1965

Temporal Parameters of Behavior: A Psychopharmacological Approach

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TEMPORAL PARAMETERS OF BEHAVIOR:

A PSYCHOPHARMACOLOGICAL APPROACH

by

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A Dissertation Submitted to the Faculty of the Graduate School

of Loyola University in Partial Fulfillment of

the Requirements for the Degree of

Doctor of Philosophy

November

1965

Life

James Bernard Erdmann was born in Springfield, Illinois, on October 27, 1937. He was graduated from Josephinum High School, Worthington, Ohio, in June, 1955. In June, 1959, he received his Bachelor of Arts Degree from the Pontifical College Josephinum, Worthington, Ohio. Following his undergraduate studies he had one semester of theological training at the above institution. In September, 1960, he was admitted as a graduate student at Loyola University, Chicago, Illinois, and received the degree of Master of Arts in February, 1964.

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Acknowledgments

The author wishes to express his deep sense of gratitude to Horace J.A. Rimoldi, M.D., Ph.D. for his constant inspiration, guidance, and assistance not only in the preparation of this research, but also in the course of the author's graduate study.

The author is especially indebted and grateful to his parents, his sister, Rita Marie, and his wife, Patricia, for their assistance, encouragement, and patience throughout the entire period of his graduate study.

Finally, the author wishes to thank Miss Kathleen Palumbo for her untiring efforts in the typing and proof-reading of this manuscript.

The research reported in this dissertation was supported by the Psychiatric Training and Research Authority, Department of Mental Health, State of Illinois, project number 17-132.

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Problem

In the course of psychological experimentation an investigator's attention is often focused on the speed of behavior. One need merely recall how often he has seen the phrases "response rate" or "frequency of response," in his reading of the literature. Seldom, however, has the pertinent research been interested in these measures for their own sake. Rather, they have been indicative of some other variable such as habit strength, etc.

A study involving temporal parameters of behavior or personal tempo on the other hand, is very much concerned with these measures of speed of behavior or rate of movement for their own sake. It assumes that these measures, when taken on a person in the proper conditions may yield valuable information for a judgment or characterization of that person.

Important here is the difference in the experimental situation in which the measures are obtained. Measurement of personal tempo almost exclusively involves a situation in which the subject is responding at a natural rate or at a speed which he finds comfortable. It seldom is interested in either a maximum or minimum rate. Further, the subject is expected to be free from distracting influences such as experimental variables. In other situations the prime concern is usually the assessment of an observed change in the rate of responding produced by the introduction of an experimental variable.

Using this concept of personal tempo or close approximations, several investigators have explored the area of rate of motor activities with the purpose of describing the domain and defining temporal parameters of behavior (Allport and Vernon, 1933; Rimoldi, 1951; Haley, 1963).

Earlier research had proposed a single general factor of personal tempo, but this monistic interpretation gave way to a pluralistic one as a result of the more refined and exhaustive studies of the authors cited above. They defined several factors in their description of the domain of personal tempo and in many cases, the results of one verified what had previously been found by another.

On the basis, then, of factors which these authors have found to provide a clear structure in the description of certain aspects of personal tempo with normal subjects in a drug-free situation, the present author hopes to observe and describe the changes that the factorial structure may or may not undergo when normal subjects are subjected to the influences of certain basic pharmacological agents. That is, the question is whether the same tests, which to a great extent are factorially pure, will serve to define the same factors under various drug conditions as under normal or control conditions. Stated in a slightly different manner, the problem can be viewed as one of the "permanence" of a domain under different drug conditions.

The various agents employed are:

1. Atropine Sulfate .5 mg.
2. Chlorpromazine Hydrochloride (Thorazine) 50 mg.
3. Physostigmine Salicylate (Eserine) 2 mg.
4. Dexedrine 5 mg.

Besides a condition for each of the above four drugs, a placebo and a normal (no capsule administered) condition was included in the design. This meant that six separate factor structures were obtained, one for each of the six conditions. The normal and placebo conditions will be compared with previous research, and the drug conditions interpreted in the light of the normal and placebo conditions of the study and also in terms of previously known effects of the various agents employed.

The agents used in this research can be classified in the following manner:

	Stimulants	Depressants
Sympathetic	Dexedrine	Chlorpromazine
Parasympathetic	Physostigmine	Atropine

In summary, the specific aims of this research are to evaluate and compare the effect of specified pharmacological agents on experimentally defined and factorially identified variables, in terms of the basic factors that underlie the development of behavior in time.

In any attempt to report the pertinent literature of a specific problem under investigation, it is necessary to carefully delineate the salient features of the research being considered so that the evidence cited can be of value both in the design, and later, in the interpretation and evaluation of the results. From the statement of the problem in the first chapter, such features can be seen to be threefold: the study of a domain of personal tempo, the effects of five (including placebo) experimental treatments on this domain, and the use of normal human subjects. The coincidence of these three features defines a problem for which literature of direct relevance is practically non-existent. Several considerations make this statement more plausible.

The variable about which this study pivots, personal tempo, is relatively unexplored according to the literature. This is particularly remarkable when one considers not only the potential implications of such study, but also the fact that tempo variables go so far in satisfying the stringent demands of scientific methodology. It is often said that the obvious is overlooked in favor of the bizarre. Perhaps this is the case here, since measures of the obvious natural or comfortable rate of behavior are more frequently overlooked for the maximal or minimal measures.

Another consideration is a practical one, viz., that it is extremely difficult to obtain human subjects for drug research. Those that are available are generally found in various hospitals, a fact which, in a

great majority of the cases, does not permit their use as normal subjects. This being the case, most of the pharmacological and even the psychopharmacological research cited has been done either with animals or abnormals.

Further, two of the drugs being observed, atropine and physostigmine, are quite new to the field of psychopharmacology, and even with chlorpromazine and dexedrine, the majority of the literature cited is based on results found when working with the mentally disturbed.

On the basis of the above consideration, the paucity of research having direct relevance is more understandable and the format for this section becomes more definable. The literature pertaining to the area of personal tempo in human subjects in a drug free situation will be given most extensive coverage. Then basic pharmacological information concerning the various agents employed in the study will be presented. This will be followed by a summary of the studies with drugs having the greatest relevance to the present research.

The concept of personal tempo first makes its appearance in psychological literature in the work of Neumann (1913), Reymert (1923), Braun (1927), and Guttmann (1931). These psychologists together with Downey (1923), Frischeisen-Kohler (1933) and Wu (1934) tended to agree with the popular notion that there is a general unitary factor of tempo explaining the rate of bodily movements. This was done on the basis of different degrees of experimental evidence. According to the Downey Will Temperament profile, it is suggested that the rate of writing a given ex-

pression is indicative of the general speed capacity of the individual. Frischeisen-Kohler proposed her generalized tempo on the basis of high intra-individual consistencies in tests of finger and foot-tapping and preferred metronome rate. Though the basis of this observation was only a few tests, she felt confident of her results and went on to submit a biological or genetic explanation for personal tempo. She did so on the basis of evidence she collected from monozygotic and bizygotic twins, siblings, and persons not related. The first showed the greatest amount of similarity, the last, the least amount. Support for this finding may be seen in Monnier (1956) and Kastenbaum (1959) where a physiological basis for tempo in the nervous system was posited.

Wu provided additional experimental evidence for the monistic interpretation of tempo. This study involved six tests, employing finger and foot-tapping, counting numerals and words, reading, and observing octagons. All correlations were positive with a median value of .875. This was interpreted as clear evidence that in each of the six specific tasks studied, the individual worked at his own characteristic rate or "personal tempo." The same 26 persons were tested again in a situation where maximal rates were explored and here also the intercorrelations were found to be all positive. This led the author to conclude that, though no theoretical "g" factor could be demonstrated, a "general phenomeon" seemed to exist in the several tasks, in that there was always an element of community between any two of the six tasks studied. By way of extension, then, a person fast in one task might be expected

to be also fast in others.

This concept of a general tempo factor was not without its antagonists. In fact, present opinion and the weight of the evidence seems to support a specificity or pluralistic interpretation of the domain of tempo. Lauer (1933) found little relationship between specific response rates in typical samplings of voluntary and involuntary rates. He suggested that any tendency for bodily tempos to vary together would hold only for habitual responses, if at all. Similar evidence was offered by Foley (1937) who indicated that speed of reactions was conditioned primarily by specific environmental factors. His conclusions also favored a specificity interpretation.

One of the most important and refined studies in the early work on tempo was the study of Allport and Vernon (1933). In their Studies in Expressive Movement, they proposed that a basically stable and constant individual style was reflected in both gesture and handwriting and that theories of specificity and identical elements are inadequate to account for the constancy obtained. They also suggested that motion was a reflection of personality dispositions. They concluded that there was no uniform psychic tempo which pervaded all activities and described three factors: 1) a verbal speed factor including reading, counting, and writing 2) a drawing speed factor including drawing on paper and blackboard with the hands and also foot drawing 3) a rhythmic speed factor including tasks involving small muscle move-

ment.

The relationship between speed and personality is commented on by Kennedy (1930) who found a significant positive relationship between scores on the Army Alpha Test and a composite score of several speed performances only when a limited time was allowed for the intelligence test; when the time interval was unlimited, the correlations vanished.

After the work of Allport and Vernon, Harrison and Deveno (1938) and Harrison (1941) concur in the interpretation of the domain of tempo as lacking a unitary explanation. Harrison and Deveno conclude that, 1) the intercorrelation of speed measurements indicates no unitary speed trait which is characteristic of various spontaneous movements or motor adjustments of an individual and 2) individuals tend to perform at a fairly consistent rate from one time to another. Harrison, in his 1941 article, disputes the idea of Lauer (1933) that habituation may be an explanation of the general phenomenon in personal tempo.

At this point in the history of the literature of personal tempo, the area could be characterized as one plagued by confusion. Operational definitions of tempo varied, terminology differed from study to study and the controversy of the monistic versus pluralistic explanation prevailed. Inspired by the composite approach of Allport and Vernon and the recent advances in the methodology of factor analysis and hoping to clarify some of the ambiguities of the tempo research, Rimoldi performed his research which he published in 1951. Researchers partial to

a specificity interpretation had suggested that many of the studies having monistic conclusions were probably due to the limited number of tests of tempo employed. A larger and more varied battery, the pluralists argued, would not reproduce the general phenomenon. This was one of the main questions investigated by Rimoldi. He performed a factor analysis of 59 tests using, as his description of personal tempo, the consistent temporal pattern adopted by individuals in any given task or related group of tasks which were performed at a rate natural and comfortable to the subject. An exception, of course, would be reaction time measures or those forbidding such an interpretation by their very nature. His battery represented a comprehensive range of psychological functions of and allied to tempo. The subjects were 91 males between 19 and 25 years old.

The factor analysis revealed nine factors including speed of: large motion of trunk and limbs, small movements, drawing with feet, drawing with hands, perception, reaction time, and cognition. The second order analysis revealed four factors: speed of all motor activities, speed of perception, speed of cognition, and reaction time.

On the basis of Rimoldi's study and the later verifying results of Haley (1963, 1965), factors were selected to be utilized in this study. To represent Rimoldi's large muscle movement factor, three tests were selected, viz., arm swinging, arm swinging parallel and arm swinging symmetrical. Representing his small muscle movement factor are the finger tapping tests with both hands. The drawing of circles and lines

represented his drawing-with-hands factor. His speed of perception factor is represented by the reading of news test. Tests of preferred metronome rate and time estimation despite their lack of clear interpretation from the literature, were included because of their seemingly obvious connection with the subject matter, compelling interest, and evidence from the study of Haley (1963). According to the design the author would expect to recover these factors in the normal condition (the no-capsule administered situation), and perhaps in the placebo condition.

Haley's (1963, 1965) studies basically involve tempo variables while giving special emphasis to physiological correlates and time estimation. His important findings relevant to this research are his verification of the large and small muscle movement and drawing factors of Rimoldi and his work with the time estimation variable. According to his results, metronome rate and time estimation help to define separate factors.

The important finding of Rimoldi of the high consistency of tempo over periods of time of varying length is not an unique observation. Haley (1963) found supporting evidence also in his reliability measures. Wu (1934) likewise had reported reliability coefficients in the high .80's. Mishima (1951) had similar findings. He found that even the introduction of distracting influences had little effect. This is relevant to the research in that the introduction of drugs may be considered to be distracting influences and that the reliability of the tests has been established as very high.

The consistency of a tempo task was the subject matter of the study of Rimoldi and Cabanski (1961). The research involved tapping out patterns of dots visually grouped. The amount of time spent in tapping each pattern was linearly related to the number of dots in the pattern and the time between patterns remained a straight line function regardless of the size of the patterns. This is interesting in the light of the present study, in that if the linear function of different size patterns holds they should appear in the same factor. Also the lengths of intervals between patterns of various sizes should define the same factor since they are a straight line function. Fraisse (1946, 1956) reports similar findings and proposes that silence is a segregating framework rather than ground for the rhythmic units.

On the basis of the evidence available, then, a specificity or pluralistic interpretation of personal tempo seems the more plausible. Further, Rimoldi has shown good reason to link perception and cognition to tempo functions. A study by Gator (1934) has suggested that tempo may have potential in the diagnosis of mental disorders by his finding that large variations in "agreeable" metronome rate was characteristic of pathology. Epileptics were found to tap at a faster rate than normals. These findings are, of course, expections to the highly consistent performances of normals in tempo functions.

Also the literature has suggested that the observer's attention should not be diverted from the segregating framework of silence separating patterned tempo functions. Fraisse (1964, 1956) and Rimoldi and Cabanski (1961) have urged their value in the understanding of rhythm.

At this point in the review a summary of the important characteristics of each drug will be presented. A recent textbook of pharmacology by Musser and Bird (1961) provided the majority of information found in the following paragraphs on the various agents.

