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Effects of time factors in paired-associate verbal learning

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EFFECTS OF TIME FACTORS IN PAIRED-ASSOCIATE VERBAL LEARNING

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INTRODUCTION

In studies of stimulus familiarization (SF), there is a tendency on the part of experimenters to attribute contradictory findings to the interval between a stimulus (S) term and its following stimulus-response (R) term. This time period is sometimes called the anticipation interval. Some investigators (Cieutat, 1960; Gannon & Noble, 1961; Hakes, 1961; Schulz & Tucker, 1962a) have found SF to facilitate acquisition in paired-associate learning, whereas others (Morikawa, 1959; Schulz, 1958; Schulz & Tucker, 1962a; Sheffield, 1946; Weiss, 1958) have found SF to be ineffectual or to have an inhibitory effect.

A methodological inconsistency between studies exists in that some investigators have required Ss to articulate the S term during acquisition, whereas other investigators have not required S term articulation. In attempting to account for the positive effect of SF found by Gannon and Noble, Schulz and Tucker (1962b) reasoned that facilitation would occur when Ss were required to articulate the S term during the learning situation. Past articulation during familiarization would transfer to the learning situation thus allowing Ss to verbally produce the S term more readily than Ss without prior familiarization. Familiarized Ss, then, would have more time for anticipation. They further reasoned that SF would have its greatest effect on acquisition when the anticipation interval is short (2 sec. or less), and that with longer intervals SF would be inconsequential.

The Schulz-Tucker argument rests on the assumption that there is a direct relationship between paired-associate performance and the length of the anticipation interval. The present investigation attempts to test this prediction, and to establish the validity of assuming a relationship between SF and the length of the anticipation interval. The relationship should show up as a significant two-factor interaction.

A major stumbling block is encountered when attempts are made to manipulate the anticipation interval using ordinary laboratory exposure devices. The conventional method used in studying the interval has been to insert blank spaces between the S and the subsequent R term. This procedure also produces variations in trial duration and in the interval between subsequent S terms. Their effects are unknown. Noble (1963) suggested a method which eliminates some of the criticisms leveled at the conventional method. He recommended inserting blank spaces not only between the S and R terms, but also between the R term and the following S term, thus maintaining constant trial times and S-R intervals for varying values of the anticipation interval. However, concomitant variations would be produced in the interval between R and the following S term (post-anticipation interval).

It seems that a prerequisite to answering questions regarding differential effects produced by the experimental manipulation of SF and the anticipation interval is basic information concerning these distributional factors. The present study involves an attempt to determine the role of such factors in paired-associate learning.

Method

The experiment consisted of three phases: (1) the administration of a group learning task to be used for matching; (2) a factorial experiment (a) designed to determine the relevance of the post-anticipation interval (T_{r-s}) and the inter-trial interval ($T_{r_n-s_1}$), and (b) designed to determine a T_{r-s} and $T_{r_n-s_1}$ segment such that differential effects due to within-segmental variations were obviated; and (3) a factorial experiment designed to test the effects of SF, the anticipation interval (T_{s-r}), and method of T_{s-s} manipulation. For convenience and clarity a diagrammatic representation of the time factors involved in paired-associate learning and the design employed in Phase III appears as Fig. 1.

Insert Fig. 1 here

Phase I (Group-Administered Learning Task)

Apparatus. The apparatus consisted of two sets of pasteboard cards. The stimulus set of 10 cards approximately 18 in. x 5 in. in size each displayed one stimulus word. The reinforcement card set of 10 cards approximately 36 in. x 5 in. in size each displayed a stimulus-response pair. Homogeneous word pairs from the upper end of the scaled meaningfulness (*m*) range (Noble & Parker, 1960) were used as stimulus materials. The word pairs and the randomized presentation orders are reproduced in Table 1.

Insert Table 1 here

Procedure. Introductory psychology students were tested in class groups. All *S*s were given four reinforced trials and four test trials in alternating order beginning with a reinforced trial. Reinforced trials consisted of *E* presenting the reinforcement card set at approximately a 5-sec. rate; test trials consisted of *E* presenting the stimulus card set at approximately a 10-sec. rate. On test trials *S*s wrote the response words on a printed answer sheet. About 8 sec. elapsed between trials.

The frequency of correct responses (R+) constituted S's total score. A response was correct if not more than one letter was in error except in those cases where the erroneous letter produced a new English word. If three or more responses were sequentially correct but positionally in error, the datum was rejected. Adherence to these criteria resulted in a pool of 491 Ss, random assignment of whom to Phase II and Phase III conditions was made on the basis of Phase I scores such that subgroups of the later two phases were equated in learning ability and representative of five score intervals. These separations partitioned the distribution into strata having proportions of approximately 20 per cent each.

Instructions. General informative instruction designed to acquaint them with standardization and validation procedures in test construction were read to Ss. They were also told not to write down cues or to whisper during reinforced trials. They were told to simply keep in mind which words went together and to write the appropriate response word to the stimulus word on test trials. Looking back at previously completed pages and filling in previously missed responses was prohibited.

Phase II (Post-Anticipation and Inter-Trial Intervals)

Apparatus. The apparatus consisted of two Patterson memory drums projecting through a plywood screen. Five dissyllables and four random presentation orders previously employed by Gannon and Noble (1961, Table 2, forward list) were presented at a 1:1 sec. rate. The 1:1 sec. rate was characterized by an item exposure time of 1 sec., followed by a 1-sec. period during which a shutter covered the aperture thus concealing the revolving drum.

