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

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Ss listened to a standard tone for 2, 4, or 8 sec., followed by an interference tone lasting 2, 4, or 8 sec., followed by a comparison tone lasting 2 sec., followed by a 4-sec. period in which they decided whether the standard and comparison tones were the same or different and stated their confidence on a scale from 1 to 5. Operating characteristics were approximately straight lines on normal-normal paper, and d′ values were computed for each condition for each of 10 Ss. The d′ value for a condition is a measure of the difference in strength of the correct and incorrect comparison tones at the time of the test, greater d′ meaning more accurate performance. By this measure, trace strength increased with longer duration of the standard tone, decreased with longer duration of the interference tone, and generalized to adjacent tones.

A simple generalization of the psychophysical method of successive comparison has appeared to many psychologists to be an elegant way of studying nonverbal memory. The generalized procedure in question is generally referred to as "delayed comparison" because it takes into account the interval between the standard and the comparison stimuli, suggesting experiments which vary the nature and duration of that interval. After a brief summary of what is known about delayed comparison of pitch, the present paper will discuss some difficulties involved in this type of experiment and propose the use of a powerful analytic tool from signal-detection theory, the operating characteristic. Then, the operating characteristic will be used to analyze the results of two experiments on delayed comparison of pitch, and various theoretical interpretations of the data will be discussed.

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Most studies on delayed comparison of pitch have varied the duration of a "blank" interval between the standard and comparison stimuli. On the whole, the results are that accuracy decreases with increasing time interval (Angell & Harwood, 1899; Bachem, 1954; Harris, 1952; Koester, 1945; König, 1957; Postman, 1946; Wolfe, 1886). Anderson (1914) found no significant differences in pitch discrimination for interstimulus intervals (ISIs) of $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, 3, and 4 sec., and Irwin (1937) even got a reversal in the relationship between an ISI of 1 sec. and an ISI of 10 sec. As suggested by Harris (1952), experiments in which ISI has had very little effect are all experiments in which only one standard stimulus was used. This is extremely conducive to the development of long-term memory (LTM) for the one standard stimulus. The decline in accuracy with increasing ISI appears to be entirely reflected in an increasing difference limen with no change in the point of subjective equality, i.e., no time error (Koester, 1945; Postman, 1946).

Only one study on delayed comparison of pitch (Postman, 1946) introduced a retroactive-interference (RI) tone into the interval between standard and comparison tones. Once again, no time error was found, but Postman does not report whether the RI tone increased the difference limen. Surprisingly enough, no one has ever studied the relationship between *duration* of an RI tone and pitch discrimination, and this is the first purpose of the present study.

In standard pitch-discrimination experiments with brief ISI (less than 1 sec.), increasing the duration of the standard and comparison tones is generally found to increase accuracy (Anderson, 1914; Békésy, 1929; Turnbull, 1944), but there appears to be an optimum duration of about 1 sec. (König, 1957). The second purpose of the present study is to determine if much longer durations of the standard tone (4 or 8 sec.) are optimal when pitch judgments are limited by memory, rather than by sensory discriminative capacity.

There appear to be three difficulties with delayed comparison as a method for studying memory for pitch. First, there is the problem of rehearsal during the ISI. Rehearsal of tones (silent or vocal) is probably less effective than rehearsal of verbal material because of the limitations of the speech-motor system. Nevertheless, attempts to hum the standard tone during the ISI must be presumed to have some effect, and elimination of this rehearsal would be highly desirable. The present experiment attempts to do this by the obvious procedure of filling the ISI with an interference tone of variable duration. Naturally, this does not permit us to distinguish between decay and interference as the cause of forgetting, but blank intervals do not either. The only proof that filled intervals are better than blank intervals is the reliability and simplicity of the results obtained, but the decision to use filled intervals is rather well motivated by results in verbal memory.