Atropine Sulfate, U.S.P., B.P., I.P. is a depressant of the parasympathetic nervous system or a cholinergic blocking agent. It blocks the action of acetylcholine at the effector cells or the neuromuscular junction of tissues and organs (smooth and cardiac muscles and glands) innervated by the postganglionic cholinergic nerves. Therefore, all functions controlled by these nerves are depressed. Heart rate is more rapid, smooth muscles are relaxed, secretions of the exocrine glands are checked, and the pupils of the eyes are dilated. It does not prevent the formation of acetylcholine, nor does it destroy it; rather it competes for cites on the receptor cells which acetylcholine normally excites in the propagation of impulses.

Atropine is one of the most effective antagonists to the action of acetylcholine of the belladonna group. Its effects are similar to those obtained when the sympathetic nervous system is overactive or when epinephrine is injected.

Therapeutic doses of atropine are from .5 to 1 mg. It stimulates the cerebral cortex and the medulla. Doses of therapeutic size seldom have been found to effect psychic functions.

Physostigmine Salicylate, U.S.P., B.P., I.P., (Eserine Salicylate) stimulates the parasympathetic nervous system (a cholinergic agent). It emulates the action of acetylcholine, the hormone of the parasympathetic nervous

system. It acts by inactivating cholinesterase and prolonging organs and tissues innervated by cholinergic fibers. The effects noted are slowing of the heart, vasodilation, increased intestinal activity, increased glandular secretion, pupillary constriction, and paralysis of accomodation of the eye. Small doses sensitize the effector cells at the myoneural junction to the action of acetylcholine; hence, skeletal muscle contracts.

The usual dosage is 2 mg. Overdoses cause marked weakness, nausea, vomiting, and a slow pulse. Blood pressure is lowered, breathing is labored, and convulsions may occur.

Chlorpromazine Hydrochloride, U.S.P. (Thorazine) depresses the sympathetic nervous system centrally. It depresses the reticular formation and the profuse thalamic projection system and diminishes alertness. A patient thus becomes less sensitive to troublesome situations that would cause emotional responses. Psychotic patients are insulated against hallucinations and terrifying flights of the imagination. Chlorpromazine acts on the hypothalamus which is partially responsible for the vasodilation of the blood vessels and fall in blood pressure. This action of the hypothalamus also causes a lowering of body temperature and the basal metabolic rate. It also depresses the chemoreceptor trigger zone in the medulla and prevents the nausea and vomiting caused by certain drugs and diseases.

Chlorpromazine also blocks the neurohormones in the autonomic nervous system and produces adrenolytic (vasodilation) and anticholinergic (anti-

spasmadic-dry-mouth, etc.) effect. It also has an antihistamine action. Further, it potentiates the action of narcotics, anesthetics, and hypnotics.

The most usual therapeutic dosage is 25 mg. 4 times a day or 10 mg. to 1 Gm daily.

Dexedrine Sulfate, Dextro Amphetamine Sulfate, U.S.P., Dexamphatamine Sulfate, B.P., is a stimulant of the sympathetic nervous system having primary action in the cerebral cortex. It has little or no action on the peripheral nervous system and thus does not affect blood pressure. It is used to curb the appetite and depresses the sense of smell and sweet taste. It gives rise to brighter spirits and increases the physical activity of the patient. It is used therapeutically as a psychic stimulant in depressed states.

The usual dosage is 5 mg. twice a day. It inhibits aminoxidase, an enzyme that tends to oxidize certain amines to aldehydes. By lessening the production of the aldehydes, which apparently depress tissue respiration, the drug may allow the brain to function at a higher degree of activity.

This section shall conclude with a brief inspection of the available literature on the drugs and variables relevant to this study.

Probably the most relevant single piece of research was that performed by Cabanski (1961). His design did not involve a factor structure comparison nor involve factor analysis at all and therefore differs from the present research in this respect. It involves two drugs, dexedrine and Miltown, only one of which is used in this study. He did employ several tests similar to the ones of the present research. He found significant changes in the

in the drawing of circles and squares task under the influence of the stimulant (dexedrine, 5 mg) and in tapping tasks after the administration of the tranquilizer. However, these changes were not significantly greater than similar changes after administration of the placebo, so no definite conclusions were drawn.

Leonard Uhr in Drugs and Behavior (1960) reviews the recent literature of drug effects on simple psychomotor tasks. Among the pertinent studies Kornetsky, Humphries, and Evarts (1957) found increasing impairment under increasing amounts of chlorpromazine on simple psychomotor tests such as pursuit rotor. The first two authors found more pronounced deficits on simple psychomotor tasks for normals than for schizophrenics. Lehmann and Csank (1957) found chlorpromazine to affect tapping speed in a direction opposite to dextro-amphetamine sulfate (dexedrine).

In terms of the chemical balance of the normal individual, it is interesting to note that Vincent (1955) found that small doses of chlorpromazine given normal subjects resulted in "an increase of certain signs assumed to be indicators of anxiety."

Schneider and Costilos (1957) found tendencies toward increased reaction time under chlorpromazine. Benjamin, Ikai, and Clare (1957), however, with prochlorperazine found no significant effects on the simple psychomotor tests of their battery. The dosage was small however. Burbridge (1958) found chlorpromazine to produce a decrement in key tapping.

Payne and Moore (1955) observed that amphetamine produced an early rise in proficiency on the SAM multidimensional pursuit test.

Uhr (1960) concludes on the basis of his review of experimental evidence with normals that several tranquilizers, among which is chlorpromazine, rather consistently improve performance under stress. The point is that if the testing situation were a stress provoking situation, chlorpromazine may be expected to produce an increased rate of tapping over a placebo condition for example, if there were any anxiety associated with taking the capsule. This idea is suggested by Steinberg (1963) when she says that the depressant or stimulant characteristic of a drug can be modified by one's psychological organization.

It may have been noted that experimental evidence has not been cited concerning atropine and physostigmine. This is due to the absence in the literature of the effects of these drugs on normal human subjects in psychomotor or related tasks. In fact most citations in the literature concerning these drugs is based on animal research.

No attempt will be made to review the literature of the pertinent drug effects on animals, but this section will be concluded with a report on one study with rats since it involves tempo variables. In Condon (1965), drug and no drug conditions were compared for a stimulant (Meretran) and a tranquilizer (Librium). No significant differences were observed between conditions. The discussion suggested that one explanation may lie in the consistency of the tempo variables that seemed to be quite resistant to change. The findings of Cabanski (reviewed earlier) with drug effects on human subjects was cited as perhaps corroborative evidence

As stated previous to the review of the related literature, the specific aim of this research is the study of the permanence of a specified domain of personal tempo under the influence of four pharmacological agents and a placebo. As has been seen, the factor analytic approach is quite new in the study of drug effects on tempo.

Method

Subjects: A total of twenty subjects, ten male and ten female, between the ages of twenty-one and thirty-five, without history of psychiatric and/or clinical disturbances were studied. The purpose of the age limitation was to avoid the complex psychological changes due to maturation and ageing. All the subjects were students of either senior college or graduate level, to obtain homogeneity with respect to education. For their services in this research and other testing conducted during the same sessions, the subjects were remunerated. This research was part of a larger project supported by the Psychiatric Training and Research Authority of the State of Illinois.

At this point it must be admitted that the size of the sample is not as large as might be desired. However, it was restricted because of financial and other practical considerations. Such problems seem to be quite common in drug research with humans since even a casual perusal of the literature (Krus and Wapner, 1962; Linton and Lang, 1962; Hughes, Forney, and Gates, 1963) will indicate that the size is not atypical.

Instruments

As was indicated previously, the battery of tests employed in this research were for the most part, those that were highly loaded in the factors selected for investigation. In this section, the individual tests will be described as to content and method of measurement. The numbers associated with the various tests will be the identifying code numbers for the tests throughout the entire paper. It should be noted that these numbers do not necessarily indicate the order in which the tests were administered. The order in which each test was presented will be indicated separately for each test.

Before any of these tests were administered, the following instructions were given:

In this experiment you will be given a series of tasks which you are to perform at the rate that is most comfortable for you. Before each performance you will be given specific instructions which you are to carry out at your most natural speed. You will start at a given signal and continue until told to stop. If at any time the instructions are not clear, do not hesitate to ask questions.

1. Reading - The subject was given an editorial clipped from a daily newspaper and was instructed that he would be given a signal to begin, and that he was to read at his customary rate until told to stop. He was asked the last word that he read since the reading was not done aloud. Since six different forms were needed to avoid familarity with the material for later occurring sessions, the same columnist's articles were selected from six different issues to control in some way for style and readability. The columns were from old issues to avoid the possibility of the subject's having just read the article in his morning paper. The measurement was the number of words for a thirty second interval. The test was given first.

2. Arm Swinging - At a signal the subject was asked to begin swinging his non-preferred arm at his side at a comfortable rate until told to stop. Measurement was the number of complete cycles during a thirty second interval. This test was presented fourteenth.

3. Arms Parallel - In this test the subject was asked to extend his arms out in front of him in a parallel fashion and keeping them parallel to swing them, again at a comfortable rate, from a point parallel to his left shoulder to the point parallel to his right shoulder and back through the same arc. Measurement: number of cycles in a thirty second interval. This test was given fifteenth.

4. Arms Symmetrical - The subject was instructed to extend his arms out to his sides, parallel to his shoulders and while holding them outstretched to swing them toward the center, touching their hands, and to return them to the original position. This, of course, was to be done at his most comfortable or natural rate. Measurement: number of cycles per 30 second interval. Order: sixteenth.

5. Circles - The subject was given a blank sheet of 8 1/2 by 11 paper and was told to draw as many or as few circles of any size in any position that he liked. Measurement: number of circles per 30 second interval. Order: seventeenth.

6. Lines - The subject was in this case asked to draw lines, as many or as few, of any length, in any position on the blank paper. Measurement: number of lines in a 30 second interval. Order: eighteenth.

7. Time Reproduction - The experimenter said "start," allowed 40 seconds to pass and then said "stop." The subject was then asked to reproduce this interval as exactly as he could by saying "start," allowing what appeared to be the same time period to pass, and saying "stop." The subject was instructed not to count or make use of any cues. Measurement length of interval reproduced in seconds. Order: nineteenth.

8. Time Production - The subject was instructed to produce a 40 second interval by saying "start," allowing what appeared to be a 40 second interval to elapse, and then saying "stop." Measurement: length of interval produced in seconds. Order: twentieth.

9. Metronome - The subject was asked to adjust the weight of the pendulum of a metronome until he found a preferred rate. Measurement: preferred number of beats per minute. Order: twenty-first.

The remaining measures were obtained from separate tasks of tapping patterns of two, three, and four dots with both the preferred and non-preferred hands. The tapping of the patterns was done with either the index

or middle finger of the appropriate hand. The tapping was done either on or near a microphone which was used to record the tapping on tape. The tapping sound on the tape was later transferred to polygraph paper by means of a Sanborn Polygraph. This made it possible to have a visual representation of the patterns of taps and the intervals of silence between the patterns. Since both the polygraph machine and the tape recorder ran at a constant rate, the length (in terms of millimeters) of the patterns and silence intervals on the polygraph paper would be linearly related to an actual measure of time occupied by a particular pattern or silence interval. The relationship between a measure of time and length (millimeters) can be expressed by a constant value. The determination of the constant would depend on the speed of the polygraph machine, provided the tape recorder was run at the same speed as during the testing session, and this was the case. The units of measurement used in all the following tasks were millimeters; and because of their linear relationship with the corresponding time measures, no information was lost nor were the correlations effected in any way. However, a great deal of unnecessary calculation was avoided.

It will be seen below that each tapping task yielded two measures which have been treated as separate variables in the analysis. It is, therefore, a moot question which occurred first in the testing session but for identification and organizational purposes, the length of the particular pattern measure was arbitrarily designated the prior occurring measure.

In all these tapping tasks, of course, the subject was instructed to tap at a comfortable and natural rate.

10. 2P - This measure of the length of the two dot pattern was obtained from the two-dot pattern tapping task with the preferred hand. Measurement: mean length in millimeters over a 30 second interval. Order: second.

11. 2BP - Measure of the silence intervals between the patterns of the two-dot pattern tapping task with the preferred hand. Measurement: mean length in millimeters for a 30 second interval. Order: third

12. 3P - Measure of three-dot pattern with preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: fourth.

13. 3BP - Measure of silence intervals between three-dot patterns with preferred hand. Measurement: mean length in millimeters over 30 second interval. Order: fifth.

14. 4P - Four-dot pattern, preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: sixth.

15. 4BP - Silences between four-dot patterns, preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: seventh.

16. 2PN - Two-dot pattern, non-preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: eight.

17. 2BPN - Silences between two-dot patterns, non-preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: ninth.

18. 3PN - Three-dot pattern, non-preferred hand. Measurement: mean length in millimeters for 30 seconds. Order: tenth.

19. 3BPN - Silences between three-dot patterns, non-preferred hand. Measurement: mean length in millimeters for 30 second. Order: eleventh.

20. 4PN - Four-dot pattern, non-preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: twenfth.

21. 4BPN - Silences between four-dot patterns, non-preferred hand. Measurement: mean length in millimeters for 30 second interval. Order: thirteenth.

In order to maintain measures which would be comparable and to avoid artifacts of the scoring system confusing the analysis of the results, it was attempted to provide the same unit of measurement throughout. That is, all tests were scored in terms of units of performance per time interval with the exception of tests 7 and 8 and tests 10-21. These were scored in terms of time per unit of performance. The signs of tests 7 and 8 were reversed in the correlation matrix, since their factorial identification was not as well known as those from 10-20. These latter were expected to define two factors, one for the even and another for the odd-numbered tests. The composition of these two factors was not expected to be shared with any other test in the battery so it was not deemed practical to reverse their signs. As presented in the various tables, then, all tests are scored in terms of units of performance per time interval, with the exception of tests 10-21, which represent time per unit of performance.

The problem of test reliability is not an issue in the present research. Rimoldi (1951) has undertaken a systematic exploration of the reliabilities of these tests and found that, for periods of from two to four weeks, the measures were highly reliable. The correlations ranged from a lower limit of .78, with many falling in the high .80's. This time interval is well within the range of any individual's testing in the present research. These results were reinforced by Haley (1963).