Procedure. Sixteen independent groups (matched on the basis of Phase I scores and randomly assigned to groups) of five Ss each were given the experimental treatments. Four values of each of two experimental variables, T_{r-s} and $T_{r_n-s_1}$, were employed in an attempt to find a joint segment such that distributional effects were equated and to assay simultaneously the efficacy of these factors in paired-associate learning. Values of 2, 8, 16, and 32 sec. were used for T_{r-s}. Values of 4, 10, 20, and 40 sec. were used for $T_{r_n-s_1}$. A diagram of the experimental design of Phase II appears as Table 2.

Insert Table 2 here

All experimental groups received a constant T_{s-r} interval of 2 sec. and one acquaintance trial followed by 29 acquisition trials (or practiced until a criterion of five perfect consecutive trials was reached). Both the S term and the R term were pronounced, and S was instructed to correct himself in the event of an erroneous anticipation. Responses were scored as correct (R+) in accordance with the criteria used by Gannon and Noble (1961). To eliminate rehearsal during the longer time intervals ($T_{r-s} > 8$ sec. and/or $T_{r_n-s_1} > 4$ sec.) Ss called out numbers in rhythm to the clicks of the drum.

Instructions. All groups, with the exception of Group 1 which was not read the section pertaining to counting, were read the following instructions:

"This is an experiment on verbal learning. We are interested in the general learning process common to all people and are not testing your intelligence or personality. With this memory drum, I am going to show you some two-syllable stimuli similar to actual words. Probably you have never seen any of them before, so there is no standard or correct pronunciation. Whichever way you pronounce each word when we start is all right, but try to say it the same way each time the word comes up."

"Shortly after the apparatus starts, you will see a stimulus word in the window. You are to pronounce it, for example DINNER. Then the drum will turn and you will see another word - a response word - paired with it, for example SUPPER. You are to pronounce this response word also. After you have seen the list once, try to anticipate the response word of each pair before it comes up. In other words, as you see the stimulus word, pronounce it, then try to say the response word that goes with it before it comes up. If you think you know what the next response word will be but you aren't sure, make a guess. It won't hurt your score any more than if you don't say anything, and if you get it right it will count as a success. If you fail to anticipate a response word, or make a mistake, say the response word correctly when it appears. Remember to try to say the words the <u>same way</u> each time. Please try to pronounce all words the same way each time they appear so that I can give you credit for a correct response."

"After you have seen the entire list once, and the list begins to appear again, I will give you the signal to begin anticipating the response word of each pair by saying, 'begin anticipating now.' Do not try to memorize the <u>order</u> of the pairs. Although the same two words will always be paired together, the order or sequence of these pairs will change every time you go through the list. Do not try to make up any special system to aid in the learning process. Simply associate each response word with its paired stimulus word."

"Between presentations of the (lists and/or pairs) there will be time periods in which you won't be engaged in learning. During these periods I want you to call out random numbers to the clicks of the drum. In other words, every time you hear the click say out loud the number you are thinking of. It can be any number whatever, but do not count in order, and do not repeat numbers. (E gave S 30 sec. of practice.) The asterisks will warn you that the next (list and/or pair) is about to appear, and I will also remind you. When you see the asterisks, stop saying numbers and get set to begin anticipating again." (This paragraph was read to only those Ss in the conditions having the previously specified, longer time intervals.)

"Do you have any questions? Remember to correct yourself out loud if you make a mistake during the learning phase. Remember that you must pronounce the response term the same way each time, in order for me to count it as correct. (E gave S a 1 min. review of the procedure.) Ready? Here is your first pair."

Phase III (Anticipation Interval, SF, Method)

Apparatus. Two Patterson memory drums (No. 1-A) in the same physical setting as in Phase II were employed, one being utililized for familiarization, the other for learning. Learning materials were identical to those of Phase II. The dissyllables used for familiarization training were identical with respect to item, order, and relevancy to those used by Gannon and Noble (1961, Table 1, S_{20}-R_0). The drum operated at a 1:1 sec. rate.

Procedure. The experimental design called for eight ultimate groups of 10 Ss each, matched on the basis of Phase I scores and randomly assigned to the experimental treatments. The eight independent groups represented two values of each of three variables: SF (0 and 20); T_{s-r} (2 sec. and 8 sec.); Method (T_{s-s} constant 18 sec. and T_{s-s} variable 14 sec. to 20 sec.).

Phase III consisted of two stages: stimulus familiarization and learning. In the familiarization stage 80 Ss received either 0 (SF_0) or 20 (SF_{20}) independent exposures of 10 items, five of which were used later in the learning stage as S terms (relevant items). The 40 Ss receiving SF_{20} were instructed to pronounce each dissyllable aloud as it appeared in the aperture of the drum. Familiarization instructions were similar to those of Gannon and Noble (1961), differences being those due to drum vs. projector presentation.

In the learning stage the SF groups were further classified on the basis of T_{s-r}, 40 Ss being allowed 2 sec. to anticipate the R term and 40 being allowed 8 sec. As before, all Ss received one acquaintance trial, then received 24 acquisition trials or practiced until a criterion of five perfect consecutive trials was reached. Self-correction, S and R pronunciation, and response scoring was identical to Phase II procedure. In all groups Ss called out numbers to the drum clicks to prevent rehearsal.

