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The Retention Curve for Mastering Piano-technique of Simple Passages.

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It has long been known that the retention curve can be roughly approximated by an empirical equation (1). Recently, however, Förster and London independently obtained a theoretical equation (4) which fitted the data with more acceptable agreement. The theory underlying the equation is interesting. But if we wish to have a better understanding of mechanism underlying retention, we are hindered by unfortunate circumstances that most retention curves are based on only verbal material.

In this article we have presented experimental evidence that the form of retention curve in the learning of piano-technique for a simple passage is similar to that of verbal material, i. e., describable by Equations (1) and (4) not only when material is mastered once as is the case in most experiments on retention but also when the learned technique is repeated a few times at intervals of various length.

In Exp. I to IV, simple passages as shown in Fig. 1 were used as material to be retained which were as convenient as nonsense syllables in the sense that no special association was involved and variations in innumerable ways were available. Retention was always measured by the saving method in terms of time referring to the original learning. Subjects, O, T, and E were unaware of the purpose of the experiments and the subject K was one of the writers. All subjects had no difficulty in playing the material on the piano.

In Exp. I, in which K and T participated, each subject relearned, after an interval t, the material she had previously mastered until a certain criterion was met. It was found not necessary to repeat measuring retention at an interval because results were stable enough to be fitted by Equations (1) and (4) as shown in Fig. 2. Both equations fit the data well but superiority in fitness of Equation (4) is apparent when the interval is long. In Equation (4), λ and μ are defined as coefficients of decay and restoration of retention respectively, R_0 as a measure for the initial state of retention, i.e., when $t=0$.

In Exp. Ⅱ, relearning was repeated at Δt interval following the original learning until no forgetting occurred during the interval. There were five series according to the length of Δt, which varied from 2 min. to 20 min. and measurement was repeated five times in each series. The result of T is shown in Fig. 3 as an example. The data of other three subjects follow exactly the same pattern. An equation for learning curve (9) was found to apply. A parameter α_i is a simple function of Δt (16) while β is a constant independent of Δt. Besides it became clear that retention at s-th relearning in each series could be considered as a function of time elapsed since the original learning ($s\Delta t$). In Equation (11), a parameter a_s is a function of s as shown in Equation (17) and b is independent of s. Fig. 6 shows Equations (9) and (11) fitted to the data of O as an example. Since Equation (11) involves Equation (1) as a special case i.e., when $s=1$, we would like to call it tentatively the generalized retention curve. This should be distinguished from the usual retention curve because the abscissa is defined in a different way. Equations (11) and (17) can be derived from Equations (1) and (9) as proved in Equations (12) to (17) with the aid of Fig. 4. The necessary condition for Equation (9) to be valid may be stated that forgetting which should occur during the Δt interval decreases, as the result of s-th relearning, by the amount I_s which is proportional to $\log(s+1)/s$ but independent of Δt.

As shown in Fig. 7, the generalized retention curves are also described in terms of the adjusted equation of Förster-London (19). It is of importance that all parameters involved were discovered to be generated from basic ones, R_0, λ, μ, b and β by Equations (20) to (22). Therefore none of the parameters was newly estimated in fitting the curves of Fig. 7 except m and n in Equations (21) and (22). Goodness of fit is satisfactory though the curves are not the best fitting ones because values previously estimated were employed as to the basic parameters. With other subjects' data, results were essentially the same.

On the evidence of these facts, it can not be doubted that the generalized retention curve is closely related to the usual retention curve. But it means nothing more than that retentions at s-th relearning in each series form a curve which is equivalent to the usual retention curve if retention is assumed to decrease from R_{s0} which is larger than R_{10} and that the coef ficient of decay, that of restoration and the initial state R_{s0} have respectively a definite relation with corresponding parameters in the usual retention curve. It is still a question, therefore whether it really can be considered as a retention curve or not. Exp. Ⅲ and Ⅳ were undertaken to answer this question. In Exp. Ⅲ relearning was repeated twice in such a way that the first relearning was at Δt_1 interval following the original learning and the second relearning was at Δt_2 interval following the first relearning. There were five series according to the length of Δt_1 varying from 2 min. to 20 min., and Δt_2 varied also from 2 min. to 20 min. In Exp. Ⅳ relearning was repeated thrice and the third relearning was at Δt_2 interval following the second relearning. There were two series as Δt_1 was always equal to Δt_2 and they were either 3 min. or 10 min. All four subjects participated in Exp. III and IV. As examples, the result of K for Exp. III is shown in Fig. 8 and that of T for Exp. IV in Fig. 9. According to definition of the generalized retention curve, percentage of original learning saved is plotted against time elapsed since the original learning. Curves in Fig. 8 represent Equation (25). The parameter to be newly estimated was μ_{2j}. It is apparent that the equation is satisfactory unless $\Delta t_1 > 10$ min. Curves in Fig. 9 represent Equation (26). Again it was only μ_{3j} that was to be newly estimated. The equation fails to fit the data when $\Delta t_1 = \Delta t_2 = 10$ min. As to μ_{2j} or μ_{3j}, it was not possible to find empirical equations. Results were essentially the same with other subjects though individual differences were apparent concerning the range within which Equations (25) and (26) applied. It is worth mentioning that the range was about the size of $2\bar{t}$ so far as these four subjects were concerned. The value of $\bar{t}$, an individual constant, is given by Equation (27).

If the usual retention curve, Epuation (4), is fitted to the data where percentage of the original learning saved is plotted against the time interval between the last relearning and the previous one, acceptable agreements are always obtained irrespective of the length of Δt_1 or Δt_2. However, value of all parameters varies from case to case in a hazard way and it seems hopeless to find any empirical equation. And if R is defined as percentage of the latest relearning saved, there appears too much irregularities to be treated analytically.