Facilities: The entire testing program was conducted at the facilities of the Department of Medicine, Stritch School of Medicine, Hines, Illinois,

under the medical supervision of Dr. Peter Talso, Internist and Chairman of the Department of Medicine. Each subject was given a physical examination to determine the advisability of his participation in the program, both for his own and the experimenter's protection. The normal (no capsule administered) and placebo conditions were also administered in these facilities to maintain a constant experimental setting for all conditions or treatments.

Drugs: The following were the pharmacological agents and the corresponding dosages employed in this research:

1. Atropine Sulfate .5 mg.
2. Chlorpromazine Hydrochloride (Thorazine) 50 mg.
3. Physostigmine Salicylate 2 mg.
4. Dextro-amphetamine Sulfate 5 mg.

These agents and dosages were determined by consultation with the experts, Dr. Alexander Karczmar, Chairman of the Department of Pharmacology, and Dr. Peter Talso, Internist and Chairman of the Department of Medicine (both of the Stritch School of Medicine). They provided information as to the administration of the agents, the length of their optimum effect, and prescribed instructions for the subjects as to their diet prior to the testing. It was through their suggestions that provision was made in the testing schedule so that no subject would be tested twice within a three-day period. The purpose of this was to avoid possible contamination of the effects of a given drug by one administered too recently.

The dosages were selected so as to produce an optimum effect in contradistinction to a paralyzing effect. Optimum effect is here considered to be the effect of the usual therapeutic dosage. This latter dosage was preferred to larger ones or those more likely to produce dramatic changes because of the necessity of avoiding paralyzing effects. Such effects, would either completely incapacitate performance on the psychological tasks or seriously restrict their sensitivity to distinguish the effects of the various agents. Further, since the normal therapeutic dose is the most frequent treatment, it was considered quite important.

The drugs and placebo were administered in capsule form. All capsules were of the same size, shape, and color, and otherwise lacked distinguishing characteristics. The administration of the capsules was done in a double-blind fashion - neither experimenter nor subject knew the contents of the capsule. Also the subject was not told the identity of the agents employed until the conclusion of the entire program

Experimental Design: The design called for six testing conditions, one for each of the four drugs, a placebo condition, and a normal (no capsule administered) condition. The entire battery of tests was administered during each condition.

The presentation of the six conditions was accomplished in a systematic-randomization fashion, i.e. each condition was presented approximately three times first, three times second, three times third, and so on through all six possible orders. Thus twenty (since there were twenty subjects) unique orderings of the six conditions were established such that all conditions

appeared approximately the same number of times in all the six orders. Since there were twenty subjects, it was, of course, impossible to establish a design allowing each condition to appear exactly the same number of times in each order. The number of subjects would have to be some multiple of six to permit this. At any rate, no condition appeared more than four times and less than three times in any given order. The twenty orderings or presentations were matched randomly with the twenty subjects.

This design was necessary to prevent the obscuring of the effects due to the drugs, by the effects of learning and practice, which were variables to be considered in the tests of intelligence, etc., which composed the rest of the project conducted during the same sessions. From the point of view of the tempo tests themselves, practice or learning effects could safely be ignored, considering the simplicity and general familiarity of the tasks involved. However, a serial effect due to the same order of presentation of the various conditions might conceivably have been present without this design, to influence the results both of the tempo and other variables tested in this project.

No individual testing session went beyond the period of time specified by the experts as the optimum effect period for the various drugs employed. This means that the testing was not begun before the drugs were considered to have reached their optimum effect nor was the testing concluded after the optimum effect period had subsided.

Upon the conclusion of the testing phase, the data was collected by con-

dition. The intercorrelations of the twenty-one measures were performed for each condition by means of the I.B.M. 7094 computer. This same computer was used to factor analyze each of the six conditions according to the principal axes solution.

The factor analytic technique is obviously indicated in research which calls for the comparison of various domains. Not so obvious, however, is the rationale for the exclusion of a treatment which would test for mean differences between crucial conditions on various variables. Of primary interest is a change in structure or domain from one condition to another. This information cannot be inferred from the results of mean tests of significance. It is possible, for instance, for the means to be significantly different but for no change in factorial composition to be observed. It is likewise possible that no difference may be found between the means but a change is noted in the factorial composition. This situation probably would occur more frequently than the former. At any rate, there is no necessary connection between a significant change in means and a change in factorial composition. With reference to this same question, Eysenck (1961) formed the conclusion that the only approach to drug studies which can give psychologically meaningful information is the factorial or dimensional approach. While this statement may be open to criticism because of its extensiveness and generality, the present author thinks that it may have been instances such as the present research which prompted his remark. For these reasons mean tests of significance will not be presented; however, for those readers who may wish them, the means

and standard deviations will be presented in the Appendix, Tables 38 and 39.

The problems of communalities was handled in this way. Particularly with reference to determining the best communality estimates, factor analyses of the six conditions were run with unity in the diagonals. This, of course, meant that not only common factors but also specific and error factors would be obtained. These factor solutions were then inspected with the purpose of determining the common factors. A decision as to their number was made on the basis of three criteria: 1) the value of the eigen value associated with a given factor 2) the percentage of variance extracted 3) an inspection of the factor loadings with a view toward reproducing the correlation matrix. On these bases the number of common factors was estimated for a given problem, and on the basis of these factors communalities were computed. These latter values were seen to agree quite well with a simple estimate based on the maximum correlation of a column. At this point the factor analyses were repeated with the diagonal values being estimated according to the maximum "r" criterion. The computer was programmed to continue factoring until all the variance had been extracted. These factor solutions were then checked in terms of their ability to reproduce the original correlation matrices, i.e. final residual matrices were computed. These residuals indicated that the estimates of communality (maximum "r") and therefore the factor solutions were in excellent harmony with the original data as represented in the matrices of correlations.

In this way the orthogonal factor solutions for each of the six conditions were obtained. For the purposes of psychological interpretation, it was then necessary to rotate each orthogonal solution to the criterion of simple structure. Oblique hand graphical rotations were then taken in each condition until the closest possible approximation to simple structure was obtained.

A comparison of the final oblique solutions was then undertaken. Involved in this comparison of factors from different conditions was an index called, by Tucker, a coefficient of congruence, or, by Burt, an unadjusted correlation, or, by Wrigley and Neuhaus, the degree of factorial similarity, as reported by Harman (1960). This measure was used to assess the degree of relationship between a given factor of one condition and all the factors from another condition. This measure will then be useful in describing the permanence of the domain under study from one condition to another.

Results

Due to the large volume of results to be reported, it is expedient to indicate the rationale behind their order of presentation. The first part of this section will consist of the presentation and interpretation of the six factor structures, condition by condition. The first structure analyzed will be that of the normal (no capsule administered) condition. This will be followed by the analysis of the placebo condition. Next in sequence will come the drug conditions; of these, those expected to have

similar effects because of their pharmacological characteristics will be presented successively. That is, the order will be parasympathetic depressant (atropine), sympathetic stimulant (dexedrine), sympathetic depressant (chlorpromazine), parasympathetic stimulant (physostigmine).

Following the separate analysis of each condition will be the second part of this section, viz., the comparison of the structures of those conditions where interesting and meaningful information may be forthcoming. The comparison of this concluding part will be accomplished by means of the coefficients of congruence mentioned in the previous section.

In order to maintain uninterrupted presentation of the text as much as possible, pertinent tables are placed in the Appendix. Thus, the intercorrelations of the twenty-one measures for each of the six conditions can be found in Tables 8-13 of the Appendix. Tables 14-19 contain the unrotated principal axes solutions for the six conditions. Tables 20-25 present the final transformation matrices for the various conditions. Tables 26-31 contain the corresponding cosine matrices. Tables 32-37 present the final oblique rotated factor matrices for the six conditions. In all the above cases, the order in each set of tables will follow the presentation of the conditions in the first part of the text. Thus, all information pertinent to the factor analysis of the normal condition can be found by inspecting Tables 8, 14, 20, 26 and 32. In the interpretation of the various factors only values with an absolute value greater than .30 will be considered.

Normal Condition

Six factors were extracted in this condition. Of these six, one was seen to be a specific factor and the other a doublet. As shown by the factor loadings of the final oblique matrix, the structure is very clear and quite compelling, the factors being very clearly indicated. The letter designation used to identify the factors in this and the other conditions is strictly arbitrary nomenclature and in no way affects the interpretation of the structure or its comparison with other structures.

Factor A

Tests	Loadings
19. 3BPN	.74
13. 3BP	.69
15. 4BP	.65
11. 2BP	.64
21. 4BPN	.64
17. 2BPN	.56

Without exception, the measures defining Factor A are those of the length of the silence intervals separating the various tapped patterns of both the right and left hand. Both Fraisse (1956) and Rimoldi and Cabanski (1960) stressed the importance of these silence intervals as more than an accident of the tapping procedure. Both suggested that these silence intervals are the segregating framework for the various size patterns. The silences undoubtedly form a necessary part of the rhythm with which the patterns are tapped; but this factor confirms their importance beyond this mere fact and certainly qualifies the study of them in their own right. Their influence seems to be independent of the handedness of

the subject and, at least for patterns up to and including a size of four taps, independent of the length of the patterns involved. In fact, Rimoldi and Cabanski (1960) found evidence which indicated that the silence intervals remained of constant length for the various pattern sizes. Thus, it seems that though the length of the silence interval is positively related to the pattern as seen by an inspection of the correlations and by noting the cosine of -.52 between the reference axes of the two hyper-planes involved, two separate factors are needed to explain the motor activity involved in the normal condition.*

Factor B

Tests	Loadings
5. Circles	.76
6. Lines	.66
7. Time Reproduction	.64
10. 2P	.33

This factor is obviously the intended replication of Rimoldi's (1951) drawing factor. Somewhat unexpected is the appearance of the Time Reproduction measure. The interpretation here seems to be that one's experience of the passage of time seems to be involved in his speed of drawing, i.e., those "impatient" with the passage of time (those who tend to give an underestimate in their reproduction of a given interval) demonstrate this impatience by drawing at a faster rate (more of a given unit in a given period of time). The inclusion of the measure of the two-dot pattern in this interpretation is difficult to see; it especially seems worthy

* A negative cosine for the reference axes of the two hyper-planes indicates a positive relationship for the hyper-planes involved and vice-versa.

of little note since the loading is low and since more of the other pattern measures make an appearance. This factor is quite unrelated to the other factors in the normal condition as seen in Table 26 of the Appendix.

Factor C

Tests	Loadings
16. 2PN	.79
12. 3P	.77
18. 3PN	.77
20. 4PN	.77
14. 4P	.76
10. 2P	.68

This factor is clearly a speed of tapping factor, called by Rimoldi (1951) the small muscle movement factor. It is quite evident that this factor includes both right and left hand initiated patterns and involves patterns of different sizes. This was expected from the results of Rimoldi and Cabanski (1960) where the lengths of patterns of different numbers of taps were linearly related to the number of taps in the pattern. It is interesting to note that this hyper-plane is seemingly negatively related to the specific factor for reading rate, Factor F, the cosine being .51. The negative is an artifact of the scoring system since the patterns were measured in terms of time per unit, while Reading was measured by units per time. The positive relationship is even more strongly suggested by Rimoldi (1951) who suggested that the oculomotor movement in reading may explain the relationship.

Factor D

Tests	Loadings
4. Arms Symmetrical	.86
3. Arms Parallel	.82
2. Arm Swinging	.55
7. Time Reproduction	.32

This factor clearly defines what Rimoldi (1951) called the large muscle movement factor. The three tests with the high loadings are typically this type of movement. If the loading of test 7 merits interpretation in this factor, it may suggest that persons "impatient" in their experience of time (a tendency to underestimate an interval in its reproduction) may tend to swing their arms at a faster rate. It is interesting to note that this hyper-plane and the small muscle movement hyper-plane are practically perpendicular, suggesting that perhaps two entirely different mechanisms are involved in the two types of muscle movement.

Factor E

Tests	Loadings
9. Metronome	.59
8. Time Production	.54

This factor, obviously a doublet, suggests that one's estimate of the passage of time when instructed to produce an interval of a given length, is closely allied with what one experiences as a pleasing or comfortable rate of metronome beating. In other words, one's time estimation in the above sense, may tend to depend on how fast he would like time to pass.

Factor F

Factor F was a specific factor of reading speed, with a loading of .55 and as such does not form part of the common factor space.

From the description of the various factors of the normal condition, it is readily apparent that the factors introduced into the study on the basis of the previous findings of Rimoldi (1951) and their verification by Haley

(1963) have been recovered intact. The tests of time estimation introduced because of their compelling relevance to the area, have been the cause of some interesting possibilities.

Haley (1963) did not observe any relationship between the three measures of subjective time used in this study as was found in Factor E. However, he did note that certain psychomotor activities were related to time estimation measures and this has been observed also in this condition.

Placebo Condition

Seven factors were extracted in this condition. Of these, the last, Factor G, is clearly a residual factor. This factor was a centroid extracted by hand primarily for purposes of clarification in the biradial rotation procedure. One of the remaining, Factor F, is the same doublet that was encountered in the normal condition in Factor E. Factor E in the placebo condition, though it appears to be a doublet, is very likely the specific reading factor reported in the normal condition. Again the structure is very clear and definite and each of the factors are very well indicated.

Factor A

Tests	Loadings
3. Arms Parallel	.76
4. Arms Symmetrical	.69
2. Arms Swinging	.40

This factor is obviously the large muscle movement factor defined by Rimoldi (1951) and verified by Haley (1963). This factor is defined in this condition very similarly to its definition in the normal condition. The only difference in composition is the absence of Test 7, Time Reproduction, in this condition. Its loadings was quite low (.32), however,

in the previous condition.

Factor B

Tests	Loadings
14. 4P	.74
16. 2PN	.74
20. 4PN	.74
12. 3P	.72
18. 3PN	.67
10. 2P	.65

This factor is obviously a redefinition of the speed of tapping or small muscle movement factor found in the normal condition. The factor seems to be equally well defined in this condition and the same conclusions as to handedness and pattern size apply also here. In this condition also the cosine (-.64) reveals a positive relationship between this factor and the silence interval factor to be identified below.

