PRACTICE EFFECT IN TACHISTOSCOPIC AND REACTION TIME TASKS

TIME ESTIMATION AS A DETERMINANT OF THE PRACTICE EFFECT IN TACHISTOSCOPIC RECOGNITION AND CHOICE REACTION TIME

by

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SCOPE AND CONTENTS:

Two experiments, involving 70 subjects, were performed which support the conclusion that it is the experience that subjects have with a regular foreperiod which is in large part responsible for the improvement with practice that is found in tachistoscopic recognition and in reaction time tasks.

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Chapter I

HISTORICAL INTRODUCTION

The research reported in this thesis is concerned with the improvement with practice that is found in both tachistoscopic recognition and in reaction time experiments. Specifically, we were interested in determining what is responsible for the practice effect in these two tasks. In this section we will first discuss some of the relevant tachistoscopic recognition data. We will then discuss some of the reaction time data and several important transfer experiments. We propose that it is the experience the subject has with a constant foreperiod (warning tone offset-stimulus onset interval) which is responsible in large part for the practice effect in these two tasks and which is also responsible for the transfer in the studies we will mention.

The experiments mentioned in this historical review and our own research may be placed under the general heading of perceptual learning. We will not attempt a comprehensive review of the literature in the area since there are several reviews already available (Gibson, E. J. 1953, 1963; Drever, 1960; Wohlwill, 1966).

Perceptual learning refers both to changes in perception that occur over the life span of the organism with particular emphasis on the formative years and to changes which occur within an experimental session. It is the second category in which we are interested. Reviewers of this area cite a substantial amount of data from experiments employing a wide variety of tasks in which subjects show an increased accuracy in judgment evidenced by correct responses made to smaller stimulus differences or where subjects make increasingly accurate estimations of stimulus dimensions. The problem, as Newbigging (1965) suggests, is to identify and describe the mechanism which will account for the practice effects or learning that is demonstrated. As was already mentioned we will concentrate on two tasks in which there is evidence for perceptual learning, viz., tachistoscopic recognition and reaction time experiments, and we will present evidence that suggests that the same mechanism is responsible for much of the practice improvement in both tasks, viz., the experience the subject has with a constant foreperiod.

Renshaw (1945) was the first experimenter to mention a practice effect in tachistoscopic recognition. He was interested in determining if tachistoscopic training with numbers could improve airplane recognition, but he also noted that recognition thresholds for the numbers were reduced over trials.

Howes and Solomon (1951) using the ascending method of limits determined thresholds for a list of sixty words of mixed frequency. They found that thresholds continued to decrease throughout the list although about 75% of the improvement occurred in the first quarter of the list.

Doehring (1962) tested subjects over four one-hour sessions on a tachistoscopic task. During each session the subjects had to recognize a total of twenty-four words, six from each of four categories. The categories were high frequency, low frequency, "good" words (eg. rose, heal), and "bad" words (eg., rage, thief). The good and bad words were matched for frequency. The sessions were separated by two to six days and different lists of words were used in each session. All four of the word conditions showed a practice effect. This effect appeared to have reached a limit by the third session.

Hay (1963) demonstrated approximately equal amounts of transfer from numbers, high frequency words, and low frequency words to a list of low frequency words. What was important here was the demonstration that transfer was not dependent on the specific items used in the training and transfer tasks.

Hay's studies and several of the earlier studies, including Howes and Solomon (1951), employed a Ger-brands tachistoscope in which an audible microswitch click occurred almost exactly two seconds before the stimulus exposure. Hence the possibility remains that the practice effect in these studies may have been, at least in part, due to the experience subjects had with a regular foreperiod. It seems reasonable that with practice subjects would be better prepared for the stimulus by making a more accurate estimate of the length of the foreperiod.

Munoz (1963) presents data which indicate that experience with a regular foreperiod might indeed mediate the practice decrement. He examined the effect of three regular foreperiods, either two, four, or eight seconds, on the tachistoscopic recognition of low frequency nine-letter words. The curve showing the practice decrement for Munoz's two-second condition is almost identical to a curve of Hay's (1963) in which an audible microswitch click occurred approximately two seconds prior to the stimulus exposure.

Lake (1966) used seven constant foreperiods between one-half and eight seconds in an experiment in which subjects had to recognize seven-letter sequences. His data conform closely to Munoz's (1963). Lake found a significant overall practice effect. He also found that for intervals greater than two seconds that the longer the interval, the higher are the average thresholds. Lake found that for intervals of two seconds or less there were no significant differences in threshold values.

The practice improvement in the reaction time task may also be explained, at least in part, in terms of an improved ability at determining the length of the foreperiod.

Several experimenters discuss the practice improvement and foreperiod effects. We believe these data can be interpreted using our time-estimation argument.

Mowbray and Rhoades (1959) in a choice reaction time experiment divided their data into trial blocks of 500 trials each. The mean reaction times for the first two blocks were 293 and 255 milliseconds. By the 15th trial block the lone subject had a mean reaction time of 213 milliseconds. The subject experienced a regular foreperiod since the stimuli were presented every five seconds.

An experiment by Noble, Alcock and Frye (1962) required subjects to snap one of four switches corresponding to the relative position of a red light to a green light. The relative position could be either above, below, left or right. They divided their data into eight blocks of twenty trials each. They also employed an instructional variable, i.e., specific vs. non-specific instructions. For non-specific instructions the means for the first three and for the last block of trials were approximately 600, 520, 480, and 370 milliseconds. For specific instructions the means for the same trial blocks were 450, 400, 320, and 290 milliseconds. They employed a one-second average foreperiod with the range of foreperiods being from 0.5 to 1.5 seconds.

These studies clearly demonstrated a practice effect. The Mowbray and Rhoades study used a regular foreperiod and the Noble et al. study used a foreperiod which had a very small range, viz., one second. It would seem likely that subjects could be prepared for stimulus at the shortest foreperiod, and still maintain their attention for another second should the 1.5 second foreperiod occur. These results, we believe, do not conflict with our idea that it is the experience with a fairly regular foreperiod which may be in part responsible for the improvement in practice found in reaction time studies.