A further subdivision of groups was made during the learning stage on the basis of two different methods of manipulating the T_{s-s} factor. The conventional method (Method 1) was characterized by the insertion of blank spaces between the S and R terms only, to manipulate T_{s-r} values. Other Method 1 distinctions were a constant T_{r-s} interval of 12 sec. and a T_{s-s} interval varying concomitantly with T_{s-r} manipulations.

Method 2 involved the insertion of blank spaces between the S and

R terms to produce variations in T_{s-r}, and the additional insertion of blanks between R and the following S term to hold the T_{s-s} factor constant at 18 sec., thus necessitating T_{r-s} values of 10 and 16 sec. Values of T_{td} were constant for Method 2, but covaried as T_{s-r} covaried for Method 1 (cf. Fig. 1).

Instructions. The instructions used in the learning stage for groups receiving SF_0 were identical to those used in Phase II. For those groups receiving SF_{20} the sentences "This is the second part of the experiment. Here is another memory drum." were substituted in place of the first paragraph of Phase II instructions.

Results

Phase I (Group-Administered Learning Task). The total scores attained by 421 Ss on the paired-associate card test were cast into a frequency distribution and partitioned into five ability groups, as described above. Interval values, ordered from low to high, are given in parentheses as follows: Low (5.5-26.5), Medium Low (26.5-32.5), Medium (32.5-35.5), Medium High (35.5-37.5), High (37.5-40.5). An odd-trial vs. even-trial reliability coefficient calculated on the card test scores yielded an r value of .846, N = 421. By applying the Spearman-Brown formula, the adjusted r value came to .917.

In a preliminary investigation designed to indicate the validity of the card test as a predictor of paired-associate drum learning, 20 Ss were selected from the pool of 491 and subjected to six trials of drum learning. Other than number of trials, these Ss received the same treatment as Group 1 of Phase II (see Table 2, Group 1). A relationship between total card test scores and total R+ scores for six trials was indicated ($r = .392, \sigma_r = \pm .194, N = 20$). Since there was skewness in both distributions and possible curvature of regression, the true relationship between the two tasks may be even higher.

A further evaluation of the effectiveness of the card test as a matching variable was accomplished by Spearman rank order correlations, given in parentheses, calculated between Ss' total card test scores and Phase III total R+ scores as follows: Group 1 (-.14), Group 2 (.74), Group 3 (.25), Group 4 (.61), Group 5 (.46), Group 6 (-.01), Group 7 (.80), Group 8 (.62). The average rho was .42 (z = 3.54; $P < .005$; Taylor & Fong, 1962).

Phase II (Post-Anticipation and Inter-Trial Intervals). The general results of Phase II are shown in Fig. 2. The data for the 16

Insert Fig. 2 here

experimental groups learning the list of five dissyllable pairs under combinations of T_{r-s} and $T_{r_n-s_1}$ are expressed in terms of the percentage of correct responses (R%) as functions of T_{r-s} and $T_{r_n-s_1}$. To insure the initial comparability of the subgroups, a simple-randomized analysis of Variance (Lindquist, 1956) was calculated on Phase I scores. This test resulted in an F value less than unity (F = .127, df = 15/64; $P > .20$).

To determine the effects of practice (29 trials in this phase and symbolized by N), T_{r-s}, and $T_{r_n-s_1}$, a 29 x 4 x 4, Type III mixed-factorial analysis of variance (Lindquist, 1956) was performed on the R+ scores from which Fig. 2 was constructed. The summary, shown in Table 3,

Insert Table 3 here

indicates significant main effects of N and T_{r-s}.

The influence of T_{r-s} is greatest for an interval of 2 sec., having little differential effect for values between 8 sec. and 32 sec. The interaction of major interest is that between T_{r-s} and $T_{r_n-s_1}$, which failed to reach significance. This indicates relatively independent experimental variables. The tendency toward significance of the $T_{r_n-s_1}$ factor is probably due to the relatively lower scores obtained by those groups receiving a $T_{r_n-s_1}$ interval of 4 sec.

An inspection of the acquisition data of Groups 7 and 11 showed them to be highly similar in performance. Group 7 received a T_{r-s} interval of 8 sec., whereas Group 11 received a T_{r-s} interval of 16 sec. In all other respects the two groups received identical treatment. Since one of the purposes of Phase II was the determination of a T_{r-s} segment with boundary values that could be considered equivalent with respect to performance, a replication of the treatments administered to Groups 7 and 11 was undertaken to evaluate the stability of the observed similarity. Two new groups of five Ss each were selected in the same manner as Groups 7 and 11. One group received an experimental treatment identical to that received by Group 7. The other group received an experimental treatment identical to that received by Group 11. The Phase I scores of the four groups comprising the replication study failed to differ significantly when subjected to a simple-randomized analysis of variance ($F = .10$; $df = 3/16$; $P > .20$).

To test the stability (initial groups vs. secondary groups, hereafter called replications and symbolized by RP) of the performance similarity of groups receiving $T_{r-s} = 8$ sec. and those receiving 16 sec., an N x RP x T_{r-s}, Type III mixed-factorial analysis of variance was calculated. A significant main effect for N was found. All other sources of variance resulted in *P* values greater than .20, with the exception of the N x RP interaction which approached significance (*F* = 1.32; *df* = 28/448; $.10 < P < .20$).

Phase III (Anticipation Interval, SF, Method). To insure the comparability of the eight subgroups, a simple-randomized analysis of variance was performed on *Ss'* Phase I scores. The resulting *F* value indicated that the groups performed similarly on the matching task (*F* = .11; *df* = 7/72; $P > .20$).

