimulus. On the other hand, the theory proposed here assumes that I stimuli actively affect the memory trace of the S tone. For example, the sensory traces of the adjacent tones built up by the I tone might have a cueing effect on STRM for the S tone. A similar I tone would then give *S*s a perceptual anchor or comparison that can be employed to judge the difference between the S and C tones. Thus, a psychophysically similar I tone may facilitate recognition memory of the S tone. On the other hand, *S*s may try to ignore the I stimulus and a similar I tone might interfere with pitch discrimination.

The present theory assumes that memory for pitch involves two processes: storage of the stimulus event and the decrease of the sensory trace over time. The parameters of the theory reflecting these processes enable us to see how they are affected under different experimental conditions. For example, the parameter corresponding to forgetting can indicate how the decrease in memory over time differs with different stimuli in the I interval.

The theory is a strength theory since it determines *S*'s response with a probability of one from the possible values of memory strength (Wickelgren, 1968). The measure of memory strength employed is d', the difference in trace strength between C tones equal (C = S) and unequal (C ≠ S) to the S tone.

Presentation of the S tone increases the trace strength of that tone to some value t, and of a similar tone to some proportion of t. The amount of trace strength generalized to other tones is positively related to the similarity of the tones to the S tone. For example, after the S tone presentation, a tone 10 Hz. lower than the S tone will have more trace strength than a tone 20 Hz. lower than the S tone. At the presentation of the C tone, *S* searches in memory for the trace of that particular C tone. If the trace strength, t, of the C tone exceeds some criterion k, *S* will report "same." That is,

$$P(\text{same}|t) = P(s|t) = P(t > k). \quad [1]$$

Assume that t_s and t_e are the trace strengths in memory of the equal and unequal C tones, respectively. In the present study, a correct recognition, $P(s|t_s)$, is defined as *S* responding "same" on a trial where C = S. An incorrect recognition, $P(s|t_e)$, is defined as *S* responding "same" on a trial where C ≠ S. The relationship between correct and incorrect recognition probabilities is derived in a manner similar to that of Wickelgren and Norman (1966). Therefore, memory strength (d') is defined as the difference between the means of the t_s and t_e normal distributions and will have a standard deviation of one.

In the present study, the unequal C tone was always 10 or 20 Hz. lower than the S tone. Therefore, the difference in memory strengths of the C = S and C ≠ S tones is given by the following equation:

$$d(\text{S}, \text{S} - x, \text{I}, n) = t_s - t_e, \quad [2]$$

where $d(\text{S}, \text{S} - x, \text{I}, n)$ is the predicted difference in memory strength of an equal C tone of S Hz. and an unequal C tone of S − x Hz., given an I stimulus of value I and an I duration of n sec. The following derivations will be determined for $d(\cdot)$, a measure of *relative* memory strength independent of k, the criterion value.

The memory strength stored at the S tone presentation is dependent on pretrial events, duration of the S tone, and the I stimulus. Since pretrial events (i.e, events preceding the S tone presentation) and duration of the S tone were not systematically varied in the present study, they are not considered here. The discrimination and sensory storage of the S tone can be represented as a variable Δ so that

$$d(\text{S}, \text{S} - x, \text{I}) = \Delta_x, \quad [3]$$

where $d(\text{S}, \text{S} - x, \text{I})$ is the difference in memory strength of an equal C tone of S Hz. and an unequal C tone of S − x Hz., given an I stimulus of value I. Furthermore, the relative trace strength stored is dependent on the difference between the equal and unequal C tones so that

$$d(\text{S}, \text{S} - x) = \frac{\Delta_x}{\Delta_y}[d(\text{S}, \text{S} - y)]. \quad [4]$$

Hence, for a given equal C tone of S Hz., the relative trace strength stored with an unequal C tone of S − x Hz. is some constant times the relative trace strength stored with an unequal C tone of S − y Hz.

We now assume that after storage there is an immediate exponential decrease in the strength of the trace that acts to decrease the stored trace to some proportion, ϕ, of its strength. That is, after an I interval duration of n sec.:

$$d(\mathrm{S}, \mathrm{S}-x, \mathrm{I}, n) = \phi^n \Delta_x, \; 0 \leq \phi \leq 1, \quad [5]$$

where ϕ is equal to the decrement every second. The value ϕ is not independent of the I stimulus. As mentioned previously, some I stimuli may produce faster forgetting (smaller ϕ) than other stimuli. Blank I intervals should not interfere with the perceptual trace of the S tone, and any observed decrease in memory over time might be attributed to a pure decay of the sensory trace.