It has been established that subjects do better on a reaction time task when they are given a preparatory signal (Wundt, 1903). There is clear evidence that subjects do better on a reaction time task using a constant foreperiod as opposed to a variable one. Using a simple reaction time task, Drazin (1961) found that the overall mean reaction time was an increasing function of the foreperiod variability.

An experiment by Klemmer (1956) on simple reaction time also showed that reaction time increases as the variability of the foreperiod increases. Subjects who experienced the largest range of foreperiods, eight seconds, had a mean reaction time of 281 milliseconds. Subjects given a two second range of foreperiods with a mean foreperiod of 1.25 seconds had a mean reaction time of 259 milliseconds.

It seems fairly clear, then, that subjects do better on a reaction time task when given a regular rather than a variable foreperiod. This we believe is because they are better prepared for the stimulus. Rose (personal communication) performed a tachistoscopic experiment in which the stimuli were either a series of horizontal or vertical lines. He found that his two highly-practiced subjects got a significantly greater percentage correct when a constant foreperiod was used rather than a variable one.

The experience subjects had with a constant foreperiod could be offered as an explanation for an experiment of Lake's in which he gave subjects different amounts of training on a simple reaction time task and then had them recognize tachistoscopically exposed seven-letter sequences using an ascending limits method. The same two-second foreperiod was used during both the training and transfer tasks. A control group received only the tachistoscopic task. Lake found, with one reversal, that the greater the amount of practice in the reaction time task, the lower were the thresholds in the tachistoscopic (transfer) task. We believe it may have been the experience the subjects had with the regular foreperiod which mediated the transfer in these two tasks.

Newbigging (personal communication) also found that recognition thresholds for tachistoscopically-exposed seven-letter sequences could be lowered by giving subjects prior practice on either a simple or disjunctive reaction time task. The greater the amount of training on the reaction time task, the lower were the thresholds on the tachistoscopic task. The same foreperiod, two seconds, was used in both tasks.

The more reaction time trials a subject received, the more experience the subject had with the interval that was used in the subsequent tachistoscopic task. It seems likely that this additional temporal information would be useful in enabling the highly-practiced subject to be consistently better prepared for the stimulus presentation than subjects who have not had as much experience with the interval.

In another study, Newbigging (personal communication) demonstrated transfer from three types of reaction time tasks, simple, discriminative, and choice, to a tachistoscopic task involving the recognition of seven-letter sequences. Subjects experienced the same foreperiod, either two, four, or eight seconds, in both tasks. Once again it might be argued that it was the experience with the constant interval that mediated the transfer. Subjects trained on a choice reaction time task showed the greatest amount of transfer and subjects trained on the simple reaction time task showed the smallest amount of transfer. Since the choice reaction time task is the most difficult it follows that more transfer would result from this type of training.

We have been maintaining that subjects with practice are able to more accurately estimate the length of foreperiod, and thus are better prepared for the stimulus presentation, be it in a reaction time task or tachistoscopic task. Most experiments on time estimation have not talked about practice effect. There is, however, evidence that subjects can improve at time estimation. Woodworth (1930) using a one second interval found that the threshold (standard deviation from the mean) for such an interval was 8.6%. Hawickhorst (1934) with training reduced this to 3.6%. Renshaw (1932) reduced this to 1.2%, but his subjects required 159 days of practice. It obviously taks a considerable amount of training to demonstrate any improvement in time estimation. The reason would seem to be that subjects do rather well from the beginning of training. There is evidence that subjects can estimate shorter intervals more accurately than longer ones. Woodrow states "as in the case of discrmination, accuracy is greater for very short intervals than for those of four seconds or longer. The greatest accuracy for both discrimination and reproduction lies in the range from 0.2 to 2.0 seconds. When the same empty interval is presented repeatedly and reproduced at each presentation the standard deviation of the reproductions is typically, for the most favorable intervals, about 8% of the standard, but is increases to twice this magnitude for intervals of four to thirty seconds. (Woodrow, in Stevens, 1951). We know from early studies that a one to four second foreperiod would seem to be optimal. (Woodrow, 1914; Breitweiser, 1911). There would seem to be some basis for suggesting that subjects can estimate shorter intervals more accurately than longer ones and hence time estimation could be offered as an explanation for why subjects at least do better from the outset on tachistoscopic and reaction tasks which employ a short foreperiod. This evidence would seem to support a time-estimation explanation for the experiments of Lake (1966) and Munoz (1963). They found that subjects did best on tachistoscopic recognition of words and seven-letter sequences when the foreperiod was two seconds or less. Subjects given a four-second foreperiod did not do as well, and subjects given an eight-second foreperiod did poorest of all. Foley (1959) found that subjects given a two-second foreperiod in a simple reaction time task did significantly better than those who were given a four- or eight-second interval, so it would seem that two seconds is an optimal foreperiod in more than one situation. The importance of this point will be brought up again in the discussion.

The experiments which we have performed were designed to test the hypothesis that it is the experience with a regular foreperiod which is responsible for the practice improvement in two tasks as dissimilar as tachistoscopic recognition and reaction time.

In the first study two groups of subjects received fifty practice trials on a time-estimation task in which the interval that had to be reproduced was either two or eight seconds. These subjects then had to recognize six, seven-letter sequences which were presented tachistoscopically using the ascending limits method. The same foreperiod was used in both the training and transfer tasks.

Two other groups, given either a two-second or eight-second foreperiod received the tachistoscopic training prior to the time-estimation training in which the foreperiod was preserved. We wished to demonstrate that experience on one task would result in transfer to the subsequent task. We would then have evidence that it is the experience subjects have with a regular foreperiod which mediates the transfer.

The second study gave one group of subjects fifty trials on a choice reaction time task and then fifty time estimation trials. Another group received the opposite task order. A third group received tachistoscopic training prior to the reaction time task. All groups received an eight-second foreperiod in both tasks. Any transfer would be evidence for our time-estimation hypothesis.

