TEMPORAL CONDITIONING IN HUMANS AS A FUNCTION OF INTERTRIAL INTERVAL AND STIMULUS INTENSITY

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ABSTRACT

TEMPORAL CONDITIONING IN HUMANS AS A FUNCTION OF INTERTRIAL INTERVAL AND STIMULUS INTENSITY

by Robert F. Morgan

Past decades of Soviet research on the classical conditioning of a temporal response to a periodic stimulus led to the formation of several testable theories and attitudes. Pavlovians consider temporal conditioning to be a respectable member of the conditioning family, subject to the laws of inhibition and differential stimulus intensity; without upper limit as to size of intertrial interval (ITI). Over the years, accumulated Soviet evidence indicated ITIs below three to five minutes were difficult or impossible to condition. Sporadic American research came to an opposite conclusion: temporal conditioning became more difficult as ITIs increased to one minute or larger. Major purposes of the following experiments were to resolve the apparent American-Soviet ITI contradiction and to study temporal conditioning phenomena in depth through the use of the larger subject (*S*) samples, statistical evaluation, and experimental control common to less neglected areas of American experimental psychology.

Male and female volunteer college student Ss vocally anticipated a periodic photic stimulus (US) once each trial in all experiments. Anticipations occurring in the last fifth of the ITI were defined as conditioned responses (CRs).

Experiment I gauged conditioning efficacy over 20 trials at ITIs of 45, 135, or 240 seconds and at high (100 watt) or low (7 watt) US intensity. With 3 Ss at each ITI-intensity condition, conditioning level at 135 seconds trailed the shorter and longer ITIs. High US intensity depressed conditioning level at the shortest ITI, raising it at the highest ITI. Introspective reports of methods of synchrony, estimation of ITI length, and stimulus unpleasantness were analyzed in this and the following experiments.

Experiment II replicated Experiment I's conditioning results in 15 trials at ITIs of 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 seconds with high or low US intensity. With 6 Ss at each ITI-intensity condition (120 Ss total), conditioning level at ITIs of 60 seconds or less and of 210 seconds or more excelled that of ITIs in between. High US intensity again depressed performance at short ITIs (30, 60, sec.) but enhanced performance significantly only at middle range ITIs (150, 180 sec.). Independent conditioning measures of CR frequency and error magnitude showed similar results, demonstrating general increase in conditioning level with blocks of trials. Galvanic skin response (gsr) measures yielded a highly significant positive relationship between pre-experimental relaxation and subsequent performance. Gsr readings taken at the midpoint of every ITI showed a significantly increasing level of relaxation at the midpoint over blocks of acquisition trials in the presence of temporal conditioning which was absent or inconsistent when such conditioning was absent. This held true even for Ss having overall gsr decrease in relaxation in response to the entire experiment. Gsr findings supported neo-Pavlovian inhibition theory prediction and a complementary discrimination-production hypothesis.

Experiment III demonstrated conditioning for 12 Ss at high US intensity ITIs of 60 or 240 seconds to significantly improve with a second day of 15 acquisition trials and to significantly extinguish with 15 subsequent trials lacking the periodic US.

Experiment IV failed to demonstrate significant Pavlov-predicted temporal conditioning over 15 high US intensity acquisition trials with ITIs of 30 and 60 minutes. The 3 Ss at each ITI did show higher estimation accuracy and less mean per cent time counting than Ss at the lower ITIs of the earlier experiments.

These experiments generally reconciled American and Soviet thrusts towards the demonstration and understanding of the parameters of temporal conditioning, a gateway to the psychology of time.

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By

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INTRODUCTION

Time was one of experimental psychology's first independent variables. Subsequent decades of research have not diminished this central role. Quite recent research, for example, supported temporal discrimination as critical to operant avoidance learning (Anger, 1963)and as critical to response latency in repetitive vigilance tasks (Hardesty and Bevan, 1965). This dissertation will concentrate the focus on this ubiquitous variable to its importance as a stimulus in the context of classical conditioning.

A recent summary, translated from the Russian, reviewed over half a century of such temporal conditioning research (Dmitriev and Kochigina, 1959). Beginning in 1907 with Zelenyi, a student of Pavlov, 68 studies have subsequently been completed. Subjects ranged from bats to hedgehogs to collies to humans; unconditional stimuli varied from shock to food powder to temperature; measured responses included salivation, leg flexion, ear temperature, and even white blood cell count. Thus, over a wide range of species and techniques the Russian investigators have demonstrated respondent conditioning to a time interval to be an accomplished fact.

Psychology here in the United States has, however, barely acknowledged the phenomenon of temporal conditioning. Learning texts list it in a sentence or two but usually without discussion. Conditioning studies vary their inter-trial intervals (ITIs) or otherwise control for temporal conditioning but typically without much conviction or overt rationale. Only two temporal conditioning studies could be located in American psychology journals.[1] Brown (1939) shocked rats at 12 second intervals, measuring the force of the jump response on a postage scale. After 35 trials, rats were shocked at 3, 6, 9, 12, 15, 18, 21, or 24 seconds after the last shock. Rats jumped with most force at the 12 second test shock with decreasing force as the interval grew smaller or slightly larger. Bugelski and Coyer (1950) trained rats to jump a barrier in response to periodic shock and found quicker temporal conditioning at a 15 second ITI than at a 60 second ITI.

On the other hand, American psychology has dealt more fully with temporal response in the context of fixed interval schedules in operant learning (Ferster and Skinner, 1957). Nevertheless, of 79 studies classically conditioning a response to a temporal CS (as located in Psychol. Abstracts up to August 1965), 72 originated in the USSR with others in France, West Germany, and Japan.

The Russian studies were generally strong on detailed observation and imagination but too often weak on experimental controls and statistics even of descriptive nature.

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[1]This does not include Grant, McFarling, and Gormezano (1960) or Prokasy and Chambliss (1960) since an external CS remained in their "temporal conditioning" studies. Neither human eye-blink study found fixed ITIs (15 and 25 sec.) to excel variable ITIs but Prokasy (1965) later cited unpublished data supporting significant temporal cue effects with an alternate measure.

Number of subjects (Ss) rarely exceeded five, often with one S per condition. Furthermore, these very Ss were traditionally passed down over the years from experiment to experiment much as precision timers might be here in the USA. A final drawback prevalent until very recently has been a relatively rigid adherence to only those areas of exploration the early Pavlovians demonstrated as viable. Within this ground there was much imagination,but beyond it studies never reached the printed page. One case in point was the long exclusive Russian ITI range of five to 30 minutes, below or above which no Pavlovian went.

One of Kochigina's more modern studies (Dmitriev and Kochigina, 1959) is a good example of the Russian technique. Conditioning the leg flexion of dogs to periodic shock, she observed three successive stages of temporal anticipation. Stage 1, the "generalized reflex to time," was characterized by increasing, then decreasing, intersignal errors throughout the ITI. (The intersignal error refers to premature leg flexions anticipating the shock.) Stage 2, the "differentiated reflex to time," begins when intersignal errors occur only during the last half of the ITI. Over further trials errors converge in time on the end point of the ITI. Stage 3, the successfully conditioned temporal response, is operationally defined as occuring when any and all intersignal errors fall within the last 20% of the ITI or to a criterion of 80% accuracy. Kochigina's ITI in this case was the current Russian mode of 5 minutes; four dogs took from 90 to 135 trials to reach criterion.

Temporal conditioning in its classical framework has much relevance for American psychology today. Research is needed, if for nothing else, than to justify controls against it[2] as well as to explain "sensitization" effects where periodic US presentations elicit an enhanced response level. Russians use this latter effect to increase livestock yield: optimal periodic feeding and milking rhythms are determined experimentally and universally applied (Dmitriev and Kochigina, 1959). Some of the aspects of temporal conditioning demanding basic well controlled research are the effects of ITI, stimulus intensity (Int.), concurrent temporal estimation, concurrent interoceptive process or methods of synchrony, and the role of inhibition.

When Russian psychologists had first determined that a fixed rhythm of stimulation enhanced response magnitude over that elicited by random or haphazard stimulation, animal husbandry specialists set up immediate searches for optimal species-specific ITIs. Unfortunately, the academic temporal conditioners did not follow suit so extensively. Today the differential effect of ITI length on level of conditioning has not yet been broadly investigated. Bugelski (1956) acknowledged this need: "The area of temporal intervals is still largely unexplored. We do not as yet know the most effective intervals for such conditioning." (p. 131)

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[2]. . .Whether fixed or varied, the time functions adopted can influence behavior (i.e., can produce some form of temporal conditioning) and are worthy of analysis in their own right." (p. 121 , Prokasy, 1965) An illustrative "pseudoconditioning" study is Kimble, Mann, and Dufort (1955). Prokasy rejected temporal influence as critical to "pseudoconditioning" in 1960 but reversed himself in 1965 on the basis of new data.

The findings to date on this point are, at first glance, among the most directly contradictory of all the explored aspects of temporal conditioning. There is what might be called a Washington-Moscow ITI controversy. Bugelski and Coyer (1950) in the study already cited found conditioning in rats at the 15 second ITI to be faster than at the 60 second ITI. Bugelski concluded that temporal conditioning became more difficult with increasing ITI length. The other American study operated at a 12 second ITI (Brown, 1939) while the French contribution (Fraisse & Jampolsky , 1952) successfully conditioned human gsrs to shock at an ITI of 8 seconds. On this side of the globe then, ITIs have been in terms of seconds backed by the cited opinion that intervals beyond a minute would yield diminishing or non-existent returns. The Russians came to the opposite conclusion.

Zelenyi (1907) launched temporal conditioning in Pavlov's laboratories with a 10 minute ITI. The following year it was replicated at an ITI of 20 minutes (Krzhishkovskii, 1908). Four years later came the much discussed work of Feokritova (1912) with an ITI of 30 minutes. Under Pavlov's supervision (Pavlov, 1927) she brought salivary conditioning well within Kochigina's third stage at this ITI with no canine salivation until the last minute before stimulation. But with the 1930's came moderation. From then up to the present, Soviet ITIs have clustered about five minutes with a general range of three to seven minutes. Nevertheless, there was a consensus that no upper ITI length limit need apply. Pavlov decreed: ". . . any length of time interval can be employed. No experiments, however, were made with intervals longer than half an hour" (Pavlov, 1927, p. 42). On the other hand, a lower limit soon crept in. In 1937 Baiandurov found it impossible to condition pigeon activity to periodic shock at ITIs of from 5 to 15 minutes. He had to push as far as 300 trials before 'even' a 30 minute ITI allowed criterion to be reached. Dogs, regarded as capable of conditioning at a somewhat lower ITI than pigeons, still seemed to have a lower limit of their own. A good illustrative study is that of Bolotina (1952a) who conditioned canine time flexion to either a 10 minute or 3 minute ITI. All Ss conditioned at 10 minutes with a mean 180 trials to criterion. Only 1/3 of his dogs were able to condition at the 3 minute ITI and these Ss needed a mean of 520 trials to criterion. Testing the possibility that this finding was a function of his choice of species, he replicated his study with monkeys (1952b) achieving substantially the same results. Bolotina concluded that ITIs of 3 minutes or less were nearly impossible for temporal conditioning since neural excitation was too arhythmic at short intervals to allow the neural traces of inhibition to concentrate. The next year Bolotina (1953) attempted to artificially set aside this neural difficulty by administering bromides to both his dogs and his monkeys. The relaxed animals were able to go as low as ITIs of 2 minutes with level of conditioning improving with increasing bromide strength. A possibility of course was that the bromides were aided by continued use of the same Ss from experiment to experiment. Dmitriev and Grebenkina (1959) demonstrated this possibility when, unable to temporally condition leg flexion in any of six dogs directly to ITIs of 1 or 2 minutes, they trained down Ss at successively lower ITIs (starting with 5 minutes) and eased their dogs into the difficult ITIs. The moral was clear: temporal conditioning became more difficult with decreasing ITI length; any ITI at 3 minutes or less would yield diminishing or non-existent returns.

Bugelski (1956), aware of these conflicting perspectives, recommended further research. None has as yet appeared. One possible result of such research would be to support both sides. The Soviet-oriented and Washington-oriented studies are standing on different geographical ranges of ITI. Perhaps there is something involved in the exposure of complex mammals such as dogs and humans to that 1 to 3 minute range that depresses performance. Or perhaps the two ranges reflect the dominance of separate methods of temporal synchrony. What was needed was a comparative ITI study to explore the gap.

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Among the Russians only a recent few have crossed that gap at all (Dmitriev and Kochigina, 1959; Elkin, 1964). With Kochigina, Dmitriev temporally conditioned a verbal anticipatory response to an auditory stimulus in children aged 8 to 14. The ITI was 30 seconds. Elkin has very recently conditioned humans to ITIs as low as 3 to 10 seconds. His study will be discussed more fully in another section.

/The intensity of the unconditional stimulus has special implications for temporal conditioning although it has been a central variable in classical conditioning since its inception.

Pavlov (1927) reported the speed of conditioning as well as resistance to extinction to vary with the intensity of the unconditional stimulus. American research has supported this over the years. Passey (1948), for example, found that conditioning the eye-blink reflex to an air puff varied significantly with the pressure of the puff: both rate and final level of conditioning increased with increasing air puff intensity (cf. Spence, Haggard, and Ross, 1958; Ratner and Denny, 1964). In general it has been found that performance in the learning situation improves with increasing amount of positive or negative reinforcement (Kimble, 1961)./ Therefore, in that temporal conditioning is a member of the category of classical conditioning, similar results should be expected. But not necessarily.

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Temporal conditioning has a property which at the same time distinguishes it from the other more complex forms of conditioning (of which it often is a basic component) and which leads to opposite predictions. That property is the internal nature of the CS; interoceptive rhythms must be set up as cues to achieve the CR. It is relatively easy to set up a range of US intensities which does not prohibit the S's discrimination of an external CS. In temporal conditioning, however, a stimulus intense enough to disturb the S disturbs both the discrimination of internal rhythms as well as the regularity of these rhythms. Pavlovians have long demonstrated level of temporal conditioning to be inversely related to S's level of arousal. Feokritova (1912) noted that somnolent dogs excelled normal animals. Stukova (1914) found "excitable" dogs to be more prone to distraction from extraneous stimuli than dogs with "well developed inhibition processes." The tranquilizing effect of bromide injections has, as previously mentioned, been used to facilitate temporal conditioning (Stukova, 1914; Deriabin, 1916; Bolotina, 1953; Dmitriev and Kochigina, 1959) while the excitant of caffeine retarded the process (Dmitriev and Kochigina, 1959). Presumably, the increased arousal somehow interfered with the production and/or discrimination of the interoceptive CS. Pavlovians prefer to discuss this effect in inhibition terminology; the discrimination interpretation is my own.

It might be expected then that increasing intensity would retard level of temporal conditioning where the ITIs are so short as to allow _S_ insufficient recuperation or relaxation time before the next ITI occurs. On the other hand, when ITIs are quite long enough for relaxation to occur in spite of a strongly arousing US, one would expect the traditional superiority of the more intense US to emerge.

Data from fixed interval studies in operant conditioning contexts support this prediction. While stronger reinforcement at _moderate_ or _long_ ITIs has excelled performance at weaker reinforcements (Collier and Myers, 1961; Guttman, 1953; Collier, Knarr, and Marx, 1961; Dufort and Kimble, 1956), the opposite was found at very _short_ ITIs (Collier and Myers, 1961; Conrad and Sidman, 1956).

One final aspect of the intensity variable worth mentioning is the too often neglected obligation of the researcher to demonstrate that cranking up physical intensity produces any substantial subjective increment as well. Often a Russian study would designate a certain acid dosage on a dog's tongue as noxious without any proof; without appropriate and controlled avoidance measures the US might well only have been "tangy." Temporal conditioning with humans, especially, offers an easy opportunity for _S_ to vocally identify the intensity as to pleasantness or unpleasantness.

The interaction of US intensity and ITI was once predicted and observed (ITIs of 15, 45, 135 sec.), but not significantly supported, in a human eyelid conditioning study where photic CS overlapped air puff US (Prokasy, W., Grant, D., and Myers, N., 1958). The simpler temporal conditioning procedure, omitting the external CS, may clarify the issue.

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Temporal research with humans has been well cultivated along another area parallel to our interests: temporal estimation. Taking advantage of the unique phylogenetic link between _E_ and _S_, humans for nearly a century have been asked to produce, reproduce, estimate, and describe intervals of time. During temporal conditioning, human _S_s maintain some conscious impression of the magnitude of the ITI. That this process, if not directly related to the conditioning process, is at least affected by it has been shown by Elkin (1964). Elkin temporally conditioned 11 human _S_s to ITIs of 3, 5, or 10 seconds. A temporal estimation of all 3 ITIs was made before and after training. Each _S_ showed improvement at estimating the ITI he had been conditioned to with no generalization in increment of estimation accuracy at the other ITIs. This was the only study to ever tie together the two processes of temporal estimation and conditioning. Further investigation of the aspects of their inter-relations is needed.

American, French, and German psychologists have turned out volumes of temporal research when it comes to estimation. Among the best current review sources are Fraisse (1963), Woodrow (1951), and Wallace and Rabin (1960). Some of the aspects of estimation might well be investigated in a temporal conditioning context since the large body of research, despite its bulk, is contradictory on many points. Many studies associate over estimation

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with high stress and arousal (Gulliksen, 1927; Cutler, 1952; Eson and Kafka, 1952; Anliker, 1963) while many others associate over estimation with low stress and relaxation (Rosenzweig and Koht, 1933; Bakan, 1955; Hare, 1963; Geiwitz, 1964). Johnson (1962) found no relationship between over estimation and stress concluding that "available methods in time perception experiments do not provide an adequate test." Less pessimistically, Zelkind and Spilka (1965) found over estimation to correlate positively with an optimistic outlook for the future. Even general non-directional accuracy of estimate has been found to increase with high anxiety (Burns and Gifford, 1961) as well as decrease with high anxiety (Weybrew, 1963). But if the literature is far from clear as to arousal effects, the influence of ITI length is generally clear. Accuracy of estimation has been found to increase as the interval increases. Furthermore, the ranges of interval tested have been quite broad. Gilliland and Humphreys (1943), for example, found Ss estimated a 14 second interval at a mean accuracy of 72% as opposed to a mean accuracy of 82% for a 117 second interval. Stimulus intensity ties in to estimation in so far as it heightens anxiety or arousal. Yet, as has been mentioned, the consequences of this are far from clear. If Benussi (1907), using an auditory stimulus, is any guide, increasing intensity shortens the perceived interval. A final point of temporal estimation worth exploring is that of S's

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retrospective opinion of that estimation; an estimation of the estimation. Bakan (1962) found this retrospection to add information or accuracy to the estimate. Ss in a temporal conditioning context then might be generally expected to identify the direction and possibly the magnitude of the error of their estimate of the ITI. All these S reports are worth brief investigation.

Verbal reports also offer a look at some of the ongoing interoceptive processes used to accomplish temporal synchrony. The question of which process or processes are basic to time perception has long teased psychology. Long range process change (blood sugar count, white blood cell count, and hormonal secretions) have been linked to circadian rhythms (Kayser, 1952) and even conditioned (Dmitriev and Kochigina, 1959). Along these lines, Kleitman (1939) determined the existence of a diurnal temperature cycle in humans and conditioned it to different cycle lengths in an assistant (Kleitman, Titelbaum, and Hoffman, 1937). This kind of approach with slow moving processes has demonstrated the relative ease with which interoceptive rhythms can be made to synchronize with exogenous ones. Waking at a specific time each morning, for example, has been traced to individual empathy with degree of bladder distension (Fraisse, 1963). But when synchrony with intervals of minutes or seconds is involved, some more immediately periodic processes must be examined. Fraisse (1963) lists breathing, pulse, and EEG

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activity as the three most important such rhythms, giving priority to the last. In the area of temporal estimation, choice of the critical interoceptive rhythm has again led to a wide variety of findings. Schaefer and Gilliland (1938) ruled out pulse rate, breathing rate, and blood pressure change as reliable indicators of estimation accuracy for intervals of 4 to 27 seconds. Bell and Provins (1963) also ruled out pulse and changes in room temperature as well. However, body temperature has been shown to be related to temporal estimation and production (François, 1927, 1928; Hoagland, 1933, 1934, 1936a, 1936b, 1936c, 1936d, 1943). As to EEG activity, Adrian (1934) has demonstrated that the alpha rhythm can be synchronized with intermittent light. Werboff (1957) brought EEG into the estimation of short intervals and found alpha activity highly related. With brain activity as a possible cue rhythm, one might expect research designed to locate its physiological source. Dimond (1964) has concisely summarized the ablation approaches to locating a temporal center in the cortex. Over the last thirty years, parietal lobes, prefrontal lobes, dorsomedial thalamus, mammallary bodies, and other slices of cortex have been removed in this search (Ehrenwald, 1931; Harrison, 1940; Remy, 1942; Hyde and Wood, 1949; Spiegel and Wysis, 1949; Partridge, 1950; Spiegel, Wysis, Orchinik, and Freed, 1955) with "temporal confusion" (as Dimond put it) occuring in all cases. The search for an exact location goes on although Dimond preferred the prefrontal areas as the most likely suspects.

Theory has not lagged behind research in attempts at pinning down this internal programming. Popov (1948, 1950a, 1950b), taking off from Adrian's EEG work of 1934 evolved the general temporal theory of "cyclochronism."

"Cyclochronism" bases itself on the nervous system which at all levels supposedly reproduces external excitations in the same order and at the same temporal intervals as when they first acted on the organism (cf. Fraisse, 1963). This theory of nervous mimicry, currently accepted by French psychology (Fraisse, 1963), does not directly oppose Pavlovian doctrine since Pavlov (1927, 1928) insisted that <u>all</u> interoceptive processes had their effects on the cortex. However, Popov de-emphasizes the role of the middle man: the interoceptive processes relaying the periodicities to the cortex. Pavlov, for example, attributed temporal conditioning of the salivary reflex primarily to the slow rhythms of the digestive organs. Thus, ITIs were long to allow for the substantial latencies of digestion; it was not until the 1930's, when motor reactions were first investigated (Beritov, 1932), that Soviet ITIs dropped to the 5 minute range. Furthermore, Pavlov felt that excitations were not immediately reproduced internally but rather gradually took on this form with repeated exposures. The process which ultimately separated responses from one another for the correct time interval was, according to Pavlov, inhibition.

Before discussing inhibition, a final word might be said about the search for critical methods of synchrony. Recently human Ss were asked to identify their methods of time judgement in a well controlled study. Spivack and Levine (1964) identified "visual clock" (S sees an imaginary clock and judges time by it) and "feel" (S has a strong intuition) methods as well as some form of counting when short intervals of 1 to 64 seconds were estimated. An inventory of the conscious methods used by human Ss as well as their differential effectiveness should be done for temporal conditioning. Recent evidence suggests that breathing rate, for example, may be as important as Munsterberg (1889) once thought it was. Stolz (1965) found vasomoter conditioning impossible when breathing was "controlled" by synchronizing it to a metronome. The relative frequency and effectiveness of methods of choice for a large number of humans temporally conditioned would, if nothing else, say something about human species behavior in a temporal situation.

Whatever the rhythm, another process is needed to hook up the external stimulus with an internal response specific in time. To Pavlov (1927, 1928, 1957) this process was the concentration of cortical inhibition in the right temporal areas. Extinction or unlearning involved irradiation of this inhibition such that concentration was destroyed. Although Pavlov thought of inhibition as a strictly cortical event, it was analogized with other physiological events from the beginning. Frolov (1937), for example, said:

> . . . since nearly all activity of the musculature consists in the alternating flexion and extension of the extremities at the joints the . . . fact of reciprocal excitation and inhibition by means of reflex action acquires almost universal significance. All interfering movements are inhibited as soon as they become unnecessary (p. 107).

Although inhibition retained its central role for Pavlovian conditioning (Prokasy, 1965), its definition broadened over the years. Inhibition soon came to include relaxation of the musculature in any form up to and including sleep. Rather than demonstrating nervous tissues' concentration or irradiation of inhibition, Russian studies now only differentially manipulate observable relaxation. Operationally this approach has been quite productive, especially in the area of temporal conditioning. Feokritova, as far back as 1912, noted that her dogs took better account of the passage of time during sleep than during a period of activity (Frolov, 1937). Bromide and caffeine studies, manipulating relaxation by drug, have found temporal conditioning superior for those _S_s best able to inhibit their responses at the right time: those relaxed artificially by drug (Stukova, 1914; Deriabin, 1916; Bolotina, 1953; Dmitriev and Kochigina, 1959). Pavlovian theory rests on the assumption that conditioning is learning when (and being able) to relax or (see Denny and Adelman, 1955, for "Secondary Elicitation," a similar emphasis on relaxation in an American learning theory.)

learning when not to respond. Naturally, it is represented in other more complex terminology:

> It appears that in the establishment of a conditioned reflex to time, internal inhibition becomes stronger, as a result of which it can at some point and under certain conditions become prepotent over the stimulation of the dominant response and delay the . . . reaction . . . . From this point of view, the conditioned reflex to time is the result of the imminent relative insufficiency of internal inhibition during interaction of the dominant response (Rozin, 1959).

Inhibition supposedly grows from the midpoint of the ITI, since that is the farthest point in time from stimulation, expanding to concentrate over the entire non-stimulated interval with sufficient trials (Pavlov, 1927; Dmitriev and Kochigina, 1959). How could this be measured?

Birman (1953) classified human Ss as "excitables" and "relaxeds" on the basis of their observed waiting room behavior before the experiment began. Trace conditioning was far superior for the "relaxeds." A better way to get at pre-treatment arousal as well as the development of relaxation during conditioning would be by gsr recording. A good deal is known about this measure (Woodworth and Schlosberg, 1954) and quite recently gsr changes have been found to be associated with CRs in a human operant learning situation (Doehring, Helmer, and Fuller, 1964) and URs in an earthworm responding situation (Morgan, Ratner, and Denny, 1965).

In summary, the literature has delineated the independent variables of ITI, stimulus intensity, and prior relaxation as potentially important to temporal conditioning. The concurrent dependent variables of temporal estimation, interoceptive process or methods of synchrony, and relaxation during the ITI also seem relevant for inclusion in any parametric study of temporal conditioning. It was decided to attempt such an investigation of these variables through a series of temporal conditioning experiments with humans in a common methodological context.

Pilot research, including a variety of conditioning methodologies, ultimately led to the adoption of Dmitriev's (1959) vocal anticipation of the periodic stimulus as most fruitful method for pursuing the temporal variables suggested by the literature. Human Ss selected for the pilot research performed well in the vocal anticipation paradigm of temporal conditioning.