The value of Δ_x can be thought of as an index of perceptual storage. The value ϕ is an index of the magnitude of the decrease over time of the memory trace. These two parameters reflect the psychological processes postulated by the present theory, perceptual storage and forgetting.

Method

Experiment I

Subjects.—The *S*s were four female students attending the University of Massachusetts. They were paid \$1.50/hr for participation in the experiment.

Apparatus.—Two push-button audio oscillators (Hewlett Packard Model 241A) and a noise generator (Grason-Stadler Model 455c) were used to produce the pure tones and noise, respectively. All time intervals were controlled by interval timers (Hunter Model 100-C). The stimuli were presented over matched headphones. The intensity of the tones was 80 db. SPL. The loudness of the noise was subjectively determined by *E* to equal that of the tones.

Design.—Three S tones (810, 820, and 830 Hz.), three I tone durations (1, 2, and 4 sec.), four I stimuli (noise, S + 10, S + 50, and S + 90 Hz.), and two C − S differences (0 and −10 Hz.) were factorially combined. The 24 possible conditions of S Tones × I Stimuli × C − S Differences were randomized within a block of 72 trials, with one block at one of the three possible I tone durations per session with about 6 sessions per day. Seven different sessions were presented, with 4 sessions replicated seven times and 3 sessions replicated eight times. The data from the first session were ignored, leaving a total of 51 sessions (17 at each I tone duration) for data analysis. Fifty observations were recorded for each *S* under each of the 72 conditions.

Procedure.—The onset of the S tone started a trial. The S tone lasted 1 sec. and was followed immediately by an I stimulus lasting 1, 2, or 4 sec. The C tone followed the I stimulus and lasted 1 sec., followed by a 5 sec. period in which *S*s reported whether the C tone was "same" or "different" from the S tone and rated their confidence in the decision on a scale from "1" (least confident) to "3" (most confident). The time between onset of Trial n and Trial $n+1$ was 15 sec., giving a blank interval of 7–12 sec. before each trial. It was assumed that this interval was sufficient to eliminate any proactive interference from preceding tones and, therefore, any possible sequential effects due to signal values of previous trials. Also, if this assumption were not met, the random presentation of events would have presumably balanced out the sequential effects.

Experiment II

Subjects.—The *S*s were 50 University of Massachusetts undergraduates fulfilling an introductory psychology course requirement.

Apparatus.—The experimental equipment employed in Exp. I was used to record the stimuli on tape. The *S*s were run in two groups, and the tapes were played at a normal listening intensity over a speaker at the front of the room.

Design.—Three S tones (820, 840, and 860 Hz.), three I durations (1, 2, and 4 sec.), four I stimuli (blank, noise, S + 20, and S + 90 Hz.), and two C − S differences (S = C and S ≠ C) were factorially combined. The 72 possible conditions were randomized within each block of 72 trials. Two tapes of 108 trials each were recorded. Each tape was replicated once, giving a total of 432 trials for each *S*. The results were pooled over S tone frequency so that 18 observations were recorded for each *S* under each of the 24 conditions.

The two groups of 25 *S*s each differed with respect to the unequal C tone frequency. The *S*s under the "easy" condition heard unequal C tones that were 20 Hz. lower than the S tone, whereas *S*s given the difficult condition heard unequal C tones that were 10 Hz. lower than the S tone.

Procedure.—The same procedure as Exp. I was employed, with the exception that a five-point rating scale was employed.

Results

The statistical analyses of Exp. I and II are presented in detail elsewhere (Massaro, 1968). The variables of interest (I stimulus and duration) were statistically significant. For our purposes, it will be sufficient to analyze the results in terms of the parameters of the theory.

For tests of the models, the observed d' values were computed by first pooling the correct and incorrect recognition probabilities over *S*s and S tone frequency. The respective d' values were determined by subtracting the Z transformation of the incorrect recognition probability from the Z transformation of the correct recognition probability at each experimental condition.

The model does not predict response probabilities directly, but rather the relative memory strength (d') between the equal and unequal C tones. Therefore, the predicted values of d' were determined by estimating the parameters using a least-squares criterion between observed and predicted values of d'. To determine the goodness of fit of a model, a chi-square value was computed by searching for correct and incorrect recognition probabilities that corresponded to the predicted d' values and minimized the chi-square value between observed and predicted recognition probabilities. The number of degrees of freedom was found by taking the number of independent conditions and subtracting the number of parameters estimated from the data.