Chapter II

EXPERIMENT I

Method

Subjects

Forty paid male and female undergraduates from McMaster University served as the subjects.

Apparatus

A tone generator was used to produce all of the tones used in the experiment. A Scientific Prototype Time Interval Generator timed the two tones that bounded the standard interval. The standard interval (either two or eight seconds) was timed by one of the timers from the Scientific Prototype Model GB Tachistoscope. Subjects received the two tones separated by the standard interval by pressing a small button of a switch. A telegraph-type key was used for the reproduction attempts. The two tones that the subjects received during the reproduction attempts were timed by two Hunter Decade Interval Timers. The reproduction attempts were timed with a Hewlett-Packard Electronic Counter.

Stimulus Materials

The stimuli were six sequences of seven letters each. They were professionally printed in capital letters. The letter height and width was two mm. The entire sequence was 20 mm. in length. (For the derivation of the sequences see Lake, 1966).

Experimental Design

The experimental design was a Lindquist Type III (Lindquist, 1953). Each of the forty subjects was randomly assigned to one of four groups. One group (8-TE) received time-estimation training with an eight-second interval and then was switched to the tachistoscopic task in which the interval was preserved. Another group (8-Tach) received the opposite order of training and transfer tasks with an eight-second interval. A third group (2-TE) received the time-estimation training with a two-second interval and then was switched to the tachistoscopic task in which the interval was preserved. A fourth group (2-Tach) received the opposite task order with the two-second interval.

Procedure

Time Estimation

The subject wore headphones and pressed the button of a switch which he held in his left hand throughout the experiment. When the button was pressed the subject received a one-second tone, then a blank interval of time, and then another one-second tone. The blank interval of time was called the "standard", and the subject was told that this interval would always be the same length of time. When the second tone finished, the subject attempted to reproduce the "standard" in the following manner: The subject depressed a telegraph-type key with his right index finger. Upon doing this, the subject received a one-second tone. The subject was instructed to hold the key down for a length of time that he felt was equal to the "standard". When he felt he had held the key long enough the subject was to release it as quickly as possible. A second tone was thenddelivered through the earphones. The reproduction attempt began from the offset of the first tone. When the subject released the key the experimenter recorded the reproduction attempt. After a pause of about three seconds the subject presented the "standard" to himself again, and again tried to reproduce it. There were fifty reproduction attempts, all of which were preceded by the "standard".

Tachistoscope

The subject pressed the same button which was used to present the "standard" in the time-estimation task. Upon pressing the switch the subject received a one-second tone and an interval of either two or eight seconds. The interval was followed by a tachistoscopic exposure of a seven-letter sequence. The initial presentation of the sequence was for 150 milliseconds, and the duration of each succeeding exposure was increased by ten milliseconds, until the subject correctly called aloud all seven of the letters in the correct order. The point at which the subject correctly identified the sequence was called his threshold. Thresholds for six sequences were determined for each subject.

Results

Table I contains the results of a Lindquist Type III analysis of variance which was performed on the data. We found significant main effects of interval, task order, serial position, and a significant task order by serial position interaction. Figure 1 contains the average thresholds for each of the six serial positions for each group of subjects.

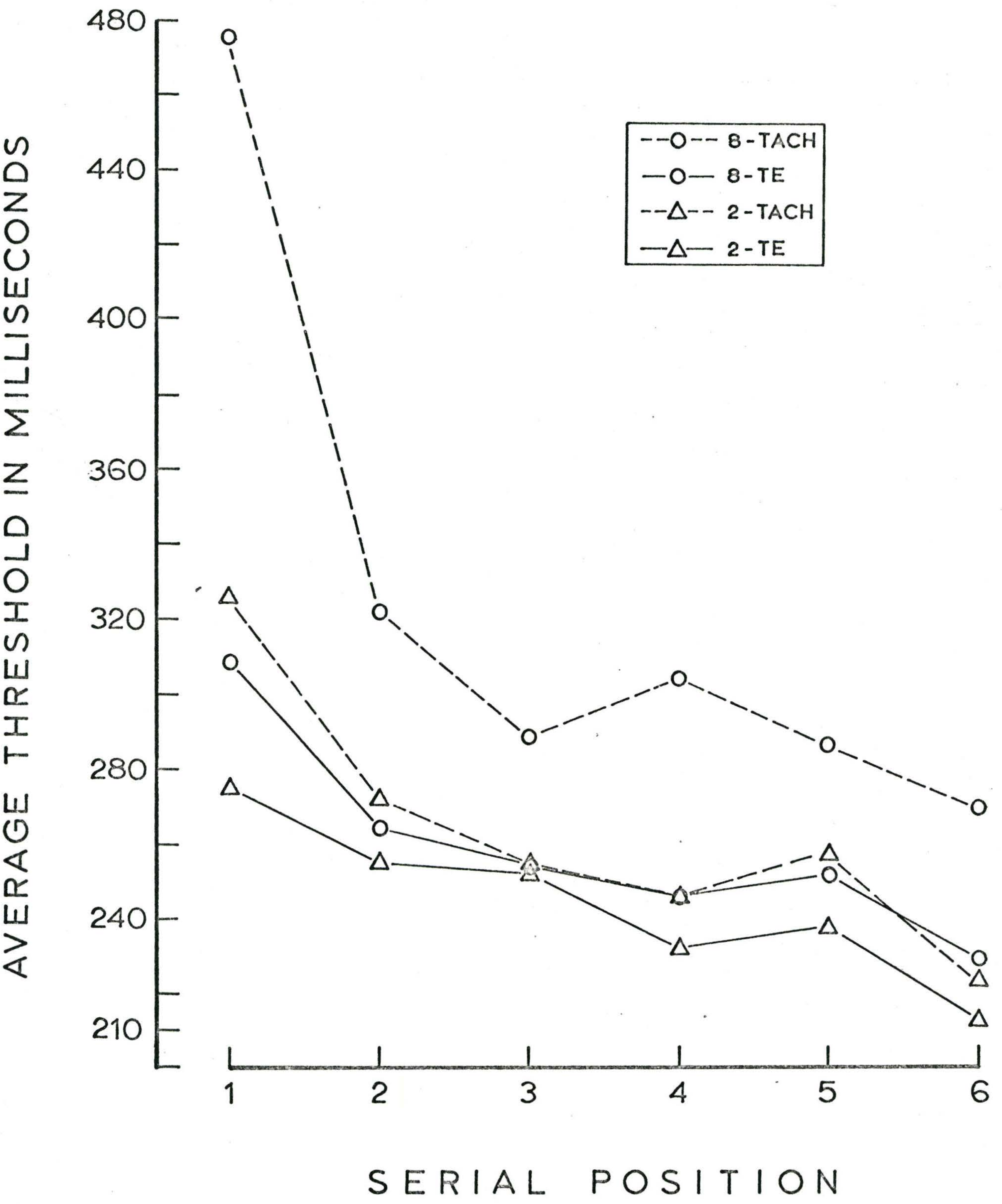
The significant effect of interval indicates that subjects who experienced a two-second interval did better on the tachistoscopic task than subjects who experienced an eight-second interval. The 8-Tach group would seem to be mainly responsible for this significant effect since they did considerably worse than both of the two-second groups, while the 8-TE group did not seem to differ from the two two-second groups.