A photic flash in a dark room was adopted as the periodic US. This reduced the problem of manipulating stimulus intensity to switching light bulbs of differential wattage Theoretically, US intensity might also have been changed by varying the intensity level during the ITI with absence of light as the US. In either case, the change in photic intensity should have subsequent unconditional response consequences for S if such a change can in fact be taken as a US. Pilot work indicated that both high and low wattage flashes, at ITIs of 30 seconds or more, elicited consistent gsr arousal in humans. This gsr arousal had not habituated after 20 successive flashes. The gsr drops were only part of a generalized response complex including slight head withdrawals, eye blinks, and general skeletal movement. Thus the US consistently produced a UR or URs. However, in the pursuit of a discrete and more readily identifiable response, the vocal anticipation was chosen. This choice departed from most American classical conditioning research in that the vocal response, in the absence of prior instructions, would not be a consistent (unconditional) response to the photic flash. The prior instructions, however, allow the vocal response to function as such a UR within the specific experimental context of the temporal conditioning situation. Since it's significance as a consistent stimulus is thus acquired, we are realy dealing here with a higher order conditioning of the temporal response. Fortunately, through the use of the human "second signalling system" of language, such conditioning is eminently feasible. One objection that might have been raised by American psychologists of an earlier era would be to the "voluntary" nature of the response in what is purported to be a classical conditioning paradigm. However, since in recent years "involuntary" responses have been conditioned in operant situations and even controlled by voluntary procedures (Stolz, 1965; Kimble, 1961), American definitions of the classical procedure have somewhat liberalized. Kimble (1961) says:

> The original distinction between instrumental and classical conditioning is made purely on operational grounds. The two designations refer respectively to training procedures in which the response of the subject does and does not determine whether the US appears (p. 78). . . . the conditioned response is a combination of voluntary and involuntary processes (p. 108).

Pavlov was sensitive to the controversy of volition, which he regarded a pseudo-controversy, and for years the word "voluntary" was forbidden in the Pavlov laboratories (Frolov, 1937).

Pilot research led to the establishment of experimental conditions designed to reduce, as much as plausible, all competing or distracting extraneous stimuli from the environment to maximize the chance of temporal conditioning's occurrence. Since such conditioning at the ITI range contemplated had long been regarded as difficult or impossible, such maximizing steps seemed warranted. The final pilot study is included in this dissertation as it was the prototype of the experiments that followed.

On the basis of the relevant literature discussed here, as supported by pilot research, certain hypotheses seem tenable:

A. Temporal conditioning in a classical framework can be demonstrated for adult humans.

B. When a temporal response is acquired it will show improvement with continued amounts of periodic stimulation and extinction when anticipations are elicited in the absence of that periodic stimulation.

C. Performance observed in acquisition will be a function of ITI with performance at ITIs of more than 3 minutes and at 1 minute or less excelling performance of ITIs in between.

D. Performance observed in acquisition will be enhanced by increasing stimulus intensity at high ITIs and retarded by increasing stimulus intensity at low ITIs.

E. Post-conditioning estimation of ITI length will be affected by some of the factors affecting temporal conditioning. Accuracy of estimation, for example, will increase with increasing ITI.

F. The more relaxed a subject before conditioning begins, the higher the subsequent level of conditioning obtained. Gsr drops obtained directly before acquisition will therefore be reliable predictors of subsequent performance.

G. As temporal conditioning occurs over trials, increased relaxation during the ITI will also be observed with trials. Gsr changes from the center of one ITI to the next will therefore show increased relaxation over trials in the presence of temporal conditioning.

H. Reported interoceptive process will vary with the subject and the ITI. Specifically, counting methods of synchrony will decrease in percentage of use as ITI length increases.

The following experiments attempt to gather sufficient basic data to support or reject these hypotheses and to lay the framework for a better understanding of respondent conditioning to an interval of time.

EXPERIMENT I

Experiment I, as the last pilot study, stood as basic prototype to the experiments following it. Its purposes were twofold. One was to demonstrate the feasibility of temporal conditioning at the stimulus conditions contemplated within the context of the experimental procedure and setting evolved for that purpose. Secondly, a first look at the differential effects of ITI and stimulus intensity was to be taken.

Method

Subjects.--The Ss were 18 volunteer college students, or their wives, ranging in age from 19 to 25. There were 13 males and 5 females.

Apparatus.--The experiment took place in a relatively light-tight single room. E sat at a desk directly behind S and collected data by the light of a red 60 watt bulb. The photic US was a bulb flash controlled by E with a Lafayette Stimulus Timer. The bulb was 7.5 watts white-frosted for the low intensity condition and was 100 watts white-frosted for the high intensity condition. The bulb was at eye level or below on a lamp 18 in. in front of S. The bulb and lamp rested on a table which S faced. S's left hand rested on this table within the gsr finger electrodes. The gsr electrodes were connected to a Lafayette D.C. gsr unit placed over the Stimulus Timer at E's table. E also remained within reach of the room overhead lights. S sat in a comfortable wooden swivel chair with arm rests facing the lamp and US bulb which had a blank white wall behind it. E timed S's vocal responses with a Meylan stop watch, checking these readings at the shorter ITIs against tape recordings made during the experimental session. Dittoed data sheets (see Table 30) were used for uniform data recording; typed procedure and instructions for S were taped to E's desk.

Procedure.--Before each S, E warmed up gsr and timer apparatus for 10 minutes. At the end of this time, S was allowed to enter the experimental room, minus any wrist watch, and settled in chair and gsr finger electrodes. At this time E recorded S's name, age, sex, and any other descriptive data that seemed relevant. E next handed S a carbon copy of the acquisition instructions. S followed this copy visually while E read the original out loud. The acquisition instructions were as follows:

> This experiment is designed to measure your gsr or the electrical resistance of the skin. The finger electrodes are for measurement only and will not shock you. A brief explanation of the gsr's purpose will follow the experiment; any questions about our purpose will be answered at that time.
>
> 1. Because of the delicate balance of the electrical equipment please keep your left hand perfectly still throughout the experiment.

2. Find as comfortable a sitting position as you can, facing straight ahead.
3. The light in front of you will flash on and off very quickly every so often. The time between these flashes is a FIXED INTERVAL of time. There will be the same amount of time between each flash.
4. Your job is to say "NOW" whenever you think the bulb is about to flash. Try to say "NOW" as closely as possible to the actual flash. I will be scoring your accuracy. The closer you come to the flash, the more accurate the score.
5. Say "NOW" only once between flashes.
6. If you don't beat the flash; if the bulb flashes <u>before</u> you can say "NOW," then say "NOW" <u>while the bulb flashes</u> and try to beat it next <u>time</u>.
7. Except for saying "NOW" please do not talk during the experiment.
8. When I turn off the lights the experiment will begin. When I turn them on it will be over.

There will be a short wait of a few minutes before the first flash while the gsr warms up. Are there any questions?

<u>E</u> answered any questions by rereading the relevant portion of the instructions. Then <u>E</u> reclaimed the carbon copy of the acquisition instructions, shut the overhead lights, and turned on the red desk light. The stop watch was started. For some <u>S</u>s, gsr readings were made at 0.5 minutes and at 2.5 minutes during the 3.0 minutes of habituation which now followed. At the end of these 3.0 silent minutes <u>E</u> set off the first photic flash. Twenty-one subsequent flashes seperated by a common ITI followed (20 trials) with the time of <u>S</u>'s "NOW" anticipation recorded by <u>E</u> in every case. Various gsr measures were made by <u>E</u> throughout the trials. After the last flash, the following instructions were read to <u>S</u>:

> You've done very well. Before I turn on the lights I'd like you to guess how much time there was between each pair of flashes.

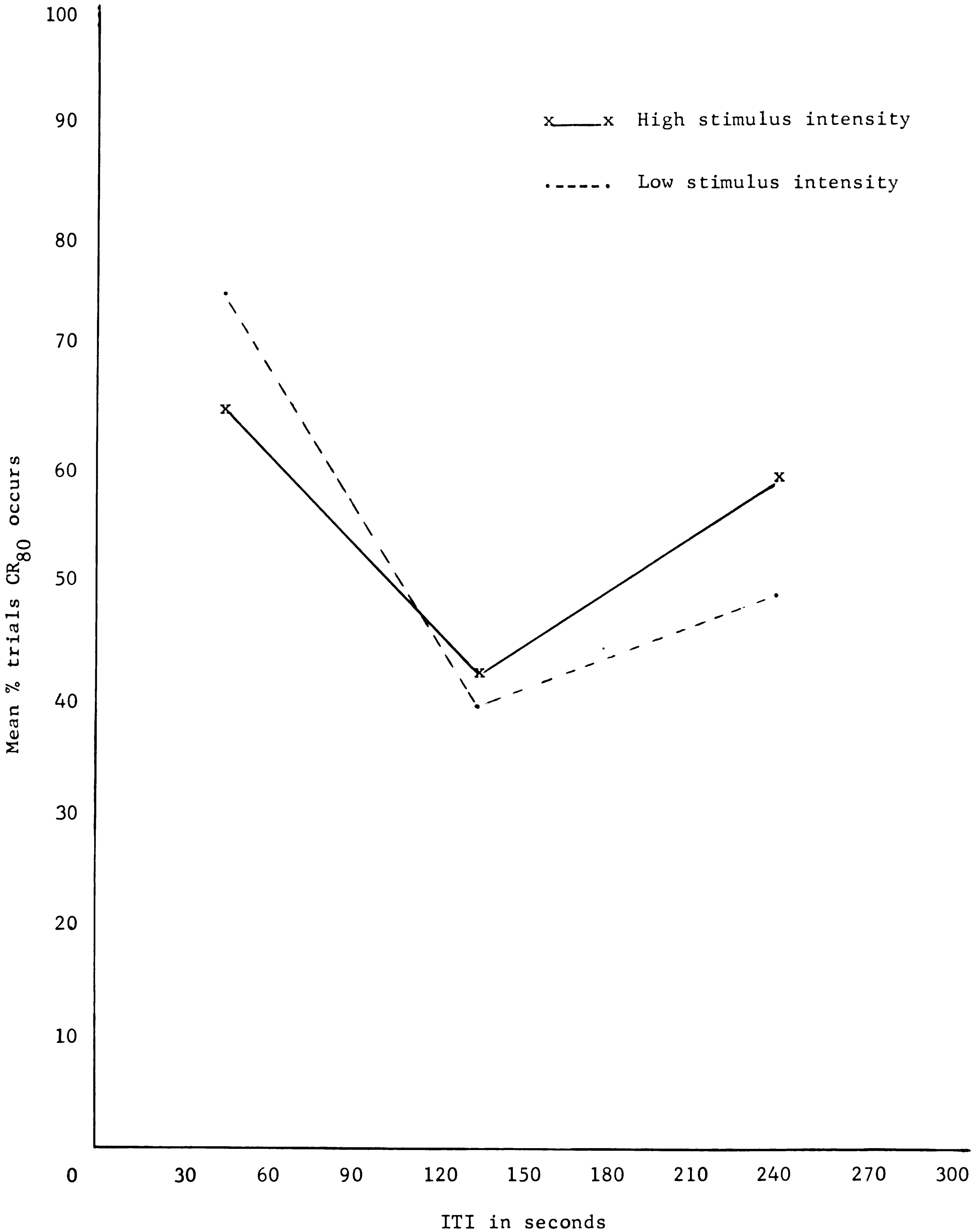
(Bakan, 1955, has shown that lack of response set does not significantly affect temporal estimation.) After these estimation instructions, E recorded S's answer, and turned on the overhead lights. E then recorded S's introspections on methods of synchrony used, percent of time devoted to each method, and subjective unpleasantness of the flash. Finally, S was given a brief lecture on the history and uses of the gsr and released from the experimental situation. Ss were not told the exact ITI they had been run at until Experiment I was completed for all Ss.

Experimental Design.--ITIs of 45, 135, and 240 sec. were used at either high or low US intensity. This formed six ITI-Int. conditions and 3 Ss were randomly assigned by card draw to each condition.

Results

Table 1 summarizes the most important abbreviations used in this and subsequent experiments. Table 2 summarizes the important S data for Experiment I. Looking first to temporal conditioning as a function of ITI and Int., mean occurence of the temporal CR for these variables is depicted in Figure 1. As Table 1 indicates, a temporal CR or CR_{80} is any response anticipating the US within the last 20% of the ITI (Dmitriev and Kochigina, 1959). With this criterion, analysis of the binomial probabilities (Siegel, 1956) indicated that a frequency of occurence of the CR_{80} of 55% or higher in a 5-trial block or 38% or higher in 20 trials would be significant at $p < .05$. Figure 1 shows the predicted near chance level dip at the (135 sec.) ITI falling between previously successful short American ITIs and long Soviet ITIs. An analysis of variance (Table 3) showed this ITI effect to be highly significant ($F = 7.10$, $df = 2, 12$, $p < .01$). Int. also looked as predicted with L Int. excelling H Int. at the short ITI and vice versa at the long ITI. However, neither the Int. nor its interaction with ITI were significant in the analysis of variance (Table 3). Figure 2 illustrates temporal conditioning over blocks. The over-all increase in level of conditioning with blocks of 5 trials was highly significant as gauged by analysis of variance ($F = 1038$, $df = 3, 36$, $p < .005$). Note in Figure 2 that this increase was only evident for the short and long ITIs after the second block of trials. Blocks at the 135 sec. ITI remained at or below chance level. Note also that conditioning at the long 240 sec. ITI levels off or drops after the third block of trials. This may have been the result of fatigue. The curves generally demonstrated that temporal conditioning in the experimental setting of Experiment I was demonstrably present or absent by the end of 10 to 15 trials. Analysis

Figure 1.--Mean % occurrence of CR_{80} at both stimulus intensities over all 20 acquisition trials as a function of ITI in Experiment I

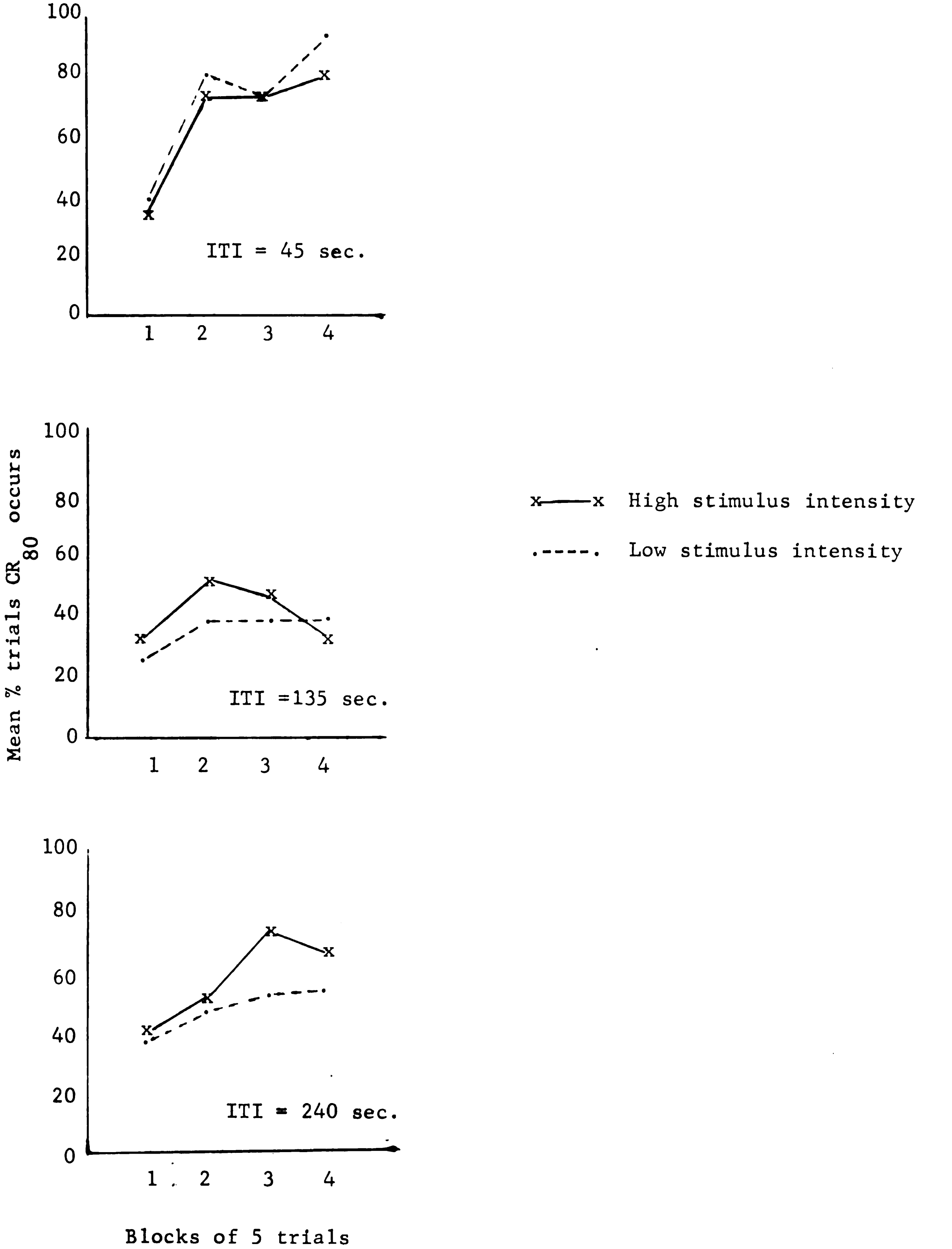


of variance showed none of the interactions between blocks of trials and ITI or Int. to be significant (Table 3).

As for estimation of ITI length, a product-moment correlation between A. Est. and CR_{80} scores for all blocks was +.26 or not significant at the 5% level for the number of _S_s involved. Those _S_s showing the best conditioning did not necessarily show the most accurate estimation. An analysis of variance of per cent A. Est. as a function of ITI and Int. (Table 4) showed significant effects for ITI ($F = 8.63$, $df = 2, 12$, $p < .005$), Int. ($F = 55.38$, $df = 1, 12$, $p < .005$), and their interaction ($F = 12.12$, $df = 2, 12$, $p < .005$). Estimation grew in mean accuracy as ITI length grew, had greater mean accuracy at H Int. than L Int., and showed a more dramatic increase with ITI for the L Int. _S_s than for the H Int. _S_s. These results from this miniature experiment suggested that the estimation process is sensitive to the same variables as the conditioning process.

Three _S_s had their gsr changes gauged during the habituation period. The change from 0.5 minutes to 2.5 minutes, designated H gsr (for habituation), is plotted in Table 5 opposite the respective and subsequent CR_{80} score over all trial blocks in acquisition. The product-moment correlation between H gsr and CR_{80} score for these 3 _S_s was -.985 ($P < .02$). This finding was suggestive enough to give it more thorough consideration with the substantial number of _S_s in Experiment II. Various methods of gsr

Figure 2.--Mean % occurrence of CR_{80} at both stimulus intensities for each ITI as a function of 5-trial acquisition block in Experiment I



reading were attempted during acquisition. Of these, the most feasible appeared to be the taking of gsr readings at the midpoint of every ITI. Although ITIs as large as 300 seconds would leave that amount of time between readings there is evidence that even such 5 minute readings are reliable measures (Morgan and Bakan, 1965). All gsr results were analyzed in terms of square root conductance units since it has been shown that these units have a more normal distribution than any other method of depicting gsr data (Schlosberg & Stanley, 1953).

On the H Int. condition, 7 out of 9 Ss reported the stimulus flash "unpleasant" as opposed to "neutral" or "pleasant." On the L Int. condition, only 2 of 9 Ss reported the stimulus flash "unpleasant." This finding was significant ($p < .05$) according to Fisher's test of probability (Siegel, 1956).

Ss introspected that a mean 93.5% of their time was spent counting by one method or another at the short 45 sec. ITI while this decreased to a mean 68% and 70% for the two longer ITIs. There was approximately 76% mean time per S spent counting at each stimulus intensity. While counting was the favored method, as Woodrow (1951) would have predicted, it was far from the only one. Fifteen Ss of the 18 counted at least one trial but only 4 Ss counted numbers divorced from any internal rhythm. Some Ss tapped their finger; others listened to their pulse or breathing; others just guessed. Some Ss used a "Feel" or intuition method which, as opposed to blind guessing, gave them some definite physical sensation of anticipation prior to the US. One S, scoring 6 out of 20 possible CR_{80}s, visualized a clock with a second hand in motion at a constant rate of speed. He relaxed and let his thoughts wander at random until his "Feel" indicated a flash was close at which time he checked his imaginal clock to see how much time was left. Here was a real biological clock! (See Table 6.)

Discussion

Experiment I demonstrated that temporal conditioning could occur as a result of the experimental procedure and surrounds evolved from prior pilot research. Furthermore, the occurence of the conditioning was significantly related to the stimulus conditions.

ITI showed the predicted dip in the gap area between Soviet and American explored ITI ranges. Int. was as predicted in effect but was not significant for the number of Ss tested. Level of conditioning significantly improved with trial blocks. Since there was the suggestion of fatigue at the long 240 sec. ITI after three 5-trial blocks, subsequent experiments will restrict themselves to three blocks of acquisition trials. Classical conditioning studies with humans have usually domonstrated significant effects within 20 trials (Kimble, Mann, and Dufort, 1955; Prokasy, Grant, and Myers, 1958).

Introspections were suggestive and seemed worthy of expansion. It was decided that the next experiment would also collect methods of synchrony and per cent of time spent on each, as well as estimates of ITI length with additional estimates of the direction and magnitude of error of that estimate, and, again, introspective proof that the H Int. US was more subjectively unpleasant than the L Int. US.

Experiment I allowed for the evolution of the most experimentally feasible, reliable, and theoretically meaningful gsr measures for subsequent experiments. Besides the general refinement of measures and procedures, critical variables demanding further scrutiny had been delineated.

EXPERIMENT II

Experiment II was an extended replication of Experiment I. It was conducted under improved, refined, and expanded conditions, across a wider spectrum of critical ITIs, and, most important, with a much more substantial number of Ss.

Method

Subjects.--The Ss were 120 volunteer college students from an introductory psychology course. Males outnumbered females 79 to 41. Age was restricted to from 18 to 22 years; nearly half the sample was 18 (58 Ss) with a mean age of 18.7 years for the full sample. All Ss received course credit for their time in the experiment.

Apparatus.--This and subsequent experiments took place in a new light-tight room which was also sound-proofed to outside noise by virtue of being the insulated inner chamber of a double room. Figures 3 and 4 illustrate this. Otherwise the apparatus was exactly as described in Experiment I.

Procedure.--The procedure was substantially identical to that of Experiment I with a few additions and changes which will be noted here. The positions of S and E in relation

Figure 3.--Photograph of entrance to double experimental rooms used in Experiments II, III, and IV

Figure 4.--Photograph of experimenter at data collection desk as situated in Experiments II and III

to each other and the apparatus remained the same (see Figures 5 and 6). The acquisition instructions read to S by E (still followed by S on a carbon) were not re-worded. Again, after the overhead lights were turned off, there was a 3 minute habituation wait before the first US was presented. In this experiment all Ss had their gsrs recorded at the 0.5 minute and 2.5 minute marks of the habituation period. This H gsr change represented an increase or decrease in arousal as a function of the habituation wait. After the first flash, 16 subsequent US flashes separated by a common ITI (15 trials) followed with the time of S's "NOW" anticipation recorded by E in every case. E recorded S's gsr at the midpoint of every ITI up to and including the midpoint of the ITI following the last US flash. The mean gsr change from midpoint to midpoint for each block of 5 trials was termed the I gsr after inhibition (since Pavlovian inhibition theory predicted this mean change would be towards greater relaxation over trials). From these readings, E was also able to measure an overall experimental gsr or OE gsr by subtracting the pre-treatment 2.5 minute habituation reading from the very last or post-treatment ITI midpoint reading. This gave a before and after measure on arousal of the effect of the experiment as a whole. After the last midpoint gsr reading, E asked S for a verbal estimate of the ITI length. Following this estimate, additional retrospective information was collected.

Figure 5.--Photograph of experimenter collecting data from GSR as situated in Experiments I, II, and III

Figure 6.--Photograph of subject in GSR electrodes facing photic stimulus as situated in Experiments I, II, and III

S was asked to indicate the direction and magnitude of the error in his initial estimation. The overhead lights were then put on and further introspective information gathered. S was again asked what methods of synchrony were used, what per cent of the time they were used and when they were used. S was again asked to classify the US as "pleasant," "unpleasant," or "neutral." Following any final comments, S was lectured on the gsr. All Ss received credit slips and were then released.

Experimental Design.--ITIs of 30, 60, 90, 120, 150, 180, 210, 240, 270, 300 sec. were used at either high or low US intensity. This formed 20 ITI-Int. conditions and 6 Ss were randomly assigned by card draw to each condition.

Results[3]

Table 7 summarizes the data for Experiment II. Again, abbreviations are defined in Table 1.

A first consideration was the pre-treatment composition of the sample in terms of the major independent variables. Chi square analyses (Table 20) did not show S distribution by sex, age, or pre-treatment H gsr to be significantly clustered on any one Int. or ITI. A similar check of H gsr

[3]Because of the large number of Ss and subsequent bulk of data, all calculations were computed and checked on Friden and Monroe calculators with correlations checked, in addition, on a CDC 3600 computer.

by ITI and Int. was made with analysis of variance (Table 8) and, again, H gsr scores were not found significantly different by ITI, Int., or their interaction. These results supported the random assignment of Ss to conditions as not biasing the stimulus variables with differential S characteristics.

Another preliminary consideration was the nature of the inter-relationship of S characteristics. Both sexes had a mean age of 18.7 years. However, females had H gsrs significantly more relaxed than males as tested by t-test ($t = 3.28$, $df = 118$, $p < .01$). Age (18 years vs. 19-22 years) and H gsr (+ vs. -,0) showed no significant relationship by chi square analysis nor did "excited" Ss (+ H gsr) differ significantly by age from "relaxed" Ss (0 or - H gsr) as gauged by t-test.

(In Experiment II: all non-significant and significant chi squares can be observed in chi square Table 20; all t-test analyses can be observed in Table 19; all correlational analyses can be observed in Table 16.)

Subjective unpleasantness of the US (Sb Un) was found to bear no significant relationship to ITI, or the sex, age, or H gsr of S as analyzed by chi square. As expected, Ss at high stimulus intensity (H Int.) significantly more frequently labeled the US as "unpleasant" than Ss at the low stimulus intensity (L Int.) as tested by chi square (chi square = 8.89, $df = 1$, $p < .01$). At H Int. 53% of the Ss chose "unpleasant" as opposed to 27% of the Ss at L Int.