Second, there is the problem of what judgment to use. One might consider various subsets containing two or more of the following responses: "same," "different," "higher," and "lower." Subjectively, there appear to be four and only four qualitatively different reactions to a delayed comparison, corresponding to the four responses listed above. There is nothing surprising about this, except the fact that *S*s can react to the comparison tone as different from the standard tone without reacting to it as either higher or lower than the standard tone.

Since there seem to be four subjectively different reactions, it might appear reasonable to have a different response for each reaction. However, no theoretical framework exists for analyzing these four-category judgments. For that matter, there is no theoretical framework for the three-category judgment: "same," "higher," or "lower," though a choice model of the type suggested by Luce (1959, 1963) might be developed for it. Until recently there was a satisfactory method of analysis only for the two-category judgment: "higher," "lower." Now with signal-detection theory and the operating characteristic, there is an elegant way to analyze the other reasonable two-category judgment: "same," "different." In the latter case "different" includes "higher" and "lower" reactions as well as the anomalous "different" reactions that are neither "higher" nor "lower."

The present study uses "same-different" judgments rather than "higher-lower" judgments, and the choice is well motivated. If the four qualitatively different reactions specified above really exist, there can be no ambiguity in how S partitions the four reactions among the two responses "same" and "different." On the other hand, there is considerable ambiguity in the assignment of "same" and "different" reactions to "higher" and "lower" responses, and unknown response biases could influence the results rather markedly. The only theory that justifies the use of "higher-lower" judgments in preference to "same-different" judgments is the theory that there are *only* "higher" and "lower" reactions. Even if this theory were correct (which intuitively it is not), "same-different" judgments would provide almost the same information as "higher-lower" judgments, albeit in a less convenient form. When "same-different" judgments are employed, it is less ambiguous to refer to the experiment as concerned with recognition memory for pitch. When the retention interval (ISI) is less than 1 min., the clearest name for such an experiment would seem to be short-term recognition memory (STRM) for pitch. This convention will be observed in the rest of the paper.

The third difficulty in delayed comparison studies is concerned with the method of analysis. Previous studies have not found any simple law relating ISI to a measure of the memory trace for pitch. In early studies the trace measure was the percentage of correct judgments in various conditions. In later studies the trace measure has been the difference limen computed on "higher-lower" judgments. Signal-detection theory suggests an alternative analysis of two-category judgments in terms of the operating characteristic. This analysis can be applied to recognition-memory experiments in exactly the same way that it is applied to detection experiments (Egan, 1958; Norman & Wickelgren, 1965) to separate the effects of memory-trace strength and response bias on the observed judgments. If the assumptions of the theory are valid for recognition memory, then the operating characteristic yields a measure on an interval scale of the strength of the memory trace (d'). The theory makes testable predictions about the shape of the operating characteristic, and the first task in analyzing the present experiments is to examine the validity of these assumptions. But even if the normality and equal-variance assumptions of signal-detection theory are not valid for recognition memory of tones, some measure of the height of the operating characteristic may serve as a reliable measure of trace strength, independent of response bias. The d' value assessed at the intersection of the operating characteristic with the negative diagonal (Pollack, 1959) or the area under the operating characteristic (Pollack, Norman, & Galanter, 1964) have both been suggested as measures of trace strength in recognition memory. Thus, the second task of the present study is to determine if some measure of trace strength has a relatively simple relationship to the durations of the standard and interference tones.

Method

Experiment I

Procedure.—On each trial Ss listened to a "ready" signal, followed by a standard tone (S tone) lasting 2 sec., followed immediately by an interference tone (I tone) of 930 cps lasting 2, 4, or 8 sec., followed immediately by a comparison tone (C tone) lasting 2 sec., followed by a 4-sec. period in which Ss decided whether the S and C tones were the "same" or "different" and stated their confidence in that decision on a rating scale from "1" (least confidence) to "5" (most confidence).