We obtained a significant effect of task order, indicating that subjects given time-estimation training first did better on the tachistoscopic task than subjects

Table I

Analysis of Variance for Four Groups with
Two Task Orders and Two Intervals

Source	df	M.S.	F	P
Between Ss	39			
Interval	1	85126.75	8.649	.01
Task Order	1	107103.75	10.882	.01
Interval x Task Order	1	32433.50	3.295	NS
Error(b)	36	9842.635		
Within Ss	200			
Serial Position (S.P.)	5	60134.79	17.352	.01
S.P. x Interval	5	7262.60	2.096	NS
S.P. x Task Order	5	11210.70	3.235	.01
S.P. x Int. x Task Order	5	3139.85	0.906	NS
Error (w)	180	3465.615		
Total	239			



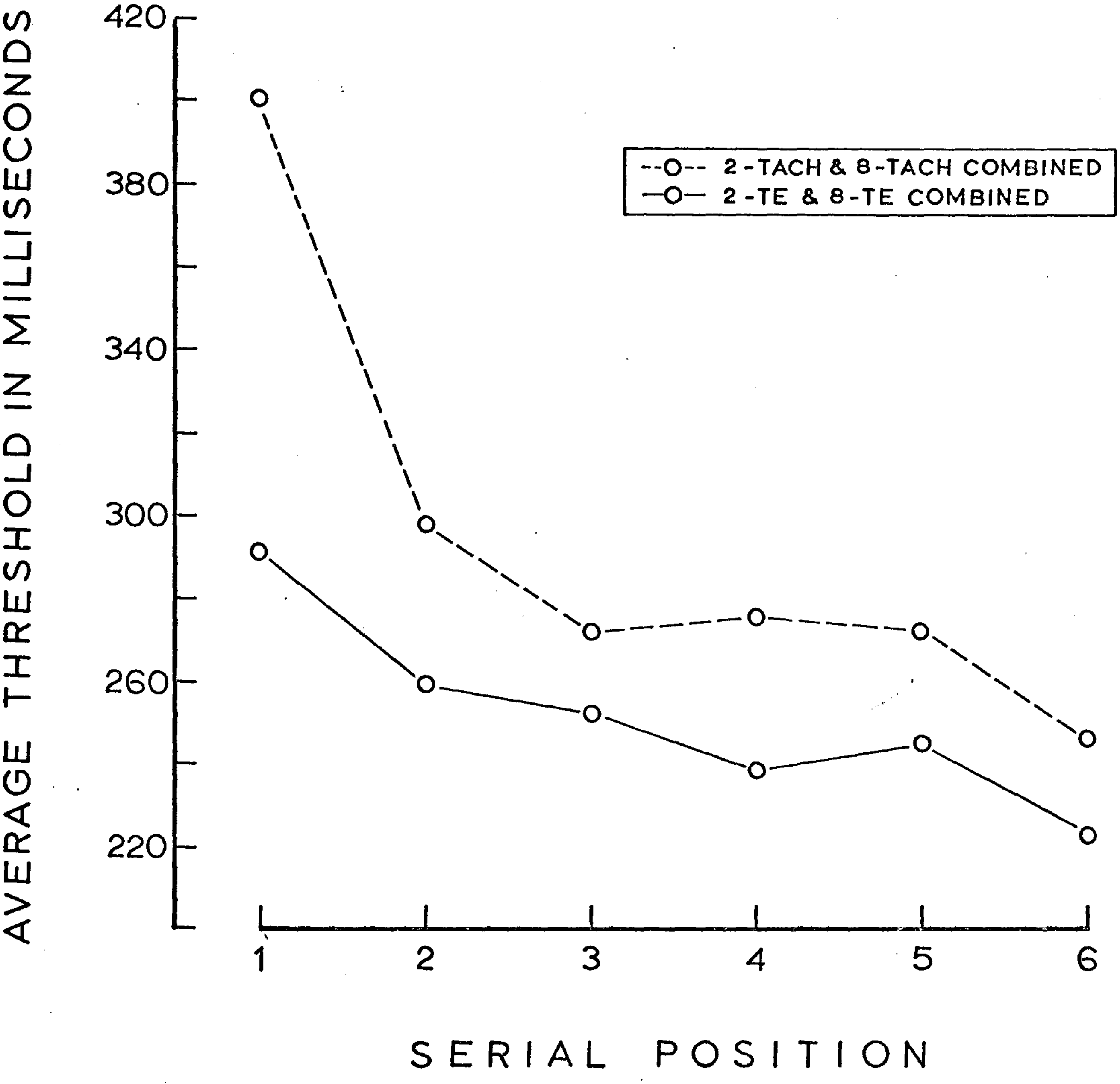
480
440
400
360
320
280
240
210
AVERAGE THRESHOLD IN MILLISECONDS
1
2
3
4
5
6
SERIAL POSITION
8-TACH
8-TE
2-TACH
2-TE

who had not received prior time-estimation training. The large difference between the two eight-second groups would seem to be the source of the effect. Task order does not seem to be as important when a two-second interval is employed.