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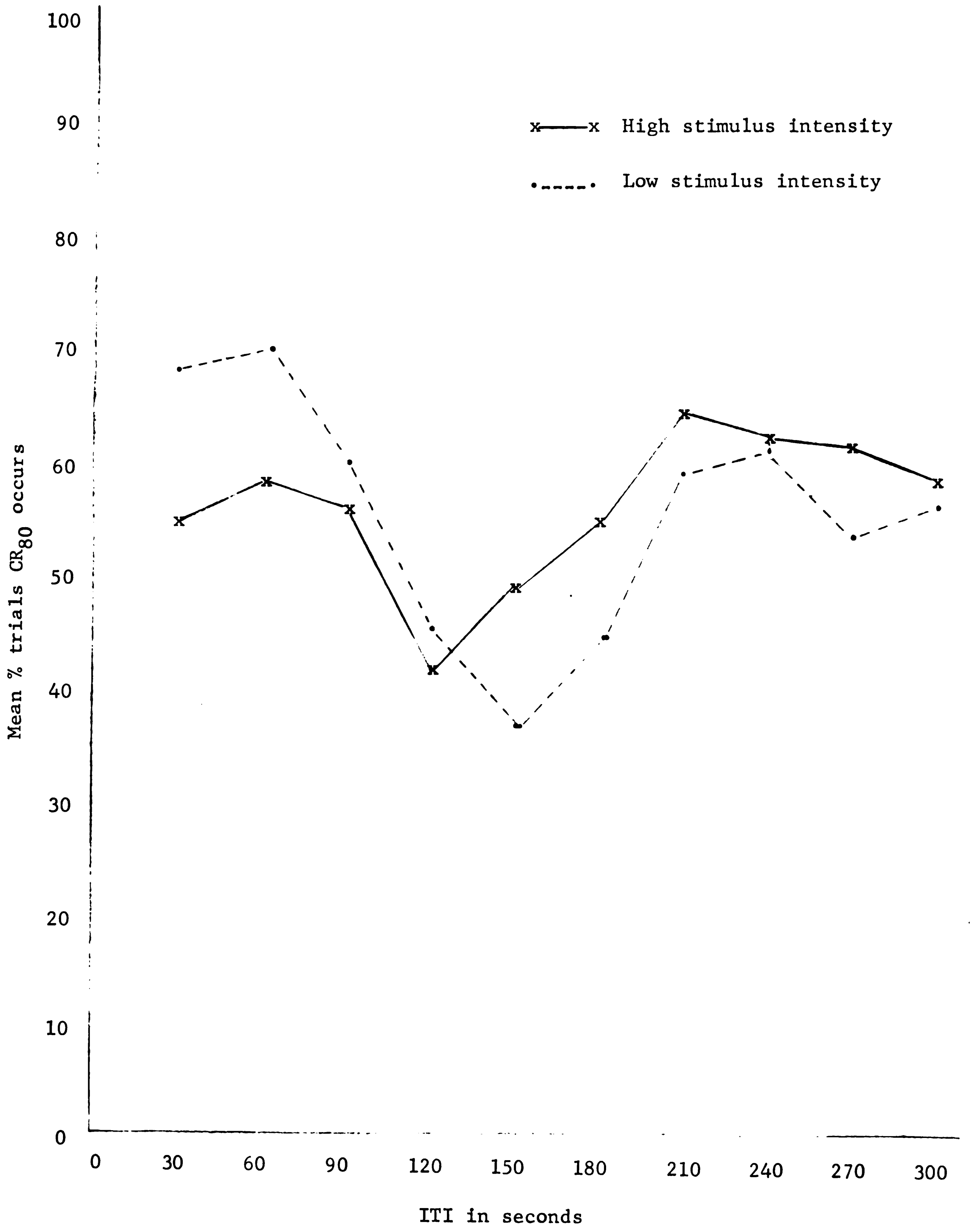
Figure 7 illustrates the mean per cent occurence of CR_{80} over all acquisition trials as a function of ITI and Int. Binomial probabilities (Siegel, 1956) indicated that a frequency of occurrence of the CR_{80} over 15 trials of 41% or higher would be significant at $p < .05$. Once again, there was a dip of level of conditioning between ITIs of 1 and 4 minutes. The bottom of the dip was at or below chance level. Analysis of variance (Table 9) showed ITI to significantly affect the level of conditioning ($F = 3.54$, $df = 9,100$, $p < .005$). Int. appears to interact with ITI as in the last experiment with L Int. excelling H Int. at short ITIs and vice versa beyond the 120 sec. ITI. Analysis of variance (Table 9) did not show Int. or its interaction with ITI to be significant over all the ITIs. However, it must be noted that for the four shortest ITIs mean level of conditioning was higher for the L. Int. groups while for the six longer ITIs mean level of conditioning was higher for the H Int. conditions. The cross-over was between 120 and 150 seconds. Tukey (1949) has developed a procedure for testing the significance of individual comparisons between condition means following an analysis of variance. Winer (1962), labeling it the "honestly significant difference" procedure, gave it laurels as a widely applicable but conservative measure. Edwards (1960a) referred to the procedure more simply as "Tukey's significant gap test." Basically it employs the error mean square of the analysis of variance as a common

Figure 7.--Mean % occurrence of CR_{80} at both stimulus intensities over all 15 acquisition trials as a function of ITI in Experiment II



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measure of error variance for t-test comparisons and converts this by formula to a minimum difference necessary to all comparisons for a specific level of significance. Table 10 lists selected comparisons and their significance at the 5% level (where applicable) according to Tukey's gap test. Returning now to the question of Int., it is seen from Table 10 that L Int. significantly excelled H Int. at both the 30 and 60 sec. ITIs thus supporting the hypothesis that short ITIs lead to this kind of result. On the other hand, only at 150 and 180 sec. ITIs did H Int. excel L Int. to a significant extent. The evidence for superiority of H Int. was supportive then only at middle range ITI lengths. Turkey's gap test also allows for another look at the effect of ITI length at both intensities. Comparing each ITI to its next highest and next lowest neighbor in time, Table 10 illustrates that the subsequent ITI groupings were quite familiar. At H Int., level of conditioning separated 30, 60 and 90 sec. ITIs from middle range 120, 150, and 180 sec. ITIs, while the latter group was separated from the longer ITIs of 210 to 300 sec. This same division was found at L Int. with the additional isolation of the 90 sec. group from both shorter and longer ITIs. Here again are the American, Soviet, and untouchable ranges. Further analysis of these data-determined ITI groupings (ITI gps.) was made according to the following schema: 30 and 60 sec. ITIs were considered as the "short" (s) ITI group; ITIs of 120, 150, and 180 sec. were considered "medium" (m) length ITIs; ITIs of 210, 240, 270, 300 sec. were considered "long" (l) ITIs. The 90 sec. ITI, not clearly a member of the "short" group for both Ints., was not included in the groupings. Note that the "short," "medium," and "long" ITI groups each correspond to a different area of past American vs. Soviet exploration or lack of exploration.

Figure 8 illustrates the general increase in level of conditioning with blocks of acquisition trials observed at most ITIs and intensities. Again, a 5-trial block needed 55% frequency of occurrence of CR_{80} or better to show conditioning significant at $p < .05$. The overall increase was significant ($F = 26.54$, $df = 2,200$, $p < .005$) by analysis of variance (Table 9) although none of the interactions between trial blocks and ITI or Int. were significant.

Figure 9 demonstrates the mean per cent occurrence of CR_{80} for all acquisition blocks as a function of ITI and Int. when ITI conditions were pooled into "short," "medium," and "long" groupings. Note the striking similarity between the "V" shapes in this figure and the "V" shapes in Figure 1 of Experiment I. In Figure 1, each point represents a single ITI falling in the derived ranges of "short," "medium," and "long" as used in Figure 9.

Differences between the ITI groupings depicted in Figure 9 were analyzed by t-test. As for Int. differences, only the "short" ITI group showed a significant difference

Figure 8.--Mean % occurrence of CR_{80} at both stimulus intensities by 5-trial acquisition block for each ITI in Experiment II

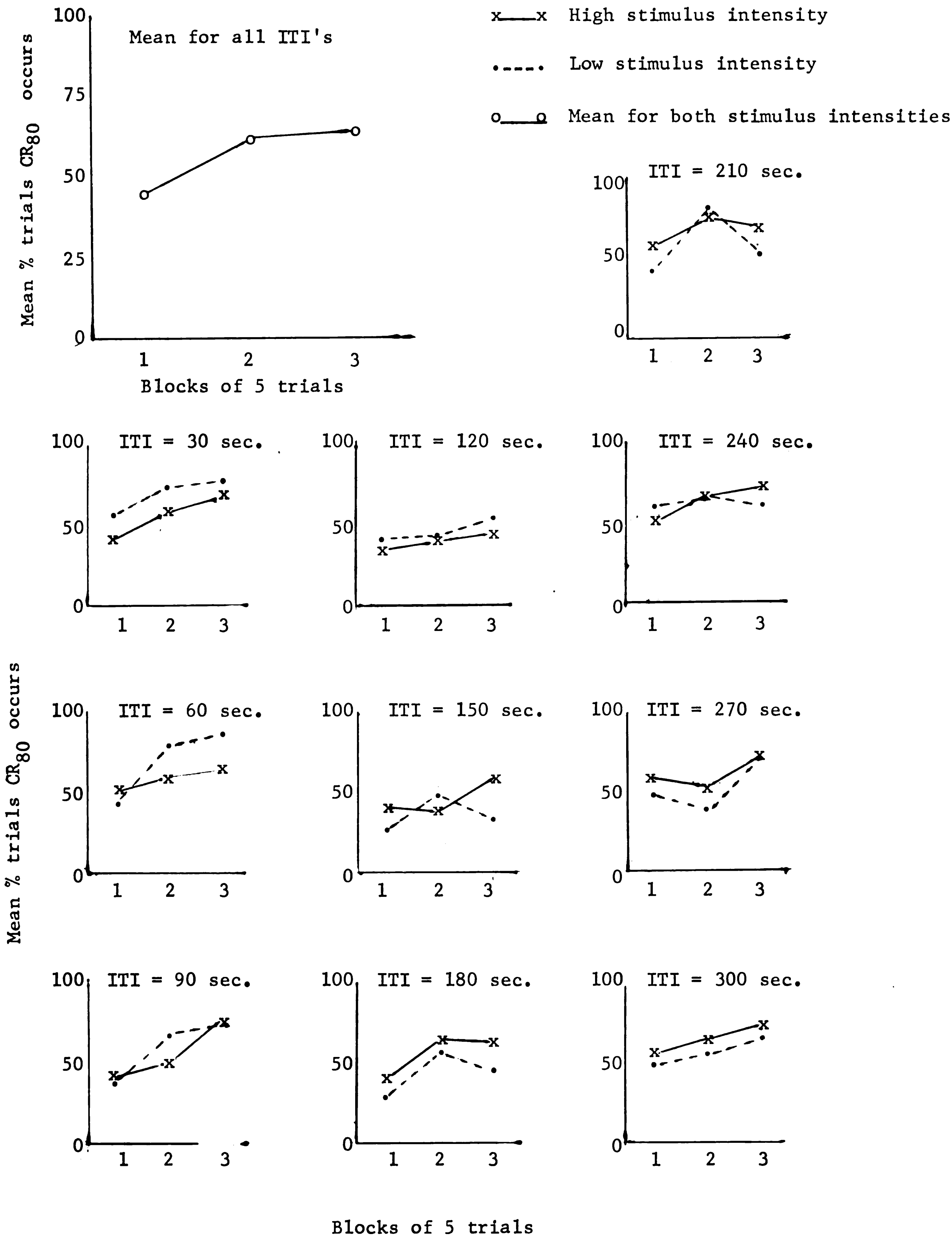
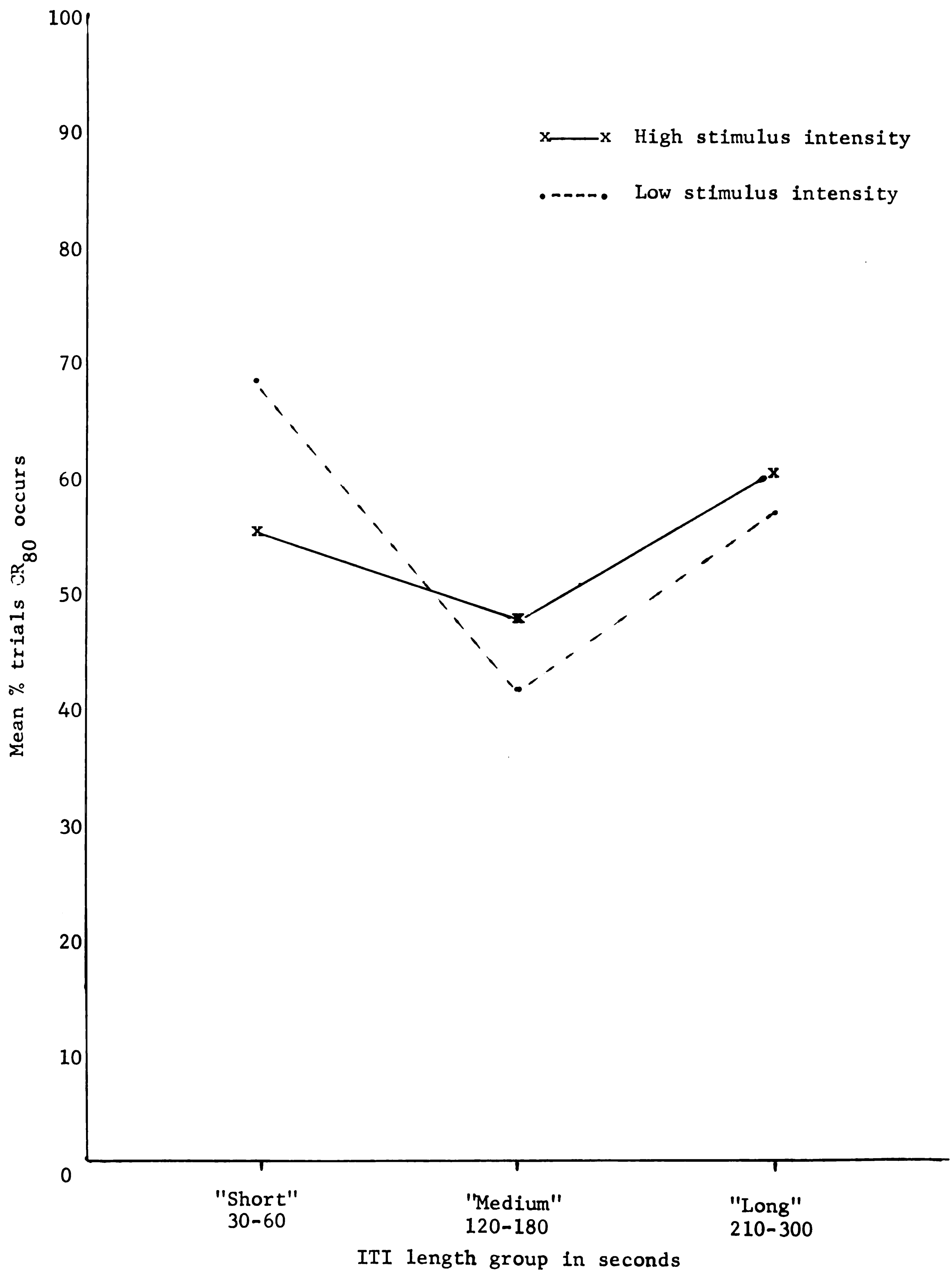


Figure 9.--Mean % occurrence of CR_{80} at both stimulus intensities over all 15 acquisition trials as a function of ITI length group in Experiment II



($t = 2.25$, df = 22, $p < .05$). As for ITI differences, at H Int. "long" ITIs significantly excelled "medium" ITIs ($t = 3.06$, df = 40, $p < .01$) while "short ITIs did not differ significantly from either "medium" or "long" ITIs (this, of course, reflected the debilitating effect on conditioning of H Int. at "short" ITIs); at L Int. "short," "medium," and "long" ITIs all differed significantly. These data are included in Table 19.

While statistical analyses with the CR_{80} measure appeared satisfactory, it was felt that another measure of conditioning might be briefly investigated and described. Magnitude of response seemed like a good companion to frequency of occurrence in such an effort. To guarantee maximum independence of the second kind of conditioning measure from the first, every S's median error of anticipation, whether a CR_{80} or not, was determined for each block of acquisition trials and over all blocks of trials. Medians rather than mean anticipations were used since occasionally S would make no anticipation in a given trial. The median values were more unstable than the CR_{80} measures, of course, as they reflected a different number of values from one S to the next. However, the median error of anticipation (E. Ant.) measure followed a pattern strikingly similar to the frequency of occurrence measure. Figure 10 illustrates that, as might be expected, the absolute error in seconds increased with increasing ITI length. Figure 11,

Figure 10.--Median error of anticipation at both stimulus intensities over all 15 acquisition trials as a function of ITI in Experiment II

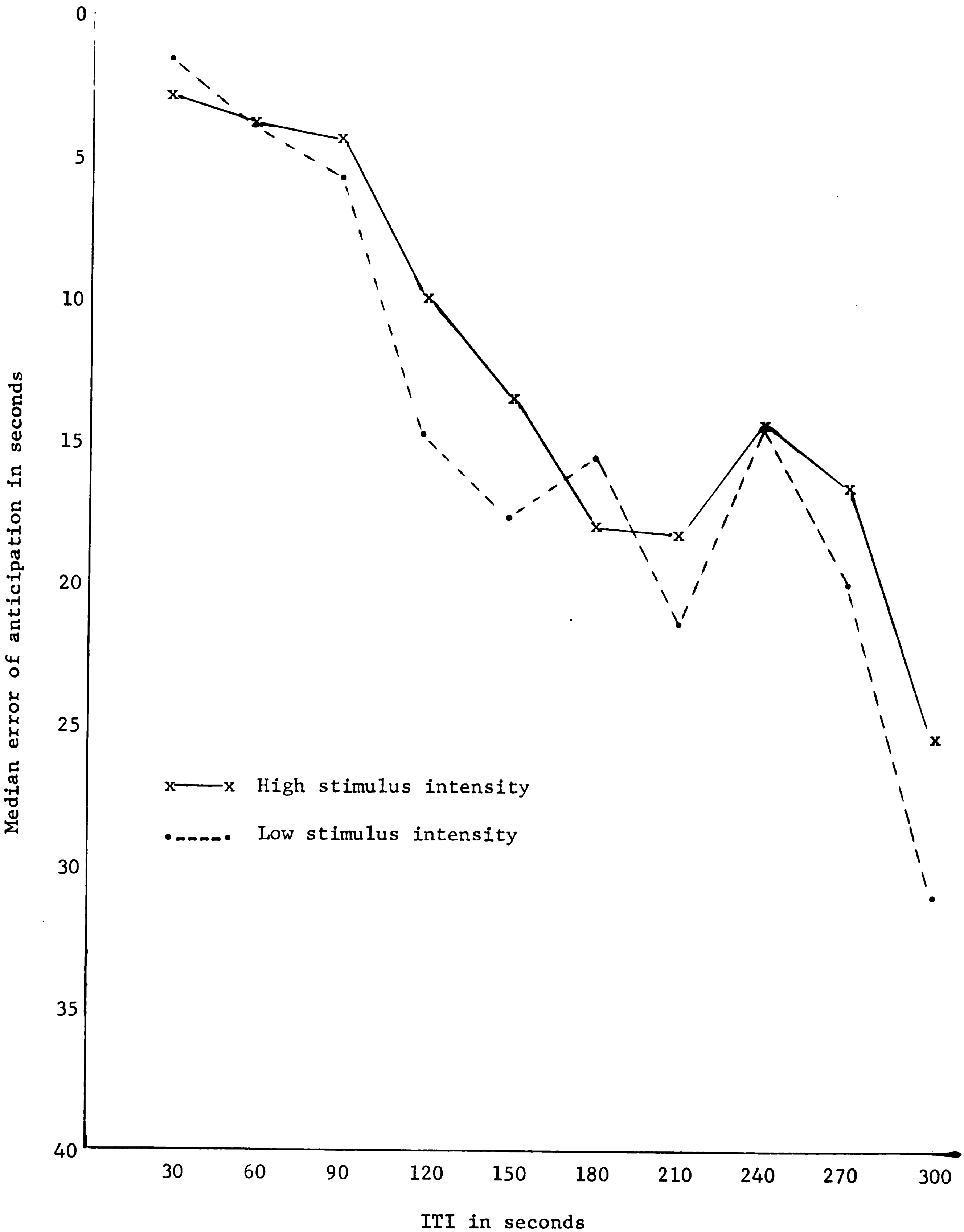
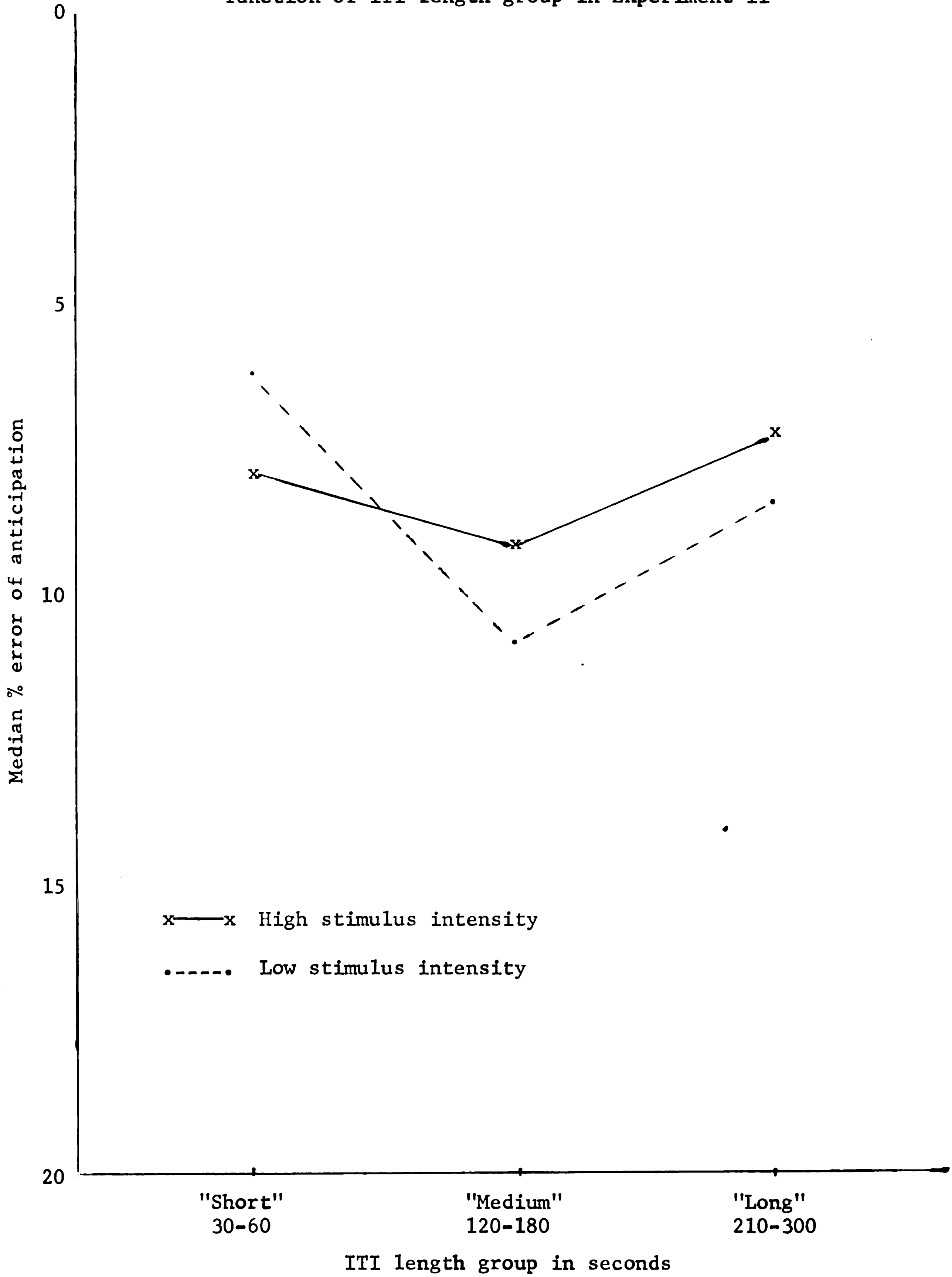


Figure 11.--Median % error of anticipation at both stimulus intensities over all 15 acquisition trials as a function of ITI length group in Experiment II



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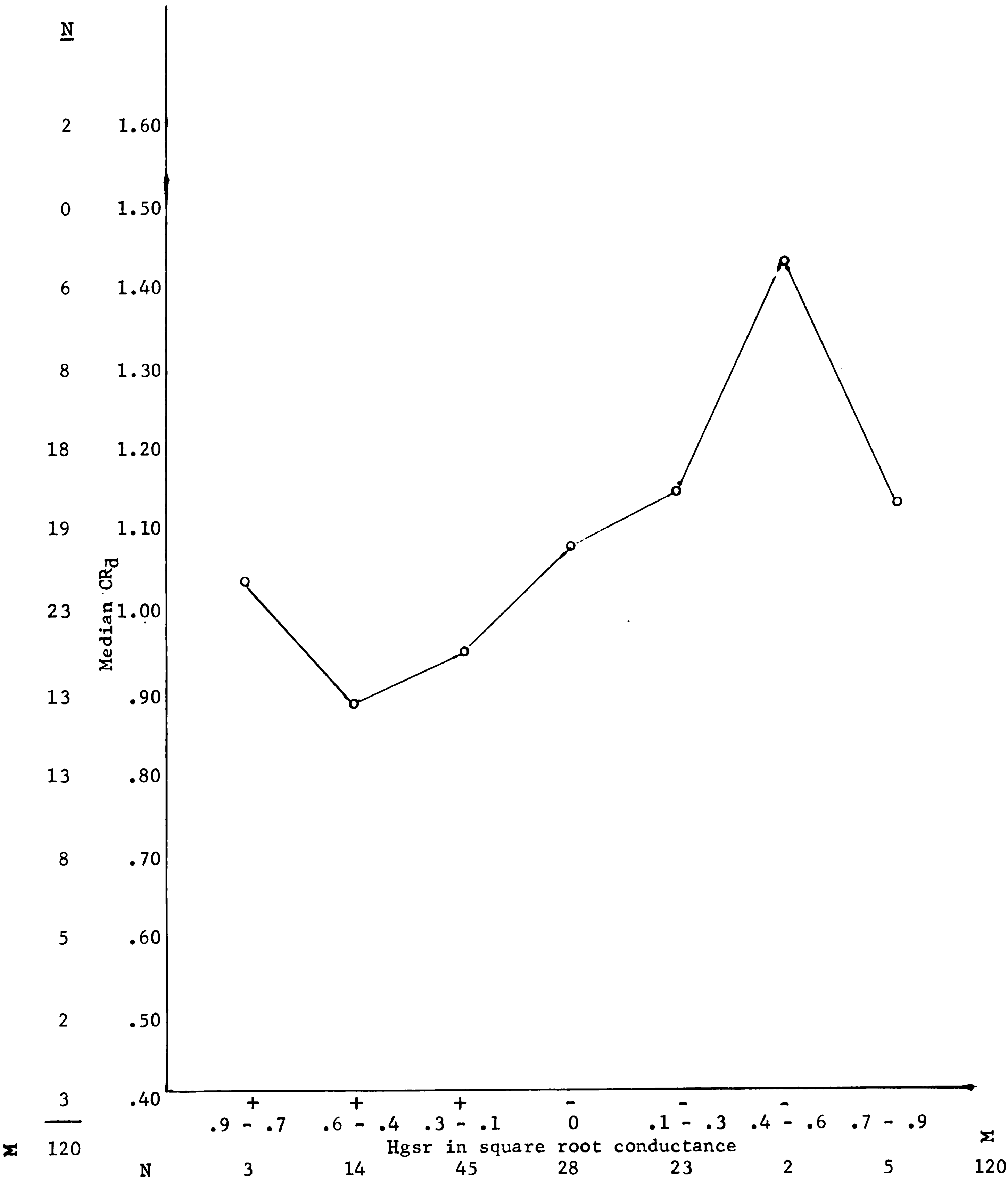
plotting the median E. Ant. as a per cent of the ITI it was associated with, illustrates the same over-lapping "V" curves for the "short," "medium," and "long" ITI groups as was observed in Figure 9 with the frequency of occurrence measure.