Experiment I

This study had four possible I stimulus values and three I interval durations. Since the data were pooled over *S*s and S tone frequency, there were 600 observations for each observed correct and incorrect recognition probability.

Equation 6 gives the predicted memory strength after an I stimulus of n sec.:

$$d(\mathrm{I},\ n) = \phi^n \Delta. \qquad [6]$$

Since Δ and ϕ are dependent on the value

TABLE 1

OBSERVED (OBS) AND PREDICTED (PRE) VALUES OF d' IN EXP. I AS A FUNCTION OF I INTERVAL DURATION AND I STIMULUS

I stimulus	I duration					
	1		2		4	
	Obs	Pre	Obs	Pre	Obs	Pre
S + 10 Hz.	1.20	1.17	1.08	1.12	1.04	1.03
S + 50 Hz.	.82	.78	.64	.70	.59	.56
S + 90 Hz.	.74	.74	.64	.63	.46	.46
Noise	.79	.78	.29	.33	.13	.06

Note.—I durations are given in seconds.

TABLE 2

PARAMETER ESTIMATES FOR THE INTERFERENCE CONDITIONS OF EXP. I

Cond.	Storage	Forgetting
I = S + 10 Hz.	$\Delta = 1.23$	$\phi = .956$
I = S + 50 Hz.	$\Delta = .87$	$\phi = .897$
I = S + 90 Hz.	$\Delta = .87$	$\phi = .854$
I = Noise	$\Delta = 1.85$	$\phi = .421$

Note.—Theory: $d\ (\mathrm{I},\ n) = \phi^n\Delta$.

of the I stimulus, the theory requires eight parameter estimates for the 12 independent experimental conditions. The observed and predicted d' values in Table 1 indicate that the theory describes the data very nicely, $\chi^2\ (4) = 3.22$, $p > .5$.

Table 2 presents the parameter estimates under the four I stimulus conditions of Exp. I. The parameter estimates show that both Δ and ϕ were dependent on the I stimulus. The acquisition of memory strength (Δ) was largest under the I noise condition. On the other hand, the estimated values of ϕ indicate that the rate of forgetting increased as the psychophysical similarity between the I stimulus and S tone decreased.

Experiment II

Experiment II had four stimulus values and three I interval durations. Also, the group of *S*s under the easy condition heard unequal C tones that were 20 Hz. lower than the S tone, whereas the group given the difficult condition heard unequal C tones that were 10 Hz. lower than the S tone. The correct and incorrect recognition probabilities were pooled over *S*s and S tone frequency. This gives 450 observations for each recognition probability at each of the 24 experimental conditions.

According to the storage-forgetting model, the relative trace strength, Δ, stored under the difficult condition should be smaller than the trace strength stored under the easy condition because generalization from the S tone should be greater for the S − 10-Hz. tone than the S − 20-Hz. tone. More specifically, Equation 4 shows that for each I interval condition, the trace strength stored under the easy condition should be some constant K times that stored under the difficult condition. However, the rate of forgetting (ϕ) for a given I stimulus should not

TABLE 3

Observed (Obs) and Predicted (Pre) Values of d' in Exp. II as a Function of I Interval Duration and I Stimulus

I stimulus condition	I duration					
	1		2		4	
	Obs	Pre	Obs	Pre	Obs	Pre
d (S, S − 10 Hz.)						
S + 20 Hz.	.76	.65	.61	.53	.32	.34
S + 90 Hz.	.67	.72	.40	.55	.20	.32
Noise	1.00	1.04	.94	.88	.49	.62
Blank	1.30	1.20	1.19	1.14	.97	1.02
d (S, S − 20 Hz.)						
S + 20 Hz.	1.28	.134	1.05	1.08	.70	.70
S + 90 Hz.	1.48	1.45	1.17	1.11	.66	.64
Noise	2.14	2.12	1.72	1.79	1.35	1.27
Blank	2.35	2.44	2.35	2.31	2.08	2.08

Note.—I durations are given in seconds.

differ under the easy and difficult conditions. Hence, this study gives 24 independent predictions of d' with 9 parameter estimates for the model.