The general results of Phase III are shown in Fig. 3. R% is plotted

Insert Fig. 3 here

as a function of N grouped in blocks of three trials for four conditions (Methods combined). The summary presented in Table 4 indicates that the

Insert Table 4 here

time variables defining the Method factor failed to produce a significant main effect and did not interact significantly with any of the other experimental variables. Therefore, the two methods can be considered as essentially equivalent. The tendency for the Method, T_{s-r}, and SF factors to interact ($.10 < P < .20$) was analyzed graphically. This analysis showed the performance of Group 8 to be superior to its control, Group 4. On the other hand, Group 3, the control for Method 1, attained a higher score than experimental Group 7. This reversal, however, may be regarded as being more apparent than real because of the high *P* value and the lack of an *a priori* reason why it should have occurred.

As predicted, a significant main effect for T_{s-r} was found. Inspection of Fig. 3 shows groups receiving 8 sec. in which to anticipate the R term performed better than those groups allowed 2 sec.

The only interaction of interest is the tendency for SF to interact with T_{s-r}. Although the $\underline{P}$ value associated with the interaction does not reach the level of restriction usually placed upon it using a two-tailed test, the interaction is of the hypothesized form. A one-tailed test would give a more appropriate evaluation of the interaction; this resulted in a $\underline{P}$ value between .05 and .10.

Prior experimental findings, reference to Fig. 3, and the anticipated SF x T_{s-r} interaction all point to SF facilitation when the T_{s-r} interval is about 2 sec. A 24 x 2 Type I mixed-factorial analysis of variance (Lindquist, 1956) was performed on the R+ scores of the two groups receiving a T_{s-r} interval of 2 sec. The main effect of SF appeared as an $\underline{F}$ value of 2.56; $\underline{df}$ = 1/38; $.10 < \underline{P} < .20$. Transforming $\underline{F}$ to $\sqrt{\underline{F}}$ (Lindquist, 1956) yielded a $\underline{t}$ value of 1.6 ($\underline{df}$ = 38; $.05 < \underline{P} < .10$; one-tailed test). A Mann-Whitney $\underline{U}$ test (Siegel, 1956) was performed on the same scores ($\underline{U}$ = 134.5; $\underline{P} < .05$; one-tailed test). The nonparametric $\underline{U}$ test probably gives a better estimate of the effects of SF than does the parametric $\underline{F}$ test, since the convergence of the acquisition curves near the asymptote and the occurrence of any non-homogeneity of variance would reduce the power of the $\underline{F}$ test. Although the four-dimensional analysis of variance was cut back to 18 trials and recalculated to circumvent the converging curves, no new information resulted.

Of further interest is the lack of interaction between SF and N in the above mentioned, Type I analysis of variance ($\underline{F}$ = 1.11; $\underline{df}$ = 23/874;

P $>$ .20). This tendency for the control group and the experimental group to parallel each other has been a consistent finding in SF experiments.

Discussion

Phase II served simultaneously as an elimination experiment and as a basis for further time factor manipulations. The suggestion (Gannon & Noble, 1961; Hakes, 1961; Schulz & Tucker, 1962b) that distributional variables were operating which led to inconsistent findings in prior experiments employing SF gains plausibility in light of the present results.

One factor differing from study to study which need not be considered as a source of the conflict is $T_{r_n-s_1}$. The present results are in accord with Underwood's (1951) finding that paired-associate learning is unrelated to $T_{r_n-s_1}$ for values from 4 sec. to 2 min. In both Underwood's and the present study, however, the 4-sec. interval resulted in the poorest performance. Furthermore, the probability of a T_{r-s} x $T_{r_n-s_1}$ interaction as a source of differential results in prior experiments is diminished since the results suggest statistical independence. The results of the present experiment do indicate the T_{r-s} factor to be of prime importance when values of less than 8 sec. are used. Due to incomplete reporting, it is impossible to ascertain the consistency of the T_{r-s} value used in previous experiments involving SF. There is a good possibility some of the conflicting reports stem from this factor.

A direct test of the effects of factor T_{s-r}, suggested as a source of conflicting evidence, is made difficult by covariations in factors

T_{s-s} or T_{r-s}. In Phase II values of T_{s-s} (10 sec. and 18 sec.) in conjunction with values of T_{r-s} (8 sec. and 16 sec.) were established such that a direct test of the effects of T_{s-r} (2 sec. and 8 sec.) could be made without confounding effects arising from concomitantly varying factors. In Phase III T_{s-s} and T_{r-s} were allowed to interact with other Phase III variables. The negative results obtained regarding the Method factor in Phase III simultaneously strengthen the findings of Phase II and demonstrate the relative empirical independence of T_{s-s} and T_{r-s} with regard to other Phase III variables. The consideration remains, however, in that had other values been used, complex interactions may have resulted. Thus, the results of prior experiments remain uncertain in this respect.

The major predictions regarding Phase III were confirmed. The test of the relevance of the T_{s-r} interval leads to the conclusion that it is an effective variable in paired-associate learning. When *S*s are allowed 8 sec. to anticipate the R term, SF ceases to be an effective variable. According to Schulz and Tucker (1962b), SF is important when the T_{s-sr} interval is short, presumably because *S* is able to quickly articulate the S term thus leaving more time for anticipation. The inference can be made that it is not SF *per se* that leads to facilitation, otherwise it would affect 8-sec. anticipation groups also.