Returning to the frequency of occurrence measure, it was decided to gauge the effects of the S variables of age, sex, and H gsr on temporal conditioning. Since the independent variables had been shown effective in this regard, a derived or standard score was computed to allow common analysis of the full 120 S sample. This was done by dividing every S's CR_{80} score for all trial blocks by the mean CR_{80} score of the ITI-Int. condition group to which that S belonged. Bartlett's test (Edwards, 1960b) had shown absence of significant heterogeneity of variance by ITI-Int. condition. The derived conditioning score (CR_d) represented S's frequency of occurrence of CR_{80}s in comparison to the other Ss undergoing the identical stimulus conditions.

Neither sex evidenced a significantly higher mean CR_d score as determined by t-test comparison. However, 18 year olds had a significantly lower mean CR_d score than 19-22 year olds ($t = 2.39$, $df = 118$, $p < .02$). "Excited" Ss (+ H gsr) had a significantly lower mean CR_d score than "relaxed" (0 or - H gsr) Ss ($t = 3.28$, $df = 118$, $p < .01$). To further examine the pre-treatment H gsr measure of arousal as a predictor of conditioning, a product-moment correlation was computed for H gsr and CR_d. It was -.300 ($df = 118$, $p < .01$). Since the plot of these variables seemed somewhat curvilinear, the correlation ratios were also computed. These were -.408 and -.483. A final check with the more conservative Spearman rank order correlation produced a value of -.309 ($df = 118$, $p < .01$). Thus it seemed fairly safe to conclude that the magnitude of pre-treatment arousal was significantly related to subsequent level of temporal conditioning. This relationship is depicted in Figure 12 as are the relatively normal distributions of Ss over the values of each variable.

I gsr was not significantly influenced by either ITI, Int., or their interaction as analyzed by analysis of variance (Table 11). However, I gsr did become more relaxed with successive trial blocks as predicted ($F = 17.23$, $df = 2,200$, $p < .005$); none of the interactions of trial blocks with ITI or Int. were significant (Table 11). If ITI was not a significant factor for I gsr over all acquisition blocks, it did become meaningful when observed a block of trials at a time. Figure 13 illustrates the mean I gsr for "short," "medium," and "long" ITI groups for each successive block of trials. By block 3 the ITI groups had assumed the customary "V" shape common to the conditioning curves with "medium" ITIs showing an I gsr change towards greater arousal while "short" and "long" ITIs showed a

Figure 12.--Median CR_d over all 15 acquisition trials as a function of pre-treatment Hgsr in Experiment II



[illegible] in square root conductance

[illegible] in square root conductance

Figure 13.--Mean Igsr averaged over both stimulus intensities by each 5-trial acquisition block as a function of ITI length group in Experiment II

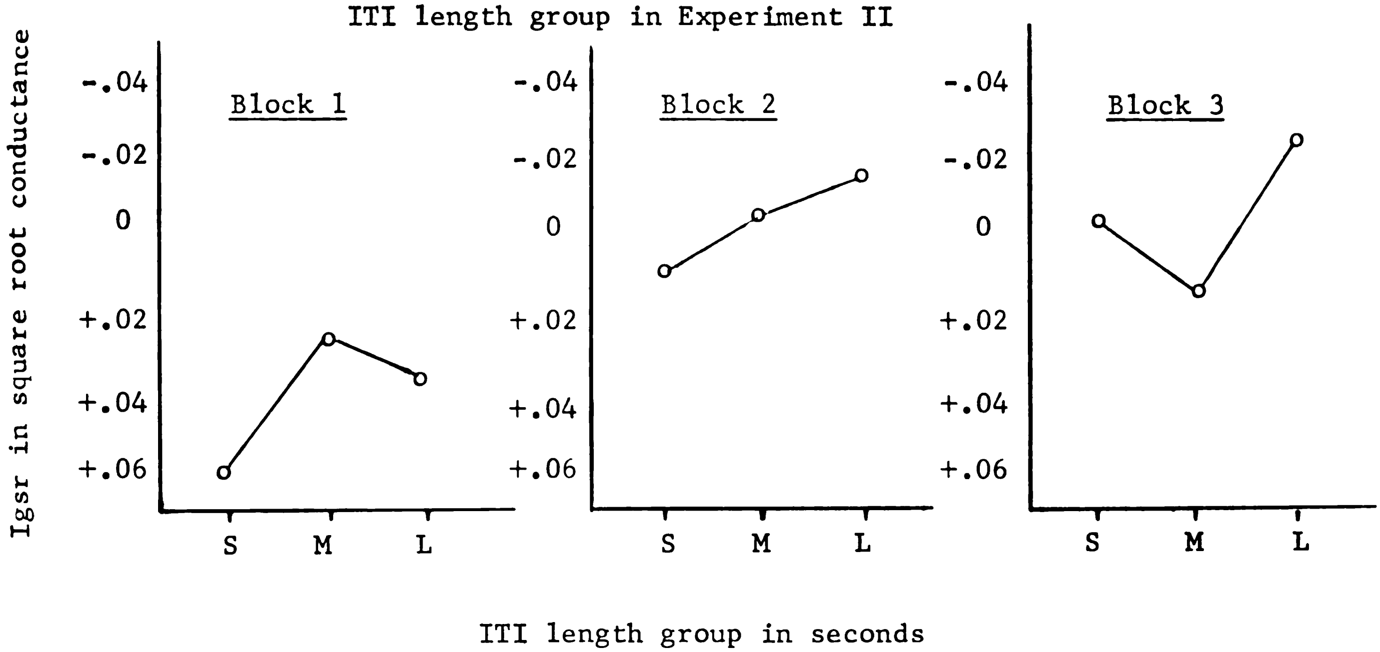
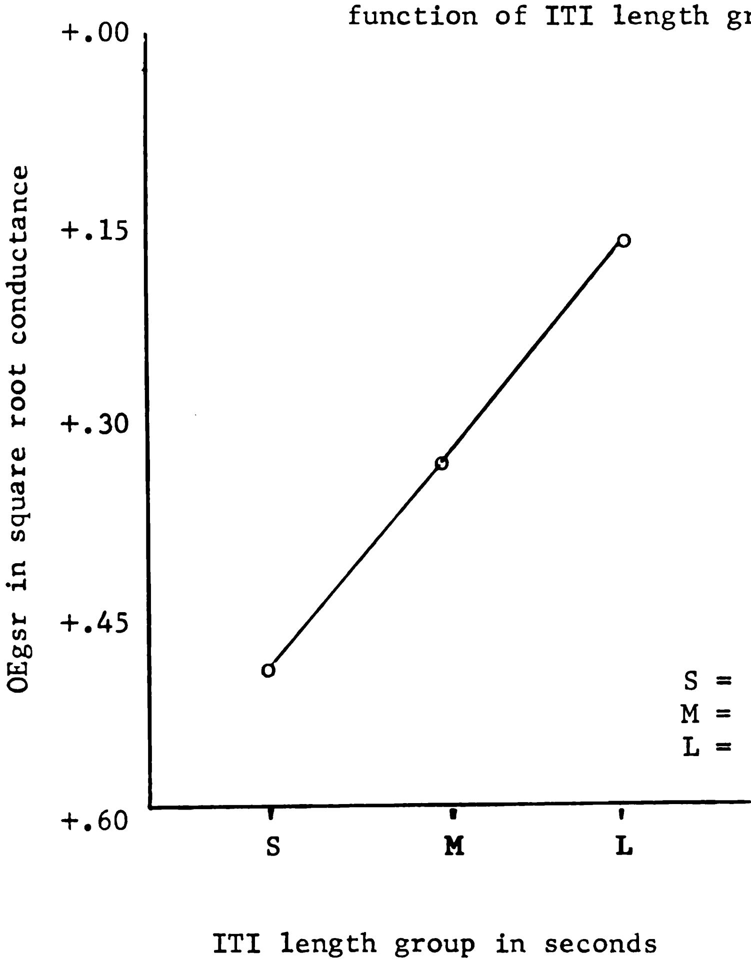


Figure 14.--Mean OEgsr averaged over both stimulus intensities as a function of ITI length group in Experiment II



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mean I gsr movement towards greater relaxation. Analysis by t-test found no significant difference of I gsr between "short" and "long" ITI groups at any block. These groups were therefore pooled and compared to the "medium" ITI length group. The latter showed a significantly less relaxed mean I gsr only in block 3, the last 5-trial block ($t = 2.47$, $df = 106$, $p < .02$). Thus by the last block of trials, Ss at "medium" ITIs were showing substantially less relaxation from one ITI midpoint to the next than Ss at the more fruitful ITIs in the "short" or "long" range.

I gsr was not significantly related to S's sex or age as analyzed by chi square. Product-moment correlations between I gsr and H gsr were not significant for any block of trials. Thus H gsr and I gsr seemed to be measuring relatively independent processes.

The OE gsr decreased with increasing ITI as measured by product-moment correlation (r was $-.230$, $df - 118$, $p < .02$). This decline in arousal with ITI length increase is illustrated in Figure 14. Might this over-all change in arousal have influenced the I gsr results? To control for this likelihood, an analysis of variance of I gsr as a function of trial blocks was conducted for only those Ss ($n = 83$) showing a + OE gsr. Trial blocks still showed a significant successive relaxation for I gsr ($F = 20.80$, $df = 2,246$, $p < .005$). Thus, even for those 83 Ss showing an overall increase in arousal as a result of the experiment,

the gsr change from the midpoint of one ITI to the next showed a mean decrease in arousal or increase in relaxation (inhibition) with continuing acquisition trials (Table 12).

An analysis of variance of OE gsr (Table 13) showed it to vary significantly with ITI ($F = 2.22$, $df = 9, 100$, $p < .05$), as has already been reported, but not to vary significantly with Int. or the inter-action of ITI with Int. As to S variables, OE gsr was significantly less relaxed for males ($t = 4.66$, $df = 118$, $p < .01$) than for females while age had no significant influence as gauged by t-test or chi square. A product-moment correlation of +.226 ($df = 118$, $p < .05$) between OE gsr and H gsr suggested some commonality in process. This would explain the sex difference common to both gsr measures.

Moving now to methods of synchrony, an analysis of variance of per cent time per S spent counting showed no significant relationship between this variable and ITI, Int., or their interaction (Table 14). The mean per cent time spent counting per S decreased from 88% at "short" ITIs to 86% for "medium" ITIs to 81% for "long" ITIs but none of these decreases proved to be statistically significant by t-test.

Table 17 breaks down the mean per cent time per S by every method of synchrony used. Counting methods were again predominant in a free choice situation but "Feel" and internal clock methods as well as wild guessing were

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all in evidence. Table 18 relates the methods used at least 51% of the time per S, "majority method," to the number of Ss using them and to the median CR_d score associated with that particular method. Note that only those Ss using a breath counting method scored significantly higher on CR_d than the guessers (Mann-Whitney $U = 2.0$, $n_1 = 6$, $n_2 = 4$, $p < .05$). Those 5 Ss using the "Feel" method a majority of the time did no better or worse than Ss using any counting method. All of these 5 intuitioners choosing to "Feel" the imminence in time of the US as a majority method were males ($p < .06$ by chi square); no other method showed any significant clustering by sex. As to age, all 6 Ss counting breaths a majority of the time were over 18 ($p < .02$ by chi square) while the 4 Ss using repeated mental events as a majority method of synchrony were all 18 ($p < .05$ by chi square). No other age clusterings by method approached significance. "Excited" (+ H gsr) Ss did not spend more time counting per S than "relaxed" (0 or - H gsr) Ss as tested by t-test although "excited" Ss more often chose a counting method of synchrony as majority method than did "relaxed" Ss ($p < .01$ by chi square). Thus pre-treatment arousal as measured by H gsr affected a S's choice of whether or not to count, the more relaxed Ss choosing less often to do so.

The methods classified in Table 17 and Table 18 should be clarified further. Counting by successive numbers meant counting in the absence of conscious listening

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to any internal rhythm or S-produced periodic events. Those counting these independent numbers in common still managed individual differences of style. Such personal tempo styles ranged from the traditional "1 and 2 and 3 . . ." to "1 hippopotamus, 2 hippopotamus, 3 hippo- . . . ." Those who tapped for a method of synchrony tapped fingers, toes, toes within a cast, or even tapped fingers and toes simultaneously while rubbing eyebrows. Those who listened for pulse or breaths generally did so intently and without elaboration. Ss choosing to synchronize with repeated mental events naturally showed a good deal of individuality in events chosen. These included "a graduation march with endless encores," the Gettysburg address, "running along a figure eight with each circuit as one count," imaginary swimming strokes, etc. Those Ss using the intuitive "Feel" method all experienced active sensations prior to the US, reporting: "I felt excitement just before the flash"; "I got nervous just before the flash"; "I sensed it when it was about to go off." Guessers were able to report no conscious methods or tip-off experiences whatever. Again one S created an imaginal clock to check with whenever the time grew short before a US. A few Ss at higher ITIs admitted dozing off shortly. One S, thinking he was in a non-temporal conditioning experiment, wasted his first few trials listening for a CS. A female S counted off "Hail Maries" through all trials but without above average temporal success.

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Accuracy of estimation (A. Est.) of the ITI by S after the experiment was concluded did not, in this experiment, relate significantly to ITI, Int., or their interaction as analyzed by analysis of variance (Table 15). The ITI groupings reflected this as, although per cent accuracy increased slightly from "short" ITIs to "medium" and "long" ITIs, no t-tests showed significant differences. Thus for the 30-300 sec. ITI range, the findings of Experiment I regarding accuracy of estimation were not replicated. Nor did t-test indicate per cent accuracy of estimation differed significantly for sex or age of S. A product moment correlation of per cent A. Est. with H gsr was not significant. A. Est. was therefore sensitive to none of the independent variables affecting level of temporal conditioning over the range of values tested.

As Bakan (1962) indicated it would be, retrospective judgement of the direction of error of estimate was correct for a significant majority (62%) of the Ss (binomial probability = .016). Choosing the correct estimate of direction of error (CEDE) was not significantly related to ITI, Int., sex, age, or H gsr as analyzed by chi square. Since assessing the magnitude as well as the direction of error of the first estimate actually comprised a retrospective second estimate, both estimates were included in the analysis of variance gauging the effect of ITI and Int. on A. Est. There was no significant order effect for these estimates nor

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nor were any of the first order interactions with ITI or Int. significant (Table 15). Both estimates averaged a per cent A. Est. of 67%; i.e., the second more retrospective estimate was no more accurate than the first when magnitude as well as direction was taken into account.

Direction or error of estimation (DEE) of the initial estimate was approximately evenly divided between over estimators (52 Ss) and under estimators (49 Ss). DEE was not found to be significantly related to ITI, Int., sex, age, or H gsr as analyzed by chi square.

The 19 Ss initially estimating their ITI with 100% accuracy could not be significantly related to the stimulus conditions of ITI or Int. nor the S characteristics of sex, age, and H gsr as analyzed by chi square.

Another question that might be asked about the initial retrospective estimate of ITI length is what is most reflects. Does it relate more to S's memory of the time between the last two US flashes (the last S-S gap) or does it relate more to S's memory of the time between the second last US flash and S's subsequent response of anticipation (the last S-R gap)?

Since over estimators would by definition fall closer to the S-S interval, a fair test of the S-R hypothesis would consider only those 68 Ss who did not over estimate their ITI. The estimated ITI in seconds for these Ss was correlated with the last S-S gap in seconds and the

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last S-R gap in seconds. The product-moment correlation between the last S-S and S-R gaps was +.973 (df = 66, $p < .01$), a value which suggests that by the last trial S's anticipation quite closely approximated the ITI. The product-moment correlation between S's initial estimate and the last S-S gap was +.849 (df = 66, $p < .01$) while the product-moment correlation between S's initial estimate and the last S-R gap was +.790 (df = 66, $p < .01$). Hotelling's (1940) test showed the S-S correlation to significantly excel the S-R correlation ($t = 3.99$, df = 65, $p < .01$).

Final analyses of results in Experiment II concerned the inter-relationships of the dependent variables. Comparing the two conditioning measures of frequency of occurence (CR_{80}) and median error of anticipation (E. Ant.), Spearman rank order correlations of -.338 (df - 118, $p < .001$) for block 3 and -.423 (df = 118, $p < .001$) for all blocks were obtained. CR_d correlated nonsignificantly with per cent A. Est.; with I gsr for each block; with OE gsr. Chi square analyses showed no significant relationship between CR_d score and CEDE, DEE, Sb Un. Those 19 Ss achieving 100% A. Est. ("ons") were compared to all other Ss and to the 19 Ss of lowest per cent A. Est. ("offs") in terms of CR_d: chi square analysis showed no significant differences.

Analysis by t-test found no significant relation of per cent A. Est. to CEDE, Sb Un, or use of the breathing method of synchrony. On the other hand, t-test analysis showed under estimators significantly more accurate at estimation than over estimators (73% as apposed to 49%) (t = 3.97, df = 99, $p < .01$). A check on this finding with Mann-Whitney U procedures yielded the same significant result (U - 833.5, $n_1 = 49$, $n_2 = 52$, $Z = 3.01$, $p < .005$). Product-mement correlations showed no significant relationship between per cent A. Est. and per cent counting per S or OE gsr. However, the product-moment correlation between per cent A. Est. and I gsr (block 3) was +.201 (df = 118, $p < .05$). Inotherwords, the more aroused Ss became over the last block of trials, the less inhibition developing, the greater the per cent A. Est.; development of inhibition inhibited accurate estimation.

CEDE was not significantly related to DEE, I gsr (block 3), OE gsr, or Sb Un by chi square analysis.

DEE was not significantly related to I gsr (block 3), OE gsr, or Sb Un by chi square analysis.

"Ons" were not significantly related to I gsr (block 3), or Sb Un by chi square analysis comparing "ons" with "offs" and "ons" with all other Ss. However, being an "on" vs. being an "off" was significantly related to OE gsr ($p < .02$ by chi square); a comparison between "ons" and all other Ss by OE gsr was also significant ($p < .05$ by chi square). Greater overall experimental arousal led to the 100% A. Est. of the "ons."

Product-moment correlations between OE gsr and I gsr by block were as follows: block 1 was +.783 ($df = 118$, $p < .01$); block 2 was +.362 ($df = 118$, $p < .01$); block 3 was +.312 ($df = 118$, $p < .01$). Thus the OE gsr was more a product of gsr change during the first block of trials than subsequent blocks of trials. That the correlation was significant is a natural reflection of the fact that the I gsr measures arithmetically summed would in total equal the OE gsr measure; i.e., they were different aspects of the same over-all process.

Neither I gsr nor OE gsr were significantly related by chi square analysis to Sb Un.

Discussion

The findings of Experiment II supported and elaborated on the findings of Experiment I.

Again the more intense stimulus intensity elicited significantly more "unpleasant" ratings after the experiment, supporting its status as a more noxious US. The choosing of "unpleasant" as a descriptive term for the US was not significantly related to any other independent or dependent variable besides stimulus intensity.

Some of the S characteristics had interesting effects. Females were more relaxed than males both before the experiment (H gsr) and as a result of it (OE gsr). Females did not however evidence a significantly higher level of conditioning or a greater development of inhibition over trials (I gsr). Nor did females show performance significantly different from males on any of the aspects of temporal estimation gauged. Both sexes averaged the same age. Age differences had no significant effect on any of the gsr measures or temporal estimation measures. However, 18 year old Ss did not show as high a level of temporal conditioning as Ss 19 to 22 years did. The S characteristic of pre-treatment arousal or H gsr had significant consequences for temporal conditioning as theory predicted it would. By this measure, "relaxed" Ss significantly out performed "excited" Ss, supporting Birman's (1953) similar observations. Furtherfore, the magnitude of the pre-treatment H gsr was found to be a significant predictor of subsequent level of temporal conditioning thus supporting the Pavlovian inhibition research findings (where inhibition has been operationally defined as relaxation). The correlation between H gsr and OE gsr was low, but positive and significant. Those Ss relaxing before the experiment generally relaxed as a result of it. However, H gsr was not significantly correlated with the buildup of inhibition at the midpoint of the ITI (I gsr). The inference was that these are independent systems. H gsr did not significantly relate to any of the measured aspects of temporal estimation.

Thus it was demonstrated that, of the S characteristics, age and pre-treatment arousal (but not sex) affected the level of temporal conditioning achieved. The stimulus variables of ITI and Int. were also shown to be effective in this regard. Measures of frequency of occurrence of the CR and magnitude of error of anticipation, correlating significantly with each other, both confirmed the drop in level of conditioning at ITIs between 1 and 4 minutes as well as the performance depressing effect of increased stimulus intensity at short ITIs of a minute or less. Significant facilitation of level of conditioning by increased stimulus intensity was evident only at "medium" range ITIs. Apparently, beyond a maximum ITI length, stimulus intensity may no longer be a critical variable for temporal conditioning.

Level of conditioning significantly rose over blocks of acquisition trials and I gsr grew progressively and significantly more relaxed with it. This Pavlovian theory and practice predicted and it held true even when analyzed solely for those Ss whose overall reaction to the experiment (OE gsr) was one of greater arousal rather than greater relaxation. However, the I gsr did not take on the customary "V" shape as a function of ITI group until the third and last block of acquisition trials. At this block, the "medium" Washington-Moscow ITI gap ITIs showed significantly less relaxation by I gsr than "long" Soviet range ITIs or "short" American range ITIs. There was, therefore, an inhibition differential by the last block of trials. I gsr in this last block of trials was also found to correlate significantly and positively with accuracy of estimation.

Apparently, then an increase in I gsr (a decrease in growth of relaxation or inhibition) is associated with an increase in estimation accuracy; the growth of inhibition thus is positively associated with temporal conditioning level and negatively associated with temporal estimation accuracy.

The OE gsr demonstrated less arousal as ITI length increased. This might have been a function of the ITI length in itself or the over-all increased experiment length which naturally grew with the length of the ITI. Correlations with I gsr by block of acquisition trials suggested that OE was based more on change in the first block of trials than in subsequent blocks of trials. OE gsr had no demonstrable relationship to level of conditioning but those Ss scoring 100% accuracy of temporal estimation were less relaxed by OE gsr than their peers. This ties in with the finding that less relaxed I gsrs in the last acquisition block were associated with superior estimation performance.

Methods of synchrony were catalogued as to commonality and conditioning efficacy. The emergence of breathing as the only method to significantly excel guessing on level of conditioning was consistent with the literature available on the subject. It is interesting, for example, that Rozin (1959) made a point of observing breathing movements in his dogs (but did not relate it to level of conditioning as translated). This method might well be further scrutinized in its own right in future temporal conditioning investigations.

It was also of interest that per cent counting per S did not significantly decline from "short" to "long" ITI group. ITIs of more than 5 minutes seemed necessary to bring out this decline if it in fact exists.

Accuracy of estimation was shown to be an ability independent of temporal conditioning performance. Furthermore, Experiment I estimation results were not replicated in that accuracy of estimation in Experiment II was not significantly related to the stimulus variables of ITI or intensity. Nor did A. Est. vary with sex, age, or H gsr as has already been mentioned.

Bakan's (1962) findings that retrospective judgement added information to temporal estimation was borne out in the sense that a majority of Ss correctly identified the direction of their error. However, the identification of the magnitude of error in conjunction with direction of error did not produce a second estimate any more accurate than the initial one. Neither knowing the correct direction of error nor the actual direction of error were found to be significantly related to any of the independent or dependent variables in this experiment. For example, none of the gsr arousal measures related to over estimation. As has already been discussed, however, accuracy of temporal estimation did increase with arousal as gauged by the OE gsr and I gsr measures. This supported the study of Burns and Gifford (1961) although it must be recognized that the interval

estimated after temporal conditioning was unique in that it had been presented a number of times prior to estimation and had been synchronized with actively by S each of these times; there is evidence that accuracy of estimation can be affected by this procedure (Elkin, 1964). Therefore, the finding that arousal relates significantly to accuracy of estimation at the end of temporal conditioning must for now be limited to the context of temporal conditioning.

The magnitude of the temporal estimate was found to reflect the last S-S interval more closely than the last S-R interval even when analysis excluded Ss over estimating the ITI (putting them by definition closer to the S-S interval).

Experiment II generally supported, replicated, and elaborated all the conditioning results of Experiment I. On the other hand, some temporal estimation results were not replicated nor did amount of counting per S significantly decrease over the ITI range explored.

EXPERIMENT III

Experiments I and II dealt with the acquisition of a temporal CR over trials in a single one day session. Experiment III analyzed the acquisition process as a function of two successive daily sessions with subsequent extinction procedure.

Method

Subjects.--The Ss were 12 volunteer college students drawn from the same introductory psychology course as in Experiment II. Males outnumbered females 8 to 4; a ratio nearly identical to that of the last experiment. Age, again restricted to from 18 to 22 years, averaged 19.0 with exactly half the sample 18 years old.