Design.—There were 3 I-tone durations ($t_I = 2$, 4, and 8 sec.), 3 S tones (800, 820, and 840 cps), and 3 C-S tone differences (0, +10, and +15 cps). The zero-difference condition occurred as often as both positive-difference conditions put together. The design was factorial and the order of conditions was randomized in blocks of $3 \times 3 \times 4 = 36$ trials. There were four blocks in a 1-hr. session (144 trials), 3 different sessions, and 4 replications of each session (12 sessions altogether).

Apparatus.—Two Hewlett-Packard wide-range oscillators (Model 200CD) and one Hewlett-Packard audio oscillator (Model 201C) were used to produce the pure tones for recording on tape. Time intervals were controlled by Hunter decade interval timers (Model 111-C). The entire experiment was recorded on tape and played back over a loudspeaker at a comfortable listening intensity.

Subjects.—The *S*s were five volunteers recruited through the Massachusetts Institute of Technology student employment office. They were paid $1.50 per hr. for participation in the experiment.

Experiment II

The apparatus and procedure were the same as in Exp. I, except that the duration of the I tone was held constant at 8 sec. and the duration of the S tone (t_S) was varied from 2 to 4 to 8 sec. The design was identical to the design of Exp. I, substituting three different S-tone durations for different I-tone durations. There were five *S*s recruited in exactly the same way as in Exp. I, with one *S* participating in both experiments (Exp. II first).

Results

Form of the operating characteristics.—The confidence-judgment method was used to obtain operating characteristics for each *S* for each condition in the experiment. Discussions of this method for determining operating characteristics in recognition memory can be found in several sources (Egan, 1958; Norman & Wickelgren, 1965). In brief, the operating characteristic is a plot of the probability of correct recognition as a function of the probability of false recognition. In the present experiments, correct-recognition probabilities are obtained from conditions in which the C tone is identical to the S tone (0-cps different) and false-recognition probabilities are obtained from conditions in which the C tone is 10 or 15 cps greater than the S tone. Thus, for each of the five *S*s in Exp. I we obtain 18 operating characteristics (by plotting the 0 vs. 10 and 0 vs. 15 operating characteristics for each of the nine combinations of three S tones and 3 t_I's). Similarly we obtain 18 operating characteristics for each of the five *S*s in Exp. II.

If one only obtained "same-different" judgments from an *S*, there would be only one probability value for each condition. When a confidence judgment is also obtained, one can order the responses on a unidimensional scale from a "most confident same" through the less confident same's and different's to a "most confident different." In the present experiment this means 10 responses on a scale: S5, S4, S3, S2, S1, D1, D2, D3, D4, D5. By assuming that the trace strengths necessary to elicit these responses are also ordered, we can make a cut between any two responses and determine the probability that *S* made any of the responses to the left of the cut. Thus, nine probabilities are obtained for the condition, coming from what are presumed to be nine different criteria on the underlying strength scale. Each of these probabilities of being to the left of some cut are called "recognition probabilities," regardless of where the cut is located. Whether the recognition probability is correct or false depends on whether it is obtained from a condition in which the C tone is the same as the S tone or different from it.

When plotted on normal-normal probability paper, the 180 operating characteristics (for individual *S*s in particular conditions) appear to be straight lines, exactly as required by the normality assumption of signal-detection theory. A few operating characteristics are markedly curvilinear on normal-normal paper, but these deviations from the general rule do not appear to be systematic in any way. Thus, it is reasonable to suppose that there is some (approximately) normal variation in either the trace strengths or the decision process that maps these trace strengths into recognition-memory responses. For five *S*s, the slopes of the best-fitting straight lines do not appear to deviate significantly from unity, which implies that the variances of the underlying normal distributions for correct and incorrect tones are approximately equal. For the other five *S*s, the slopes tend to be significantly greater than unity, indicating that the variance of the trace strength of incorrect tones is greater than that of correct tones. A selected sample of these operating characteristics is shown in Fig. 1 and 2. The number of points on each curve varies, up to a maximum of nine, depending on how many confidence categories an *S* chooses to use with any frequency.