It may be that *S*s allowed 2 sec. in which to produce the R term are having an arbitrarily defined response threshold created for them, as Hakes (1961) suggests. Perhaps the only mediational facility these *S*s can utilize in the time allowed is derived from the S term. There would, then, be a direct relationship between SF and performance as found by Schulz and Tucker (1962a). If Ss were stimulus bound (i.e., had to rely solely on the S term), then groups receiving increasing values of SF, within limits, would parallel the control group in acquisition at increasing levels of proficiency. As seen in Fig. 3, the 2-sec. groups do follow this pattern until near the asymptote.

On the other hand, Ss allowed 8 sec. in which to produce the R term may use mediators stemming from situational cues, pre-experimental experiences, and the S term in developing habit strength. The lack of experimental control, in long T_{s-r} intervals, leading to heightened effects of background variability, make predictions difficult. It might be expected that in a large number of experiments employing SF with relatively long T_{s-r} intervals, the average effects of SF would be normally distributed with $SF_0 = SF_{20}$. The results in Fig. 3 show the 8-sec. group receiving SF_{20} to be superior to its control group early in practice, but not superior at the later stages. If SF does have any effect when longer anticipation intervals are provided, this effect might be positive on the first few trials, the effect decreasing as a function of practice. At later stages of practice the effect might become inversely related to practice, according to some complex transfer principle.

Although the above suggestions are ad hoc, they provide for further experimentation and the possibility of a fuller understanding of the processes and variables involved in paired-associate learning. Regardless of the underlying processes involved, the data permit three unequivocal statements: (a) time factors characteristic of differences between Methods failed to produce distinct effects or to interact with other experimental variables; (b) T_{s-r} is a relevant variable in paired-associate learning; (c) SF is a relevant variable in paired-associate learning when T_{s-r} is short (2 sec.), but ceases to be of consequence as T_{s-r} increases.

Summary

The effects of time factors and stimulus familiarization (SF) in paired-associate verbal learning were investigated. Phase I consisted of the development of a group-administered paired-associate task, involving 491 Ss, to be used in later phases as a matching variable. The reliability of the task was high (r = .917), and a validity coefficient ($\bar{\rho}$) of .42 was obtained.

Phase II was designed to determine the effects of the inter-trial interval ($T_{r_n-s_1}$) and the post-anticipation interval (T_{r-s}), and to simultaneously provide two values of T_{r-s} which could be considered empirically equivalent and used in a later phase to manipulate the anticipation interval (T_{s-r}). Eighty Ss, divided into 16 independent groups of five each, received the treatment combinations derivable from four values of $T_{r_n-s_1}$ (4, 10, 20, 40 sec.) and four values of T_{r-s} (2, 8, 16, 32 sec.). All groups then practiced a five-unit list of dissyllables, T_{s-r} being 2 sec., for 30 trials. The influence of T_{r-s} was positive and significant ($P < .001$). Neither $T_{r_n-s_1}$ nor the interaction reached significance. Two of the groups (T_{r-s} = 8 sec. and T_{r-s} = 16 sec.) were considered equivalent, and the experimental treatments were replicated with two new groups of five Ss each. The replication groups failed to differ significantly in all respects.

On the basis of the results obtained in Phase II, values of T_{r-s} (8 sec. and 16 sec.) were used to manipulate the inter-stimulus interval (T_{s-s}) in order to discover interactions between T_{s-s}, T_{s-r}, SF, and amount of practice (N). Eighty Ss divided into eight independent groups of 10 Ss each on the basis of T_{s-r} (2 sec. and 8 sec.) and Method (T_{s-s} variable and T_{s-s} constant) received either 0 or 20 units of SF, then practiced for 25 trials on the list used in Phase II. Analysis of total correct responses (R+) showed T_{s-r} to be an effective variable when T_{s-r} was 2 sec. ($P < .01$), but ceased to be influential when T_{s-r} was 8 sec. The method factor failed to be relevant in interaction or in main effect.

Similar and contradictory results from other laboratories were discussed in view of the present findings and suggestions for further experiments were presented.

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Table 1

Stimulus Material and Presentation Orders for the Group-Administered Paired-Associate Learning Task

Nominal Number	SR Pair		Order	Trial Sequence							
				R_1	S_1	R_2	S_2	R_3	S_3	R_4	S_4
1	KITCHEN	LEADER	1	1	10	8	5	8	9	4	8
2	UNCLE	ARMY	2	3	7	3	8	5	4	5	10
3	CAPTAIN	MONEY	3	8	9	4	4	10	8	1	3
4	DINNER	TYPHOON	4	10	2	2	3	6	6	8	6
5	GARMENT	VILLAGE	5	6	6	7	6	3	5	9	2
6	HEAVEN	INCOME	6	5	3	6	2	9	7	10	1
7	HUNGER	OFFICE	7	9	5	9	10	7	10	2	7
8	YOUNGSTER	JEWEL	8	7	4	10	7	4	3	3	4
9	WAGON	INSECT	9	4	8	5	9	2	1	7	5
10	JELLY	ZEBRA	10	2	1	1	1	1	2	6	9

Note - Reinforced trials (R) and test trials (S) are defined in the text. Numbers under R and S trials are nominal and refer to specific word pairs. The mean $\underline{\mathring{m}}$ value is 9.19.