Factor C

Tests	Loadings
5. Circles	.78
6. Lines	.61
7. Time Reproduction	.58
9. Metronome	.42

Again it is apparent that the factor is clearly defined and that its composition is quite similar to the normal condition. The factor is the drawing speed factor of Rimoldi (1951) and Haley (1963) with the additional implication of the time reproduction test. This finding duplicates the results found in the normal condition. However, also in this factor is the Metronome test. Certain difficulties are encountered here in attempting to explain its presence. As seen in the normal condition, Metronome

and Time Production combine to form a doublet and here it is observed that Metronome is found in the same factor with Time Reproduction. This does not vitiate the previous interpretation but merely seems to indicate that the Metronome measure is a quite complex one as far as its factorial make-up is concerned. The interpretation that might be offered here is that a preferred rate of metronome beat may also be involved in one's estimate, in terms of seconds, of an unknown interval of time given to him. Or, in other words, the implication seems to be that if one tends to prefer a faster beat of the metronome, he would tend to look on a given interval as passing more quickly and tend to underestimate its length. Preferred metronome rate may be such a diverse measure that it is involved in both Time Production and Time Reproduction despite the fact that the latter two are not found in the same factor and do not have any common variance. Rimoldi (1951) found basically a metronome doublet, but his lines drawing test had a low loading in the factor. This may have been a hint of what has been seen here. However, his battery did not involve any time estimation measures so no comparison is possible. Haley (1963) did have Metronome and time estimation measures, but his findings were negative with respect to any relationship between them.

Factor D

Tests	Loadings
21. 4BPN	.69
15. 4BP	.64
19. 3BPN	.60
13. 3BP	.58
17. 2BPN	.56
11. 2BP	.52

Factor D very pointedly shows this factor to be the silence interval factor discussed previously in the normal condition. It has exactly the same composition as Factor A in the normal condition. This Factor D as noted above in the connection with Factor B, shows a positive relationship between speed of tapping (Factor B) and the silence interval (Factor D). Thus it has been seen that in both the normal and placebo conditions a two-factor explanation of the tapping task is indicated. The two factors are not independent, but the rotational procedure was clear in indicating the two-factor interpretation.

Factor E

Tests	Loadings
1. Reading	.54
7. Time Reproduction	.32

This factor is very similar to the specific reading speed factor found in the normal condition with the exception of the rather low loading in the Time Reproduction task (.32). It is questionable whether this factor should be interpreted as a doublet because of the low loading and the opposing evidence from Factor F of the normal condition.

Factor F

Tests	Loadings
8. Time Production	.52
9. Metronome	.45

This factor is a doublet which had been found previously in Factor E of the normal condition. An interpretation was suggested there. Finding a recurrence of this doublet in the placebo condition suggests very strongly

that its appearance in the normal condition is more than accidental. Ordinarily, the principal benefit of a doublet finding is to suggest further research in this particular area. Its double occurrence seems to make this exhortation all the more urgent.

Factor G

This factor is seen to be a residual factor with the highest loading being .39, and all the other loadings being lower than .30.

From the description and interpretation of the various factors of the placebo condition, it can be seen by means of inspection that there is a high degree of similarity between it and the normal condition. Specific measures of the degree of the relationship between the various factors will be presented in the last part of this section. However, it does not seem premature at this point to suggest that the administration of the placebo has produced very little change in the structure as it was found under normal conditions. That is, the domain remains quite permanent from the normal to the placebo situation.

Atropine Condition

In this condition six factors were extracted and only five will be interpreted since Factor F is residual. No specifics were noted as will be evident from what follows. Basically the same factors have been extracted here as in the previous conditions with slight variations in the composition of some of the factors. It might help to recall, at this time, that atropine is a depressant of the parasympathetic nervous system.

Factor A

Tests		Loadings
18.	3PN	.61
16.	2PN	.59
10.	2P	.57
12.	3P	.54
1.	Reading	-.54
20.	4PN	.53
14.	4P	.46
2.	Arm Swinging	.42

Six of the eight tests in this factor give reasonable assurance that this is the small muscle movement factor observed before. In this case, however, the rate of reading test and Arm Swinging emerge also as part of this factor. This suggests that atropine has changed somehow the nature of the two tasks such that their factorial composition is altered. With respect to Reading, the following seems plausible. A known effect of atropine is the dilation of the pupil of the eye. This would definitely affect the ability of the person to read. Dilation of the pupil causes blurred vision and thus more fixations would seem to be necessary. This would seem to increase the necessity of the use of the muscles controlling the eye. It is suggested, then, that the activity of reading more nearly resembles the tapping movements. Perhaps the reading rate reverts to a more authmatic level. The negative is an artifact of the scoring method so the relationship is positive.

With regard to the .42 loading of Arm Swinging, the first consideration is that despite the positive nature of the loading as presented, when viewing the measures from the aspect of the method of scoring, the loading should

be considered to be negative. In terms of its interpretation as part of this factor, it would seem that under atropine, arm swinging rate is negatively related to rate of tapping or small muscle movement. The appearance of the arm swinging task in the small muscle movement factor may be partially derived from the observation of the experimenter that at times the subject seemed to swing just the forearm rather than the whole arm. This seems to indicate that shoulder and trunk muscles were not involved in the task. The negative relationship is difficult to interpret.

Factor B

Tests	Loadings
5. Circles	.75
6. Lines	.74
7. Time Reproduction	.31

Factor B seems not to have been affected by atropine. These three tests also defined the comparable factor in the normal and placebo conditions. Drawing speed and its relationship to Time Reproduction seems not to have been disturbed by the administration of atropine.

Factor C

Tests	Loadings
3. Arms Parallel	.91
4. Arms Symmetrical	.85
2. Arm Swinging	.55

This factor of large muscle movement has been found in practically identical forms in the normal and placebo condition. This suggests that atropine has had little or no effect on large muscle movement, at least as far as the factorial composition is concerned.

Factor D

Tests	Loadings
8. Time Production	.68
7. Time Reproduction	.60
9. Metronome	.60

This factor is quite interesting. From the standpoint of structure it is clearly defined. This factor is composed of the three measures most commonly referred to as estimates of subjective time. Under the two-no-drug conditions (normal and placebo) and in the study of Haley (1963) such an emergence of these three tests in a single factor failed to appear. That is, there is no evidence that both time estimates are involved with what is experienced as a pleasing beat of the metronome. Atropine seems to be responsible for this event. Just how this occurs is impossible to say, But this finding does shed some light on the discussion concerning whether time estimation is internally or externally regulated. Some have said that external cues alone should be considered. In the present research these were reduced to a minimum, and the subject was instructed to avoid making use of any cues. If this attempt was successful, only disturbances of the internal chemistry and related mechanisms would be involved. This may mean that though external events can certainly affect time estimation, the possibility of something like a "cerebral rhythm" or "internal clock" should not be ignored.

Factor E

Tests	Loadings
15. 4BP	.66
13. 3BP	.63

19.	33PN	.59
11.	2BP	.56
17.	2BPN	.54
21.	4BPN	.54

Clearly defined in this factor is the silence interval composite that was recovered with the same component tests in both the normal and placebo conditions. There was some problem in the oblique biradial rotations involving this factor and Factor A. The cosine indicating the angular separation of the reference axes of these two hyper-planes was dangerously high. Some consideration was given to the likelihood that perhaps the hyper-planes should be identical and that only one factor was needed to explain the silence intervals and the tapping of the patterns. This alternative was tried in the biradial rotations and the separation of the two factors was judged preferable. Further evidence for the separation of the two factors came from the application of the single-plane method of rotation which showed a separation of the hyper-planes. Finally, an oblique plot was made to eliminate distortion and two definite separate clusters were observed. Thus, though the factors involved were obviously highly related, two separate factors best explained the data. Therefore, in the atropine condition, the structure may be said to be more oblique than in the normal condition.

Factor F

This factor will not be interpreted since it is a residual factor.

To briefly summarize the atropine condition, it seems that the drug had the greatest effect on the factorial composition of Reading, time estima-

tion tasks and Metronome. The obliqueness of structure seemed to be increased. These would be things to be carefully observed in any other factorial research with the drug.

Dexedrine Condition

Dexedrine, it should be recalled, is a stimulant of the sympathetic nervous system. Its effects should, then, be somewhat similar to those of atropine which is said to block parasympathetic action. For this reason, the two conditions were considered successively.

This condition, of those discussed so far, is certainly the one which has exhibited the greatest change in structure. Six factors were extracted.

Factor A

Tests	Loadings
12. 3P	.94
14. 4P	.91
13. 3BP	.88
16. 2PN	.88
10. 2P	.87
18. 3PN	.86
20. 4PN	.84
11. 2BP	.82
15. 4BP	.79
17. 2BPN	.79
19. 3BPN	.77
21. 4BPN	.73
7. Time Reproduction	.44

One glance at Factor A is enough to assure one that this factor is a combination of the silence interval and small muscle movement factors, which have been recovered singly in previous conditions. Now, therefore, the tapping seems to be no longer linearly independent of the silence intervals. The one seems to be a function of the other. Since such seems

to be the case, the previous importance of the silence intervals as a segregating framework, therefore an active contributor to the experience of rhythm, may no longer hold. Possible corroboration of this is the observation of the experimenter, that in certain instances, no patterning seemed recognizable, especially in the four-dot patterns. If such were the case, this would certainly explain the collapse of two factors in all other conditions into one in the dexedrine condition. Dexedrine has repeatedly been observed to increase the activity level of the subject. If this is the case, it is reasonable to see how a sense of rhythm may be decreased in a hyperactive subject.

The same rotational problem which was observed in the separation of the two factors in the atropine condition was also observed in this condition, Only in this case the resolution of the dilemma was in the direction of a single factor explanation. The weight of the evidence suggested this solution. Both the oblique plot and the single plane favored the single factor explanation. Also the biradial plots were cleaner in the single factor solution.

The loading of the Time Reproduction task should be interpreted in the light of a negative loading because of the difference in scoring with the other measures. The interpretation indicates that perhaps the hyperactive person thinks that more time has passed than actually has. That is, the more active he is, (the faster he taps and therefore the lower the value he would have in measures 10-21), the longer he would tend to reproduce a given interval. The reason may be that he looks on the silent period as

having represented too great a waste of time and therefore, exaggerates its duration in his reproduction of it.

Factor B

Tests	Loadings
3. Arms Parallel	.89
4. Arms Symmetrical	.79
2. Arms Swinging	.37

The large muscle movement factor obviously has been little affected by the administration of dexedrine.

Factor C

Tests	Loadings
5. Circles	.83
6. Lines	.73
9. Metronome	.41
10. 2P	.35

The drawing speed factor with the presence of Metronome was observed also in the placebo condition and therefore, cannot be considered an unique effect of dexedrine. The presence of the measure for the tapping of the two-dot pattern with the preferred hand shall not be interpreted because of the absence of any other tapping measure.

Factor D

Tests	Loadings
1. Reading	.41
10. 2P	-.36
15. 4BP	.35
21. 4BPN	.33
16. 2PN	-.32

In the opinion of this author, if this factor is anything more than a

residual factor, it would be a specific factor of reading. However, the interpretation of it as a residual factor seems preferable.

Factor E

Tests	Loadings
1. Reading	.65
8. Time Production	.62
7. Time Reproduction	.30

This factor seems to relate one's subjective estimate of the passage of time with his reading rate. Further, it may be hazarded that the increased level of activity due to dexedrine has speeded up the "internal clock" such that reading is performed faster than had been learned and also that time is experienced as moving faster. The other measure of subjective time, Metronome, is notably absent from this factor. Since the Metronome task is a measure of preferred time, it may mean that this hyperactivity is not a pleasant experience for normal subjects.

Factor F

Tests	Loadings
9. Metronome	.54
7. Time Reproduction	.44
2. Arms Swinging	.44
12. 3P	.31

In view of the three tests composing this factor, an interpretation is extremely difficult. Metronome and Time Reproduction have occurred together in Factor C of the placebo condition and Factor D of the atropine condition, but never in conjunction with Arm Swinging. Any reason why these three should define a factor as an effect of dexedrine is difficult to surmise.

In summary, the large muscle movement factor and the drawing composite remain fairly resistant to change through all the conditions tested. Atropine increased the relationship between the small muscle movement factor and the silence interval, and dexedrine increased it to such an extent that they could no longer be considered separate factors. On the bases of these results, it seems that the usual therapeutic dosage of dexedrine has a greater disruptive effect on the domain of tempo under study than the usual therapeutic dosage of atropine.

Chlorpromazine Condition

Chlorpromazine, or Thorazine, is a sympathetic depressant and as such should demonstrate antagonistic effects to those of the previous two drugs.

Seven factors were extracted; however the last is clearly a residual factor and Factor E seems to be a specific.

Factor A

Tests		Loadings
19.	3BPN	.63
17.	2BPN	.57
15.	4BP	.55
13.	3BP	.54
21.	4BPN	.51
11.	2BP	.47
8.	Time Production	-.38

Factor A is very clearly defined and straightforward in interpretation. It is the silence interval factor found in the normal condition with the addition of the Time Production test. Thus in this factor as one tends to overestimate the given interval, he also tends to lengthen the interval between patterns. It is logical to accept the occurrence of this event in the

chlorpromazine condition since this drug has been known to slow tapping rates.

Factor B

Tests	Loadings
12. 3P	.73
18. 3PN	.71
10. 2P	.67
16. 2PN	.67
20. 4PN	.65
14. 4P	.57

The small muscle movement factor is obviously recovered intact in the chlorpromazine condition.

Factor C

Tests	Loadings
3. Arms Parallel	.70
4. Arms Symmetrical	.69
2. Arm Swinging	.51

The large muscle movement factor likewise seems to undergo no change as a result of the administration of chlorpromazine.

Factor D

Tests	Loadings
5. Circles	.62
6. Lines	.56
9. Metronome	.43

The factor of the drawing speed composite with the presence of Metronome was noted in the placebo condition. There it was suggested that a pleasing experience of time as represented by the beat of a metronome is reflected also in the rate of drawing. Chlorpromazine thus seems to have no unique

effects on this factor either.