Apparatus.--The apparatus was identical to that of Experiment II.

Procedure.--On day 1, Ss were run through a procedure identical to that of experiment II with the single following exception. After the last post-treatment data were collected, S received no explanation or credit slip but was told to return the next day at the same start time for part II of the experiment. On day 2, S was again run through the full acquisition procedure. Following collection of post-treatment data, S was read the following instructions by E:

> We have one more phase of the experiment to complete and then we'll be finished.
> 1. You will be given two more flashes. They will be the same time apart as all the flashes so far.
> 2. After the second flash, whenever you think another flash is due, say "NOW."
> 3. There will be no more flashes after the second flash but continue to say "NOW" anyway every time a flash would have been due. Keep this up until I turn on the lights.

These were the extinction instructions. As in acquisition, the times of S's anticipations were recorded and this recording continued until 15 such responses had been made. Following the last extinction response, the overhead lights were turned on, S lectured on the gsr, given a credit slip, and released.

Experimental Design.--ITIs of 60 and 240 sec. were used at high US intensity only. This formed two ITI conditions with 6 Ss randomly assigned by card draw to each condition. The same Ss returned on day 2 to run under the same stimulus conditions as they had on day 1.

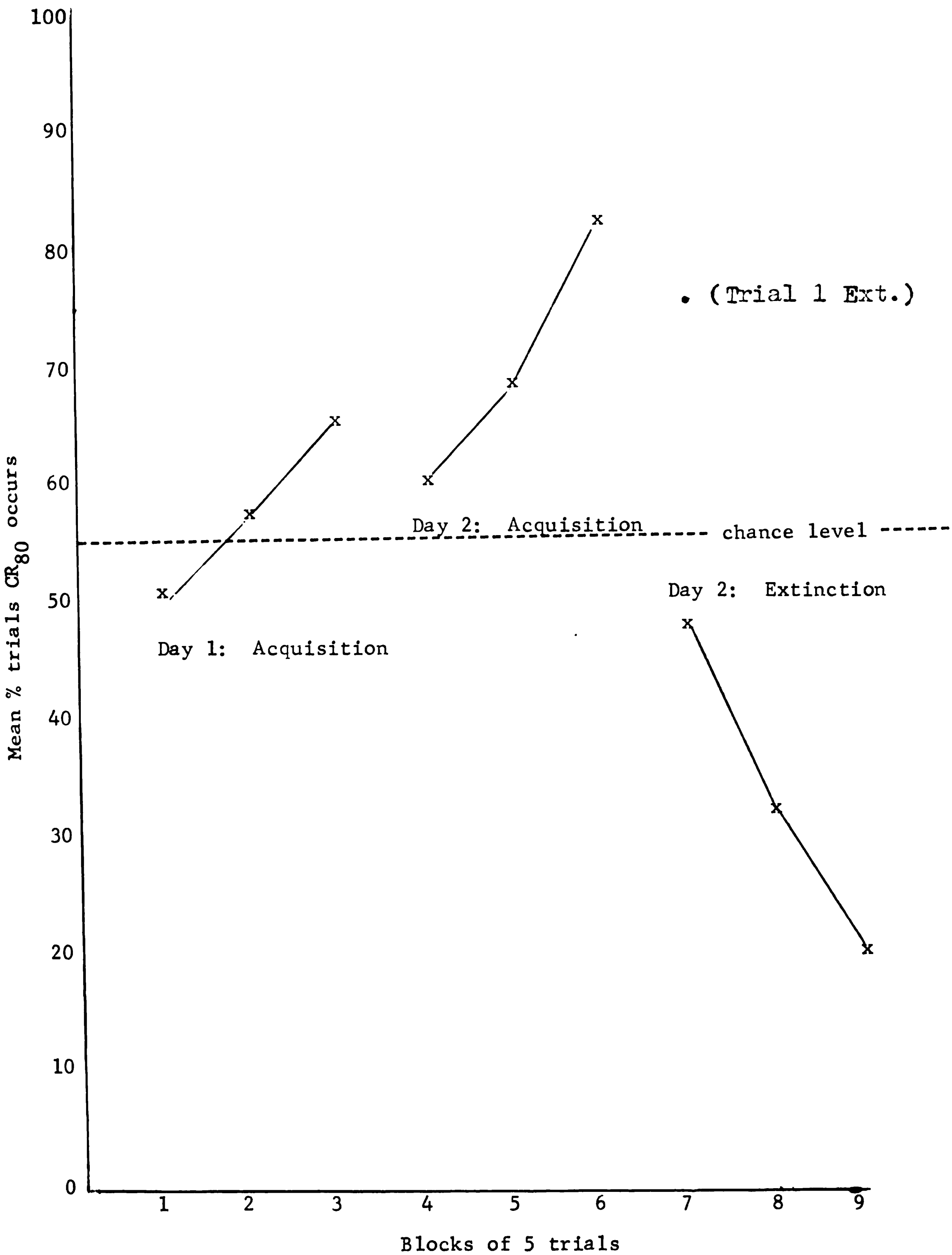
Results

The sample of Experiment III resembled the sample run under the same stimulus conditions in Experiment II in both S characteristics and day 1 performance. Fisher's exact test of probability (Siegel, 1956) did not show the distribution of sex, age, or H gsr to be significantly different for either sample or significantly different by ITI for the Experiment III Ss.

Carrying the comparison between Ss at 60 and 240 sec. ITIs (H Int.) in both experiments further, analysis of variance found no significant difference in level of conditioning between S samples in Experiment II and Experiment III (day 1) nor was there a significant difference between level of conditioning of the 240 and 60 sec. ITIs over both experiments; the analysis of variance also found the experiment x ITI interaction to be non-significant (Table 22). (The measure of conditioning analyzed throughout this results section was in all cases the CR_{80} or frequency of occurrence measure.)

Having established the comparability of the day 1 acquisition results at both ITIs in this experiment with the last experiment, analysis moved exclusively to Experiment III data. An analysis of variance of level of conditioning for day 1 alone (Table 23) found no significant difference by ITI, trial blocks, or their interaction. However, block 3 was at a significantly higher level of conditioning than block 1 ($t = 2.13$, $df = 22$, $p < .05$). Figure 15 illustrates this increase by block for day 1. ITIs have been pooled due to lack of significant difference between them.

Figure 15.--Acquisition and extinction of a temporal CR: Mean % occurrence of CR_{80} at high stimulus intensity averaged over both ITI, by 5-trial blocks in Experiment III



An analysis of variance of level of conditioning over acquisition trials for day 2 alone (Table 24) found no significant difference by ITI, trial blocks, or their interaction. However, again block 3 was at a significantly higher level of conditioning than block 1 ($t = 2.36$, $df = 22$, $p < .05$). The ITIs pooled again, Figure 15 illustrates this increase by block for day 2. Note that all acquisition blocks (except the first on day 1) showed significant (55% or better) conditioning levels.

In analysis of the extinction results, an anticipatory response was considered a CR_{80} only if it occurred in that last 20% of the ITI which <u>would have</u> been defined if the US had not been deactivated. An analysis of variance of level of conditioning over extinction trials alone (Table 25) found no significant difference by ITI or the interaction of ITI with trial blocks. However, the F for trial blocks ($F = 4.01$, $df = 2.20$, $p < .05$) indicated the drop in level of conditioning over blocks of extinction trials was significant. This is also illustrated, with ITIs pooled, in Figure 15. Note also that <u>all</u> extinction blocks show less than significant (55% or better) levels of conditioning. (Alternate measures in appendix B, p.130.)

Complete t-test analyses of these data are presented in Table 21. The t-tests indicated that it was not until block 2 of acquisition on day 2 that level of conditioning significantly excelled block 1 of day 1, but that by block 3 of day 2 acquisition was significantly beyond all the blocks of day 1. The analyses further bore out what Figure 15 suggests: the extinction was quite rapid in comparison to acquisition. The second block of extinction trials was already significantly below the level of conditioning of all the day 2 acquisition blocks while the third block of extinction trials was significantly below <u>all</u> acquisition blocks for days 1 and 2. In fact, the mean 20% frequency of occurrence for the third block of extinction was what would most be expected by chance since a CR_{80} was any anticipation occurring in the last fifth of the ITI. In other words, the results indicated 15 trials to have fully extinguished the temporal CR at both ITIs, with even 5 trials of extinction sufficient to drop CR_{80} occurrence below the normally accepted chance level.

Conditioning level in acquisition day 1 correlated +.617 (df = 10, $p < .05$) with conditioning level in acquisition day 2. Conditioning level in extinction correlated -.967 (df = 10, $p < .01$) with acquisition level on the same day and -.337 (df = 10, $p < .25$) with acquisition level of the day before (day 1). In all cases conditioning level was represented by the overall CR_{80} score for 15 trials. Thus the correlation between the same process on different days was lower than the correlation between different processes on the same day. Time relations again seem to have had some relevance.

An analysis of variance was used to evaluate the effect of ITI, initial and secondary estimation, and day of testing, on per cent A. Est. (Table 26). ITI had no significant effect nor did order of estimate nor any of the interactions. However, there was a significant <u>decrease</u> in per cent A. Est. from 83.5% on day 1 to 76.2% on day 2 ($F = 7.35$, df - 1.30, $p < .05$). Estimation was made directly after acquisition on both days.

An analysis of variance of OE gsr by ITI and successive days of acquisition (Table 27) found the OE gsr to be significantly less relaxed on day 2 than on day 1 ($F = 9.98$, df = 1.10, $p < .05$). ITI and the interaction were not significant.

An analysis of variance of I gsr by ITI, trial blocks, and successive days of acquisition (Table 28) found no significant effects from ITI, successive days, or any of the interactions. However, as in Experiment II, I gsr grew significantly more relaxed with blocks of trials on both days of acquisition ($F = 5.71$, df = 2, 50, $p < .01$).

Discussion

In this experiment, level of temporal conditioning was shown to improve from one day of 15 acquisition trials to the next day of 15 acquisition trials. Temporal conditioning also showed significant extinction after 5 trials in the absence of periodicity from the US. The extinction process thus appeared to be more rapid than the acquisition process and was highly (negatively) correlated with conditioning level in acquisition the same day. However, extinction failed to correlate significantly with the acquisition of the day before. Despite the high significant correlation between acquisitions on subsequent days, extinction only related significantly to acquisition results of the same day. Here was evidence that human conditioning can be more similar for separate learning processes the same day than for the same learning process on separate days.

It is worth noting that although a "short" and a "long" ITI were tested in this experiment, there were virtually no significant differences between the two on any of the conditioning blocks or on any of the other dependent variables investigated. Temporal acquisition, savings in re-acquisition, and extinction were thus demonstrated at ITIs in both the American and Soviet investigated ranges.

The finding that accuracy of estimation decreased from one day to the next has no obvious explanation in terms of any of the theory or findings presented on past pages of this dissertation. It should be regarded as highly tentative pending replication in a future experiment. Difficulty of interpretation is compounded by the significant increase in OE gsr arousal (from day 1 to day 2) which, in Experiment II, was associated with those Ss reaching 100% accuracy of estimation. Perhaps a conservative but more accurate statement of findings would be that there was no evidence that accuracy of estimation improved after the second day of acquisition despite the observed signifcant improvement in level of conditioning.

That there was less relaxation (a larger OE gsr) as a result of the total acquisition segment of the experiment on day 2 may merely be a reflection of S's expectancy of the second (extinction) part of the experiment awaiting him. At any rate, it is interesting that even though the OE gsr averaged a daily increase in arousal which was significantly larger the second day, I gsr showed the same daily relaxation over blocks of trials as in the last experiment. This build-up of inhibition or relaxation reflected by the I gsr in the last two experiments seemed to be an all-or-none process. Whenever temporal conditioning occurred there it was, even in Ss showing a net decrease in relaxation as a result of the experiment; but not necessarily in demonstrable relation to the magnitude of level of conditioning. Although it would be premature to integrate this finding with previously cited elicitation theory (Denny and Adelman, 1955; Ratner and Denny, 1964) on the basis of these parametric studies alone, such a relationship is suggested by the data. According to elicitation theory, omission of the US elicits responses antagonistic to the UR. This "secondary elicitation" means omission of a noxious US elicits relaxation. Thus the converging elicitation and Neo-Pavlovian inhibition theories both would have predicted relaxation during the ITI pending S's discrimination of that ITI as temporally distinct from the noxious US. (See appendix B, p.131)

EXPERIMENT IV

Pavlov (1927) decreed that any length ITI could be temporally conditioned although none longer than 30 minutes had been attempted. Feokritova (1912) claimed the establishment of a CR within the last minute of this ponderous ITI after several trials only. It was the purpose of Experiment IV to attempt a replication of this conditioning of a 30 minute ITI, but in the context of the conditioning procedures used in the three previous experiments. A secondary purpose was to go beyond the 30 minute ITI and attempt conditioning at a 60 minute ITI. Pavlov's faith that ITIs of 30 minutes _or longer_ could be conditioned was in this way assessed.

Method

Subjects.--The _S_s were six paid male college students. Four _S_s were 18; two were 19.

Apparatus.--The conditioning apparatus was identical to that of Experiments II and III. However, there were some changes in positioning. _E_, with the data control and recording apparatus, moved to the outer chamber of the double experimental room (see Figure 16). _S_ remained in the inner room facing the stimulus bulb, hand in gsr electrodes. Food, water, urinal, and the dim red light were left in the inner chamber with S (see Figures 17 and 18). Since the shut door between E and S blocked out most sound as well as all light from outside, a microphone (connected to the PA system of a tape recorder next to E) was taped to the wall next to S. This recorder allowed E to time S's anticipations and even many of his activities.

Procedure.--The procedure was basically the same as in Experiment II. S was read the standard instructions; additionally instructed to use the food, water, and urinal when necessary. S was not told how long "this phase" of the experiment would be although all Ss had set aside a full day of their time for psychological testing. When E had finished the instructions he left the inner chamber, shut the door, and began the timing of the habituation period. E was now able to use full overhead lighting in the outer chamber while S, as in past experiments, had light only from the dim red bulb. S received 15 full acquisition trials with a common ITI. E kept notes on behavior as picked up by the microphone throughout the experiment. At the end of the last gsr reading, E opened the door, entered S's inner chamber and collected the normal post-treatment introspective data. Afterwards, S was lectured on the gsr and given a voucher of payment for hours put in. Ss were not told the actual time of their ITI until all Ss had been run.

ure 16.--Photograph of experimenter setting stimulus timer under gsr unit as set up in outer room in Experiment IV

Figure 17.--Photograph of subject in gsr electrodes holding water cup as situated in inner room in Experiment IV

Figure 18.--Photograph of subject in gsr electrodes holding urinal and demonstrating freedom of movement allowed in inner room in Experiment IV*

*Note: All photographs are of posed models and not actual subjects

Experimental Design.--ITIs of 30 and 60 minutes were used at high US intensity only. This formed two ITI conditions with 3 Ss haphazardly assigned to each condition.

Results

Table 29 summarizes the data for both ITIs in Experiment IV as compared to summary data from Experiment II. Sample characteristics were well balanced between the two ITIs in Experiment IV. All Ss were males and there were two 18 year olds and one 19 year old at each condition. There were "excited" and "relaxed" Ss, as gauged by H gsr, on each condition. Only one S (at the 30 minute ITI) had an H gsr varying by more than a standard deviation from the mean H gsr of the 120 Ss in Experiment II. All Ss but this highly "excited" S rated the US as "unpleasant" after the experiment.

Occurrence of the CR_{80} at these ITIs was far from as frequent as observed in Experiment II. Figure 19 illustrates this. Level of conditioning at the 30 minute ITI was, over all 15 acquisition trials, not (at 31%) significantly better than would be expected by chance. Performance at the 60 minute ITI was even lower (6%). That this may not exclusively be a fatigue effect is indicated by the fact that mean number of CR_{80}s increased somewhat with trials at both ITIs although no block exceeded 40% occurrence. Looking at the median error of anticipation by block of trials

Figure 19.--Mean % occurrence of CR_{80} at high stimulus intensity over all 15 acquisition trials as a function of ITI length in Experiments II and IV

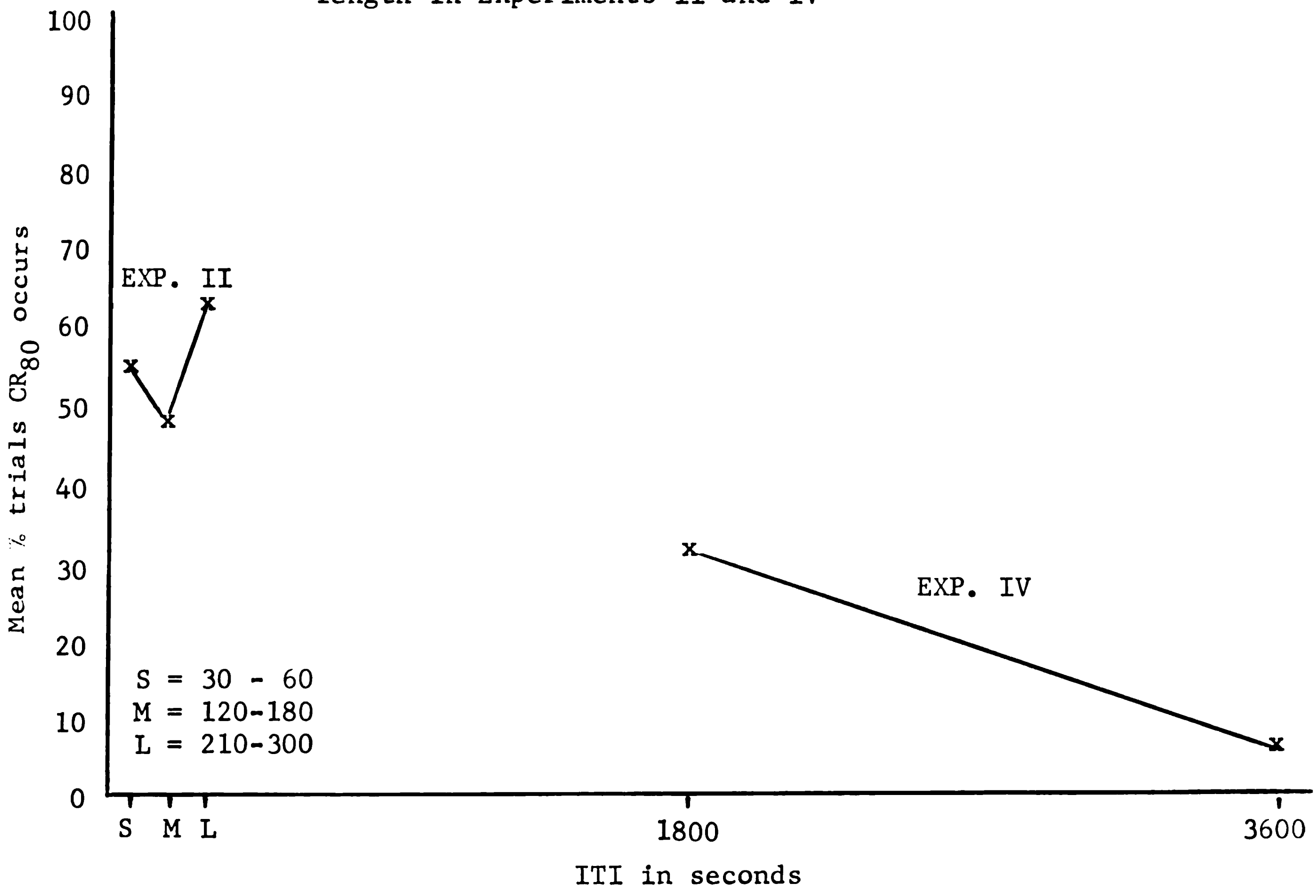
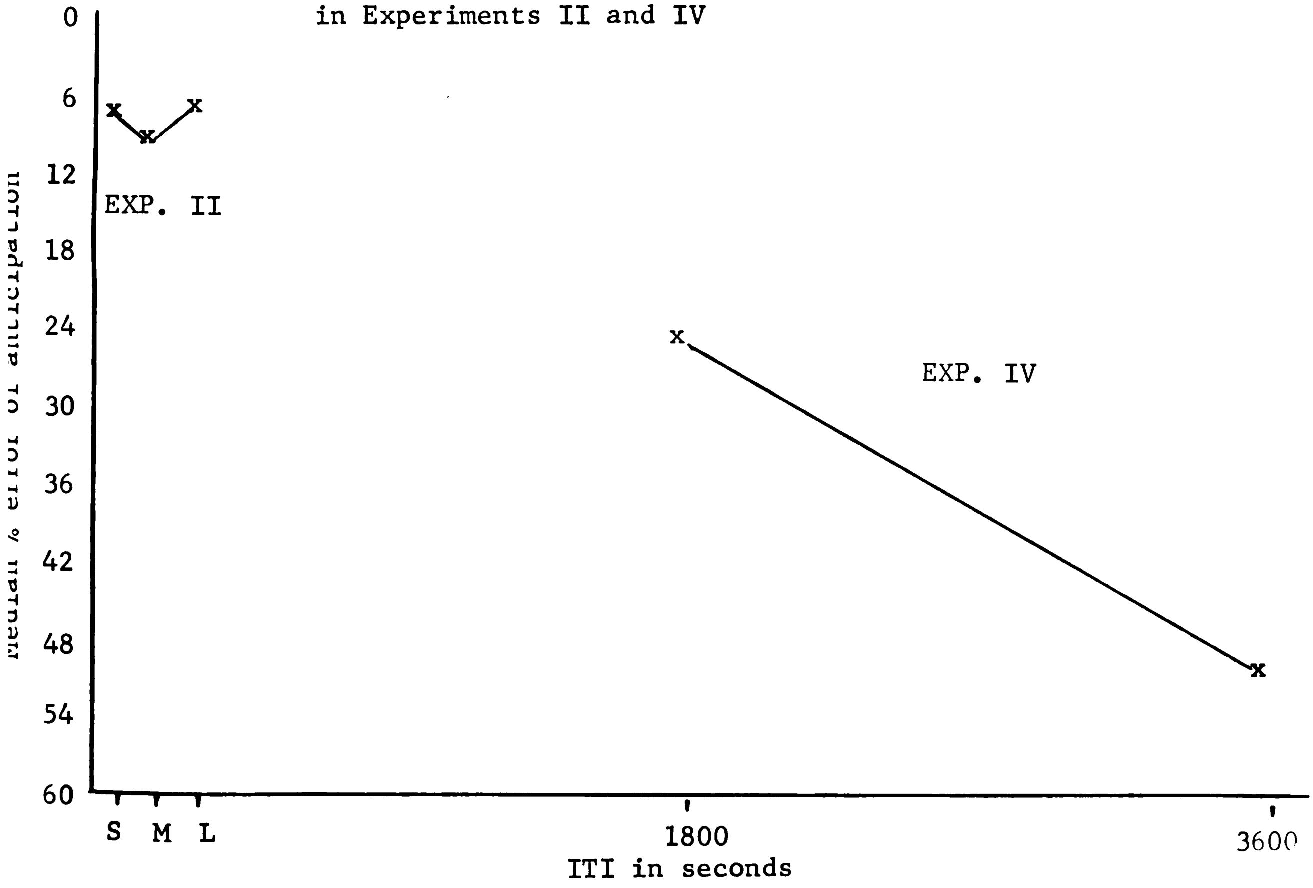


Figure 20.--Median % error of anticipation at high stimulus intensity over all 15 acquisition trials as a function of ITI length in Experiments II and IV



as it is cited in Table 29, fatigue effects were more noticeable. Block 2 had a larger median error of anticipation than block 1 at both ITIs although there was a slight improvement in block 3 at both ITIs. Figure 20 illustrates this error of anticipation measure over all acquisition blocks. Again, the results were congruent with the frequency of occurrence measure graphed in Figure 19. While the 120 Ss of Experiment II averaged an error of anticipation of 8% of the ITI over all blocks, Ss in experiment IV averaged 21% error at the 30 minute ITI and 50% error at the 60 minute ITI. Thus there was no substantial evidence of conditioning at either of the long ITIs of Experiment IV. Figures 21 and 22 illustrate level of conditioning over blocks at these ITIs for both conditioning measures.