If the operating characteristics were consistent with both the normal distribution and equal variance assumptions, it would be economical to summarize each of them by a single number, d', representing the difference in mean trace strength of the correct and incorrect C tones in units of the standard deviation of the trace-strength distributions. Although the equal-variance assumption is not valid for half of the *S*s, it is still quite reasonable to determine a single d' value for each operating characteristic, provided one determines the d' value at a point which is not very sensitive to violation of the equal-variance assumption. Such a point is the intersection of the operating characteristic with the negative diagonal. Tables 1 and 2 show d' values for each condition for each individual in Exp. I and II, with each d' being determined for the point where the best-fitting straight line intersects the negative diagonal. An average over all *S*s and all standard tones is also shown in both tables.

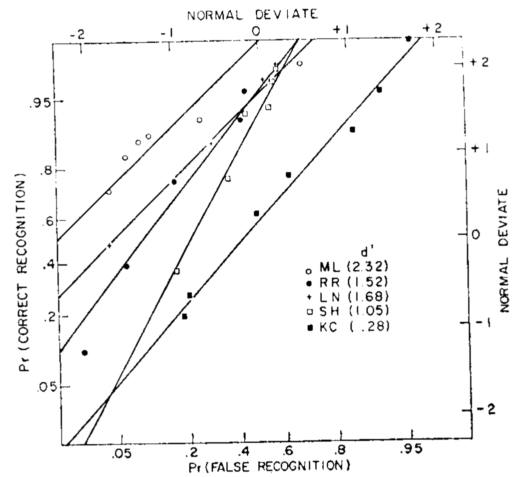

FIG. 2. Operating characteristics for individual *S*s in Exp. II with an S tone of 800 cps, an I tone of 930 cps, a C tone of 815 cps, $t_S = 8$ sec., $t_I = 8$ sec., and $t_C = 2$ sec.

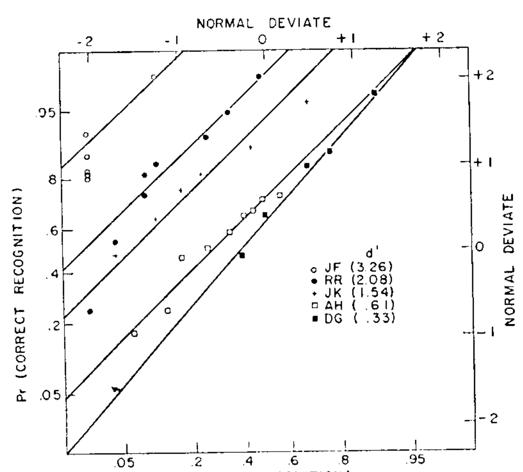

FIG. 1. Operating characteristics for individual *S*s in Exp. I with an S tone of 820 cps, an I tone of 930 cps, a C tone of 830 cps, $t_S = 2$ sec., $t_I = 2$ sec., and $t_C = 2$ sec.

Interference tone duration.—Keeping in mind that larger d' values imply better recognition memory for the correct comparison tone, it is clear from Table 1 that the longer the duration of the interference tone, the poorer is recognition memory for pitch. Analysis of variance of *S*s × Standard Tone Frequencies × Interference Tone Durations showed the effect of interference tone duration on d' for the comparison of C = S and C = S + 10 to be significant at the .001 level, $F\ (2, 8) = 23.55$. A separate analysis of variance showed the effect of interference tone duration on d' for the comparison of C = S and C = S + 15 to be significant at the .05 level, $F\ (2, 8) = 6.54$. Exponential decay of the trace strength, d', provides a far better description of the facts than linear decay, but there is a systematic deviation from the exponential decay hypothesis in the direction of too little decay from 4 to 8 sec. compared to the decay from 2 to 4 sec. The trace strengths for pitch may be approaching an asymptote above zero strength or there may be some less rapidly decaying traces involved, which are nevertheless decaying. We cannot distinguish between these hypotheses on the basis of the present data.