The significant effect of serial position reflects the fact that subjects did better on the later items than on the early ones. The significant serial position by task order interaction (see Fig. 2) was obtained since subjects who receive time-estimation training first do not show as much of an improvement with practice on the tachistoscopic task as subjects who have not experienced time-estimation training prior to the tachistoscopic task. Again it would seem that the 8-Tach group is primarily responsible for this effect.

No analyses were performed on the time-estimation data since there were clearly no interesting differences between groups. Table II contains the mean reproduction attempts and the average standard deviations for each of five trial blocks of ten trials each.

A t test was performed on the mean threshold values at the first serial position for the 2-TE and 2-Tach groups. The test yielded significance beyond the .05 level.



AVERAGE THRESHOLD IN MILLISECONDS
420
380
340
300
260
220
--O-- 2-TACH & 8-TACH COMBINED
—O— 2-TE & 8-TE COMBINED
1
2
3
4
5
6
SERIAL POSITION

Table II

Overall Means and Average Standard Deviations in Milliseconds for the Reproduction Attempts

	Means					Means				
	Trial Blocks					Trial Blocks				
Groups	1	2	3	4	5	1	2	3	4	5
8-TE	7754	7799	7919	7752	7919	507	485	528	477	364
8-Tach	7784	7758	7721	7611	7748	584	667	563	563	620
2-TE	1994	1957	1929	1964	1964	274	208	235	167	174
2-Tach	1899	1910	1923	1929	1947	223	192	186	213	207

"2" and "8" refer to the interval. "TE" refers to subjects given time-estimation training first. "Tach" refers to subjects given tachistoscopic training first.

Chapter III

EXPERIMENT II

Method

Subjects

Thirty paid male and female undergraduates from McMaster University served as the subjects.

Apparatus

The same apparatus that was employed in Experiment I was used for the tachistoscopic and time-estimation tasks in this experiment. Two telegraph-type keys were used in the reaction time task. The warning tone in the reaction time task was timed by a Hunter Decade Interval Timer. The tone-offset-stimulus onset interval (eight seconds) was timed by another Hunter Decade Interval Timer. The reaction times were timed with a Hewlett-Packard Electronic Counter. The stimuli for the reaction time task were presented in a Scientific Prototype Model GB Tachistoscope. The exposure fields were 25 foot-lamberts and the pre and post-exposure fields were 15 foot-lamberts.

Stimulus Materials

The stimuli were two pieces of plastic, 2.7 inches long and 2.4 inches wide. On one piece of plastic there were photographed a series of black horizontal lines. On the other piece there were photographed a series of black vertical lines. The plastic was glued to 5" x 7" white cardboard.

Experimental Design

A Lindquist Type I design (Lindquist, 1953) was used. Each of the thirty subjects was randomly assigned to one of three groups. All groups received an eight-second interval in both the training and transfer tasks. One group (TE-RT) received time estimation training prior to the reaction time task. Another group (RT-TE) received the opposite order of training and transfer tasks. A third group (Tach-RT) received the same tachistoscopic task that was used in Experiment I followed by the reaction time task.

Procedure

The time estimation and tachistoscopic procedures were exactly the same as those employed in Experiment I. For the reaction time task the subject was seated in front of the tachistoscope. On a table directly in front of him were two telegraph-type keys. During the session the subject was looking into the tachistoscope. The subject initiated a choice reaction time trial by pressing one telegraph key down with his left index finger and the other key with his right index finger. Upon pressing down the keys the subject received a one second tone through a set of headphones. Eight seconds after the tone went off one of the stimuli (either horizontal or vertical lines) were exposed. Half of the subjects were instructed to release the left key as quickly as possible when they saw vertical lines and to release the right key as quickly as possible when they saw horizontal lines. The other subjects received the opposite instructions. The subject's response terminated the stimulus. The subject was instructed to wait about three or four seconds after responding and then to depress the key which was just released, which initiated another trial beginning with the tone.

Subjects received a total of fifty trials. On twenty-five trials vertical lines were presented and on twenty-five trials horizontal lines were presented. The order of presentation of the two stimuli was random with the one constraint that not more than four horizontal or vertical presentations occur in succession. The experimenter recorded the reaction times for each trial. The experimenter could determine when the subject made an error by means of a light. Subjects made an average of about three or four errors. These trials were discarded.

Results

Table III contains the results of a Lindquist Type I analysis of variance which was performed on the data. The

Table III

Analysis of Variance for the Reaction Time Data

Source	df	M.S.	F	p
Between Ss	29			
Task Order	2	142304.25	5.39	.05
Error(b)	27	26803		
Within Ss	120			
Trial Blocks (T.B.)	4	9883.87	3.343	NS
T.B. x Task Order	8	3403	1.151	NS
Error(w)	108	2956.82		
Total	149			

significant main effect of task order reflects the fact that reaction times are much faster for the two groups who have had experience with the interval prior to the reaction time task. The mean reaction times for the Tach-RT and TE-RT groups are 92 and 93 milliseconds faster than the mean reaction time for the RT-TE group.

At the first trial block of ten trials the mean reaction times for the TE-RT and Tach-RT groups are 112 and 151 milliseconds faster than the mean reaction time for the RT-TE group at the first trial block.

Figure 3 contains the average reaction times for the three groups divided into five trial blocks of ten trials each.

No analyses were performed on the time-estimation data, but Table IV gives the means and standard deviations for the reproduction attempts over the five trial blocks. Clearly, there are no real differences between groups.