Factor E

This appears to be a specific factor for metronome rate.

Factor F

Tests	Loadings
1. Reading	.59
7. Time Reproduction	.47

This doublet was also noted as a possibility in the placebo condition. It may be suggested that the faster one reads the faster he would experience time to pass such that he would tend to underestimate a given interval when attempting to reproduce it. No unique effect of chlorpromazine can be asserted here either.

Factor G

Factor G is a residual factor extracted for the purposes of clarification in the rotation procedure.

It is evident from the foregoing that chlorpromazine brought about very little if any change in the domain of tempo under study. A possible explanation for this may be that the subjects were subjected to a certain amount of stress because of a general fear of the experimental situation. In such a case, a sympathetic dominance would very likely result. Chlorpromazine may have only served to restore balance to the organism. Thus, what amounted to a normal condition may have resulted in the chlorpromazine condition. If such a situational sympathetic dominance existed prior to the administration of any drug, it would tend to be heightened by agents stimulating the sym-

pathetic nervous system, or the equivalent. This could serve to explain the comparitively greater changes seen in the inspection of the dexedrine condition. This matter will be taken up again in the comparison of the various conditions by means of the coefficients of congruence.

Physostigmine Condition

Physostigmine, or Eserine, is a stimulant of the parasympathetic nervous system and may therefore be expected to behave similarly to chlorpromazine.

Six factors were extracted. Of these, one was a specific factor.

Factor A

Tests		Loadings
20.	4PN	.67
18.	3PN	.66
16.	2PN	.57
14.	4P	.55
2.	Arm Swinging	.39
12.	3P	.33
10.	2P	.29

This factor of tapping rate or small muscle movement is not so clearly defined as in all the previous cases observed, but the interpretation is still clearly indicated. For some reason, the tappings of the two smaller size patterns with the preferred hand do not exhibit as much saturation in this factor as in all the other cases. But physostigmine is supposed to cause a contraction of skeletal muscle and overdoses cause muscular weakness. If the effect was a minor one that could be overcome with effort, it is likely that automatic or customary actions would be affected most, since

they would usually be performed without effort. Such tasks would be the smaller size patterns with the preferred hand. Also the arm swinging task present is a more customary task than the other large muscle movement tasks, so that it would likely fit this interpretation. Its presence in the small muscle movement factor may be due to the lack of shoulder and trunk muscle involvement in that subjects were observed to swing the arm from the elbow rather than from the shoulder. Such a change in the task may have resulted from the contraction of the skeletal muscles caused by physostigmine. Oddly enough the presence of Arm Swinging was also observed in this factor in the atropine condition.

Factor B

Tests	Loadings
3. Arms Parallel	.84
4. Arms Symmetrical	.65
2. Arm Swinging	.52
7. Time Reproduction	.36

This large muscle movement factor with the inclusion of the time experience implication was observed in identical form in the normal condition where the interpretation was explained. Physostigmine apparently had no effect on its factorial composition.

Factor C

Tests	Loadings
5. Circles	.70
6. Lines	.67

This drawing speed doublet has been maintained intact throughout all

the conditions. It is interesting that no test of subjective time accompanies this doublet as it has in every other condition. This may mean that there is some change brought about in subjective estimates of time by physostigmine. On the other hand it is equally possible that drawing speed was altered by physostigmine, perhaps because of the contraction of skeletal muscle, so that it no longer tends to be related to a subjective estimate of time.

Factor D

Tests	Loadings
17. 2BPN	.69
19. 3BPN	.65
15. 4BP	.62
21. 4BPN	.61
13. 3BP	.47
11. 2BP	.41

This is clearly the silence interval factor which has been observed in previous conditions. It seems resistant to change that may be produced by the administration of physostigmine. Recalling the interpretation regarding the effects of physostigmine on customary motions given with Factor A, there may be some hint of a similar occurrence in the somewhat lower loadings of measures 13 and 11 in Factor D. The measures are the corresponding silence intervals for the patterns discussed in Factor A of this condition.

Factor E

Tests	Loadings
9. Metronome	.57
7. Time Reproduction	.52
8. Time Production	.39

This is the factor of subjective time. It was exactly duplicated only in the atropine condition previously. In Factor C of this condition there was some question as to whether the tests of drawing or the tests of subjective time had been altered by physostigmine. Since these tests do not define a single factor in either the normal or placebo condition, the evidence seems to indicate that the tests of subjective time have undergone alteration such that they now serve to define a single factor.

Factor F

Factor F seems best described as the specific factor for reading rate.

In general, physostigmine does not seem to have produced much overall change in the domain of tempo. The basic factors still seem to retain their basic identification. A few minor changes were suggested as resulting from physostigmine but these did not alter the structure to an appreciable degree. The tests most affected seem to be the measures of subjective time. If the stress of the experimental situation was present, the effects of physostigmine may have to a certain extent, been counteracted. This observation is made with the assumption that sympathetic dominance and the effects of a parasympathetic stimulant are antagonistic.

This completes the condition by condition analysis of the various factor structures. The following will involve the crucial comparisons of the various conditions of the research. The comparisons will be performed by relating each factor of one condition with all the factors from the other condition by means of the coefficient of congruence. The indices are not correlation coefficients but have the same range and are interpreted simi-

larly. According to Harman (1960) there does not seem to be a significance interpretation for these indices. In the literature, Harman says that Tucker has interpreted a coefficient of .45 as definitely low and therefore not indicating congruent factors.

The first comparison will be between the normal and placebo conditions. While these measures are helpful in making available a quantitative measure of the relationship of two factors, it obviously can only give a general picture and detailed analysis can only be done by inspection. Table 1 presents these coefficients for the normal and placebo condition comparison. Throughout the comparisons that follow the factors designated by letters shall also be identified by code words as to the interpretation made for each. The code words refer to the corresponding interpretations of each factor in this manner.

Sil - silence interval factor

Draw - drawing speed factor

Small - small muscle movement factor or tapping speed factor

Large - Large muscle movement factor

Time - subjective time factor

Read - reading factor

Met - metronome factor (preferred rate)

Res - residual factor

(s) - specific factor

Table 1

Coefficients of Congruence in the Comparison of the Placebo and Normal Condition

Normal Condition		Placebo Condition Factors and Code					
Factors	Code	A Large	B Small	C Draw	D Sil	E Read	F Time
A	Sil	.043	.021	.098	.983	-.174	.101
B	Draw	.040	.154	.855	.045	.286	.115
C	Small	-.005	.982	.060	.011	.166	.122
D	Large	.944	.074	.140	.015	.099	-.037
E	Time	.035	.112	.238	-.126	-.161	.707
F	Read (s)	-.102	-.275	-.239	-.054	.408	-.065

The factors exhibiting the highest degree of similarity from the normal to the placebo conditions are the silence interval, small muscle movement, large muscle movement and drawing speed factors in that order. An appreciable degree of similarity is also observed in the subjective time factor in these conditions. The F Factor of the normal condition and the E Factor of the placebo condition have an indication of similarity because both are, for practical purposes, specifics of rate of reading. On the whole the similarity between the two conditions is very good, indicating very little effect due to the administration of the placebo. This study of placebo effects by way of the structure of the tests employed is somewhat novel. The question may be raised as to how much placebo effects

would be found in other situations when studied from the factorial viewpoint.

Next, the normal condition will be compared with the atropine condition to assess the change, if any, due to atropine in the light of the normal condition. This is presented in Table 2.

Table 2

Coefficients of Congruence in the Comparison of the Atropine and Normal Conditions

Normal Condition		Atropine Condition Factors and Code					
Factors	Code	A Small	B Draw	C Large	D Time	E Sil	F Res
A	Sil	.081	.005	-.033	-.092	.916	.006
B	Draw	.140	.850	.071	.270	.127	.080
C	Small	.870	-.070	-.011	.155	.256	.088
D	Large	.112	.006	.956	.114	.002	-.080
E	Time	.218	-.002	.031	.530	-.015	-.176
F	Read (s)	-.475	-.003	.032	.000	.048	.071

An inspection of Table 2 indicates that the factors exhibiting the highest degree of similarity are, in order, the large muscle movement factor, the silence interval factor, the small muscle movement factor, and the drawing speed factor. Their high coefficients reflect little change due to atropine. There was a lowering in the similarity of the time factors for the two conditions. This seems to indicate an effect of

atropine on the measures of subjective time. Further, the Reading specific of the normal condition is, in the atropine condition, found in the small muscle movement factor, accounting for the similarity found between Factor F of the normal condition and Factor A of the atropine condition.

In sum, atropine's effect on the domain of tempo seems to have been mainly in the measures of subjective time and the reading task.

The next condition to be compared with the normal is the dexedrine. On the basis of its pharmacological characteristics, it would be expected to affect the domain in a fashion similar to atropine. This comparison is found in Table 3.

Table 3

Coefficients of Congruence in the Comparison of the Dexedrine and Normal Conditions

Normal Condition		Dexedrine Condition Factors and Code					
Factors	Code	A Sil & Small	B Large	C Draw	D Res	E Read & Time	F Time
A	Sil	.846	.022	.057	.467	-.089	-.035
B	Draw	.228	.019	.787	-.237	.031	.361
C	Small	.735	.072	.029	-.046	-.012	.341
D	Large	.070	.914	-.061	-.012	.085	.307
E	Time	.036	.077	.288	.029	.324	.395
F	Read (s)	-.131	-.022	-.089	.365	.582	-.364

Table 3 is conspicuous because of the lack of very high values which were present in the previous tables. This indicates lower agreement between comparable factors and at the same time suggests that the effects of dexedrine in altering structure are quite pronounced. The large muscle movement factor retains its identity, as does the drawing speed factor. The unique definition of the silence and the small muscle movement factors in the normal condition are both in appreciable agreement with Factor A of the dexedrine condition, indicating that the two factors have been combined in the latter condition. There is hardly any agreement in the factorial definition of time from one condition to the other. Reading shows fair agreement. In general, only the large muscle movement factor remains unaffected by dexedrine. The drawing speed composite retains much of its original identity, but the others undergo more of a radical revision. It was suggested that the subject may have entered the testing with a sympathetic dominance. If so, this would be heightened by dexedrine.

Dexedrine thus seems to have more of a disruptive effect than atropine. Both were administered in dosages considered to be the usual therapeutic treatment. The therapeutic purposes of each are different, however. Dexedrine is usually given as a stimulant in depressed cases, but atropine is mostly utilized in pre-operative care. On these bases it is difficult to say which has the greater psychological effect in terms of normal therapeutic dose. The evidence presented here seems to indicate dexedrine.

The comparison of the chlorpromazine and normal conditions is presented in Table 4.

Table 4

Coefficients of Congruence in the Comparison of the Chlorpromazine and Normal Conditions

Normal Condition		Chlorpromazine Condition Factors and Code					
Factors	Code	A Sil	B Small	C Large	D Draw	E Met (s)	F Read & Time
A	Sil	.947	-.050	-.031	-.004	.013	-.022
B	Draw	-.021	.097	.136	.720	-.204	.246
C	Small	.115	.972	-.042	-.086	.052	.034
D	Large	-.011	-.012	.963	.051	.015	.126
E	Time	-.107	.209	.025	.451	.693	-.313
F	Read (s)	-.089	-.195	-.204	-.193	-.071	.487

Large muscle movement, small muscle movement, and silence interval factors are practically identical in the two conditions with very high coefficients of congruence. Drawing and time estimation factors show appreciable similarity, the latter mainly because the test Metronome has a high loading in Factor E of the normal condition. In other words the only appreciable effects of chlorpromazine are in the realm of subjective experience of time and rate of reading. The counterbalancing effects of chlorpromazine on a possible sympathetic dominance was offered as the explanation.

The final condition to be compared with the normal is the physostigmine condition which is presented in Table 5.

Table 5

Coefficients of Congruence in the Comparison of the Physostigmine and Normal Conditions

Normal Condition		Physostigmine Condition Factors and Code					
Factors	Code	A Small	B Large	C Draw	D Sil	E Time	F Read (s)
A	Sil	.163	-.010	.051	.904	-.026	-.098
B	Draw	.173	.142	.677	.121	.413	.198
C	Small	.876	-.058	-.040	.224	.267	.031
D	Large	.141	.947	-.058	.074	.247	-.193
E	Time	.136	-.147	.383	-.004	.341	-.315
F	Read (s)	-.242	-.007	-.028	.017	-.143	.395

The factors of large muscle movement, silence intervals, and small muscle movement are in high agreement in the normal and physostigmine conditions. The drawing composite shows appreciable similarity in both conditions. The time and specific reading factors of the normal condition show no appreciable conformity in the factors of the physostigmine condition. The effect of physostigmine seems to be limited to experience of time and reading. Much the same thing was seen in the case of chlorpromazine.

The final two comparisons will be between the drugs which, according to their pharmacological characteristics, are likely to have similar effects.

Table 6 presents the comparison of the atropine and dexedrine conditions.

Table 6

Coefficients of Congruence in the Comparison of the Dexedrine and Atropine Conditions

Atropine Condition		Dexedrine Condition Factors and Code					
Factors	Code	A Small & Sil	B Large	C Draw	D Res	E Read & Time	F Time
A	Small	.681	.054	.002	-.668	-.225	.386
B	Draw	.132	-.033	.717	-.050	.042	-.009
C	Large	-.014	.954	-.054	.042	.105	.169
D	Time	.168	.043	.157	-.104	.646	.623
E	Sil	.822	-.047	.034	.330	.119	.045
F	Res	.001	-.058	.320	-.240	-.384	-.085

The large muscle movement and drawing composite factors are the only ones in the two conditions in which there is high and unambiguous agreement. The small muscle movement and silence factors of the atropine condition both have appreciable agreement with Factor A of the dexedrine condition since it is a composite of the two. The presence of more than one appreciable value in any row or column, of course, means a change in structure from one condition to the other. Thus, while in the atropine condition where there was only one factor of subjective time, it is split in the dexedrine condition. In general, then, these two drugs obviously have very limited effects which are similar. In fact where high agreement is

noted, it is more likely agreement due to the lack of effects of both drugs on the factors involved, rather than both drugs affecting these factors in the same way. The conclusion on the basis of the evidence, then, must be that despite the fact that one is a sympathetic stimulant (dexedrine) and the other a parasympathetic depressant (atropine) the two drugs have very little in common with respect to the introduction of changes in the domain of tempo.