Obviously, it is also not possible to distinguish between decay and interference theories of the degradation of the memory trace for pitch in this experiment, and the word "decay" should be interpreted as implying nothing about the mechanism that produces the decay. Perhaps the 930-cps interference tone strengthens the incorrect comparison tone more than it strengthens the correct comparison tone. Perhaps the interference tone simply holds *S*'s attention during the retention interval and permits a spontaneous decay process to occur. Perhaps both occur. The 930-cps interference tone was chosen because of a guess that it was far enough away so that its generalization gradient would be close to zero in the region of the standard and comparison tones, but close enough to prevent simultaneous

TABLE 1

Difference in Trace Strength of Correct and Incorrect Comparison Tones as a Function of Interference Tone Duration (Exp. I)

S	S Tone	d'(S, S + 10) t_I (sec.) 2	4	8	d'(S, S + 15) t_I (sec.) 2	4	8
JF	800	4.40	4.03	3.10	5+	4.30	4.20
	820	3.26	1.88	1.25	3.76	2.56	1.68
	840	3.28	2.62	2.16	5+	3.63	2.80
RR	800	2.80	2.16	1.05	3.28	2.62	1.51
	820	2.08	1.72	1.22	3.28	2.35	1.44
	840	3.14	2.56	1.94	3.44	3.10	2.56
JK	800	1.68	1.05	.51	2.35	1.83	.77
	820	1.54	1.01	.77	2.29	1.38	1.01
	840	1.61	1.05	.77	1.98	1.90	.88
AH	800	1.36	1.11	1.08	1.87	1.83	1.52
	820	.61	.01	.56	.48	.26	.51
	840	.64	.43	.37	1.25	1.03	1.16
DG	800	.26	−.05	.05	.79	.26	.08
	820	.33	.15	.08	.69	.33	.42
	840	.85	.54	.60	1.51	1.16	1.16
Avg.		1.86	1.35	1.03	2.46	1.90	1.45

TABLE 2

Difference in Trace Strength of Correct and Incorrect Comparison Tones as a Function of Standard Tone Duration (Exp. II)

S	S Tone	d'(S, S + 10) t_S(sec.)			d'(S, S + 15) t_S(sec.)		
		2	4	8	2	4	8
ML	800	.48	1.44	1.32	1.16	1.86	2.32
	820	.30	.77	.58	.54	1.01	1.41
	840	1.64	1.51	2.16	2.80	2.56	3.93
RR	800	.82	.85	1.11	1.28	1.83	1.52
	820	1.05	.85	1.08	1.16	1.61	1.41
	840	1.80	2.03	2.08	2.51	3.20	3.10
LN	800	.51	.77	1.14	.77	1.48	1.68
	820	1.02	1.01	1.16	2.03	2.26	1.76
	840	1.16	1.64	1.58	1.48	1.61	2.08
SH	800	.48	.77	1.22	1.25	1.05	1.05
	820	.56	.74	.91	1.05	1.08	1.28
	840	1.05	.80	1.19	1.35	1.80	1.72
KC	800	.08	.06	.09	−.05	.26	.28
	820	.30	.69	.48	.77	.77	.66
	840	1.08	1.11	1.01	1.32	1.83	1.90
Avg.		.82	1.00	1.14	1.29	1.61	1.74

attention to the interference tone and the standard tone. If this guess was correct, the effect of interference tone duration was a relatively pure decay effect, but there is no way of deciding this matter on the basis of the present experiment.