The change in I gsr with blocks of trials reflected the lack of conditioning. As listed in Table 29 and as illustrated in Figure 23, I gsr was moving in the direction of increased relaxation for the Ss in Experiment II by the second block of trials; this trend continued for the third. In Experiment IV, I gsr showed no mean change in either direction at the 30 minute ITI for the first two blocks of trials, but showed a slight movement towards relaxation at the ITI midpoint in the third block of trials. At the 60 minute ITI, I gsr was moving towards greater relaxation on block 2 but dropped to a mean change of zero on block 3. In other words, inhibition or relaxation as gauged by the

Figure 21.--Mean % occurrence of CR_{80} at high stimulus intensity by 5-trial acquisition block over all ITIs in Experiment II and for both ITIs in Experiment IV

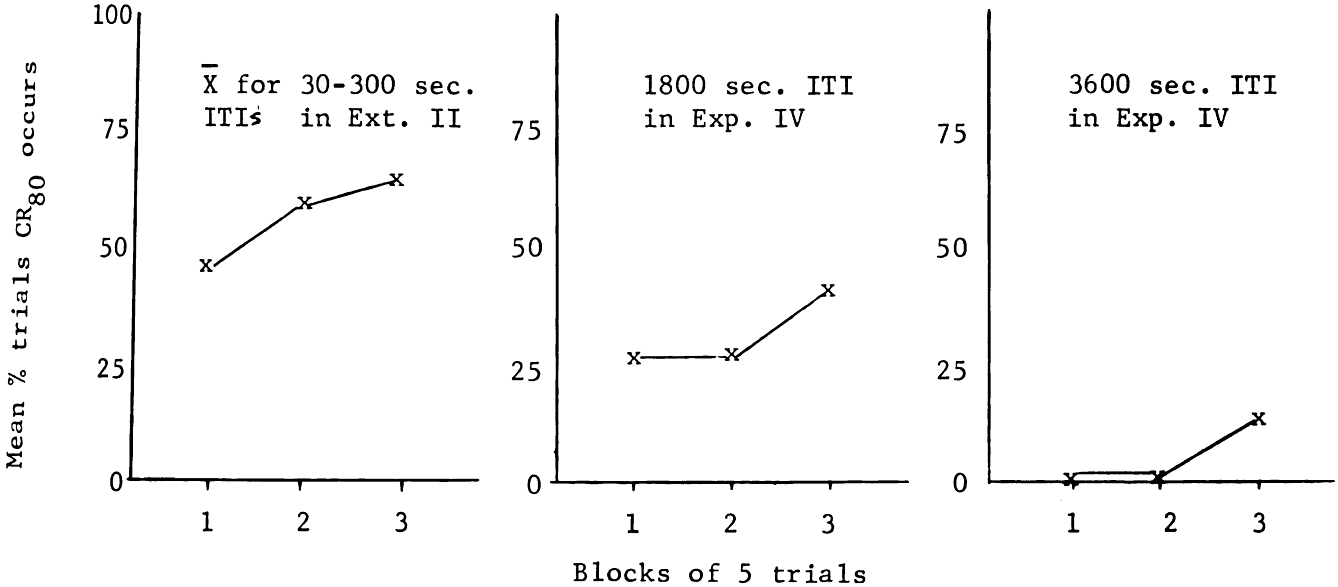
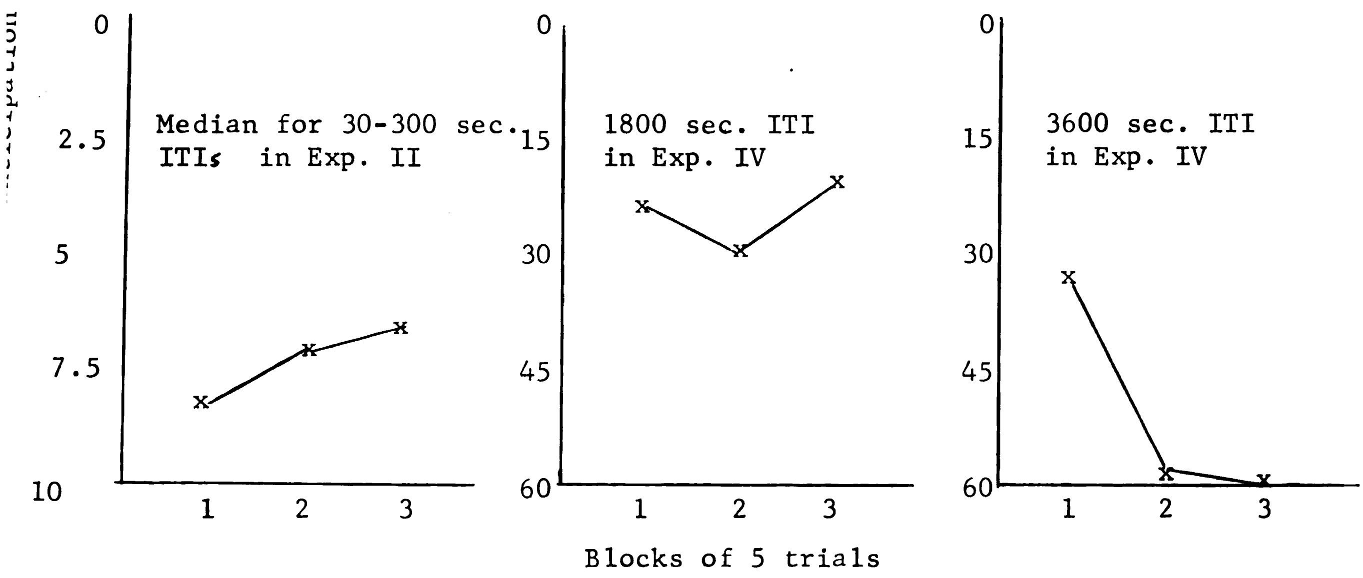


Figure 22.--Median % error of anticipation at high stimulus intensity by 5-trial acquisition block over all ITIs in Experiment II and for both ITIs in Experiment IV*



* Note that ordinate scale is expanded for Experiment IV figures to accommodate larger % error of anticipation.

Figure 23.--Mean Igsr as a function of 5-trial acquisition block over all ITIs in Experiment II and over both ITIs in Experiment IV

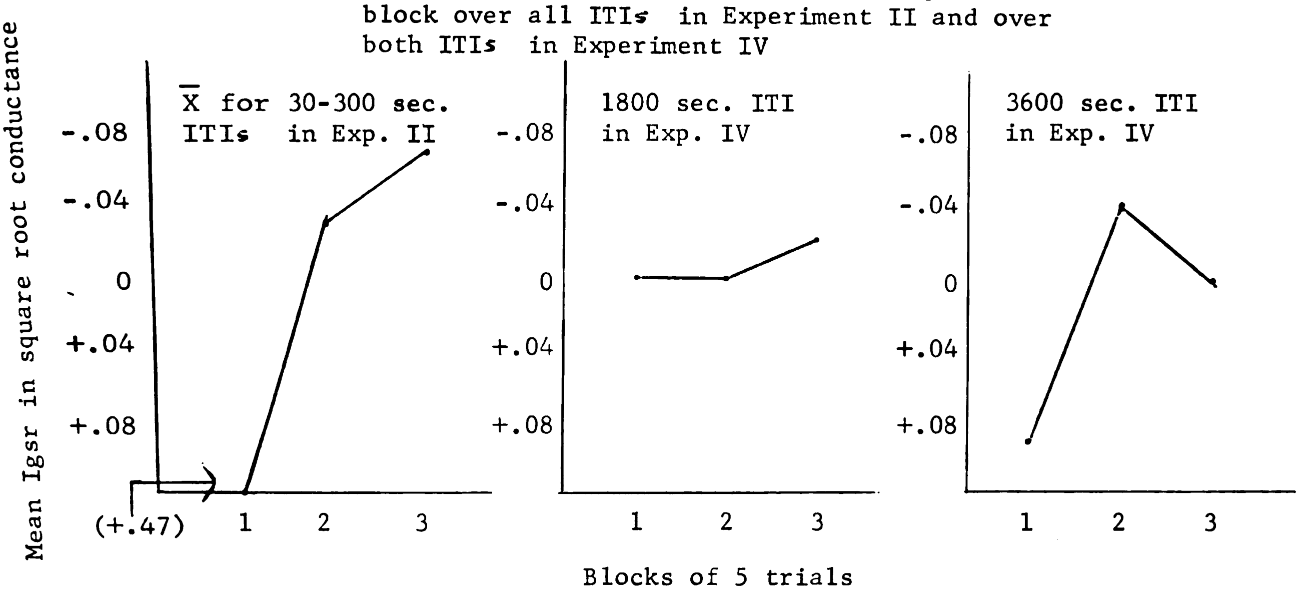
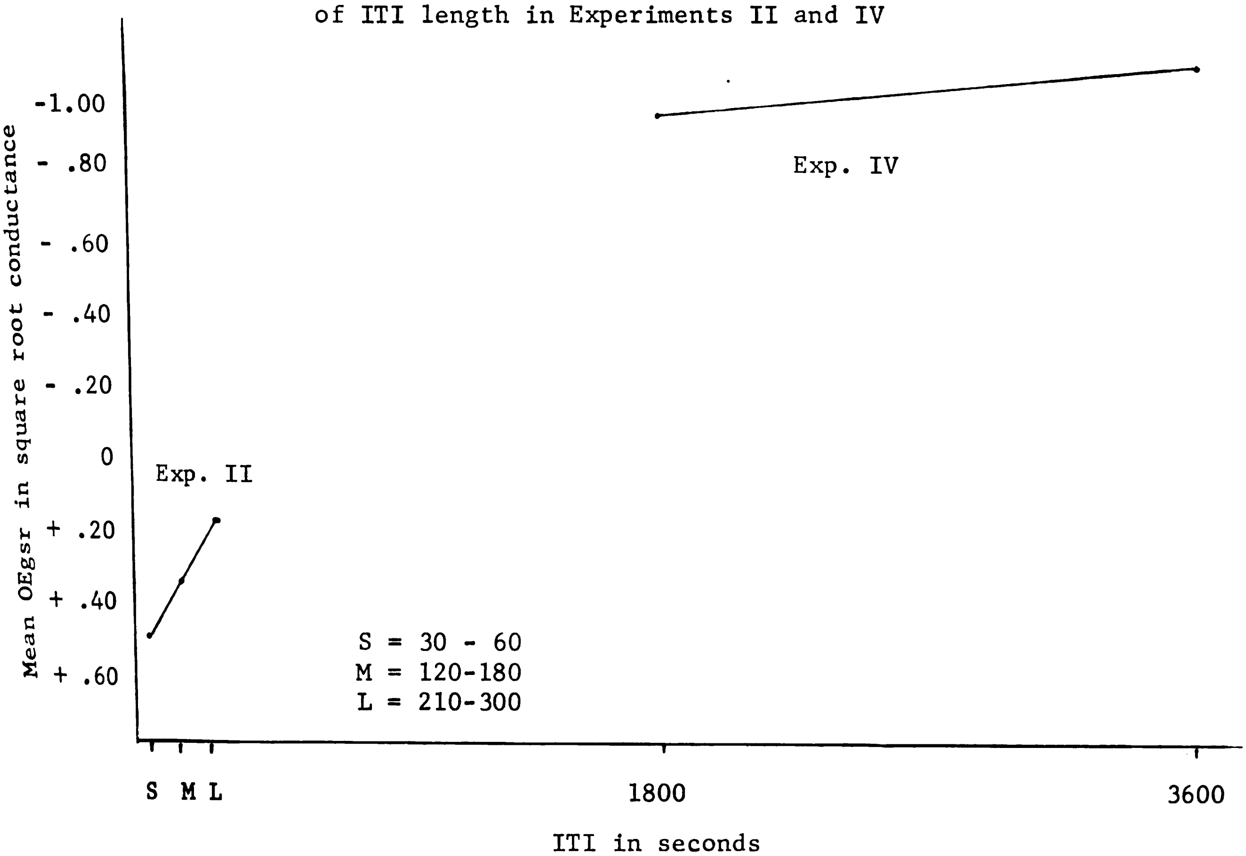


Figure 24.--Mean OEgsr at high stimulus intensity as a function of ITI length in Experiments II and IV



I gsr measure was not consistently apparent at the 60 minute ITI and occured slightly only at the last block of trials at the 30 minute ITI.

The OE gsr (see Table 29 and Figure 24) continued the trend of growth with ITI length observed in Experiment II. The experiment as a whole substantially reduced level of arousal from 30 to 60 minute ITIs. S comments indicated that this was more a function of fatigue than habituation.

The mean per cent time per S spent counting is tabulated in Table 29 and illustrated in comparison to the ITI groups of Experiment II in Figure 25. Where this per cent averaged in the 80s for the 120 Ss of Experiment II (overall mean was 84%), the mean per cent counting per S dropped to 52% at the 30 minute ITI and to 32% at the 60 minute ITI. Thus, at an ITI range of 0.5 minutes to 60 minutes, per cent counting did show a decrease. On the other hand, even the lengthy ITI of 60 minutes, taking close to 16 hours for 15 acquisition trials, still averaged counting per S approximately a third of that time. One S at this 60 minute ITI found himself counting to 1850 with every trial. Human counting methods then, while diminished with highly increased ITI length, remained a substantial method of synchrony at all ITIs.

Methods of synchrony at the Experiment IV ITIs included visualized clocks and guessing as well as the counting methods of successive numbers, tapping, and

Figure 25.--Mean % time per subject spent counting (for method of synchrony) as a function of ITI length in Experiments II and IV

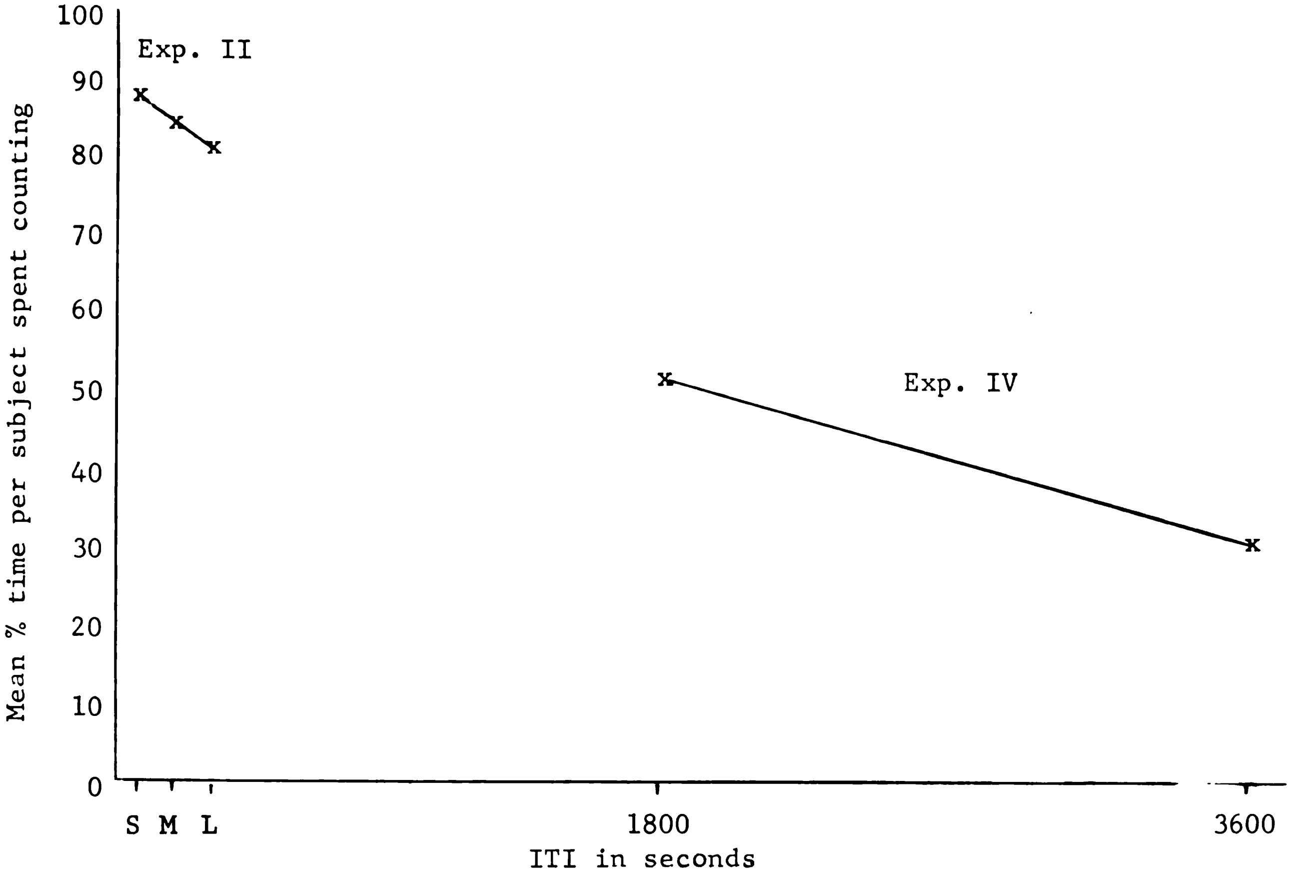
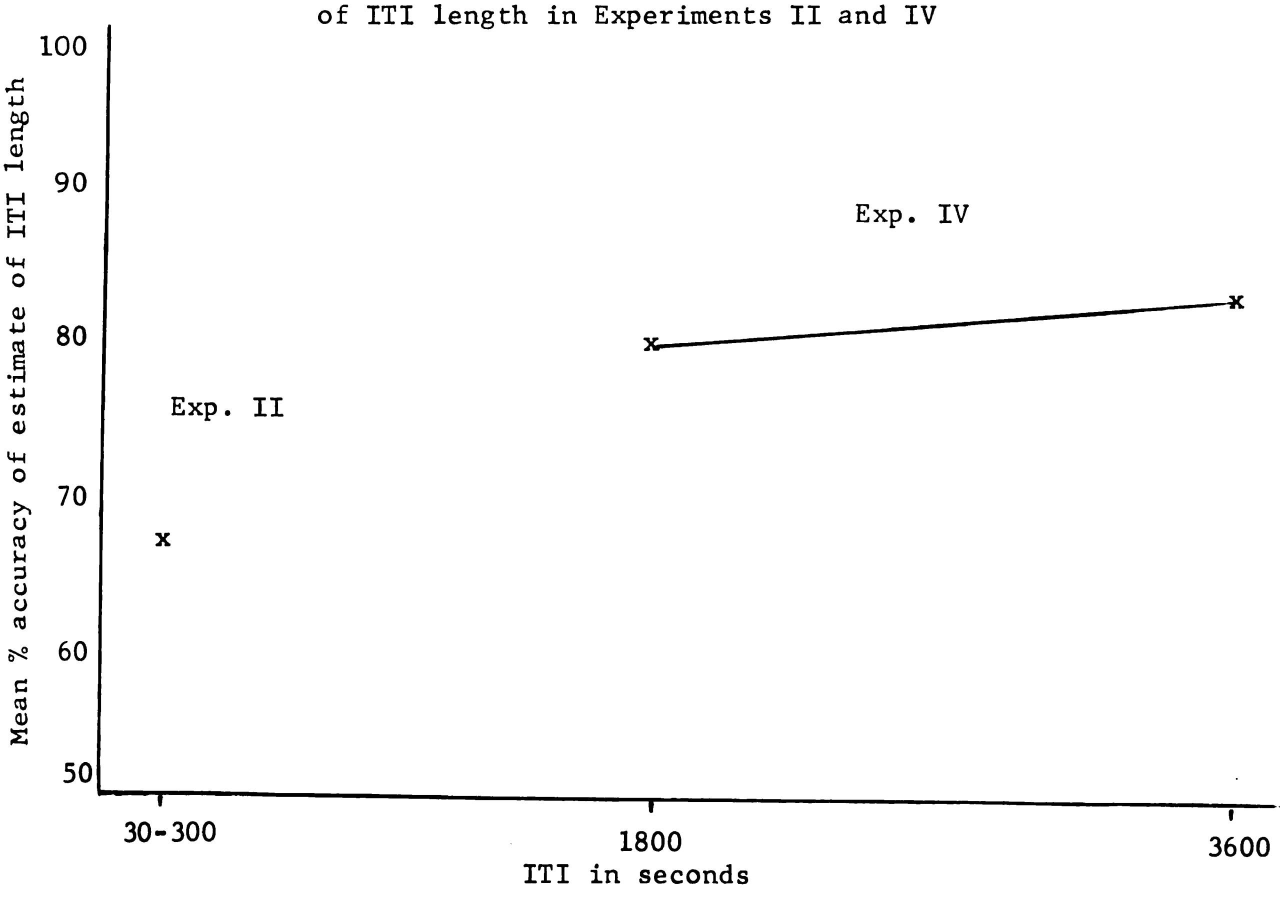


Figure 26.--Mean % accuracy of estimate of ITI length as a function of ITI length in Experiments II and IV



repeated mental events. An additional method attempted briefly by two Ss at the 30 minute ITI was synchrony with automatically flushing toilets which could be heard faintly through the vent in the inner chamber. This method was soon abandoned by both Ss as the flushing ITI of approximately 20 minutes would be disrupted by aperiodic consumer use.

Although the number of Ss in Experiment IV was far too small to justify the full classificatory listing of per cent use of methods of synchrony done in Experiment II, certain comments might be made. For one, no S synchronized with his physiological "Feel" prior to the flash although one S reported having such anxiety reactions within seconds of each US presentation. This method of synchrony could not therefore be evaluated at the extra long ITIs. Time spent guessing substantially increased in Experiment IV. Where approximately 5% of S's time was spent guessing at the 30 to 300 second ITI range of Experiment II, 48% and 35% of S's time was spent guessing at the ITIs of 30 minutes and 60 minutes respectively. The S (S2) using the visual clock method used it 100% of the time and was the most accurate on the error of anticipation measure of the three Ss at his 60 minute ITI. The bulk of counting time was spent on successive numbers or tapping methods just as in Experiment II. Repeated mental events included song choruses and mental jigsaw puzzles. Only one S counted pulse and that briefly; no one synchronized with breathing.

Figure 26 illustrates the mean per cent accuracy of estimation at the long ITIs of Experiment IV as compared to the mean 67% accuracy for the ITIs of Experiment II. Accuracy did increase to a mean of 80% for the 30 minute ITI and 83% for the 60 minute ITI. Half the Ss in Experiment IV showed 100% accuracy with their initial estimate. The other Ss all underestimated their ITI length. Only 2 of the 6 Ss had a second retrospective estimate more accurate than the initial one. Two of the 3 Ss making an initial error of estimate knew the correct direction of their error. These data are all included in Table 19.

Detailed behavioral logs were kept on each S. None quit the experiment before its completion although occasionally morale slackened enough to elicit caustic comments. These usually came in the middle block of trials and were never reflected in the attitude of S once the door to the inner chamber was opened at the experiment's end. Ss whenever face to face with E were cooperative and in good spirits. However, frequent lows in this attitude were recorded for the isolated hours spent by S in the inner chamber. A carbon of the instructions left with S during one acquisition session was found afterwards to have been crumpled, torn, and dipped in the urinal. Another S managed to remove the screws from his table with his free hand during the experiment. In general, however, hostility was covert and cooperation was always beyond the minimum necessary for a successful acquisition procedure.

Discussion

Pavlov's (1927) statement that temporal conditioning was possible at any ITI was not supported by the data of Experiment IV. Level of conditioning at ITIs of 30 and 60 minutes, as depicted by two measures of learning, remained well below that established at ITIs of 0.5 to 5.0 minutes in Experiment II. On the other hand, Feokritova's (1912) observation that conditioning at a 30 minute ITI occurred after only two or three trials is understandable in the sense that all Ss at the 30 minute ITI in Experiment IV achieved at least one or two CR_{80}s in the first block of 5 trials. However, frequency of occurrence never got much better than this over further blocks. Furthermore, an occurrence of one CR_{80} in any 5 trials is highly likely by chance alone. It is interesting that no replication of Feokritova's 30 minute ITI was included in the Soviet literature. While Experiment IV may have supported her observation, it has not supported her conclusions or those of Pavlov's.

Again I gsr reflected the presence or absence of conditioning. It was relatively absent in Experiment IV. Low conditioning levels were paralleled by a lack of clear-cut progressive movement towards relaxation at ITI midpoints as gauged by the I gsr. The OE gsr, on the other hand, continued to show less arousal with greater ITI length. Per cent time counting per S decreased and accuracy of estimation increased with increasing ITI. Apparently the ITI differential for these events must be as much as 25 minutes before their effects grow marked.

Unfortunately, neither breath counting nor "Feel" methods were attempted at the 30 to 60 minute ITI and their efficacy with conditioning remains to be tested in this context.

GENERAL DISCUSSION AND SUMMARY

The four experiments of this dissertation provided some basic data on the effects of ITI, stimulus intensity, and other variables on selected aspects of temporal conditioning in humans. These data allow consideration of the hypotheses presented at the close of the Introduction.

Hypothesis A was strongly supported by Experiments I, II and III. Temporal conditioning was demonstrated for adult humans such that it could not statistically be classified as a chance event.

Hypothesis B was supported by Experiment III. Level of conditioning was found to show significant improvement with successive days of acquisition while showing significant extinction in the absence of the periodic stimulus. General improvement in level of conditioning with 5-trial blocks of acquisition was observed in Experiments I and II as well as in Experiment III.

Hypothesis C was supported by Experiments I and II. Performance in temporal conditioning at ITIs of more than 3 minutes and at ITIs of 1 minute or less excelled the performance level of the ITIs in between. Experiment IV, in addition, suggested no support for significant temporal conditioning of humans at ITIs as long as 30 and 60 minutes. ITI was thus shown to be a critical variable for temporal conditioning.

Hypothesis D was partially supported in Experiments I and II. High stimulus intensity was shown to depress performance level in temporal conditioning at low ITIs of 60 sec. or less. However, the enhancing effect of high stimulus intensity on level of temporal conditioning was significant in Experiment II only at the middle length ITIs of 150 and 180 sec. Beyond ITIs of 3 minutes in duration, an intensity difference of the magnitude tested in these experiments did not lead to differential performance.

Hypothesis E was partially supported by Experiments II and IV in that accuracy of estimation did appear to increase substantially from ITIs of 0.5 and 5.0 minutes to ITIs of 30 and 60 minutes. Within the 0.5 to 5.0 minute range, however, the observed increase was not significant. Furthermore, the significant relationship between accuracy of estimate and the variables of ITI and stimulus intensity observed in Experiment I was not replicated with a larger number of Ss in Experiment II.

Hypothesis F was strongly supported by Experiment II. The relationship between relaxation before the experiment and the subsequent level of conditioning was positive and highly significant. Thus the work of Birman (1953), Dmitriev and Kochigina (1959), and Fraisse (1963) in this regard was confirmed. These and the present study, however, all base this conclusion on the time oriented conditioning procedures of trace or temporal conditioning. Generalization to other methods of learning on the basis of these data would not be justified. Pavlov (1927) related the importance of pre-treatment relaxation to the subsequent development of cortical inhibition. It has been suggested in this dissertation that another plausibility would be that conscious or unconscious perception and symmetric production of the interoceptive rhythms upon which time conditioning is based would be sensitive to S's degree of relaxation.

Hypothesis G was supported by Experiment I through IV. Increased relaxation during the ITI (of uncorrelated magnitude) was generally observed wherever temporal conditioning occurred and was absent or inconsistent when temporal conditioning failed to occur. This was even true for those Ss evidencing an overall decrease in relaxation as a result of the entire experiment. Insofar as neo-Pavlovians have operationally equated inhibition with overt relaxation rather than a cortical event, these data support the Pavlovian as well as the American "secondary elicitation" point of view.

Hypothesis H was supported by Experiments I, II, and IV. As in the case of accuracy of estimation, the time spent counting per S did not appreciably drop with ITI increase until ITI increased to 30 to 60 minutes. The methods of synchrony chosen by Ss were many and varied in popularity, time used per S, and efficacy in conditioning. In Experiment II, only those Ss counting breaths as a method of synchrony significantly excelled the level of conditioning of Ss guessing a majority of the time. Future experiments might well devote themselves to the conditioning efficacy of breath counting, "Feel," guess, and other methods through the pre-treatment instruction (to use a single method) of equivalent groups of Ss. One underlying inference of this approach is that what turns out to be the best conscious method of temporal synchrony might well be, at a given ITI range, the dominant interoceptive rhythm for unconscious temporal conditioning.

Among other interesting findings in these experiments were the parallelism of the two independent measures of conditioning; the increase in accuracy of estimation with the decrease of inhibition during the ITI; the enhanced conditioning observed with a small increment of adult age; the significantly greater anxiety of the college male over the college female. These and other second order findings fill out the picture of temporal conditioning in humans but demand serendipity's companions: further replication, research, and explanation.

Temporal conditioning offers a method of analyzing many more learning problems than synchrony to time in its own right. Perhaps the simplest of conditioning procedures, only conditioning to time directly hinges the CR and the UR to the same external flash or event. The growing awareness that time is periodicity and periodicity is basic to perception, learning, and all behavior will continue to bring about a convergence of approaches from a wide variety of disciplines on this single concern: the psychology of time. Temporal conditioning methods provide one of the strongest approaches of an old fertile direction.