The χ^2 (15) value of 17.76, $p > .25$, and the observed and predicted values of d' presented in Table 3 indicate that the theory also describes the results of Exp. II accurately. The parameter estimates are given in Table 4. The inferred value of K indicates that the relative trace strength for the S − 20-Hz. condition was twice that for the S − 10-Hz. condition. The estimated values of Δ and ϕ as a function of the I stimulus indicate that both the storage and forgetting of an S tone were dependent on the I stimulus. The parameter values of Δ indicate that an I tone interfered with the storage of the S tone with respect to noise or nothing in the I interval. Furthermore, I tones and noise produced faster forgetting (smaller ϕ values) than the blank I interval. This result indicates that a pure decay process is not sufficient to describe forgetting in the present study.

A decay theorist will quickly comment that the blank I interval enables *S*s to rehearse or reinstate the stimulus during the forgetting interval. However, the employment of three similar S tones in the present experiments and the limitations of the speech-motor system make it virtually impossible for *S* to rehearse the S tone so that his employment of the rehearsal will improve pitch discrimination relative to employing the perceptual trace of the S tone.

Experiment II was replicated in an undergraduate laboratory study conducted by Shirley Liu and John W. Moore with two different instruction conditions. Half of the *S*s were instructed to hum the S tone during the I interval, while the other half were instructed not to rehearse the S tone. Analysis of the results indicated that *S*s given instructions to hum the S tone performed significantly poorer than the nonrehearsal *S*s. Furthermore, this relationship held for all of the I stimulus conditions. This result indicates that rehearsal, such as humming the S tone, is not more effective with a blank I interval than a filled I interval.

It appears that rehearsal instructions disrupt performance in this paradigm. Hence, it may be that *S*s in Exp. II may have tried to hum or rehearse the S tone. Since rehearsal seems to disrupt memory, the forgetting observed under the blank I interval condition might have been due to the increased likelihood of *S*s rehearsing the tone with longer I intervals.

The present experiments have shown that the effect an I stimulus has on memory for pitch may be highly dependent on the experimental task. In Exp. I, an I tone improved pitch discrimination relative to noise in the I interval. However, in Exp. II, an I tone disrupted pitch discrimination relative to the I noise condition. These two experiments differed in two important respects. First, *S*s in Exp. I listened to the stimuli over headphones, whereas *S*s in Exp. II heard the stimuli over a speaker at the front of the room. It is likely that it would be much easier to ignore an auditory stimulus presented over a speaker than one presented over headphones. Given that *S*s in Exp. I were unable to ignore the I stimulus, they

TABLE 4

Parameter Estimates for the I Conditions of Exp. II

Cond.	Storage	Forgetting
S + 20 Hz.	$\Delta = .82$	$\phi = .804$
S + 90 Hz.	$\Delta = .94$	$\phi = .761$
Noise	$\Delta = 1.24$	$\phi = .843$
Blank	$\Delta = 1.27$	$\phi = .948$

Note.—Easy condition, d (S, S − 20 Hz.); difficult, d (S, S − 10 Hz.). Theory: d (I, n) $= \phi^n(K\Delta)$, $K = 2.03$.

could employ it as a perceptual cue for judging the S and C tones.

The second difference between the two experiments was that *S*s in the first experiment were employed over a period of 2 wk., whereas *S*s in the second experiment were given only one session. It is possible that *S*s in Exp. I employed the I stimulus only after a number of sessions. However, an analysis of the first 432 trials (the number of trials given in Exp. II) revealed that performance during these early trials did not differ from asymptotic or overall performance. Therefore, we can speculate that it was the experimental procedure rather than the practice of *S*s that led to the opposing results in the two experiments.

Due to the experimental difference, we can safely say that *S*s in Exp. II were not approaching the task as *S*s were in Exp. I. This idea is supported by verbal reports. The *S*s in Exp. I reported using the I tone as a common point of reference. This would explain the fact that the largest decrease in memory strength over time was found under the I noise condition in Exp. I. A tone does not fluctuate over time, whereas noise does. A point of reference such as noise that changes randomly over time could only function to disrupt memory. A similar I tone would be a very good reference point that could be employed to judge the difference between the S and C tones. Hence, in Exp. I, a psychophysically similar I tone (S + 10 Hz.) facilitated recognition memory relative to dissimilar tones or noise in the I interval (cf. Table 1). We can conclude from the results of Exp. I that when *S*s employ the I stimulus as a point of reference, perceptual memory will increase with increases in the psychophysical similarity between the S and I stimuli.