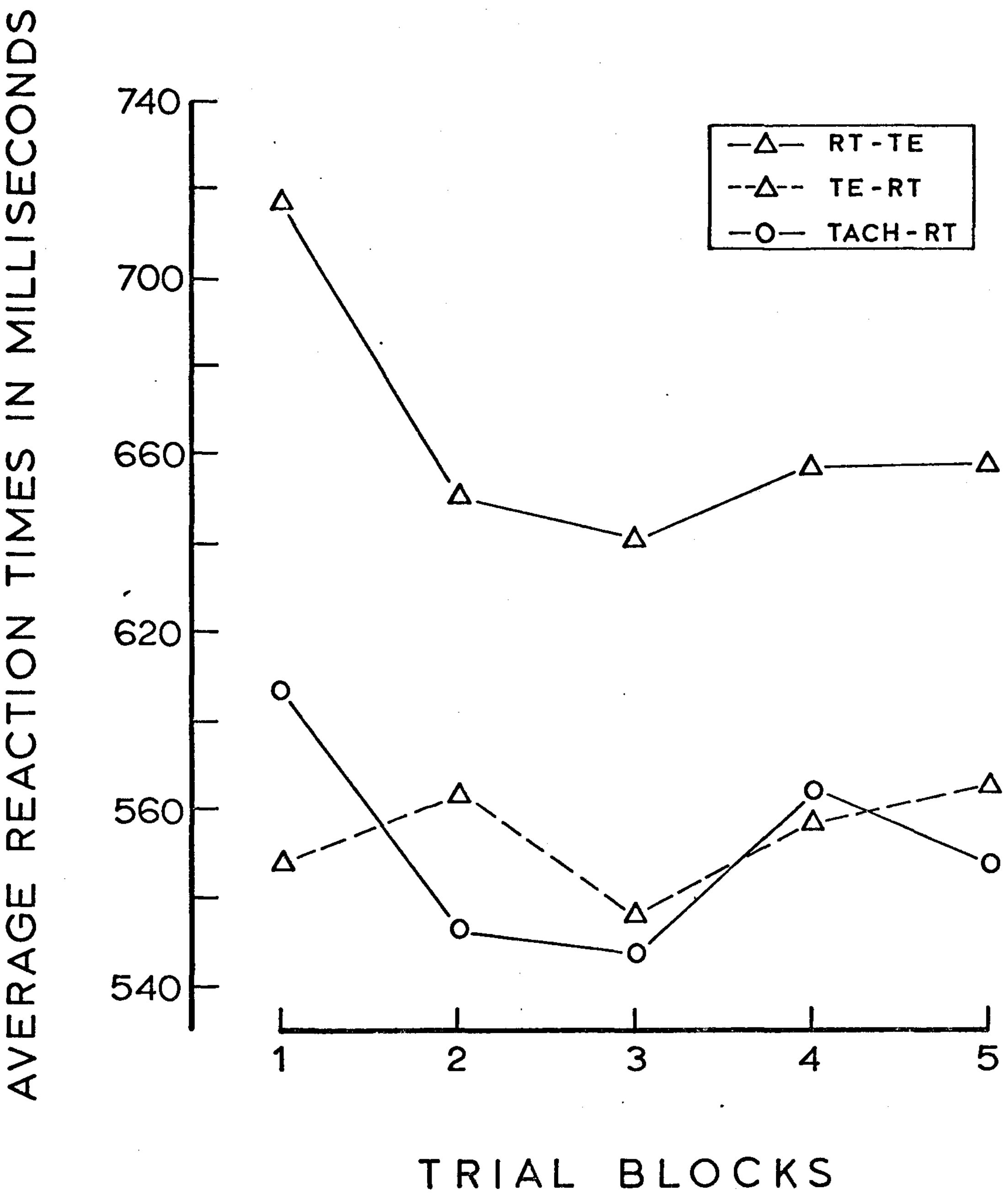

AVERAGE REACTION TIMES IN MILLISECONDS
740
700
660
620
560
540
RT - TE
TE - RT
TACH - RT
1
2
3
4
5
TRIAL BLOCKS

Table IV

Overall Means and Average Standard Deviations in Milliseconds for the Reproduction Attempts

Groups	1	2	3	4	5	1	2	3	4	5
RT-TE	7751	7815	7807	8003	8039	621	501	534	571	469
TE-RT	7716	7735	7862	7769	7699	650	620	519	567	511

Chapter IV

DISCUSSION

Two experiments were performed to test the hypothesis that the improvement with practice in tachistoscopic recognition and in reaction time experiments is in large part due to the experience that subjects have with a constant foreperiod. In Experiment I we were able to demonstrate that subjects given practice at reproducing an interval of time equivalent to the foreperiod which was employed in a subsequent tachistoscopic task had significantly lower thresholds on the tachistoscopic task than subjects who did not receive the time-estimation training. In Experiment II we were able to show that subjects given practice on a time estimation task in which the interval that was to be reproduced was equivalent to the foreperiod used in a subsequent choice reaction time task had significantly lower reaction times than subjects who did not obtain any experience with the interval prior to the choice reaction time task. We also demonstrated transfer from the tachistoscopic task to a choice reaction time task in which the interval was preserved.

Although the experience at estimating the time intervals in Experiment I resulted in significantly lower thresholds in the tachistoscopic (transfer) task, subjects failed to show any noticeable improvement in the accuracy of their reproduction attempts during the course of the time-estimation (training) task. Also, in Experiment II the TE-RT group failed to improve the accuracy of their reproduction attempts. This result was not entirely unexpected, since, as we mentioned earlier, it is clear that it is very difficult to demonstrate any improvement in time-estimation without a great deal of practice, much more than the fifty trials which we gave (Hawickhorst, 1934; Renshaw, 1932). It seems unlikely that anything except the experience subjects had with the interval could have mediated the transfer, since the time-estimation and tachistoscopic tasks are very different. It would appear that the time interval is the primary thing that is common to the two tasks. It would appear, then, that some kind of "latent" learning has occurred. Subjects benefit from experiencing the interval that is to be used in the transfer task, but this does not manifest itself until the transfer task.