REFERENCES

Adrian, E. D. Electrical activity of the nervous system. *Arch. Neurol.*, 1934, *32*, 1125-1134.

Anger, D. Discriminations in the reinforcement of Sidman avoidance behavior. *J. Exp. Anal. Behav.*, 1963, *6*, 477-506.

Anliker, J. Variations in alpha voltage of the electro-encephalogram and time perception. *Science*, 1963, *140*, 1317-1309.

Aschoff, J. Circadian rhythms in man. *Science*, 1965, *148*, 1427-1432.

Baiandurov, B. I. Conditioned reflexes in birds. Tomsk, 1937. In Dmitriev and Kochigina, 1959.

Bakan, P. Effect of set and work speed on time estimation. *Percept. mot. Skills*, 1955, *5*, 147-148.

________. Retrospective awareness of error in time estimation. *Percept. Mot. Skills*, 1962, *15*, 342.

Bell, C. and Provins, K. Relations between physiological responses to environmental heat and time judgments. *J. Exp. Psychol.*, 1963, *66*, 572-579.

Benussi, V. Zur experimentellen analyse des zeitvergleichs. *Arch. Ges. Psychol.*, 1907, *9*, 384-385.

Beritov, I. S. Individually acquired activity of the central nervous system. *Tbilisi*, 1932: In Dmitriev and Kochigina, 1959.

Birman, B. N. Essai clinico-psysiologique de determination des differents types d'activite nerveuse superieure. *Cah. Med. Sov.*, 1953, *2*, 123-134. In Fraisse, 1963.

Bolotina, O. P. Motor conditioned reflexes to time in dogs. *Proc. Pavlov Physiol. Inst.*, 1952a, *1*, 29-34. In Dmitriev and Kochigina, 1959.

Bolotina, O. P. Motor conditioned reflexes to time in monkeys. Proc. Pavlov Physiol. Inst., 1952b, 1, 196-204. In Dmitriev and Kochigina, 1959.

________. Effect of bromide and caffeine on conditioned reflexes to time in dogs and monkeys. Proc. Pavlov Physiol. Inst., 1953, 2, 52-63. In Dmitriev and Kochigina, 1959.

Brown, J. S. A note on a temporal gradient of reinforcement. J. Exp. Psychol., 1939, 25, 221-227.

Bugelski, B. R. Psychology of Learning. New York: Holt, 1956.

________. and Coyer, R. A. Temporal conditioning versus anxiety reduction in avoidance learning. Amer. Psychol., 1950, 5, 264.

Burns, N., and Gifford, E. Time estimation and anxiety. J. Psychol. Studies, 1961, 12, 19-27.

Cohen, Cooper, and Ono, A. The hare and the tortoise: a study of the tau effect in walking and running. Acta Psychologica, 1963, 21, 387-393.

Collier, G., Knarr, F. A., and Marx, M. H. Some relations between the intensive properties of the consummatory response and reinforcement. J. exp. Psychol., 1961, 62, 484-495.

________., G. and Myers, L. The loci of reinforcement. J. Exp. Psychol., 1961, 61, 57-76.

Conrad, D. G. and Sidman, M. Sucrose concentration as reinforcement for lever pressing by monkeys. Psychol. Rep., 1956, 2, 381-384.

Crawford, M. L. and Thor, D. H. Circadian activity and noise comparisons of two confined groups with and without reference to clock time. Percept. Mot. Skills, 1964, 19, 211-216.

Cutler, H. M. The effects of stress on the perception of time by normal and neurotic subjects. Unpublished doctoral dissertation, Purdue University, 1952.

Denner, B., Wapner, S., McFarland, J., and Werner, H. Rhythmic activity and the perception of time. Amer. J. Psychol., 1963, 76, 287-292.

Denner, B., Wapner, S., and Werner, H. Rhythmic activity and the discrimination of stimuli in time. Percept. Mot. Skills, 1964, 19, 723-729.

Denny, M. R., and Adelman, H. M. Elicitation theory: Analysis of two typical learning situations. Psychol. Rev., 1955, 62, 290-296.

Deriabin, V. S. Further material on the physiology of time as a conditioned stimulus of the salivary glands. Unpublished doctoral dissertation, St. Petersburg, 1916. In Dmitriev and Kochigina, 1959.

Dimond, S. J. The structural basis of timing. Psychol. Bull., 1964, 64, 348-350.

Doehring, D., Helmer, J., and Fuller, E. A. Physiological responses associated with time estimation in a human operant situation. Psychol. Rec., 1964, 14, 355-362.

Dmitriev, A. S. and Grebenkina. On switch-over of conditioned reflxes of the same type. Deiat., 1959, 9, 892-899. In Psychol. Abst., 1961, #4627.

________., and Kochigina, A. The importance of time as stimulus of conditioned reflex activity. Psychol. Bull., 1959, 56, 106-132.

Dufort, R., and Kimble, G. Changes in response strength with changes in the amount of reinforcement. J. Exp. Psychol., 1956, 51, 185-191.

Edwards, A. Statistical Methods for the Behavioral Sciences. New York: Rinehart, 1960a.

________. Experimental Design in Psychological Research. New York: Holt, Rinehart and Winston, 1960b.

Ehrenwald, H. Storung der zeitauffassung der raumlichen orientierung, des zeichnens und des rechnens bei einem hirnverletzten. Z. neurol. Psychiat., 1931, 132, 518-569.

Elkin, D. G. Anticipatory reflexes and the perception of time. Voprosy Psikhologii, 1964, 123-130. In Psychol. Abst., 1965, 39, #3399.

Eson, M., and Kafka, J. Diagnostic implications of a study in time perception. J. gen. Psychol., 1952, 46, 169-183.

Feokritova, Y. P. Time as a conditioned stimulus to the salivary gland. Unpublished doctoral dissertation, St. Petersburg, 1912. In Dmitriev and Kochigina, 1959; Fraisse, 1963; Pavlov, 1927; Frolov, 1937.

Ferster, C. B., and Skinner, B. F. Schedules of Reinforcement. New York: Appleton-Century-Crofts, 1957.

Fraisse, P. The Psychology of Time. New York: Harper & Row, 1963.

________., P. and Jampolsky, M. Premieres recherches sur l'induction rythmique des reactions psychogalvaniques et l'estimation de la duree. Annee Psychol., 1952, 52, 363-381.

François, M. Contribution a l'etude du sens du temps. La temperature interne comme facteur de variation de l'appreciation subjective des durees. Annee Psychol., 1927, 28, 188-204.

________. Influence de la temperature interne sur notre appreciation du temps. C. R. Soc. Biol., 1928, 108, 201-203.

Frolov, Y. P. Pavlov and His School. New York: Oxford U. Press, 1937.

Geiwitz, J. P. Hypnotically induced boredom and time estimation. Psychonom. Sci., 1964, 1, 277-278.

Gilliland, A., and Humphreys, D. Age, sex, method and interval as variables in time estimation. J. Genet. Psychol., 1943, 63, 123-130.

Grant, D. A., McFarling, D., and Gormezano, I. Temporal conditioning and the effect of interpolated UCS presentations in eyelid conditioning. J. Gen. Psychol., 1960, 63, 249-257.

Gulliksen, H. The influence of occupation upon the perception of time. J. Exp. Psychol., 1927, 10, 52-59.

Guttman, N. Operant conditioning, extinction, and periodic reinforcement in relation to concentration of sucrose used as reinforcing agent. J. Exp. Psychol., 1953, 46, 213-244.

Hardesty, and Bevan, W. Response latency as a function of the temporal pattern of stimulation. Psychol. Rec., 1965, 15, 385-392.

Hare, D. Anxiety, temporal estimation, and rate of counting. Percept. Mot. Skills, 1963, 16, 441-444.

Harrison, F. The hypothalamus and sleep. Res. Publ. Ass. Nerv. Ment. Dis., 1940, 20, 635-656.

Hoagland, H. The physical control of judgements of duration: evidence for a chemical clock. J. Gen. Psychol., 1933, 9, 267-287.

________. The physiological control of judgements of duration. Amer. J. Physiol., 1934, 109, 54.

________. Temperature characteristics of the Berger rhythm in man. Science, 1936a, 83, 84-85.

________. Electrical brain waves and temperature. Science, 1936b, 84, 139-140.

________. Pacemakers of human brain waves. Amer. J. Physiol., 1936c, 116, 604-615.

________. Some pacemaker aspects of rhythmic activity in the nervous system. Cold Spring Symposia on Quantitative Biology, 1936d, 3, 267-284.

________. The chemistry of time. Sci. Mon., 1943, 56, 56-61.

Hotelling, H. The selection of variates for use in prediction, with some comments on the general problem of nuisance parameters. Ann. Math. Statist., 1940, 11, 271-283.

Hyde, R., and Wood, A. C. Occupational therapy for lobotomy patients. Occup. Ther. Rehabilit., 1949, 28, 109-124.

Johnson, T. J. The influence of experimentally produced affect on time perception. Unpublished doctoral dissertation. Washington University, 1962.

Kayser, C. Le rythme nycthemeral des mouvements d'energie. Rev. Scient., 1952, 90, 173-188.

Kimble, G. A. Conditioning and Learning. New York: Appleton-Century-Crofts, 1961.

________., Mann, L., and Dufort, R. Classical and Instrumental eyelid conditioning. J. Exp. Psychol., 1955, 49, 407-417.

Kleitman, N. Sleep and Wakefulness as Alternating Phases in the Cycle of Existence. Chicago: U. Chicago Press, 1939.

Kleitman, N., Titelbaum, S., and Hoffmann, H. The establishment of the diurnal temperature cycle. Amer. J. Physiol., 1937, 119, 48-54.

Krzhishkovskii, K. N. On the physiology of conditioned inhibition. Proc. Russian Med. Soc. St. Petersburg, 1908. In Dmitriev and Kochigina, 1959.

Morgan, R. F., and Bakan, P. Sensory deprivation hallucinations and other sleep behavior as a function of position, method of report, and anxiety. Percept. Mot. Skills, 1965, 20, 19-25.

________., Ratner, S. C., and Denny, M. R. Response of earthworms to light as measured by the GSR. Psychonom. Sci., 1965, 3, 27-28.

Munsterburg, J. Beitrage zur experimentellen psychologie. Heft 2. Greiburg-Br.: Siebeck, 1889. In Woodrow, 1951.

Partridge, M. Prefrontal leucotomy. Oxford, England: Blackwell, 1950.

Passey, G. E. The influence of intensity of unconditioned stimulus upon acquisition of a conditioned response. J. Exp. Psychol., 1948, 38, 420-428.

Pavlov, I. P. Conditioned Reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex. (Translated into English by G. V. Anrep) London: Oxford U. Press, 1927.

________. Lectures on Conditioned Reflexes: 25 Years of Objective Study of the Higher Nervous Activity of Animals. New York: International, 1928.

________. Experimental Psychology and Other Essays. New York: Philosophical Library, 1957.

Popov, N. A. Le facteur temps dans le theorie des reflexes conditionnes. C. R. Soc. Biol., 1948, 142, 156-158.

________. Action prolongee sur le cortex cerebral apres stimulation rythmique. J. Physiol. Path. Gen., 1950a, 42, 51-72.

________. Etudes de Psychophysiologie. Paris: Editions du Cedre, 1950b.

Prokasy, W. F. Classical Conditioning: A Symposium. New York: Appleton-Century-Crofts, 1965.

Prokasy, W. F., and Chambliss, D. J. Temporal conditioning: negative results. Psychol. Rep., 1960, 7, 539-542.

________., Grant, D., and Myers, N. Eyelid conditioning as a function of UCS intensity and intertrial interval. J. Exp. Psychol., 1958, 55, 242-246.

Ratner, S. C., and Denny, M. R. Comparative Psychology. Homewood, Illinois: Dorsey, 1964.

Remy, M. Contribution a l'etude de la maladie de Korsakow: etude anatomoclinique. Mschr. Psychiat. Neurol., 1942, 106, 128-180.

Reynierse, J. H. The effects of stimulus sampling on the retention of an avoidance response. Unpublished doctoral dissertation, Michigan State University, 1964.

Richards, W. Time estimates measured by reporduction. Percept. Mot. Skills, 1964, 18, 929-943.

Rimoldi, H. J. Personal tempo. J. abnorm. soc. Psychol., 1951, 46, 283-303.

Rosenzweig, S., and Koht, A. C. The experience of duration affected by need tension. J. Exp. Psychol., 1933, 16, 745-775.

Rozin, M. I. The physiological mechanism of the conditioned reflex to time. Academy of Sciences Byelorussian SSR Proc., 1959, 3, 318-321. From Tech. Transl. # 60-21776, Clearinghouse, U.S. Library of Congress.

Shaefer, G., and Gilliland, R. The relation of time estimation to certain physiological changes. J. Exp. Psychol., 1938, 23, 545-552.

Schlosberg, H., and Stanley, W. C. A simple test of the normality of twenty-four distributions of electrical skin conductance. Science, 1953, 117, 35-37.

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.

Siegman, A. W. Anxiety, impulse control, intelligence, and the estimation of time. J. Clin. Psychol., 1962, 18, 103-105.

Spence, K., Haggard, D., and Ross, L. Intrasubject conditioning as a function of the intensity of the unconditioned stimulus. Science, 1958, 128, 774-775.

Spiegel, E., and Wysis, H. Physiological and psychological results of thalamotomy. Proc. Roy. Soc. Med., 1949, 42, 84-93.

Spiegel, E., Wysis, H., Orchinik, C. W., & Freed, H. The thalamus and temporal orientation. Science, 1955, 121, 771-772.

Spivack, G, and Levine, M. Consistency of individual differences in time judgements. Percept. Mot. Skills, 1964, 19, 83-92.

Stolz, S. Vasometer response in human subjects: conditioning and pseudo-conditioning. Psychonom. Sci., 1965, 2, 181-182.

Stukova, M. Further contribution on the physiology of time as a conditioned excitant of the salivary glands. Unpublished doctoral dissertation. St. Petersburg, 1914. In Dmitriev and Kochigina, 1959.

Takala, M, and Partanen, N. Psychomotor expression and personality study: III. The problem of "personal tempo." Scandinavian J. Psychol., 1964, 5, 161-170.

Tukey, J. W. Comparing individual means in the analysis of variance. Biometrics, 1959, 5, 99-114.

Wallace, M., and Rabin, A. I. Temporal experience. Psychol. Bull., 1960, 57, 213-236.

Werboff, J. The relationship between electroencephalographic activity and the estimation of short temporal intervals. Unpublished doctoral dissertation, U. of Washington, 1957.

Weybrew, B. Accuracy of time estimation and muscular tension. Percept. Mot. Skills, 1963, 17, 118.

Winer, B. J. Statistical Principles in Experimental Design. New York: McGraw-Hill, 1962.

Woodrow, H. Time perception. In S. S. Stevens (Ed.) Handbook of Experimental Psychology. New York: Wiley and Sons, 1951, pp. 1224-1236.

Woodworth, R. S., and Schlosberg, H. S. Experimental Psychology. New York: Holt, Rinehart, and Winston, 1954.

Zelenyi, G. P. Reactions of the dog to auditory stimuli. Unpublished doctoral dissertation. St. Petersburg, 1907. In Dmitriev and Kochigina, 1959.

Zelkind, I., and Spilka, B. Some time perspective-time perception relationships. Psychol. Rec., 1965, 15, 417-421.

APPENDIX A

Table 1.--Some abbreviations and definitions used in Experiments I, II, III, and IV

Abbreviations	Definitions
Acq.	Acquisition
A. Est.	Accuracy of estimation of ITI
Blk. 1, Blk. n	First 5-trial block, nth 5-trial block
CEDE	Correct estimation of direction of error in estimation of ITI
CR_{80}	Response anticipating US within last 20% of ITI
CR_d	A CR score derived by dividing S's CR_{80} score by the mean $\overline{CR}_{80}$ score of S's ITI-Int. condition
D-1, D-2	Day 1, Day 2
DEE	Direction of error of estimate of ITI
E. Ant	Error of anticipation of US
Ext.	Extinction
F	Female
Gsr	Galvanic skin response
H gsr	Pre-treatment measure of gsr change during habituation
I gsr	Mean gsr change from midpoint of one ITI to midpoint of next by acquisition block
Int.	Intensity of photic US (H for high, L for low)
ITI	Intertrial interval
ITI groups (gps):	
"Short"	ITIs of 30-60 seconds
"Medium"	ITIs of 120-180 seconds
"Long"	ITIs of 210-300 seconds

Table 1.--Continued

Abbreviations	Definitions
M	Male
N	No
OE gsr	Gsr change over entire experiment (after minus before)
"Offs"	The 19 Ss with lowest A. Est. in Experiment II (Median was 0% A. Est.)
"Ons"	The 19 Ss with 100% A. Est. in Experiment II
Sb Un	Subjective unpleasantness of US as rated by S after the experiment
src	Square root conductance (gsr units converted from ohms)
+ src	A gsr change in the direction of greater arousal
- src	A gsr change in the direction of greater relaxation
0 src	No gsr change in either direction
y	Yes

Table 2.--Data summary for ITI-Int. conditions in Experiment I: sex, age, Sb Un, occurrence of CR_{80}, estimation of ITI, counting per S

Data Category	H INT.									L INT.								
	45 sec ITI			135 sec ITI			240 sec ITI			45 sec ITI			135 sec ITI			240 sec ITI		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
Age by S	19	19	18	19	18	19	18	18	19	20	20	20	21	22	20	25	18	25
Sex by S	M	M	M	M	M	M	M	F	M	M	F	F	M	M	F	F	M	M
Sb Un by S	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	N	N	N	N	Y	N	N
% CR_{80}:																		
$\bar{X}$ Blk 1		33			33			40			40			27			40	
$\bar{X}$ Blk 2		73			53			53			80			40			47	
$\bar{X}$ Blk 3		73			47			73			73			40			53	
$\bar{X}$ Blk 4		80			33			67			93			40			53	
$\bar{X}$ All Blks		65			42			58			75			39			48	
ITI Est.:																		
Sec. by S	51	58	40	135	120	150	200	196	150	13	75	90	210	75	90	165	180	170
$\bar{X}$ % A. Est		82			93			76			21			51			72	
Counting:																		
% by S	100	90	100	50	90	85	25	55	85	100	100	80	0	100	60	10	40	100
Median %		100			85			50			100			60			40	

Table 3.--Analysis of variance of occurrence of CR_{80} by ITI, Int., and trial blocks in Experiment I

Source	SS	df	MS	F
A: ITI	28.7	2	14.35	7.10*
B: Int.	0.2	1	0.25	0.12
A x B	3.1	2	1.53	0.76
error (a)	24.2	12	2.02	
C: Trial Blks.	16.5	3	5.50	10.38**
A x C	6.6	6	1.10	2.08
B x C	1.1	3	0.38	0.72
A x B x C	1.5	6	0.24	0.45
error (b)	19.1	36	0.53	
Total	101.0	71		

* $p < .01$
** $p < .005$

Table 4.--Analysis of variance of per cent A. Est. by ITI and Int. in Experiment I

Source	SS	df	MS	F
A: ITI	1819.5	2	909.8	8.63*
B: Int.	5839.2	1	5839.2	55.38*
A x B	2555.0	2	1277.5	12.12*
error	1265.2	12	105.4	
Total	11478.9	17		

* $p < .005$

Table 5.--Occurrence of CR_{80} as a function of H gsr at 45 sec. ITI and H Int. in Experiment I

S	H gsr (src)	Total Number CR_{80}s in Acq.
1	+.23	15
2	+.75	12
3	+.89	12

Table 6.--Number of Ss at each method of synchrony used in Experiment I

Method of Synchrony	Number of Ss using method at any time *
1. Counting by any means	15
a. Successive numbers	4
b. Tapping	4
c. Counting breaths	2
d. Repeated mental events	2
e. Pulse count	2
2. "Feel"	5
3. Guess	4

* Any one S may appear in more than one category; n = 18 Ss

Table 7.--Data summary for ITI-Int. conditions in Experiment II: sex, age, H gsr, Sb Un, occurrence of CR_{80}, E. Ant., A. Est., CEDE, DEE, I gsr, OE gsr, counting per S

	Sex (#Ss)		Age (# Ss)		H gsr (#Ss)		Sb Un (#Ss)		$\bar{X}$% Occurrence of CR_{80}			
ITI-Int.	M	F	18	19-22	+	0.-	Y	N	Blk 1	Blk 2	Blk 3	All Blks
30 sec-H	3	3	2	4	4	2	2	4	40.0	56.6	66.7	54.5
30 sec-L	5	1	2	4	4	2	1	5	53.4	73.4	76.7	67.8
60 sec-H	3	3	2	4	3	3	4	2	50.0	60.0	63.4	57.8
60 sec-L	4	2	4	2	2	4	0	6	46.6	76.6	86.6	70.0
90 sec-H	3	3	6	0	3	3	3	3	40.0	50.0	76.7	55.0
90 sec-L	5	1	3	3	5	1	2	4	36.6	66.6	76.7	60.0
120 sec-H	5	1	0	6	5	1	3	3	36.6	40.0	46.6	41.1
120 sec-L	4	2	3	3	5	1	3	3	40.0	43.4	53.4	45.5
150 sec-H	5	1	2	4	4	2	2	4	43.4	43.4	60.0	48.9
150 sec-L	5	1	2	4	4	2	0	6	26.6	50.0	33.4	36.7
180 sec-H	4	2	1	5	2	4	2	4	40.0	63.4	60.0	54.5
180 sec-L	3	3	4	2	3	3	1	5	30.0	56.6	46.6	44.5
210 sec-H	5	1	5	1	2	4	5	1	53.4	73.4	66.6	64.5
210 sec-L	3	3	5	1	2	4	3	3	43.4	80.0	53.4	58.9
240 sec-H	2	4	4	2	2	4	3	3	50.0	66.6	70.0	62.2
240 sec-L	5	1	1	5	2	4	1	5	60.0	63.4	60.0	61.1
270 sec-H	4	2	4	2	2	4	4	2	60.0	53.4	70.0	61.1
270 sec-L	3	3	3	3	4	2	1	5	50.0	40.0	70.0	57.8
300 sec-H	4	2	3	3	3	3	4	2	43.4	60.0	70.0	57.8
300 sec-L	4	2	2	4	1	5	4	2	50.0	53.4	66.6	57.7
Σ	79	41	58	62	62	58	48	72	----	----	----	----
$\bar{X}$	---		18.7 yrs.		+.07 src		---		44.6	58.4	63.6	55.5
S.D.	---		2.3		.30		---		7.9	7.3	7.9	15.5

Table 7.--Continued.

	Median E. Ant. in sec.				Median E. Ant. in %				% A. Est.		CEDE	DEE (#Ss)	
ITI-Int.	Blk 1	Blk 2	Blk 3	All Blks	Blk 1	Blk 2	Blk 3	All Blks	Est 1	Est 2	#Ss	Under	Over
30 sec-H	5	2	2	3	17	7	7	9	48	49	4	3	2
30 sec-L	3	2	1	2	10	7	4	6	70	59	3	1	3
60 sec-H	2	5	6	4	3	8	10	7	68	65	3	2	4
60 sec-L	6	4	3	4	10	7	4	7	63	69	6	1	4
90 sec-H	4	4	4	4	4	4	5	5	63	69	4	3	3
90 sec-L	9	5	7	6	10	6	8	6	27	26	5	2	3
120 sec-H	7	8	13	10	6	7	11	8	77	78	5	3	2
120 sec-L	16	16	8	14	13	13	7	12	82	87	6	1	2
150 sec-H	22	16	12	13	15	11	8	9	77	77	5	2	3
150 sec-L	29	13	20	18	19	9	13	12	82	86	5	3	3
180 sec-H	34	20	12	18	19	11	7	10	86	78	4	2	1
180 sec-L	37	12	20	15	21	7	11	8	58	55	3	2	3
210 sec-H	20	10	12	18	10	5	6	9	61	55	2	4	1
210 sec-L	32	10	16	22	15	5	8	10	82	80	4	4	2
240 sec-H	14	16	12	14	6	7	5	6	67	76	6	3	3
240 sec-L	21	17	13	14	9	7	6	6	72	71	2	3	3
270 sec-H	22	17	15	17	8	6	6	6	63	65	2	1	5
270 sec-L	21	16	38	20	8	6	14	7	65	64	3	3	2
300 sec-H	24	23	22	26	8	8	7	8	69	62	4	3	1
300 sec-L	26	45	24	31	9	15	8	10	61	63	6	3	2
Σ	--	--	--	--	--	--	--	--	--	--	82	49	52
$\overline{X}$	--	--	--	--	--	--	--	--	67	66	--	--	--
S.D.	--	--	--	--	--	--	--	--	33	33	--	--	--
Median	20.5	12.5	12.0	14.0	10	7	7	8	67	67	--	--	--

Table 7.--<u>Continued</u>.