On the other hand, *S*s in Exp. II reported that they tried to ignore the I stimulus, but that the I tone usually "interfered" with their memory of the S tone. These reports are supported by the results of Exp. II since both I tones were found to interfere with the memory of the S tone.

Response bias.—The storage-forgetting model predicts memory strength values that are independent of response biases. However, it seems that response biases may also be related to the processes underlying memory. The present analysis is a preliminary study of the variables affecting response bias that theories of memory will eventually have to describe.

TABLE 5

PERCENTAGE OF "SAME" RESPONSES AS A FUNCTION OF I INTERVAL DURATION AND I STIMULUS FOR THE DIFFICULT, d (S, S − 10 Hz.), AND EASY, d (S, S − 20 Hz.), CONDITIONS IN EXP. II

I duration condition	I stimulus			
	S + 20 Hz.	S + 90 Hz.	Noise	Blank
d (S, S − 10 Hz.)				
1	.55	.66	.84	.77
2	.46	.55	.83	.79
4	.34	.43	.81	.83
d (S, S − 20 Hz.)				
1	.56	.66	.63	.54
2	.48	.61	.63	.56
4	.38	.53	.60	.58

Note.—I durations are given in seconds.

An analysis of variance was carried out on the percentage of "same" responses for individual *S*s at each experimental condition in Exp. II. The significant group effect, F (1, 48) = 10.38, $p < .005$, indicates that *S*s in the difficult task were more biased to respond "same" than *S*s in the easy task. However, Table 5 shows that this effect was due to the fact that *S*s in the difficult task were much more biased to respond "same" under the noise and blank conditions than *S*s in the easy task, F (3, 144) = 25.22, $p < .001$. As noted before, when there are other stimuli in the situation, *S*s might employ these as a perceptual anchor. With dissimilar I stimuli, the S and C tones were perceived as very similar to each other relative to their similarity to the distinctive I stimulus. Therefore, *S*s in the present study required a much larger perceived difference before they said "different" with a dissimilar I stimulus than with a similar I stimulus.

The significant effect of I interval duration on the percentage of "same" responses, F (2, 96) = 34.11, $p < .001$, indicates that *S*s became less reluctant to respond "different" as the duration of the I interval increased. However, Table 5 and the significant effect of the I Interval Duration × I Stimulus interaction, F (6, 288 = 26.04, $p < .001$, shows that this decrease in "same" responses with increases in the I interval duration was present only when the I stimulus was a tone. Hence, *S*s' bias to respond "different" as the I interval increased was found only under the I stimulus conditions that produced a high rate of forgetting (cf. Table 4). In same-different tasks, *S*s seem to become biased to say "different" as they forget the S stimulus.

Discussion

The findings of the present study have indicated that (*a*) STRM for pitch decreases as the I interval increases and (*b*) this decrease over time is highly dependent on the stimulus in the I interval. Also, by employing a measure of memory strength independent of response bias, it has been shown that the results can be predicted quite well by a storage-forgetting model of perceptual memory.

Retroactive auditory stimuli do not only prevent rehearsal, but also actively interfere with the trace of the S tone. Pure decay effects require that the retroactive stimulus does not interfere with the perceptual trace, but only prevents *S* from reinstating the trace. The present experiments have shown that retroactive auditory stimuli do interact with the trace of the S tone, and the amount of interference or facilitation is highly dependent on the nature of the I stimulus and the strategies of *S*. Therefore, Wickelgren's (1966b; 1969) findings that STRM for pitch decreased over time with an I interval tone cannot be attributed to pure decay of the memory trace.

In summary, two psychological processes underlie STRM for pitch—storage and forgetting. We have seen how the strength of the trace stored can be dependent on retroactive stimuli, and the extent to which psychophysically similar stimuli interfere with the storage of the sensory perception can be dependent on the strategy of *S*. Furthermore, the decrease of the memory trace is highly dependent on the nature of the retroactive stimulus. The I stimuli are doing more than just preventing the rehearsal of the S tone. Every stimulus in the I interval (except the blank interval) somehow actively interfered or facilitated the memory of the S tone. Under a blank condition, very little forgetting is found and can be attributed to a pure decay of memory strength.

The present experiments have demonstrated that studying pure decay effects of perceptual memory requires a "blank" interval. If *E* does not feel at ease with a blank interval and employs I stimuli, he must then take into account the effects of the I stimulus on the perceptual trace.

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(Received March 13, 1969)