Table 2

Schematic Representation of the Experimental Design of Phase II

T_{r-s} Interval	$T_{r_n-s_1}$ Interval			
	4 sec.	10 sec.	20 sec.	40 sec.
2 sec.	Group 1	Group 2	Group 3	Group 4
8 sec.	Group 5	Group 6	Group 7	Group 8
16 sec.	Group 9	Group 10	Group 11	Group 12
32 sec.	Group 13	Group 14	Group 15	Group 16

Table 3

Analysis of Variance of Correct Responses (R+)

of Experimental Groups in Phase II

Source	*df*	*MS*	*F*
Between *Ss*	79		
T_{r-s}	3	151.47	7.55**
$T_{r_n-s_1}$	3	43.91	2.19
T_{r-s} x $T_{r_n-s_1}$	9	7.25	.36
Error (*b*)	64	20.05	
Within *Ss*	2240		
N	28	158.16	592.36**
N x T_{r-s}	84	1.05	3.92**
N x $T_{r_n-s_1}$	84	.91	3.39**
N x T_{r-s} x $T_{r_n-s_1}$	252	.58	2.16**
Error (*w*)	1792	.27	
Total	2319		

** $P < .001$

Table 4

Analysis of Variance of Correct Responses (R+)

of Experimental Groups in Phase III

Source	*df*	*MS*	*F*
Between *Ss*	79		
T_{s-r}	1	141.93	8.25*
SF	1	20.02	1.16
Method (M)	1	5.43	.32
T_{s-r} x SF	1	29.49	1.71
T_{s-r} x M	1	.99	.06
SF x M	1	2.25	.13
T_{s-r} x SF x M	1	43.22	2.51
Error (*b*)	72	17.21	
Within *Ss*	1840		
N	23	160.19	266.98***
N x T_{s-r}	23	1.14	1.90**
N x SF	23	.62	1.03
N x M	23	.40	.67
N x T_{s-r} x SF	23	.80	1.33
N x T_{s-r} x M	23	.42	.70
N x SF x M	23	.32	.53
N x T_{s-r} x SF x M	23	.69	1.12
Error (*w*)	1656	.60	
Total	1919		

* $P < .01$, ** $P < .005$, *** $P < .001$

Fig. 1. Diagram representing the relationship between time factors in paired-associate learning (upper line) and the experimental paradigm of Phase III. The lines denote the onset and offset of stimulus (S) and stimulus-response (R) terms. The time lapse between the onset of an S term to the onset of the subsequent R term (anticipation interval) is denoted by T_{s-r}. The time lapse between the onset of an R term to the onset of the following S term (post-anticipation interval) is denoted by T_{r-s}. The time lapse between the onset of an S term to the onset of the subsequent S term (inter-stimulus interval) is designated by T_{s-s}. The time lapse between the offset of the last T_{r-s} interval in a preceding trial to the onset of the first S term in the next trial (inter-trial interval) is denoted by $T_{r_n-s_1}$. Trial duration is designated T_{td}. Method 1 is characterized by a T_{s-s} interval that varies concomitantly with T_{s-r} values. Method 2 is distinguished by a constant T_{s-s} interval and a T_{r-s} interval varying concomitantly with T_{s-r} values. Groups 1, 2, 3, and 4 received no prior stimulus familiarization (SF_0). Groups 5, 6, 7, and 8 received 20 units of stimulus familiarization (SF_{20}) prior to learning.