We were not able to demonstrate transfer from the tachistoscopic to the time-estimation task in Experiment I under either the two- or eight-second foreperiod conditions, nor were we able to demonstrate any transfer from a training task to the time estimation task in either experiment because of the aforementioned difficulty in demonstrating any improvement in time-estimation without a great deal more practice than we gave. It is clear that subjects benefit from time-estimation training administered prior to tachistoscopic training, but it appears that subjects may not normally utilize a time-estimation strategy in the tachistoscopic situation unless it is somehow "forced" on them through time estimation training of some kind. Looking at Experiment II makes the possibility that we "forced" a strategy on the subject appear doubtful. One might argue looking at our demonstration of transfer for the TE-RT group and our failure to demonstrate any transfer for the RT-TE group that we have again "forced" a time-estimation strategy on the subject, and that the practice decrement in the reaction time task is not normally due to the experience the subject receives with a regular foreperiod. One only has to look at the Tach-RT group to discredit this argument. This group exhibits just as much transfer as the TE-RT group, and surely the tachistoscopic training would not artificially "force" a time estimation strategy on the subject since the significance of the foreperiod is in no way stressed.

An interesting finding from Experiment I was that most of the transfer was exhibited by the 8-TE group. The 2-TE group is significantly better than the 2-Tach group only at the first serial position. 2-Tach subjects start out doing quite well on the tachistoscopic task. There isn't much room for improvement. There is evidence that subjects can estimate a two-second interval more accurately than longer ones (Woodrow, 1930). This was not the case in our experiment, at least if one uses the usual relative measure, per cent deviation from the standard. If one looks at absolute accuracy, i.e., the deviation from the standard, the two-second subjects are slightly more accurate. The eight-second subjects, however, are still quite accurate. We believe that the reason 2-Tach subjects start off doing so well in the tachistoscopic task is not because it is a great deal easier to estimate shorter intervals, but rather that they do not find it necessary to use an estimation strategy. Instead, it may be possible to maintain a high level of attention over the entire interval, and hence subjects are maximally ready for the stimulus presentation. Subjects given an eight-second foreperiod, we believe, find it is not possible to "attend" over the entire interval, so they utilize a time-estimation strategy of some kind. Most subjects do not count during the tachistoscopic task but they are probably making use of their knowledge of the length of the interval to reach a "peak" level of attention just before the stimulus exposure. Our data seem to be consistent with the earlier findings that two seconds or thereabouts seems to be an optimal foreperiod. (Breitweiser, 1911; Woodrow, 1914). The results of the 8-TE group show that a small amount of practice with an eight-second interval tends to eliminate any advantage of the shorter interval.

Both the 2-TE and the 8-TE groups continued to show some slight improvement in the tachistoscopic task in Experiment I. Transfer, while not complete, was certainly very great at least for the 8-TE group. The small practice decrement which occurred following time-estimation training was probably due to the subjects' learning where to fixate and deciding what sort of visual technique to use, e.g., left-to-right scanning of the display.

We believe that we have presented evidence that the practice effect in tachistoscopic recognition and in choice reaction time experiments is due in large measure to the experience subjects have with a constant foreperiod. Reaction time studies which we mentioned earlier showed that subjects do better when given a fixed rather than a variable foreperiod. (Klemmer, 1956; Drazin, 1961). Rose (personal communication) found a similar result for a tachistoscopic task. These studies were not particularly interested in the practice effect that is found in these two tasks. We have demonstrated that there is only a very small practice effect in tachistoscopic recognition and in a choice reaction time task if subjects are first given a very small number of trials on a time-estimation task. The fact that this kind of pre-training practically eliminates any practice effect, we see as a strong argument that it is the experience that subjects have with the constant foreperiod that normally mediates the practice effect in the tachistoscopic and reaction time tasks.

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APPENDIX A

Raw Data

for

Experiment I

Experiment I

Recognition Thresholds in Milliseconds for the Group Receiving Time-Estimation Training with an Eight-Second Interval Prior to the Tachistoscopic Task in which the Interval was preserved.

	Serial Position					
Subjects	1	2	3	4	5	6
1	280	170	360	290	220	270
2	320	180	350	200	280	180
3	440	170	200	230	180	250
4	200	320	210	230	330	210
5	360	270	180	320	220	210
6	240	340	170	160	220	170
7	290	230	190	190	190	240
8	420	310	260	275	290	220
9	320	305	290	260	280	290
10	210	340	330	300	300	250

Experiment I

Recognition Thresholds in Milliseconds for the Group receiving Tachistoscopic Training with an eight-second Interval prior to a Time-estimation Task in which the Interval was preserved.

Serial Position

Subjects	1	2	3	4	5	6
1	340	300	200	290	200	200
2	700	350	375	400	250	340
3	560	400	240	310	320	330
4	650	260	280	280	300	170
5	440	350	260	295	330	360
6	300	210	210	260	220	210
7	250	315	380	180	320	290
8	300	270	240	350	330	180
9	640	370	335	335	300	210
10	570	390	365	340	290	400

Experiment I

Recognition Thresholds in Milliseconds for the Group Receiving Time-estimation Training with a two-second Interval Prior to the Tachistoscopic Task in which the Interval was Preserved.

	Serial Position					
Subjects	1	2	3	4	5	6
1	230	280	200	180	330	180
2	350	210	300	210	250	290
3	230	230	310	270	240	240
4	300	230	190	320	200	220
5	230	260	240	200	280	220
6	230	200	210	180	180	170
7	280	210	240	215	190	170
8	280	330	230	290	190	200
9	300	290	270	250	220	180
10	320	310	330	200	300	260

Experiment I

Recognition Thresholds in Milliseconds for the Group Receiving Tachistoscopic Training with a Two-second Interval Prior to a Time-estimation Task in which the Interval was preserved.

	Serial Position					
Subjects	1	2	3	4	5	6
1	360	280	200	200	230	210
2	340	260	280	260	240	190
3	420	450	320	290	300	210
4	380	240	310	220	360	210
5	330	230	255	280	300	240
6	360	380	220	230	240	240
7	230	210	200	240	200	180
8	240	190	180	180	160	210
9	290	270	250	170	220	220
10	310	210	330	370	320	320

Experiment I

Reproduction Values for the Group Given Time-Estimation Training with an Eight-second Interval Prior to the Tachistoscopic Task in Which the Interval was preserved.