Standard tone duration.—It is clear from Table 2 that increasing the duration of the standard tone from 2 to 4 to 8 sec. facilitates recognition memory for pitch. Analysis of variance showed that the effect of standard tone duration on d' for the comparison of C = S and C = S + 10 was significant at the .01 level, F (2, 8) = 8.67. The effect of standard tone duration on d' for the comparison of C = S and C = S + 15 was significant at the .05 level, F (2, 8) = 6.75. As might be expected, the effect of the duration of the standard tone was not large, but it was quite consistent. Thus, it appears that, up to 8 sec., the longer the standard tone is present, the stronger the memory trace for that tone becomes. Consolidation of the *memory trace* for pitch occupies a much longer period of time than that required to establish the most accurate *perception* of pitch, which is on the order of 1 sec. (König, 1957).

Standard tone frequency.—Tables 1 and 2 also indicate that the three different standard tones were not equally well remembered. Almost all *S*s showed large and consistent differences in the trace strengths for different tones, but the differences were not always consistent over different *S*s. On the whole, the 840 tone seems to have been remembered best with the 800 tone being remembered slightly better than the 820 tone, but there were numerous exceptions to the latter relation. The effect of standard tone frequency was significant in two of the four analyses of variance previously mentioned, $F(2, 8) = 1.87$, 2.88, 14.11, and 6.72.

Discussion

There are four principal findings in the present study. First, the operating characteristics in recognition memory for pure tones 10–15 cps apart are straight lines on normal-normal probability paper. Second, filling the interval between standard and comparison tones with an interference tone produces a very reliable inverse relationship between interference tone duration and recognition memory for pitch. Third, increasing the duration of the standard tone from 2 to 4 to 8 sec. facilitates recognition memory for pitch. Fourth, the false-recognition rate for tones 15 cps above the standard tone is substantially less than the false-recognition rate for tones 10 cps above the standard tone. This is interesting because it implies that there is a generalization gradient in STRM for pitch and it places a lower bound of 10–15 cps on the width of this gradient.

There are two subsidiary findings. First, the memory trace for a standard tone appears to be decaying to a level substantially above zero, and second, the highest tone appears to be remembered better than the other tones. The last two findings can be given a common explanation in terms of relatively long-term traces for any characteristics that distinguish the set of standard tones from the set of comparison tones. The most obvious characteristic is tone height, since the comparison tones are on the average higher in pitch than the standard tones. If we make the rather reasonable assumption that most *S*s develop a general idea of the range of standard tones, then the incorrect comparison tones used for the 840 standard tone may be discriminable on this basis. Furthermore, there may be some gradient of long-term trace strength *within* the range from 800 to 840 cps such that lower tones have greater long-term trace strength than higher tones. This would account for why the d' values do not appear to be decaying to zero, but to some positive base strength which is decaying more slowly, if at all.

The observed shape of the operating characteristic could mean that the underlying correct and incorrect trace strengths are normally distributed, which would be the obvious analogy to signal-detection theory. However, the shape of the operating characteristic could also have resulted from a normal variation in the locations of the decision criteria for recognition-memory responses.

If the variance of a trace-strength distribution is small compared to the variance in placement of decision criteria, then it is possible to consider the underlying trace strength to be a real variable rather than a random variable. The probabilistic character of recognition-memory responses is then attributed to the decision-response system, rather than to the memory system. This is a key feature of Luce's (1959, 1963) choice theory. However, it is quite possible to use the signal-detection decision rule after adding "decision variance" to the trace strength, much as Hull, Hovland, Ross, Hall, Perkins, and Fitch (1940) did by assuming "oscillation of the reaction threshold." Either way, one achieves a great simplification in the memory model since the laws of trace consolidation and decay are assumed to apply to a real variable, at a stage before that at which the principal source of variation exists. It is important to note that such a model can be an extremely close approximation to reality despite considerable variation in the consolidation or decay of an item in memory under constant stimulus conditions, provided that this variance is small in relation to the decision variance.