The final comparison to be considered is that of the chlorpromazine and physostigmine conditions. These results are found in Table 7.

Table 7

Coefficients of Congruence in the Comparison of the Chlorpromazine and Physostigmine Conditions

Physostigmine Condition		Chlorpromazine Condition Factors and Code					
Factors	Code	A Sil	B Small	C Large	D Draw	E Met (s)	F Read & Time
A	Small	.234	.873	.059	-.058	-.054	.011
B	Large	.010	-.153	.919	.083	-.048	.321
C	Draw	-.088	-.056	-.047	.860	-.038	-.057
D	Sil	.885	.135	-.014	.017	.061	-.084
E	Time	-.068	.322	.291	.289	.327	.138
F	Read (s)	-.091	.003	-.244	-.159	-.454	.416

Both chlorpromazine and physostigmine were in agreement with the normal condition in the four situations underscored in Table 7. However, the value

in the drawing speed composite for physostigmine was not in as high agreement with the normal as it is in this case with chlorpromazine. This seems to indicate that this composite may have been affected by both and that the direction was similar for each. No similarities again are seen in the factors of subjective time or reading worthy of comment. In summary, the conclusion seems to be that both physostigmine and chlorpromazine had little effect on the domain of tempo and that, therefore, what shows up as a high degree of similarity between the effects of the two drugs is in actuality their mutual identity with the normal condition.

Discussion

This section will be quite brief since a great part of what would ordinarily appear here, was more properly treated with the interpretation of the factor structures and the analysis of the comparisons.

In discussing the relationship between the normal and placebo conditions it was noted that they were very similar in structure. This not only serves to indicate that the effects on the domain of the tempo tasks under observation were minimal, but also suggests in a post hoc propter hoc fashion that the counterbalancing effects of the design were successful. Obviously if differences had been observed between the structures, the design would have to have been assumed successful and the effects attributed to the placebo. However, since there were no differences of major import, the conclusion must either be that the placebo had no effect and that the counterbalancing of the design was successful, or that there were effects of the placebo and that these were exactly offset by the effects of poor coun-

terbalancing in the design. The latter interpretation seems much less plausible because of its high improbability.

Some critics may object that the various doses employed in the research were not determined by means of so many milligrams per kilogram of body weight. One obvious reason was the impracticality of the notion in terms of personnel. Another person who could not be used in the testing because of the double-blind control would have to be available to prepare the various doses of drugs. Besides its impracticality, the technique was not advised by the experts. Further, common medical usage of these drugs does not ordinarily employ this technique. It seems to be restricted to use with very small children, critical patients and critical situations. All the drugs have what is known as the normal adult therapeutic dose and it was decided that this satisfied the demands of this research.

Of the factors employed in this research, those involving drawing and large muscle movement seem quite resistant to any change due to the drugs employed. Small muscle movement and silence interval factors seem to have been affected only in the dexedrine condition in so far as their identification is concerned. The structure has become somewhat more oblique in the case of atropine. The result with dexedrine seems at the outset to be somewhat at variance with the findings of Cabanski (1961) and Condon (1965). Both reported negative findings. Their findings were based on conventional tests of significance whereas those of the present study were based on the factorial approach. This situation is in agreement with the arguments presented previously in connection with Eysenck's opinion concerning his re-

commended approach to the study of drug effects. That is, the conflicting results indicate that factorial composition can change despite the lack of significant differences. Further, the evidence suggests then, that dexedrine need not systematically affect all the component tests of a given factor. In terms of drug research in general, it seems appropriate to exercise extreme caution in forming conclusions based on tests of significance without the aid of a dimensional analysis. At any rate the use of the factor analytic technique seems to offer a great deal in the study of drug effects.

Since the areas most responsive to the influence of the various drugs were those of subjective time and reading, perhaps future research may want to develop more tests in these areas so as to have a better means of delineating the changes that may occur here. In the present research the subjective time factor was a quite complex one, but it was definitely sensitive to the various treatments. The literature does report the reliabilities of these tests to be the lowest of those employed in this study and, therefore, it may be suggested that this accounts for the change in factorial composition of these tests in the drug condition. However, this seems contra-indicated by the similarity of the factorial composition, even in these areas, in the normal and placebo condition.

Further, it may be observed that the most resistant factors were those which were more physiologically grounded. Those of a more complex psychological nature seemed less resistant and more sensitive to reflect the influence of the various agents at the specified dosage levels. Therefore, depending on one's purpose he may select variables of tempo along this

physiological-psychological continuum to fit the purposes of his research.

As was noted in the analysis of the structures and their comparisons, a factor of subjective time defined by measures of time production and preferred metronome rate was observed in the same form in both the normal and placebo conditions, but not in any of the drug conditions. In the physostigmine and atropine conditions the measure of time reproduction was added to the two above to define the factor. In the other two drug conditions the similarities were even smaller since Time Production and Metronome do not combine to define or help define any given factor. This is extremely interesting considering the controversy between a psychological and physiological basis for time estimation. The evidence presented here seems to indicate that neither alone can offer a satisfactory explanation. However, the supporters of a physiological basis seem to have the weight of the evidence on their side, since the changes in the factorial identification of the pertinent measures are much smaller in the two psychologically different conditions (normal and placebo) than in the physiologically different conditions. Yet since there were changes in both situations but not of the same magnitude, it seems to be a reasonable opinion that there is a physiological basis for time estimation that is modified in some instances by psychological experiences. A statement such as this seems to fit the evidence present in this research. Haley's (1963) conclusions provide additional evidence for this opinion. He found estimates of time appearing in factors defined by measures of physiological functions.

In general, the evidence of this research definitely supports a pluralistic interpretation of the domain of tempo. Also since the factors described by Rimoldi were all recovered in this research, further verification is given to his conclusions regarding personal tempo.

At this point it may be beneficial to remind the reader that all findings and conclusions must be restricted to the pharmacological agents and dosages employed. From the evidence submitted it does not seem possible to generalize from one drug to others of a similar classification. That is, not all stimulants can be expected to yield similar results. And to go a step further one cannot expect to find similar effects on the domain of personal tempo from sympathetic stimulants and parasympathetic depressants. The same thing can be said for the relationship between sympathetic depressants and parasympathetic stimulants, though here the evidence is less convincing. No evidence can be supplied concerning various agents all fitting under the classification of sympathetic stimulants, for example. This could very well be an area for future exploration. At any rate each drug appears to be worthy of study in its own right, depending, of course, on its importance to the field.

Another point of caution is the sample employed. It was basically composed of persons of a high educational level. Since there is definitely a relationship between the psychological and physiological, it would be quite presumptuous to generalize these findings beyond the population of this research.

If the author may be permitted a casual observation, it seems that the

the level of conscious attention inherent in a given task, may be an important variable to consider in evaluating the drug effects on that task. For example, the Arm Swinging task is one to which very little conscious attention would be expected to be paid. That is, one could reasonably assume that, since it is one which a person performs every day, it would be performed in the testing session on a more automatic level. If this is so, it seems reasonable that the subject would expend less conscious effort in trying to overcome the effects of a given drug on such a task, if he were aware of them. In other words, tasks performed at a more automatic level would seem to be more sensitive to drugs effects than those to which attention would be directed to insure their proper execution. A suggestion such as this may explain why the Arm Swinging task appears also in factors other than the large muscle movement factor in the drug condition, whereas the Arms Parallel and Arms Symmetrical tasks exhibit no such tendencies. This seems to be quite provocative for future research.

If tempo is a fundamental aspect of the total personality, then one would not expect dramatic changes in the domain of tempo under drug dosages which did not elicit similar changes in the total personality. The experimenter, though certainly no expert in the area, was not able to detect in his observation such changes in the personality of the subjects. Indeed, such changes would not be expected from the dosage levels of the various drugs employed. Thus with no marked changes in the total personality, one should not expect to find them in the domain of personal tempo. Such, indeed, was the finding especially in those factors which had been determined

by the literature to be quite stable. These, the present author characterized as being more toward the physiological pole of a psychological-physiological continuum. This observation of the relationship between tempo and the total personality, while suggested by other authors, certainly needs systematic empirical investigation. The purpose here was merely to indicate that such an investigation was not unwarranted.

Finally, then, it is necessary to integrate the various points discussed in this section to see how they fit into a meaningful whole. A psychological-physiological continuum for the tempo variables was suggested. Psychological and physiological effects of the pharmacological agents must be admitted realizing that the two interact very closely. Conscious attention to task and an organism under the predominant influence of the sympathetic nervous system, as a psychological effect of the experimental situation, were suggested as influencing the results. In general the results indicated practically no change in structure between normal and placebo conditions, little between normal and those conditions equivalently depressing the sympathetic nervous system, and the greatest between the normal and those equivalently stimulating the sympathetic nervous system. The lack of difference between the normal and placebo conditions was interpreted to mean that the psychological effects of the experimental situation were not sufficiently strong in themselves to bring about a change in structure. The suggestion that there may have been some, though rather weak, psychological effects of the placebo condition seems to agree with the lack of change between the normal and those conditions equivalently depressing the

sympathetic nervous system. That is, it is assumed that the effects of the placebo condition would be those similar to any stressful situation or that a sympathetic dominance would describe the organism in this situation. Agents equivalently depressing the action of the sympathetic nervous system would tend to counteract such a sympathetic dominance; the end result of such an interaction would be a dampening not only of the placebo effects, but also of the agents involved. This interpretation seems consistent with observed results. The interpretation of the appreciable changes from the normal to those conditions equivalently stimulating the sympathetic nervous system seems also consistent with the suggestion of sympathetic dominance. That is, instead of a counterbalancing effect due to the interaction between placebo effects and agent effects, there is a summation effect in which the sympathetic dominance is enhanced. This then, would explain the rather pronounced change in structure, especially noted in the dexedrine condition. At a more specific level, it was observed that tests toward the physiological end of the above mentioned continuum were more resistant to change than those located toward the psychological end. It seems characteristic of the physiologically designated tasks that more conscious attention would be paid their proper execution. This would seem to allow for less departure from what the subjects would consider normal execution. The psychologically designated tasks seem to be more automatic or habituated, thus reducing conscious attention and allowing a greater departure from the normal because of experimentally introduced influences. One cannot discount entirely the possibility that the tasks of a more complex psychological nature are less

resistant to change because they are the result of the modification of a basic physiological process by learning and that the learned aspects are more susceptible to disruption than the underlying physiological process. Therefore, the fewer the learned aspects of a task there are, the smaller the susceptibility to change.

If tempo measures are to be considered as possible measures of personality, then the more stable aspects of tempo should be investigated as useful correlates. If the stable physiological measures may be regarded as measures of personality, it may be concluded that, since the pertinent tempo measures underwent little or no influence because of the effects of the various agents employed, personality would undergo little or no change. The relationship between the stable tempo measures and personality remains to be empirically established, of course.

Finally, with respect to the tempo variables themselves and corresponding drug influences, no systematic changes may be described as delineated in a previous paragraph. However, here again the evidence strongly suggests that tasks more physiologically grounded are quite resistant to change. The evidence is more convincing concerning agents stimulating the sympathetic nervous system than for those depressing the same.

Summary

The purpose of this research was an investigation of the permanence of a domain of personal tempo under the influence of four pharmacological agents, viz. atropine sulfate, chlorpromazine hydrochloride, physostigmine salicylate, and dextro-amphetamine sulfate. The domain studied was com-

posed of factors from previous research (Rimoldi, 1951; Haley, 1963, 1965; Allport and Vernon, 1933) where they had been shown to be stable and reproducible. These factors were large muscle movement, small muscle movement, drawing speed, and the silence interval. Tasks of time estimation were included because of their compelling interest and obvious relevance to the area being studied.

In order to study the uncontaminated effects of the various agents and have a basis of comparison, six experimental conditions were employed: normal (no agent administered), placebo, atropine, dexedrine, chlorpromazine, and physostigmine. The design called for a counterbalanced presentation of the six conditions such that each condition appeared approximately the same number of times in each of the six possible orders.

The data was then collected by condition and the intercorrelations computed for the twenty-one measures employed to reflect performance on the fifteen tempo tasks. A factor analysis was performed for each of the six conditions using the principal axes method. Oblique graphical rotations were then taken by hand on each factor solution until the best approximation to simple structure was obtained. The final rotated solutions for each condition were then analyzed by inspection and compared according to the coefficients of congruence. Interpretations were suggested. The general findings were:

1) The structure of the normal condition proved to be as expected on the basis of the literature, indicating that the factors employed were verifiable and reproducible and that a legitimate basis of comparison existed.

2) The structures of the normal and placebo conditions were practically identical, indicating that placebo effects were minimal, and because of this that the design was successful. This latter observation obtains increased support from the first finding.

3) The structures of the chlorpromazine and physostigmine conditions were quite similar to the normal condition indicating only minor influence on the domain of tempo due to the administration of these agents. Since both agents are antagonistic to sympathetic dominance and since such dominance may be present because of the stress of the testing situation, it was suggested that the effects of these two agents were reduced by this antagonism.

4) The structures exhibiting the most change were those of the dexedrine and atropine conditions. Supposing a sympathetic dominance, the effects of these two agents would tend to be heightened. Of these two conditions, the dexedrine condition showed the greatest deviation from the structure of the normal condition. It was proposed that a therapeutic dose of dexedrine may be more "powerful" in terms of psychological effects than such a dose of atropine.

5) The basic factors selected to represent the domain of tempo showed the greatest resistance to the influence of the agents involved. It was proposed that these factors are defined by tasks which may be characterized as being more toward the physiological pole of a physiological-psychological continuum.

6) Tasks of time estimation and allied measures showed the greatest

sensitivity to the influence of the various agents. These seemingly can be characterized as being more toward the psychological end of the above mentioned continuum.