Trials / Subjects	1-10	11-20	21-30	31-40	41-50
1	8859	8773	8091	8604	8339
2	7911	7869	8078	8173	8132
3	8232	8161	7988	8028	7895
4	7832	7837	7648	7406	8058
5	7885	7808	7961	8065	7974
6	7047	7072	7859	7522	7785
7	7595	7718	8001	7806	8303
8	7115	7513	7839	7092	7488
9	7167	7149	7686	6811	7284
10	7754	7800	7919	7752	7919

Experiment I

Reproduction Values for the Group Given Tachistoscopic Training With an Eight-Second Interval Prior to the Time-estimation task in which the Interval was preserved.

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	8198	7596	7038	6938	7339
2	7552	7786	7458	7361	7163
3	8209	7557	7636	7897	8194
4	7593	7565	7879	7881	7814
5	7811	8231	8244	8068	7741
6	7266	7911	7583	7674	7824
7	8466	7913	8869	8025	7598
8	7909	8172	7931	7547	8660
9	7273	7298	6982	6750	7012
10	7567	7651	8093	7954	8133

Experiment I

Reproduction Values for the Group Given Time-Estimation Training with a Two-second Interval prior to Tachistoscopic Training in which the Interval was preserved.

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	2012	1936	2130	1996	2296
2	1997	1955	1757	1915	1890
3	1969	1992	2011	2042	1981
4	1978	2012	2015	1772	1877
5	1969	2154	1918	2222	2190
6	2019	1730	1666	1811	1896
7	2120	1829	1805	1874	1803
8	1803	1910	1985	1955	1971
9	2041	2043	2014	2042	2085
10	2029	2011	1986	2010	1803

Experiment I

Reproduction Values for the Group Given Tachistoscopic Training with a Two-second Interval Prior to the Time-estimation Task in which the Interval was Preserved.

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	2168	1956	2028	2121	2267
2	1791	1984	2071	2144	2019
3	2348	1997	2086	1971	2137
4	1697	1645	1775	1783	1821
5	1955	1879	1895	1969	1960
6	1967	1950	1945	1976	1893
7	1698	1873	1843	1804	1866
8	1575	1738	1782	1742	1756
9	1917	2013	1920	1840	1824
10	1880	1984	1880	1940	1925

APPENDIX B

Raw Data

for

Experiment II

Experiment II

Reaction Times in Milliseconds for the Group Receiving Time-estimation Training Prior to the Reacting Time Task

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	634	564	559	555	541
2	669	558	552	579	678
3	539	505	482	495	478
4	673	591	573	620	640
5	462	434	420	528	518
6	500	579	477	554	524
7	697	679	749	703	643
8	793	505	540	612	541
9	564	524	599	670	616
10	591	592	536	540	502

Experiment II

Reaction Times in Milliseconds for the Group Receiving Tachistoscopic Training Prior to the Reaction Time Task.

Trials / Subjects	1-10	11-20	21-30	31-40	41-50
1	464	650	575	579	612
2	505	486	479	519	562
3	448	535	536	500	538
4	646	524	506	474	486
5	678	730	687	757	746
6	634	642	576	663	647
7	473	610	530	571	546
8	652	518	493	495	549
9	536	497	499	499	472
10	645	639	683	722	698

Experiment II

Reaction Times in Milliseconds for the Group Receiving Reaction Time Training Prior to the Time-estimation task.

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	665	504	578	544	608
2	972	733	706	634	672
3	621	760	685	687	708
4	829	823	779	845	772
5	639	693	586	677	568
6	701	617	543	676	676
7	675	540	588	598	551
8	692	571	552	521	495
9	738	665	711	675	818
10	659	602	679	732	727

Experiment II

Reproduction Values for the Group Given Time-Estimation Training Prior to the Reaction Time Task.

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	7805	8452	8527	7943	8335
2	7618	7335	7772	7683	7880
3	7643	7234	8155	7667	7566
4	8087	8523	8757	8406	8111
5	6945	6764	7149	7265	7340
6	7812	7769	7442	7448	7208
7	8058	8558	8716	8358	8006
8	7360	6703	6852	6986	7045
9	8127	8095	8121	8430	7800
10	7709	7925	7133	7509	7694

Experiment II

Reproduction Values for the Group Given Practice on the Reaction Time Task Prior to the Time-estimation task.

Trials / Subjects	1-10	11-20	21-30	31-40	41-50
1	8003	8014	7713	7995	7914
2	7883	8264	7929	8032	8661
3	7790	7916	8048	7953	7913
4	6883	6881	7528	8367	7952
5	8440	8190	8458	8225	8271
6	7303	7259	7570	8219	8899
7	7583	7978	7527	8280	7997
8	8338	8196	7887	8097	7779
9	7866	7706	7830	7644	7644
10	7664	7751	7589	7222	7358

Experiment II

Recognition Thresholds in Milliseconds for the Group Receiving Tachistoscopic Training prior to the Reaction Time Tasks.

	Serial Position					
Subjects	1	2	3	4	5	6
1	300	250	210	250	350	220
2	480	425	370	390	330	370
3	340	355	370	380	295	210
4	410	280	260	295	330	290
5	470	390	260	360	200	210
6	580	320	350	380	230	280
7	570	330	380	380	380	240
8	390	350	220	240	190	210
9	490	370	380	375	370	380
10	320	350	270	200	210	200

Experiment II

Reaction Times in Milliseconds for the Group Receiving Time-estimation Training Prior to the Reacting Time Task

Trials Subjects	1-10	11-20	21-30	31-40	41-50
1	634	564	559	555	541
2	669	558	552	579	678
3	539	505	482	495	478
4	673	591	573	620	640
5	462	434	420	528	518
6	500	579	477	554	524
7	697	679	749	703	643
8	793	505	540	612	541
9	564	524	599	670	616
10	591	592	536	540	502