Because of the likelihood that some long-term traces are contaminating the present findings in STRM for pitch, it is not possible to evaluate rigorously any mathematical models of memory for pitch. However, it is clear that such a model must specify that the trace strength (in either short- or long-term memory) of the standard tone increases during presentation of the standard tone over a period lasting longer than 4 sec. and decreases during presentation of the interference tone over a period lasting longer than 4 sec. Furthermore, the difference in trace strength of the tones 10 and 15 cps above the standard tone makes it necessary to assume that tones adjacent to the standard tone get consolidated, to a lesser degree. These findings are consistent with a large variety of models, one example of which is described as follows.

Let $s(\mathrm{S}, t_\mathrm{S}, t_\mathrm{I})$ and $s(S + x, t_\mathrm{S}, t_\mathrm{I})$ stand for the strengths in STM of a standard tone S cps (lasting t_S sec.) and an incorrect C tone of $\mathrm{S} + x$ cps, respectively, after an I tone lasting t_I sec. Let $d(\mathrm{S}, \mathrm{S} + x, t_\mathrm{S}, t_\mathrm{I})$ stand for the difference between these two strengths in units of the standard deviation of the decision distribution. The *d′* value of the empirical operating characteristic is an estimate of the true *d* value. The assumptions of the model are as follows:

1. Initial Trace Strength: $s(\mathrm{X}, 0, t_\mathrm{I}) = 0$ for all tones *X*.

2. Linear Consolidation: There is a consolidation process active during presentation of a tone S, that acts to increase the strength of S and adjacent tones, $\mathrm{S} + x$, at a rate, $\alpha(x)$, which is a monotonic decreasing function of *x*.

3. Exponential Decay: There is a decay process active at all times which acts to decrease the strength of all tones in STM at a rate, βs, which is proportional to trace strength.

The linear consolidation process and the exponential decay process are both active during *presentation* of the standard tone, so their combined effects are precisely described by the following differential equation:

$$\frac{ds(t_\mathrm{S})}{dt_\mathrm{S}} = \alpha(x) - \beta s(t_\mathrm{S}) \qquad [1]$$

Under the boundary condition specified by the first assumption, this differential equation can be solved to yield the following equation for the increase in strength during the consolidation period:

$$s(t_\mathrm{S}) = \frac{\alpha(x)}{\beta}(1 - e^{-\beta t_\mathrm{S}}) \qquad [2]$$

During the interference tone the model postulates a pure exponential decay process, so the final equation for the strength of any particular tone in memory as a function of distance from the standard tone, *x*, duration of the standard tone, t_S, and duration of the interference tone, t_I, is as follows:

$$s(\mathrm{S} + x, t_\mathrm{S}, t_\mathrm{I}) = \frac{\alpha(x)}{\beta}(1 - e^{-\beta t_\mathrm{S}})e^{-\beta t_\mathrm{I}} \qquad [3]$$

Because the location of the decision criteria is variable and dependent on unknown properties of the decision system, it is not possible to test predictions of the strength of individual tones. Rather, we must test predictions of the differences in strength of correct and incorrect comparison tones, both of which are subject to consolidation and decay. These expected differences, *d*, can be compared to the obtained differences, *d′*. Letting $\alpha(0) = \alpha$ and $\alpha(x) = \alpha'$, we obtain the following:

$$d(\mathrm{S}, \mathrm{S} + x, t_\mathrm{S}, t_\mathrm{I}) = \frac{(\alpha - \alpha')}{\beta}(1 - e^{-\beta t_\mathrm{S}})e^{-\beta t_\mathrm{I}} \qquad [4]$$

Notice that the equation for *d* is identical in form to the equation for *s*, and the form is quite simple considering the fact that consolidation, decay, generalization, and decision processes have all been included in some fashion. The model is computationally simple and makes qualitative predictions consistent with the facts. However, it must be emphasized that the quantitative predictions of the model cannot be tested by the present experiments. The model should be interpreted as an *example* of the rather elegant strength models that can be constructed for STRM of pitch; many other models would be equally consistent with the present findings.

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