7) In the light of the findings in 5 and 6 the evidence of this research points to the importance in tempo drug research, of analyzing the tasks involved in terms of a physiological-psychological continuum.

8) Finally, no dramatic changes in the domain of tempo, as defined in this research, can be said to have occurred. This evidence seems to be in agreement with the concept of tempo as a basic aspect of the total personality. That is, since no dramatic changes as a result of drug influence were observed in the total personality as reflected in the observation of the experimenter, one would not expect to observe such changes in the domain of tempo studied. A subtle assumption is involved here and it is that the tasks defining the factors in the domain of tempo be characteristically at the physiological end of the physiological-psychological continuum. The reason for this is that tests tending toward the psychological end have been seen in this research to undergo change despite the lack of dramatic changes in the total personality. Though the evidence from this research bearing on this problem is limited from the standpoint of personality measures, it seems sufficient to indicate that if personal tempo is to be regarded as a fundamental aspect of personality, its characteristic measures should be those which tap functions as close to the purely physiological as possible. At any rate it is felt that this contention deserves serious consideration for future investigation.

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A P P E N D I X

Table 8

Intercorrelation between Variables for Normal Condition

Variable	Variable											
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	-13											
3	-10	64										
4	00	62	89									
5	-06	37	04	18								
6	-06	41	-03	20	69							
7	-10	42	40	48	57	46						
8	14	06	09	26	11	34	-05					
9	-38	39	09	22	38	36	09	51				
10	00	-14	-25	-19	31	08	25	-32	-09			
11	-08	-24	-36	-25	20	-04	12	-52	-28	66		
12	10	-16	-28	-19	16	-02	05	-22	-08	95	55	
13	-15	-29	-42	-31	08	-17	-10	-46	-17	58	95	53
14	12	-19	-34	-27	06	-07	04	-33	-15	91	55	96
15	-36	-22	-36	-25	06	-10	-17	-41	07	46	80	40
16	-15	-11	-29	-27	12	00	01	-38	-04	92	55	94
17	-21	-22	-30	-23	04	-11	05	-56	-28	65	92	56
18	-01	-15	-26	-21	03	-07	03	-39	-13	88	53	93
19	-20	-18	-35	-23	-03	-16	-10	-52	-14	53	88	50
20	08	-17	-28	-25	-03	-14	-03	-41	-19	86	51	93
21	-36	-24	-36	-25	-06	-13	-15	-43	01	46	78	41

Note.-Decimal places have been omitted.

(Table continued on next page)

Table 8

Intercorrelations between Variables for Normal Conditions

Variable	Variable								
	13	14	15	16	17	18	19	20	21
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14	52								
15	89	40							
16	54	94	50						
17	89	58	80	63					
18	52	96	49	95	61				
19	93	53	92	56	91	58			
20	51	97	41	94	59	96	56		
21	85	43	94	52	88	52	95	46	

Note.-Decimal places have been omitted.

Table 9

Intercorrelations between Variables for Placebo Condition

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	53											
3	20	56										
4	-06	51	78									
5	00	15	-15	14								
6	-26	20	-10	25	75							
7	14	45	07	27	73	64						
8	01	17	17	44	27	25	26					
9	20	25	12	39	53	40	43	45				
10	-16	-10	-26	-45	-06	-14	-21	-36	24			
11	01	-18	-25	-47	-24	-36	-34	-63	-12	67		
12	-06	10	-04	-25	-10	-17	-07	-36	18	87	62	
13	00	-14	-25	-45	-16	-27	-20	-69	-09	64	90	68
14	-04	14	00	-22	-16	-20	-08	-33	12	82	56	98
15	-08	-20	-36	-47	-13	-31	-24	-57	-09	57	86	58
16	-13	-05	-20	-40	-02	-05	-11	-42	18	93	61	94
17	00	-31	-30	-53	-15	-24	-33	-68	-13	63	88	58
18	-05	00	-08	-29	-09	-18	-10	-46	14	86	65	98
19	-09	-23	-29	-47	-11	-26	-22	-77	-13	61	88	58
20	-07	05	-07	-31	-06	-11	-08	-45	16	90	62	97
21	-08	-27	-36	-46	-08	-27	-24	-62	-10	55	83	52

Note.-Decimal places have been omitted.

(Table continued on next page)

Table 9

Intercorrelations between Variables for Placebo Condition

Variable	Variable											
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14	62											
15	94	54										
16	68	92	60									
17	95	50	89	64								
18	74	96	66	96	65							
19	96	53	93	63	93	68						
20	70	95	61	98	63	98	64					
21	94	48	98	57	91	62	96	57				

Note.-Decimal places have been omitted.

Table 10

Intercorrelations between Variables
for Atropine Condition

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	-08											
3	26	57										
4	26	43	90									
5	07	22	-14	14								
6	-06	07	-06	18	82							
7	10	25	10	13	35	31						
8	06	31	14	14	22	06	61					
9	-02	14	14	19	08	00	30	51				
10	-51	47	02	-02	25	22	-08	02	24			
11	-35	13	-03	-06	06	04	-05	-24	03	72		
12	-62	31	-09	-20	-06	-07	-01	09	20	88	76	
13	-45	02	-13	-20	-19	-24	-01	-11	04	59	89	82
14	-55	28	-10	-20	-03	-08	13	21	27	80	72	97
15	-35	-07	-19	-25	-27	-38	00	02	-08	35	66	68
16	-63	33	-14	-23	01	-02	02	12	18	90	74	98
17	-44	06	-17	-24	-15	-18	-13	-26	-09	63	91	77
18	-62	32	-10	-19	01	01	04	15	14	85	69	98
19	-45	05	-17	-25	-24	-26	-05	-18	-06	54	81	80
20	-56	28	-08	-16	-09	-09	05	08	13	77	68	94
21	-36	-12	-20	-22	-35	-43	-19	-13	-23	28	54	58

Note.-Decimal places have been omitted.

(Table continued on next page)

Table 10

Intercorrelations between Variables for Atropine Condition

Variable	Variable								
	13	14	15	16	17	18	19	20	21
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14	81								
15	90	70							
16	76	94	62						
17	92	72	77	78					
18	76	96	65	97	74				
19	94	77	88	76	94	78			
20	78	93	68	93	77	97	84		
21	78	56	89	56	77	61	87	69	

Note.-Decimal places have been omitted.

Table 11

Intercorrelations between Variables for Dexedrine Condition

Variable	Variable											
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	-19											
3	07	45										
4	-03	50	80									
5	20	-26	-12	05								
6	18	-35	01	11	79							
7	13	17	13	19	-04	08						
8	46	14	06	39	06	15	30					
9	12	26	10	33	46	29	04	37				
10	-15	01	-19	-18	06	11	27	-14	-14			
11	03	-13	-08	-25	-05	00	15	-23	-46	81		
12	-07	14	-13	-06	-12	-09	33	-05	-19	92	78	
13	04	01	-08	-16	-14	-16	11	-17	-44	74	92	84
14	-03	13	-09	-12	-21	-16	40	-04	-30	84	82	94
15	04	05	-01	-08	-17	-27	04	-18	-33	59	78	72
16	-14	01	-27	-27	-20	-15	36	-09	-36	88	87	92
17	06	-15	-16	-32	-16	-16	11	-24	-53	72	95	75
18	-04	09	-13	-18	-32	-30	33	-08	-41	75	82	87
19	04	04	-05	-23	-27	-28	19	-22	-53	60	85	72
20	-01	04	-13	-21	-33	-31	37	-11	-47	74	84	87
21	-01	17	-01	-16	-27	-39	07	-25	-41	54	77	64

Note.-Decimal places have been omitted.

(Table continued on next page)

Table 11

Intercorrelations between Variables
for Dexedrine Condition

Variable	13	14	15	16	17	18	19	20	21
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14	88								
15	90	69							
16	87	95	72						
17	95	81	88	86					
18	90	92	82	94	87				
19	93	81	89	82	94	93			
20	90	93	81	94	88	99	92		
21	87	68	93	72	88	82	93	81	

Note.-Decimal places have been omitted.

Table 12

Intercorrelations between Variables for Chlorpromazine Condition

Variable	Variable											
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	-07											
3	19	47										
4	01	60	88									
5	02	20	13	29								
6	19	08	02	13	84							
7	56	48	42	41	31	40						
8	07	16	16	27	28	32	02					
9	-24	28	19	38	63	46	29	21				
10	-11	07	-36	-45	-35	-35	14	-40	-10			
11	-19	-10	-45	-57	-56	-60	-24	-65	-38	65		
12	-04	01	-34	-36	-43	-45	-13	-21	-04	81	56	
13	-24	-26	-53	-62	-59	-63	-36	-58	-37	56	93	61
14	22	-17	-42	-47	-50	-44	-12	-29	-21	70	55	91
15	-45	-27	-50	-48	-52	-60	-49	-42	-15	28	72	49
16	-12	01	-40	-49	-41	-34	-18	-37	-24	90	68	86
17	-24	-13	-52	-59	-50	-52	-25	-61	-34	55	95	51
18	18	-03	-26	-38	-47	-37	-01	-27	-28	82	58	89
19	-25	-24	-53	-60	-50	-57	-35	-61	-27	50	92	57
20	21	-05	-29	-42	-48	-37	-05	-34	-32	80	60	85
21	-48	-25	-48	-46	-49	-61	-58	-33	-13	28	71	49

Note.-Decimal places have been omitted.

(Table continued on next page)

Table 12

Intercorrelations between Variables for Chlorpromazine Condition

Variable	13	14	15	16	17	18	19	20	21
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14	64								
15	87	48							
16	66	77	38						
17	94	52	78	63					
18	57	89	29	90	53				
19	98	60	88	60	93	50			
20	59	91	30	88	55	99	52		
21	81	46	94	40	74	28	86	28	

Note.-Decimal places have been omitted.

Table 13

Intercorrelations between Variables
for Physostigmine Condition

Variable	Variable											
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	08											
3	10	41										
4	-16	35	86									
5	16	-16	-05	21								
6	02	-03	-20	16	65							
7	-01	32	40	49	07	17						
8	05	-13	-15	03	17	31	36					
9	-04	02	19	37	30	44	52	36				
10	01	02	-36	-33	-10	13	20	22	23			
11	07	06	-25	-26	-10	18	25	24	19	94		
12	-07	10	-14	-17	-28	-15	22	14	05	86	82	
13	-04	05	-19	-23	-18	-06	16	05	08	84	88	94
14	-08	23	-08	-05	-16	03	30	22	16	81	79	93
15	-06	-01	-12	-15	-10	-16	14	04	01	65	74	80
16	-10	20	-12	-06	-14	14	28	26	18	84	84	87
17	13	-02	-11	-23	-18	-08	04	-01	-12	72	83	77
18	-20	25	-08	-03	-16	06	28	27	13	77	74	84
19	-02	-02	-05	-15	-16	-16	00	-04	-17	55	67	70
20	-13	34	-06	-08	-30	-06	27	21	05	77	74	88
21	-10	-09	-20	-29	-19	-26	-15	-04	-26	54	62	69

Note.-Decimal places have been omitted.

(Table continued on next page)

Table 13

Intercorrelations between Variables for Physostigmine Condition

Variable	13	14	15	16	17	18	19	20	21
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14	88								
15	90	75							
16	84	97	71						
17	88	70	87	71					
18	78	95	67	97	62				
19	82	69	91	68	92	66			
20	79	95	64	93	63	96	63		
21	79	57	88	54	87	54	93	54	

Note.-Decimal places have been omitted.

Table 14

Unrotated Principal Axes Factor Solution
for Normal Condition

Variable	Factor					
	I	II	III	IV	V	VI
1	-10	-05	43	-05	-35	38
2	-30	62	-28	-17	11	05
3	-46	48	-20	-67	12	-06
4	-39	60	-29	-49	08	26
5	04	64	-27	43	-26	-03
6	-14	58	-20	52	-16	04
7	-06	66	-21	-07	-34	-21
8	-51	16	10	37	24	32
9	-20	36	-25	40	50	10
10	84	42	23	06	-09	-13
11	85	-04	-35	-01	-35	07
12	82	35	40	03	07	11
13	86	-18	-37	02	-10	14
14	84	27	43	-02	04	08
15	78	-17	-51	08	22	04
16	86	31	28	02	20	-15
17	88	-06	-33	-13	-14	-04
18	86	28	33	-09	15	-02
19	87	-16	-41	-09	04	20
20	84	22	41	-13	11	05
21	80	-21	-47	00	22	04

Note.-Decimal places have been omitted.

Table 15

Unrotated Principal Axes Factor Solution
for Placebo Condition

Variable	Factor						
	I	II	III	IV	V	VI	VIII
1	-07	-09	-14	-15	-38	-33	18
2	-19	52	-25	-38	-14	02	-18
3	-30	30	-63	-49	03	05	24
4	-54	42	-31	-45	29	10	04
5	-20	53	68	-10	-07	-09	15
6	-31	52	58	-01	-01	30	-06
7	-29	60	42	-25	-32	-12	-08
8	-65	32	-02	22	30	-37	-07
9	-07	66	19	-01	35	-13	14
10	83	31	-05	32	12	-01	15
11	88	-18	03	-18	08	-06	06
12	83	46	-24	12	-05	-05	-05
13	93	-10	11	-29	-01	-05	-04
14	79	45	-32	14	-11	-04	-14
15	88	-18	20	-24	14	-15	-18
16	86	40	-05	25	-03	09	05
17	90	-22	17	-19	06	01	15
18	88	38	-17	08	-06	00	02
19	91	-18	20	-29	03	09	06
20	86	43	-16	13	-08	06	04
21	87	-21	26	-27	14	-08	-07

Note.-Decimal places have been omitted.