ITI-Int.	$\overline{X}$ I gsr in src Blk 1	Blk 2	Blk 3	$\overline{X}$ OE gsr in src	.$\overline{X}$ % Time spent counting per S	N
30 sec-H	+.08	+.01	0	+.02	65	6
30 sec-L	+.03	+.01	0	+.04	96	6
60 sec-H	+.04	+.03	+.01	+.07	92	6
60 sec-L	+.10	-.02	-.03	+.07	100	6
90 sec-H	+.07	+.03	+.02	+.10	78	6
90 sec-L	+.16	+.03	-.04	+.11	93	6
120 sec-H	+.06	+.02	0	+.06	92	6
120 sec-L	+.05	-.02	0	+.04	82	6
150 sec-H	+.12	+.04	+.04	+.11	80	6
150 sec-L	0	-.08	+.02	+.02	100	6
180 sec-H	-.01	+.02	+.02	-.01	83	6
180 sec-L	-.04	-.03	0	+.03	78	6
210 sec-H	+.03	+.02	-.04	+.02	78	6
210 sec-L	+.02	-.01	+.03	+.04	75	6
240 sec-H	0	-.01	-.02	+.02	82	6
240 sec-L	+.10	-.03	-.07	+.01	81	6
270 sec-H	+.03	-.03	0	+.01	93	6
270 sec-L	+.01	+.01	+.03	+.02	72	6
300 sec-H	+.09	0	-.01	+.04	82	6
300 sec-L	+.02	-.06	-.09	+.01	87	6
Σ	---	---	---	---	--	120
$\overline{X}$	+.05	.00	-.01	+.04	84	
S.D.	.11	.06	.07	.08	29	

Table 8.--Analysis of variance of H gsr by ITI and Int. in Experiment II

Source	SS	df	MS	F
A: ITI	39.21	9	4.36	0.48
B: Int.	0.00	1	0.00	0.00
A x B	96.75	9	10.75	1.18
error	908.83	100	9.08	
Total	1044.79	199		

Table 9.--Analysis of variance of occurrence of CR_{80} by ITI, Int., and trial blocks in Experiment II

Source	SS	df	MS	F
A: ITI	48.0	9	5.33	3.54*
B: Int.	1.0	1	1.00	0.66
A x B	15.5	9	1.72	1.14
error (a)	150.5	100	1.51	
C: Trial Blks	58.0	2	29.00	26.54*
A x C	31.0	18	1.72	1.58
B x C	0.0	2	0.00	0.00
A x B x C	13.5	18	0.75	0.67
error (b)	218.5	200	1.09	
Total	536.0	359		

* $p < .005$

Table 10.--Tukey (1949) significant gap test for selected differences in level of conditioning of ITI-Int. conditions in Experiment II

Comparison	Mean % difference* of % occurrence of CR_{80} for all blks.
1. ITI (sec.): H Int.	
30 vs. 60	+ 3.2
60 vs. 90	- 2.3
90 vs. 120	-14.4**
120 vs. 150	+ 7.8
150 vs. 180	+ 5.6
180 vs. 210	+10.0**
210 vs. 240	- 2.3
240 vs. 270	- 1.1
270 vs. 300	- 3.3
2. ITI (sec.): L Int.	
30 vs. 60	+ 2.2
60 vs. 90	-10.0**
90 vs. 120	-14.5**
120 vs. 150	- 8.8
150 vs. 180	+ 7.8
180 vs. 210	+14.4**
210 vs. 240	+ 2.2
240 vs. 270	- 7.8
270 vs. 300	+ 3.4
3. ITI (sec.): H vs. L Int.	
30	+13.3**
60	-12.2**
90	+ 4.5
120	+ 4.4
150	-12.2**
180	-10.0**
210	- 5.6
240	- 1.1
270	- 7.8
300	- 1.1

* A + sign indicates increase in per cent occurrence of CR_{80} from first to second condition in the comparison; a - sign indicates a decrease.

** $p < .05$ or a critical difference exceeding 9.35 %.

Table 11.--Analysis of variance of I gsr (all 120 Ss) by ITI, Int., and trial blocks in Experiment II

Source	SS	df	MS	F
A: ITI	936	9	104	1.48
A: Int.	271	1	271	3.86
A x B	1094	9	122	1.74
error (a)	7020	100	70	
C: Trial Blks	2102	2	1051	17.23*
A x C	1549	18	86	1.41
B x C	191	2	96	1.57
A x B x C	1167	18	65	1.07
error (b)	12191	200	61	
Total	26521	359		

* $p < .005$

Table 12.--Analysis of variance of I gsr (for 83 Ss having a + OE gsr) by trial blocks in Experiment II

Source	SS	df	MS	F
Trial blocks	2587	2	1293.5	20.80*
error	15302	246	62.2	
Total	17889	248		

* $p < .005$

Table 13.--Analysis of variance of OE gsr by ITI and Int. in Experiment II

Source	SS	df	MS	F
A: ITI	1369	9	152	2.22*
B: Int.	23	1	23	0.34
A x B	388	9	43	0.63
error	6839	100		
Total	8619	119		

* p < .05

Table 14.--Analysis of variance of per cent time per S spent counting by ITI and Int. in Experiment II

Source	SS	df	MS	F
A: ITI	3334	9	370	0.44
B: Int.	399	1	399	0.47
A x B	10128	9	1125	1.34
error	84210	100		
Total	98071	119		

Table 15.--Analysis of variance of per cent A. Est. by ITI, Int., and estimate order in Experiment II

Source	SS	df	MS	F
A: ITI	23395	9	2599.4	1.26
B: Int.	149	1	149.0	0.07
A x B	18616	9	2068.4	1.00
error (a)	206698	100	2067.0	
C: Estimates	4	1	4.0	0.05
A x C	1	9	0.1	0.00
B x C	22	1	22.0	0.30
A x B x C	1403	9	155.9	2.11*
error (b)	14300	200	71.5	
Total	264488	239		

* p < .05

Table 16.--Correlation analyses in Experiment II

Comparison	df	Correlation
CR_d (all blks) vs. % A. Est.	118	PPM r = +.028
CR_d (all blks) vs. H gsr	118	PPM r = -.300***
CR_d (all blks) vs. H gsr	118	Eta r = -.408*** (X.Y) Eta r = -.483*** (Y.X)
CR_d (all blks) vs. H gsr	118	SRO r = -.309***
CR_d (blk 1) vs. I gsr (blk 1)	118	PPM r = -.037
CR_d (blk 2) vs. I gsr (blk 2)	118	PPM r = -.067
CR_d (blk 3) vs. I gsr (blk 3)	118	PPM r = -.120
CR_d (all blks) vs. OE gsr	118	PPM r = -.095
I gsr (blk 1) vs. H gsr	118	PPM r = +.164
I gsr (blk 2) vs. H gsr	118	PPM r = +.066
I gsr (blk 3) vs. H gsr	118	PPM r = -.043
I gsr (blk 1) vs. OE gsr	118	PPM r = +.783***
I gsr (blk 2) vs. OE gsr	118	PPM r = +.362***
I gsr (blk 3) vs. OE gsr	118	PPM r = +.312***
I gsr (blk 3) vs. % A. Est	118	PPM r = +.201*
OE gsr vs. ITI length	118	PPM r = -.230**
OE gsr vs. H gsr	118	PPM r = +.226*
OE gsr vs % A. Est.	118	PPM r = +.040
% A. Est vs. H gsr	118	PPM r = +.084
% A. Est. vs % counting per <u>S</u>	118	PPM r = -.024
Final S-S interval vs. final S-R interval	66	PPM r = +.973***
Final S-R interval vs. ITI Est.	66	PPM r = +.790***
Final S-S interval vs. ITI Est.	66	PPM r = +.849***
CR_{80} (all blks) vs. Med. % E. Ant.:		
Block 3:	115	SRO r = -.338***
All blks:	118	SRO r = -.423***

PPM - Pearson product moment * p < .05
SRO - Spearman rank order ** p < .02
Eta - Correlation ratio *** p < .01

Table 17.--Mean per cent time spent per S on each method of synchrony used in Experiment II

Method of Synchrony	Mean per cent time per S
Counting methods	
a) successive numbers	60.5
b) tapping	15.0
c) counting breaths	5.4
d) repeated mental events	4.4
e) pulse count	3.4
"Feel"	6.1
Guess	4.8
Internal clock	0.2
Sleep	0.1
Listen for cues	0.1
N = 120	100.0

Table 18.--Median CR_d and number of Ss by majority method of synchrony in Experiment II

Majority method of synchrony	N	Median CR_d	U*
Counting methods			
a) successive numbers	69	1.00	76.5
b) tapping	17	1.10	14.5
c) counting breaths	6	1.10	2.0**
d) repeated mental events	4	1.10	3.0
e) pulse count	4	1.10	6.0
"Feel"	5	1.00	6.5
No majority method	11	1.00	9.0
Guess	4	0.85	---
	120		

* U is the Mann-Whitney U (Siegel, 1956) and is based on the comparison of the CR_ds of Ss in each method group with the CR_ds of the Ss in the Guess group.

** $p < .05$

Table 19.--*t*-test analyses in Experiment II

Comparison	df	t
Age by sex (M vs. F)	118	0.00
H gsr by sex	118	3.28***
Age by H gsr (+ vs. -,0)	118	1.72
CR_d by sex	118	0.69
CR_d by age	118	2.39**
CR_d by H gsr	118	3.28***
CR_{80} of ITI groups by Int.:		
"Short" (H vs. L)	22	2.25*
"Medium" (H vs. L)	34	0.93
"Long" (H vs. L)	46	1.07
CR_{80} of H Int. by ITI gp.:		
"Short" vs. "Long"	34	0.98
"Short" vs. "Medium"	28	1.28
"Long vs. "Medium"	40	3.06***
CR_{80} of L Int. by ITI gp.:		
"Short" vs. "Long"	34	2.80***
"Short" vs. "Medium"	28	6.15***
"Long" vs. "Medium"	40	3.42***
I gsr by ITI gp.:		
"Long" vs. "Short" (Blk 1)	70	0.71
"Long" vs. "Short" (Blk 2)	70	0.93
"Long" vs. "Short" (Blk 3)	70	0.07
"Long & Short" vs. "Medium" (Blk 1)	106	0.82
"Long & Short" vs. "Medium" (Blk 2)	106	0.04
"Long & Short" vs. "Medium" (Blk 3)	106	2.47**
OE gsr by sex	118	4.66***
OE gsr by age	118	0.61
% time per *S* counting by H gsr	118	1.06
% time per *S* counting by ITI gp.:		
"Short" vs. "Long"	70	1.04
"Short" vs. "Medium"	58	0.35
"Medium" vs. "Long"	82	0.66
% A. Est. by order of est. (1st vs. 2nd)	238	0.06
% A. Est. by ITI gp.:		
"Short" vs. "Long"	70	0.61
"Short" vs. "Medium"	58	1.66
"Long" vs. "Medium"	82	1.58
% A. Est. by sex	118	1.56
% A. Est. by age	118	0.48
% A. Est. by CEDE (Y vs. N)	99	0.70
% A. Est. by DEE (under vs. over) . .	99	3.97***
% A. Est. by Sb Un (Y vs. N)	118	0.27
% A. Est. by breath counting method (users vs. non-users)	118	0.93

* $p < .05$
** $p < .02$
*** $p < .01$

Table 20.--Chi square analyses in Experiment II

Comparison	df	Chi sq.
Sex (M vs. F) & ITI (all 10) . . .	9	3.22
Sex & Int. (H vs. L)	1	0.33
Age (18 vs. 19-22) & ITI	9	12.74
Age & Int.	1	0.07
H gsr (+ vs. -,0) & ITI	9	13.90
H gsr & Int.	1	0.13
Sex & Age	1	0.78
Sex & H gsr	1	12.70***
Age & H gsr	1	2.50
Sb Un (Y vs. N) & ITI	9	13.05
Sb Un & Int.	1	8.89***
Sb Un & Sex	1	0.15
Sb Un & Age	1	0.23
Sb Un & H gsr	1	0.07
Blk 3 I gsr (+ vs. -,0) & Sex . . .	1	1.96
Blk 3 I gsr & Age	1	2.29
OE gsr (+ vs. -,0) & Sex	1	13.97***
OE gsr & Age	1	0.00
Counting methods (Y vs. N) & Sex . .	1	0.26
Counting methods & Age	1	0.00
Counting methods & H gsr	1	8.18***
Counting successive numbers & Sex . .	1	0.82
Counting successive numbers & Age . .	1	1.68
Counting successive numbers & H gsr .	1	0.00
Tapping & Sex	1	1.24
Tapping & Age	1	0.00
Tapping & H gsr	1	0.00
Counting breaths & Sex	1	0.00
Counting breaths & Age	1	6.38**
Counting breaths & H gsr	1	0.00
Repeated mental events method & Sex .	1	0.00
Repeated mental events method & Age .	1	4.87
Repeated mental events method & H gsr	1	0.04
Counting pulse & Sex	1	1.38
Counting pulse & Age	1	0.00
Counting pulse & H gsr	1	0.00
"Feel" method & Sex	1	3.49
"Feel" method & Age	1	0.00
"Feel" method & H gsr	1	3.07
No majority method & Sex	1	0.43
No majority method & Age	1	0.00

** $p < .02$
*** $p < .01$

Table 20.--Continued.

Comparison	df	Chi sq.
No majority method & H gsr	1	1.32
Guess method & Sex	1	0.00
Guess method & Age	1	0.00
Guess method & H gsr	1	0.19
CEDE (Y vs. N) & ITI	9	12.27
CEDE & Int.	1	0.15
CEDE & Sex	1	0.03
CEDE & Age	1	2.80
CEDE & H gsr	1	0.03
DEE & ITI	9	7.10
DEE & Int.	1	0.01
DEE & Sex	1	0.04
DEE & Age	1	2.90
DEE & H gsr	1	0.68
"Ons" (Y vs. N) & ITI	9	3.15
"Ons" & Int.	1	2.25
"Ons" & Sex	1	1.10
"Ons" & Age	1	0.02
"Ons" & H gsr	1	0.02
"Ons" vs. "Offs" & ITI	9	4.74
"Ons" vs. "Offs" & Int.	1	1.24
"Ons" vs. "Offs" & Sex	1	1.12
"Ons" vs. "Offs" & Age	1	0.01
"Ons" vs. "Offs" & H gsr	1	0.00
CR_d over 1.00 (Y vs. N) & CEDE . . .	1	0.29
CR_d over 1.00 & DEE	1	0.01
CR_d over 1.00 & "Ons" (Y vs. N). . .	1	0.71
CR_d over 1.00 & "Ons" vs. "Offs" . .	1	0.11
CR_d over 1.00 & Sb Un	1	0.01
CEDE & DEE	1	0.64
CEDE & Blk 3 I gsr	1	0.00
CEDE & OE gsr	1	2.98
CEDE & Sb Un	1	0.92
DEE & Blk 3 I gsr	1	1.12
DEE & OE gsr	1	0.05
DEE & Sb Un	1	0.00
"Ons" (Y vs. N) & Blk 3 I gsr . . .	1	2.45
"Ons" & OE gsr	1	5.57**
"Ons" & Sb Un	1	0.32
"Ons" vs. "Offs" & Blk 3 I gsr . . .	1	0.91
"Ons" vs. "Offs" & OE gsr	1	3.96*
"Ons" vs. "Offs" & Sb Un	1	0.00
Blk 3 I gsr & Sb Un	1	0.01
OE gsr & Sb Un	1	0.47

* $p < .05$
** $p < .02$

Table 21.--t-test analyses of occurrence of CR_{80} with ITIs pooled by trial block and stage of learning in Experiment III

Comparison ($\bar{X}$ % occur. in paren.)	df	t
Acq. D2 vs. Acq. D1:		
Blk 1 (60) vs. Blk 1 (50)	22	1.07
Blk 1 (60) vs. Blk 2 (57)	22	0.34
Blk 1 (60) vs. Blk 3 (65)	22	0.56
Blk 2 (68) vs. Blk 1 (50)	22	2.30*
Blk 2 (68) vs. Blk 2 (57)	22	1.35
Blk 2 (68) vs. Blk 3 (65)	22	0.46
Blk 3 (82) vs. Blk 1 (50)	22	4.08**
Blk 3 (82) vs. Blk 2 (57)	22	2.95**
Blk 3 (82) vs. Blk 3 (65)	22	2.31*
All Blks (70) vs. All Blks (57)		
Ext. D2 vs. Acq. D 2:		
Blk 1 (48) vs. Blk 3 (82)	22	2.91**
Blk 1 (48) vs. Blk 2 (68)	22	1.72
Blk 1 (48) vs. Blk 1 (60)	22	0.92
Blk 2 (32) vs. Blk 3 (82)	22	4.46**
Blk 2 (32) vs. Blk 2 (68)	22	3.25**
Blk 2 (32) vs. Blk 1 (60)	22	2.31*
Blk 3 (20) vs. Blk 3 (82)	22	5.92**
Blk 3 (20) vs. Blk 2 (68)	22	4.57**
Blk 3 (20) vs. Blk 1 (60)	22	3.45**
All blks (33) vs. All Blks (70)	22	6.10**
Ext. D2 vs. Acq. D1:		
Blk 1 (48) vs. Blk 1 (50)	22	0.14
Blk 1 (48) vs. Blk 2 (57)	22	0.67
Blk 1 (48) vs. Blk 3 (65)	22	1.48
Blk 2 (32) vs. Blk 1 (50)	22	1.62
Blk 2 (32) vs. Blk 2 (57)	22	2.12*
Blk 2 (32) vs. Blk 3 (65)	22	3.05**
Blk 3 (20) vs. Blk 1 (50)	22	2.83**
Blk 3 (20) vs. Blk 2 (57)	22	3.27**
Blk 3 (20) vs. Blk 3 (65)	22	4.41**
All Blks (33) vs. All Blks (57)	22	4.25**

* $p < .05$
** $p < .01$

Table 22.--Analysis of variance of occurrence of CR_{80} in Acq. at H Int. by ITI (60 and 240 sec.) and by Experiment II vs. Experiment III (D1)

Source	SS	df	MS	F
A: ITI	1.4	1	1.40	0.89
B. Experiment	0.5	1	0.50	0.32
A x B	0.0	1	0.04	0.02
error	31.6	20	1.58	
Total	33.5	23		

Table 23.--Analysis of variance of occurrence of CR_{80} in acq. (D1) by ITI and trial blocks in Experiment III

Source	SS	df	MS	F
A: ITI	0.4	1	0.39	0.34
error (a)	11.6	10	1.16	
B: Trial blks	3.1	2	1.54	1.60
A x B	1.7	2	0.85	0.89
error (b)	19.2	20	0.96	
Total	36.0	35		

Table 24.--Analysis of variance of occurrence of CR_{80} in Acq. (D2) by ITI and trial blocks in Experiment III

Source	SS	df	MS	F
A: ITI	0.0	1	0.00	0.00
error (a)	4.3	10	0.43	
B: Trial blks	7.2	2	3.58	2.28
A x B	2.2	2	1.09	0.70
error (b)	31.3	20	1.57	
Total	45.0	35		

Table 25.--Analysis of variance of occurrence of CR_{80} in Ext. (D2) by ITI and trial blocks in Experiment III

Source	SS	df	MS	F
A: ITI	1.8	1	1.78	0.31
error (a)	57.6	10	5.76	
B: Trial Blks	12.2	2	6.09	4.01*
A x B	2.1	2	1.02	0.67
error (b)	30.4	20	1.52	
Total	104.1	35		

* $p < .05$

Table 26.--Analysis of variance of per cent A. Est. by ITI, successive estimate, and successive day in Experiment III

Source	SS	df	MS	F
A: ITI	88	1	88.0	0.10
error (a)	8599	10	859.9	
B: Successive Days	653	1	653.0	7.35*
C: Successive Estimates	99	1	99.0	1.11
A x B	143	1	143.0	1.61
A x C	1	1	1.0	0.01
B x C	2	1	2.0	0.02
A x B x C	77	1	77.0	0.87
error (b)	2664	30	88.8	
Total	12326	47		

* $p < .05$

Table 27.--Analysis of variance of OE gsr by ITI and successive days of Acq. in Experiment III

Source	SS	df	MS	F
A: ITI	23563	1	23563	2.79
error (a)	84322	10	8432	
B: Successive Days	18593	1	18593	9.98*
A x B	73	1	73	0.04
error (b)	18631	10	1863	
Total	145182	23		

* $p < .05$

Table 28.--Analysis of variance of I gsr by ITI, trial blocks, and successive days of Acq. in Experiment III

Source	SS	df	MS	F
A: ITI	29	1	29.00	0.50
error (a)	581	10	58.10	
B: Successive Days	162	1	162.00	3.12
C: Trial Blk	593	2	296.50	5.71*
A x B	12	1	12.00	0.23
A x C	91	2	45.50	0.88
B x C	162	2	81.00	1.56
A x B x C	70	2	35.00	0.67
error (b)	2596	50	51.92	0.67
Total	4296	71		

* $p < .01$

Table 29.--Data summary for ITI conditions in Experiment IV as opposed to Experiment II: age, sex, H gsr, Sb Un, occurrence of CR_{80}, E. Ant., A. Est., CEDE, DEE, I gsr, OE gsr, counting per S

Data Category	Experiment IV: 3600 sec ITI (N=3) S1	S2	S3	ITI	1800 sec ITI (N=3) S1	S2	S3	ITI	Experiment II: 30-300 sec ITI (N = 120)
Age: by S	18	19	18		18	18	19		18.7
$\bar{X}$ by ITI				18.3				18.3	
Sex: by S	M	M	M		M	M	M		
Total N of Ms by ITI				3				3	79
H gsr:									
src by S	-.08	-.05	+.02		-.04	+1.04	+.02		
Median by ITI				-.05				+.02	$\bar{X}$=+.07; SD=.30
Sb Un:									
by S	Y	Y	Y		Y	N	Y		Y=33/60 Ss at H Int
Occurrence of CR_{80}									
Number by S,									
Blk 1	0	0	0		1	2	1		
Blk 2	0	0	0		2	1	1		
Blk 3	0	1	1		2	3	1		
All Blks	0	1	1		5	6	3		
$\bar{X}$ % by ITI,									
Blk 1				0				20	45
Blk 2				0				27	58
Blk 3				13				40	67
All Blks				6				31	56

Table 29.--Continued.

Data Category	Experiment IV: 3600 sec ITI (N=3) S1	S2	S3	1800 sec ITI (N=3) S1	S2	S3	Experiment II: 30-300 sec ITI (N = 120)
E. Ant.:							
Median sec by S							
Blk 1	1210	1151	1845	455	139	445	
Blk 2	2100	894	2155	143	531	570	
Blk 3	2166	1305	2005	375	317	452	
All Blks	1845	1061	2155	371	350	507	
Median sec by ITI							
Blk 1			1210			445	20.5
Blk 2			2100			531	12.5
Blk 3			2005			375	12.0
All Blks			1845			371	14.0
E. Ant.:							
Median % error by ITI							
Blk 1			34			25	10
Blk 2			58			30	7
Blk 3			60			21	7
All Blks			50			21	8
A. Est:							
1st est. % by S	50	100	100	73	67	100	
Mean % by ITI			83			80	67

Table 29.--Continued.

Data Category	Experiment IV						Experiment II
	3600 sec ITI (N=3)			1800 sec ITI (N=3)			30-300 sec ITI (N = 120)
	S1	S2	S3	S1	S2	S3	
CEDE: by S	Y	-	-	Y	N	-	Y = 82/120
DEE: Under by S	Y	-	-	Y	Y	-	Y = 49/120
I gsr: src by S							
Blk 1	+.03	-.07	+.32	-.25	+.17	+.07	
Blk 2	+.16	-.11	-.12	+.02	-.06	+.04	
Blk 3	-.08	+.42	-.31	-.02	+.01	-.04	
$\overline{X}$ src by ITI							
Blk 1			+.09			.00	+.47
Blk 2			-.04			.00	-.03
Blk 3			.00			-.02	-.07
OE gsr: src							
by S	-.57	-1.56	-1.15	-1.36	-1.94	+.46	
$\overline{X}$ src by ITI			-1.09			-.95	+.04
Counting per S:							
% by S	27	0	69	65	50	41	
$\overline{X}$ % by ITI			32			52	84

Table 30.--Sample data sheet from all experiments

DATA SHEET   TEMPORAL CONDITIONING

Date ________ 1965   Age___   Sex___   ITI____   Bulb______

Time__________   Name of S ____________________________

Examiner _____________________

I. GSR 0.50 min.____________   2.50 min.______________

II. Acquisition (XX = UR)

Flash #	Seconds before flash "NOW" said	Time GSR Taken	GSR
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			

III. Estimation   Time in seconds______________
S: Over or under-estimated__________
How much? ____________________

IV. Questions

	Method Count	When used
1. Method of synchrony:		

2. Bulb flash pleasant, unpleasant, or neutral on average? ___________

3. Other comments:

APPENDIX B

Alternate Methods of CR Definition in Extinction in Experiment III

I. CR is defined as any vocal response within the last 10% of the ITI before the periodic flash would have occurred <u>or</u> within the first 10% of the ITI after the periodic flash would have occurred.

S	Mean % Occurrence of CR by Block of 5 Trials Block 1	Block 2	Block 3
1	60	40	60
2	40	0	60
3	100	100	80
4	40	40	20
5	100	100	100
6	0	0	0
7	100	80	100
8	80	100	20
9	100	100	60
10	0	40	20
11	100	80	100
12	80	60	0
Mean	67	62	52

II. CR is defined as any vocal response within the last 20% of the ITI before the periodic flash would have occurred <u>or</u> within the first 20% of the ITI after the periodic flash would have occurred. Note that this method doubles the acceptable time range for a CR as compared to the above definition as well as the definition used in Experiment III.

S	Mean % Occurrence of CR by Block of 5 Trials Block 1	Block 2	Block 3
1	80	100	100
2	60	20	60
3	100	100	100
4	100	100	100
5	100	100	100
6	0	0	0
7	100	100	100
8	100	100	60
9	100	100	100
10	40	100	80
11	100	100	100
12	100	80	0
Mean	82	83	75

Secondary Elicitation and Relaxation During the Acquisition of a Temporally Conditioned Response

Elicitation theory (Denny and Adelman, 1955) is basically an S-R contiguity theory of learning. One of the major postulates is that of secondary elicitation which deals with the omission of an unconditional stimulus or consistent elicitor. Secondary elicitation is defined as the elicitation of a new characteristic class of response which is typically antagonistic to the original response, and which occurs with the omission of the original elicitor (US). As used in an avoidance learning context, secondary elicitation means that cues discriminated by S as occurring in contiguity with non-shock (a safe chamber) will acquire the property of eliciting relaxational response, just as the cues associated with shock come to elicit arousal and escape responses. Extinction is explained by assuming secondary elicitation brings about relaxational response in the shock area when shock is omitted. While secondary elicitation has thus generally been used to explain the extinction of avoidance behavior, the temporal conditioning situation suggests another application.

The acquisition and extinction of a temporally conditioned response take place in the presence of common external cues. The CS or cue to be discriminated must of necessity be some periodic interoceptive process. Such a discrimination does in fact occur with repeated presentations of the periodic US. As mentioned in the Introduction (p. 19), the photic US of the preceding experiments elicited immediate URs of arousal as gauged by gsr. The omission of the photic flash during the ITI, once S has discriminated that ITI as not associated with the noxious flash, should therefore lead to relaxational response according to secondary elicitation. The secondary elicitation postulate is being applied here to explain differential behavior during the ITI (as a function of perceiving the ITI as a relaxational cue) rather than an explanation of extinction. Reynierse (1964) used the same sort of explanation to account for the effect of a delayed avoidance trial on resistance to extinction (in rats).

Interestingly enough, the gsr data support this point of view. As Figure 13 (p. 51) shows, those ITIs associated with significant acquisition of the temporal response showed significant relaxation (as measured by gsr) from the midpoint of one ITI to the next by the third block of trials. Those ITIs not associated with significant acquisition of the temporal response showed greater mean arousal from the midpoint of one ITI to the next. Whether this differential relaxation was a result or a cause of the temporal discrimination cannot yet be determined from the data. That the latter is also a possibility is suggested by the significant correlation between pre-treatment relaxation and level of conditioning.