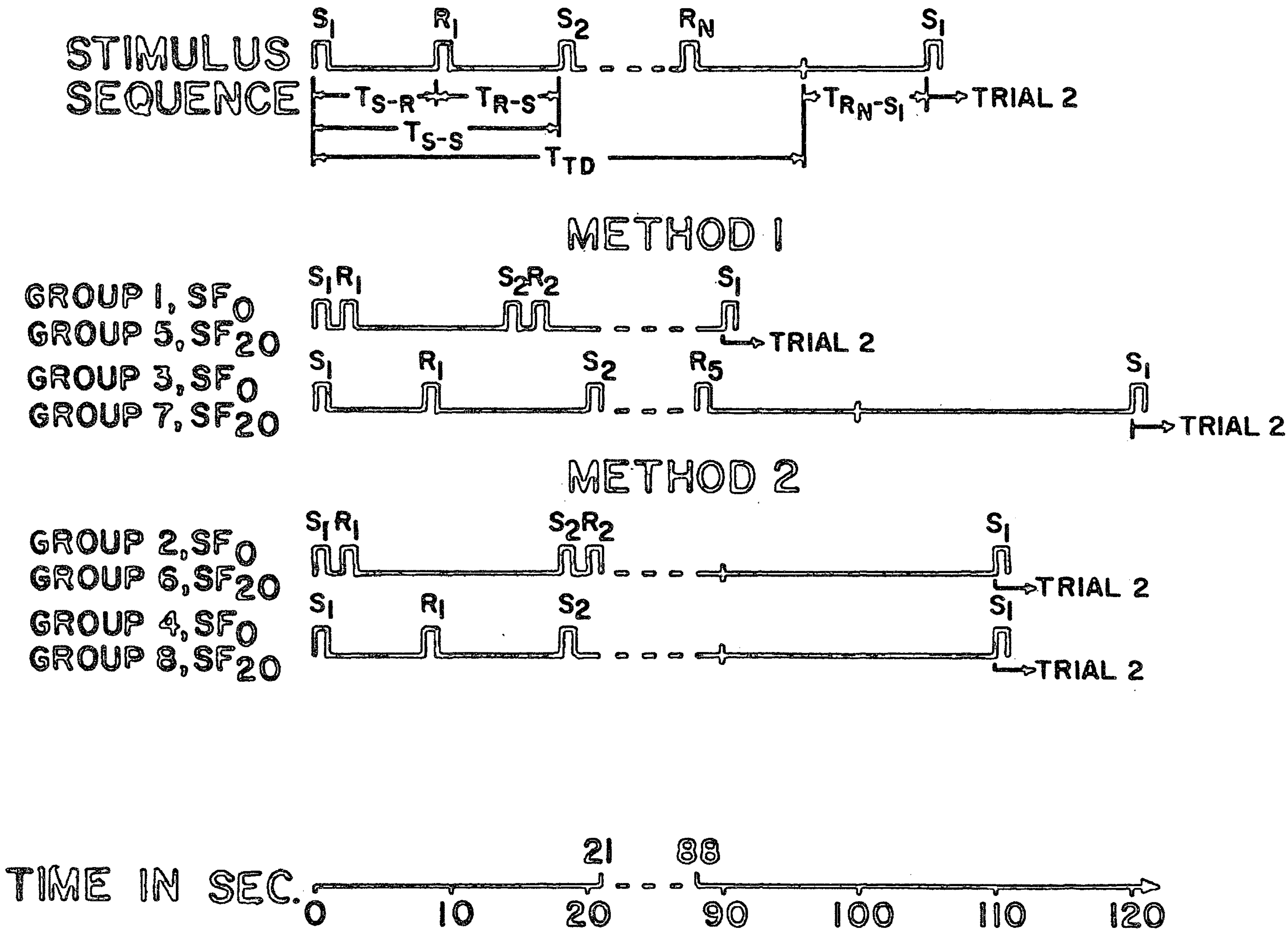
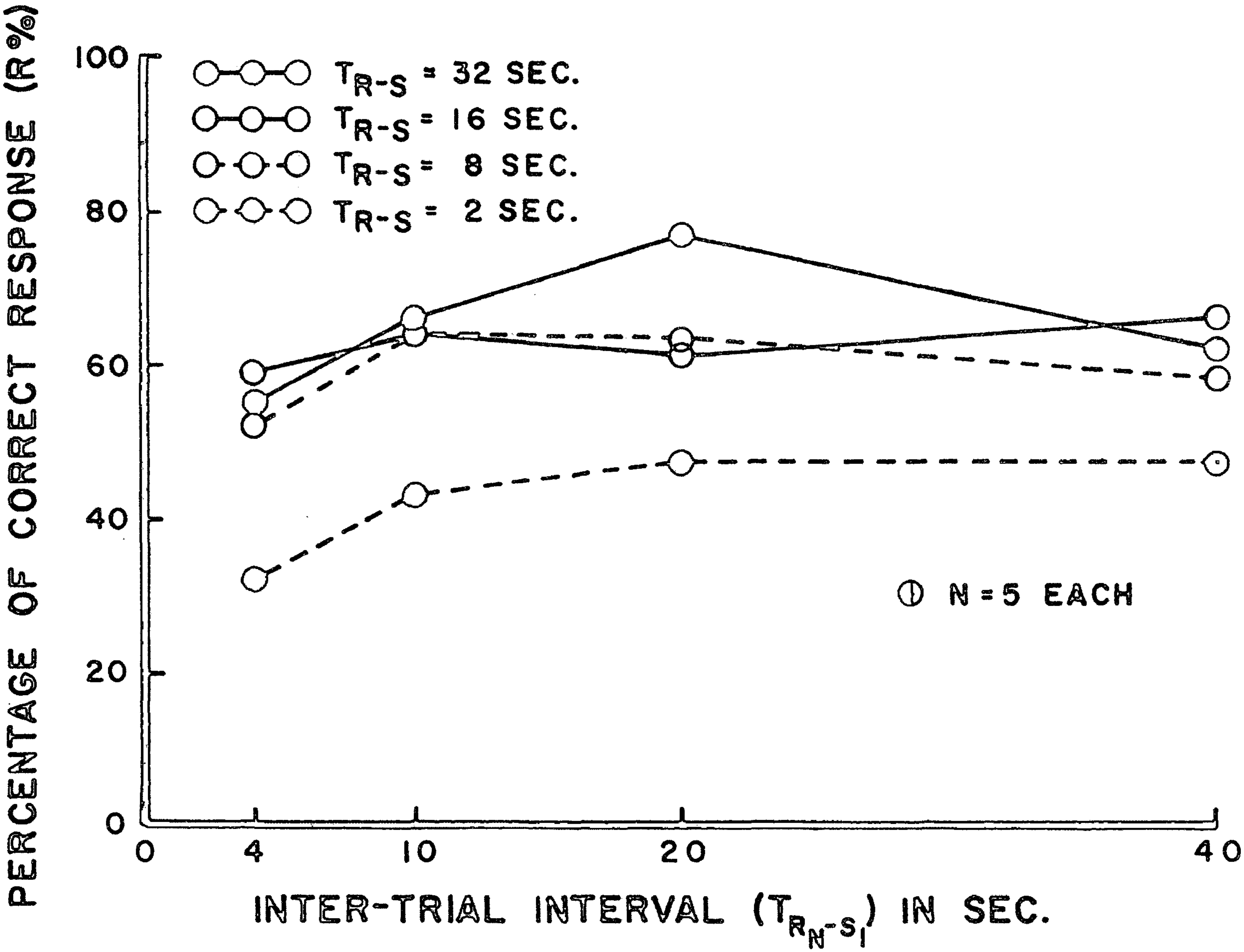

STIMULUS SEQUENCE
S1 R1 S2 RN S1
TS-R TR-S TS-S TTD TRN-S1
TRIAL 2
METHOD 1
GROUP 1, SF0
GROUP 5, SF20
GROUP 3, SF0
GROUP 7, SF20
S1 R1 S2 R2 S1
S1 R1 S2 R5 S1
METHOD 2
GROUP 2, SF0
GROUP 6, SF20
GROUP 4, SF0
GROUP 8, SF20
TIME IN SEC.
0 10 20 21 88 90 100 110 120

Fig 1

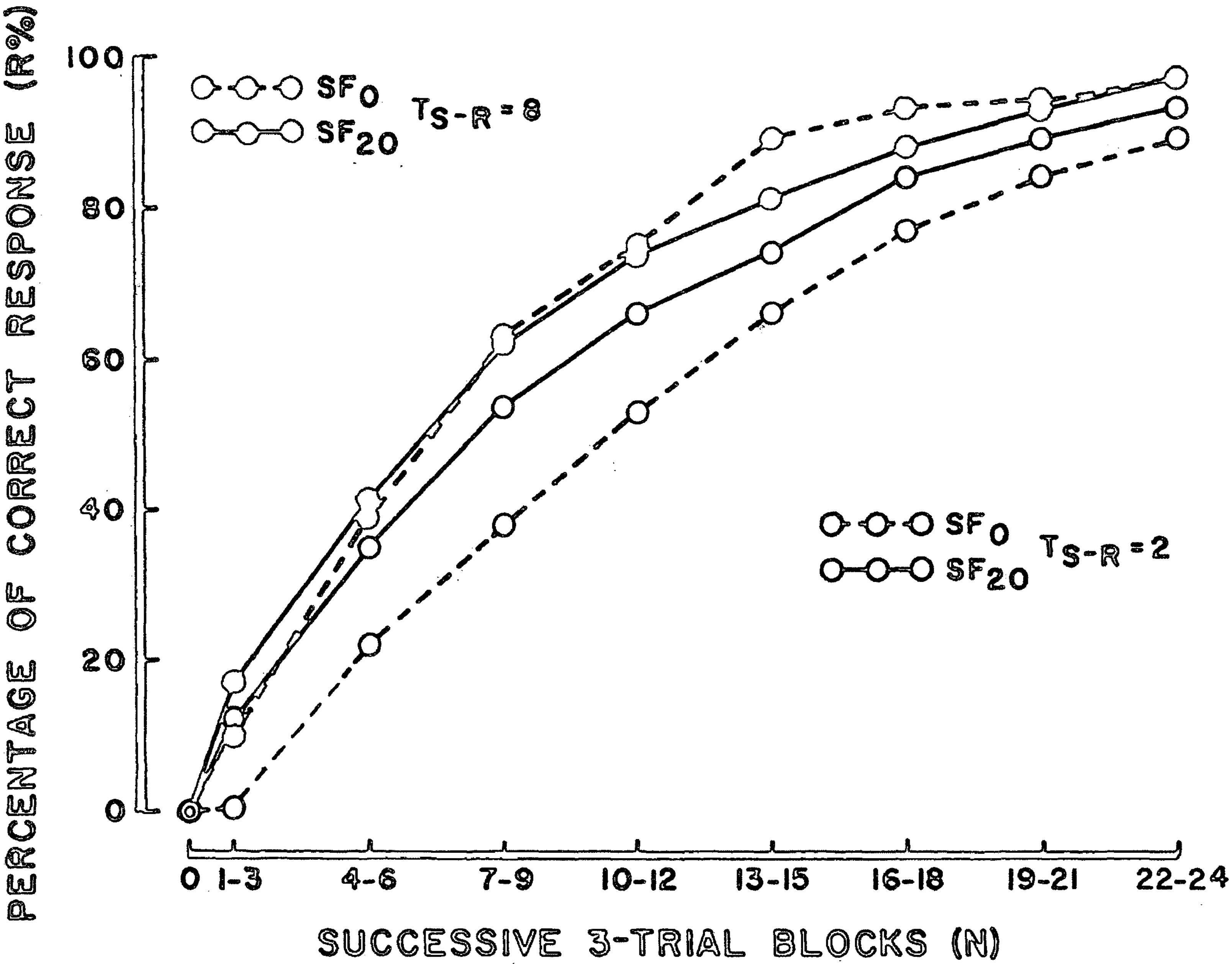
Fig. 2. Percentage of correct responses (R%) during 29 anticipation trials as a function of the inter-trial interval ($T_{r_n - s_1}$), with the post-anticipation interval (T_{r-s}) appearing as a parameter.

Fig. 3. Percentage of correct responses (R%) plotted as a function of practice (N) grouped in blocks of three trials for conditions of stimulus familiarization (0 and 20) and anticipation interval (2 sec. and 8 sec.), Methods combined.



PERCENTAGE OF CORRECT RESPONSE (R%)
100
80
60
40
20
0
T_{R-S} = 32 SEC.
T_{R-S} = 16 SEC.
T_{R-S} = 8 SEC.
T_{R-S} = 2 SEC.
N = 5 EACH
0
4
10
20
40
INTER-TRIAL INTERVAL ($T_{R_N - S_1}$) IN SEC.

Fig 2



PERCENTAGE OF CORRECT RESPONSE (R%)
100
80
60
40
20
0
SF0
SF20
TS-R = 8
SF0
SF20
TS-R = 2
0
1-3
4-6
7-9
10-12
13-15
16-18
19-21
22-24
SUCCESSIVE 3-TRIAL BLOCKS (N)

Fig 3