Table 16

Unrotated Principal Axes Factor Solution
for Atropine Condition

Variable	Factor					
	I	II	III	IV	V	VI
1	-58	-02	-22	00	-30	-17
2	18	63	-30	07	13	16
3	-16	47	-81	21	01	04
4	-25	54	-64	30	-15	05
5	-12	59	54	25	-32	07
6	-16	55	55	38	-22	10
7	-04	50	08	-40	-45	04
8	-02	53	-03	63	-13	05
9	07	45	-06	-39	08	-40
10	77	44	13	25	26	-10
11	83	04	-02	36	-22	-29
12	96	20	03	-05	18	-03
13	92	-16	-10	03	-24	-16
14	93	24	03	-19	06	-06
15	81	-30	-15	-18	-33	08
16	94	23	10	-03	20	02
17	90	-20	-04	22	-16	-10
18	94	23	07	-07	14	15
19	92	-23	-10	05	-20	02
20	94	15	-02	-08	08	15
21	75	-44	-19	-05	-21	27

Note.-Decimal places have been omitted.

Table 17

Unrotated Principal Axes Factor Solution
for Dexedrine Condition

Variable	Factor					
	I	II	III	IV	V	VI
1	-04	00	29	-23	-62	11
2	02	68	-10	14	17	23
3	-14	76	03	-40	14	-28
4	-24	82	26	-19	13	-08
5	-25	-32	72	-27	15	13
6	-25	-28	77	-20	11	-20
7	23	31	32	30	-20	26
8	-19	32	38	16	-49	-10
9	-46	22	44	11	05	42
10	80	-08	38	21	30	03
11	92	-14	15	-19	07	-12
12	88	12	27	22	13	11
13	96	00	06	-20	00	08
14	92	14	19	23	00	-05
15	87	08	-06	-33	-02	23
16	95	-04	14	27	05	-08
17	95	-16	-01	-23	-06	-04
18	97	11	00	13	-10	-03
19	94	03	-12	-20	-11	-04
20	97	08	-02	13	-12	-10
21	87	11	-21	-28	-02	21

Note.-Decimal places have been omitted.

Table 18

Unrotated Principal Axes Factor Solution for Chlorpromazine Condition

Variable	Factor						
	I	II	III	IV	V	VI	VII
1	-17	50	-18	-42	-32	-30	-12
2	-23	35	56	32	-10	12	-10
3	-56	27	65	-17	06	-05	15
4	-66	19	64	05	18	-08	08
5	-64	06	-26	58	-14	-06	13
6	-64	16	-46	40	-24	-04	11
7	-38	52	17	09	-39	-26	-15
8	-51	03	-29	-11	48	-10	12
9	-38	06	06	67	19	-21	-09
10	73	46	-03	23	07	32	-14
11	90	-10	18	06	-29	09	04
12	78	44	00	17	33	-13	-10
13	95	-21	09	02	-15	-08	07
14	79	43	-14	-06	15	-29	-14
15	78	-49	14	12	11	-24	-04
16	81	42	-06	17	09	24	11
17	88	-19	12	12	-31	01	11
18	76	63	-06	-05	10	-02	12
19	91	-27	09	12	-18	-17	06
20	77	60	-08	-08	03	-02	10
21	76	-51	13	14	22	-18	06

Note.-Decimal places have been omitted.

Table 19

Unrotated Principal Axes Factor Solution
for Physostigmine Condition

Variable	Factor					
	I	II	III	IV	V	VI
1	-06	-03	07	15	40	23
2	10	37	-38	-20	10	34
3	-18	55	-71	23	14	03
4	-21	75	-44	28	-17	-04
5	-20	30	49	49	-15	20
6	-04	43	63	22	-13	23
7	19	69	-07	01	17	-19
8	16	34	38	-06	-01	-22
9	05	64	29	10	10	-25
10	88	06	32	-13	21	-01
11	90	07	24	05	27	03
12	94	02	-06	-13	05	-11
13	96	-06	00	10	07	-05
14	94	22	-02	-15	-08	06
15	87	-14	-11	32	-04	-15
16	93	25	07	-15	-11	09
17	87	-22	-09	32	18	09
18	89	26	-02	-22	-26	08
19	83	-24	-21	36	-12	04
20	89	20	-12	33	-11	12
21	78	-42	-16	32	-14	-08

Note.-Decimal places have been omitted.

Table 20

Final Transformation Matrix
for Normal Condition

	A	B	C	D	E	F
I	36	04	42	-08	-02	-04
II	-17	54	46	49	13	-12
III	-68	-19	65	-23	-03	12
IV	-10	42	-08	-76	43	-06
V	-12	-66	39	12	59	-42
VI	60	-24	-19	33	67	89

Note.-Decimal places have been omitted.

Table 21

Final Transformation Matrix
for Placebo Condition

	A	B	C	D	E	F	G
I	-06	37	-02	33	-01	01	-04
II	25	58	42	-20	09	16	09
III	-38	-37	66	33	-01	10	-06
IV	-65	51	-21	-72	-05	10	-25
V	30	-23	-15	43	-64	59	-11
VI	43	26	09	-23	-67	-77	-21
VII	30	10	56	03	38	10	-93

Note.-Decimal places have been omitted.

Table 22

Final Transformation Matrix
for Atropine Condition

	A	B	C	D	E	F
I	37	-04	-05	03	38	01
II	34	29	42	34	-18	02
III	10	49	-76	-01	-13	03
IV	-06	37	35	-76	04	35
V	72	-57	-06	-33	-89	28
VI	47	46	34	-45	-13	-89

Note.-Decimal places have been omitted.

Table 23

Final Transformation Matrix
for Dexedrine Condition

	A	B	C	D	E	F
I	88	-04	-04	04	-01	03
II	16	74	-26	-03	16	27
III	40	13	77	-18	22	22
IV	04	-36	-31	-77	01	33
V	04	26	42	-37	-96	20
VI	21	-49	28	49	-06	85

Note.-Decimal places have been omitted.

Table 24

Final Transformation Matrix
for Chlorpromazine Condition

	A	B	C	D	E	F	G
I	33	29	-13	-12	-02	-01	-04
II	-28	68	22	08	-09	21	-05
III	31	-20	76	-21	00	-03	15
IV	23	19	17	60	16	-25	22
V	-39	59	07	-22	58	-56	-04
VI	-59	18	-21	-39	-60	-66	21
VII	41	03	53	60	-51	-38	-94

Note.-Decimal places have been omitted

Table 25

Final Transformation Matrix
For Physostigmine Condition

	A	B	C	D	E	F
I	35	-05	-02	37	09	00
II	27	48	21	-16	44	-07
III	-03	-62	47	-14	18	13
IV	-58	31	48	85	-04	-14
V	-44	37	-47	30	45	89
VI	52	38	52	-04	-75	40

Note.-Decimal places have been omitted.

Table 26

Matrix of Cosines of Reference Vectors
for Normal Condition

	A	B	C	D	E	F
A	1.01					
B	- .06	1.00				
C	- .52	- .10	1.00			
D	.30	- .17	.09	1.00		
E	.28	- .29	.10	.04	1.00	
F	.51	- .05	- .32	.21	.30	1.00

Table 27

Matrix of Cosines of Reference Vectors
for Placebo Condition

	A	B	C	D	E	F	G
A	1.00						
B	.00	1.00					
C	.15	.00	1.00				
D	.31	- .64	.21	1.01			
E	- .31	.04	.29	- .10	1.01		
F	- .19	- .22	.01	.37	.18	1.00	
G	- .19	- .19	- .47	.10	- .12	- .01	1.00

Table 28

Matrix of Cosines of Reference Vectors
for Atropine Condition

	A	B	C	D	E	F
A	1.01					
B	- .08	1.00				
C	.14	.07	1.00			
D	- .28	- .21	- .25	1.01		
E	- .64	.33	.03	.27	1.00	
F	- .22	- .42	- .21	.05	- .12	.99

Table 29

Matrix of Cosines of Reference Vectors
for Dexedrine Condition

	A	B	C	D	E	F
A	1.01					
B	.03	1.00				
C	.29	- .01	1.01			
D	- .05	- .10	.09	1.00		
E	.05	- .08	- .29	.27	1.00	
F	.36	- .26	.32	.04	- .15	.99

Table 30

Matrix of Cosines of Reference Vectors
for Chlorpromazine Condition

	A	B	C	D	E	F	G
A	1.00						
B	- .44	1.00					
C	.48	.01	1.00				
D	.57	- .01	.36	.99			
E	- .03	.18	- .09	- .11	.99		
F	.32	- .36	- .12	.03	.21	1.00	
G	- .40	- .05	- .40	- .54	.37	.17	1.00

Table 31

Matrix of Cosines of Reference Vectors
for Physostigmine Condition

	A	B	C	D	E	F
A	1.00					
B	- .01	.99				
C	.25	- .02	.99			
D	- .56	.35	.14	1.00		
E	- .42	- .04	- .45	.07	1.00	
F	- .13	.32	- .23	.12	.10	1.00

Table 32

Final Rotated Oblique Factor Solution for Normal Condition

Variable	Factor					
	A	B	C	D	E	F
1	-05	00	01	01	01	55
2	01	22	02	55	12	-09
3	-09	-06	01	82	-18	-13
4	15	04	-06	86	11	13
5	06	76	01	01	10	-05
6	-02	66	-04	-06	24	-02
7	-07	64	05	32	-28	-14
8	-15	-03	-08	-05	54	18
9	00	05	06	04	59	-21
10	00	33	68	-01	-09	-14
11	64	29	-04	-02	-18	14
12	02	09	77	04	15	04
13	69	05	-03	-06	01	11
14	01	05	76	01	07	04
15	65	-08	-01	-06	17	-13
16	-05	06	79	-02	04	-26
17	56	11	09	05	-18	-04
18	02	-01	77	07	05	-10
19	74	-08	01	08	09	10
20	01	-07	77	07	04	00
21	64	-14	01	-02	13	-12

Note.-Decimal places have been omitted.

Table 33

Final Rotated Oblique Factor Solution for Placebo Condition

Variable	Factor						
	A	B	C	D	E	F	G
1	-07	-08	03	-02	54	00	-02
2	40	15	06	-04	07	-10	39
3	76	07	-05	00	10	-06	-04
4	69	-10	06	06	-17	09	12
5	-06	-06	78	12	21	18	-09
6	05	04	61	-08	-17	-11	02
7	00	-01	58	-01	32	00	27
8	-11	-11	-02	-23	06	52	13
9	20	18	42	10	-03	45	-10
10	-08	65	08	03	-01	18	-27
11	02	08	-02	52	00	06	-07
12	02	72	-03	00	08	07	06
13	03	08	05	58	02	00	08
14	01	74	-13	-08	07	01	16
15	-09	-06	-05	64	-07	16	21
16	-05	74	11	-03	-01	01	-14
17	02	05	12	56	-01	02	-19
18	04	67	03	07	07	03	-03
19	08	04	13	60	-07	-07	-08
20	05	74	07	00	05	-02	-07
21	-04	-10	05	69	-08	11	07

Note.-Decimal places have been omitted.

Table 34

Final Rotated Oblique Factor Solution for Atropine Condition

Variable	Factor					
	A	B	C	D	E	F
1	-54	00	15	15	10	05
2	42	05	55	06	-14	-08
3	03	-17	91	-02	-05	03
4	-08	08	85	-02	03	01
5	00	75	-03	08	06	-04
6	05	74	00	-08	-03	01
7	-12	31	05	60	27	-29
8	14	01	05	68	-01	-30
9	07	-27	-04	60	-08	24
10	57	06	08	-05	-01	27
11	00	10	03	-03	56	33
12	54	-10	-03	09	17	07
13	03	-06	-06	11	63	09
14	46	-09	-06	26	25	02
15	-01	-04	-07	13	66	-22
16	59	-04	-04	05	12	05
17	08	01	-04	-11	54	13
18	61	03	02	04	16	-10
19	11	-01	-03	-03	59	-06
20	53	-01	05	-04	24	-13
21	09	-03	01	-14	54	-32

Note.-Decimal places have been omitted.

Table 35

Final Rotated Oblique Factor Solution
for Dexedrine Condition

Variable	Factor					
	A	B	C	D	E	F
1	07	-09	07	41	65	-05
2	15	37	-16	-06	-09	44
3	-06	89	-07	09	01	-14
4	00	79	09	00	07	16
5	04	-06	83	11	-05	12
6	00	10	73	-11	03	-13
7	44	-03	05	-11	30	44
8	00	16	-07	-06	62	03
9	-10	00	41	04	07	54
10	87	-05	35	-36	-22	24
11	82	03	17	00	-06	-13
12	94	-01	16	-26	-06	31
13	88	00	09	14	00	04
14	91	03	-01	-27	06	14
15	79	02	05	35	-01	12
16	88	-09	00	-32	-02	08
17	79	-07	03	15	02	-14
18	86	-02	-16	-12	10	05
19	77	03	-13	15	07	-11
20	84	-01	-20	-14	12	-02
21	73	01	-09	33	-04	09

Note.-Decimal places have been omitted.

Table 36

Final Rotated Oblique Factor Solution for Chlorpromazine Condition

Variable	Factor						
	A	B	C	D	E	F	G
1	-10	00	-10	-03	-06	64	-07
2	00	08	51	04	-05	-01	27
3	-03	-11	69	-05	-05	03	-09
4	-06	-08	69	03	12	-07	02
5	-03	-07	07	62	-01	-05	-02
6	-14	-05	-11	56	-10	07	-07
7	05	-06	26	20	-02	53	14
8	-38	18	-05	06	27	-20	-20
9	05	12	23	43	39	-08	20
10	-12	67	-11	-13	-10	-17	19
11	47	01	-02	-07	-24	04	00
12	08	73	02	-04	29	-02	04
13	54	02	-05	-03	-07	04	-08
14	14	57	-12	-07	27	26	-02
15	55	-09	-05	-04	28	-03	02
16	04	67	-02	01	-17	-21	-08
17	57	-05	-01	05	-22	04	-07
18	07	71	06	00	-07	05	-20
19	63	-05	-03	07	-01	09	-07
20	09	65	02	-02	-10	10	-19
21	51	-02	00	-01	26	-18	-06

Note.-Decimal places have been omitted.

Table 37

Final Rotated Oblique Factor Solution
for Physostigmine Condition

Variable	Factor					
	A	B	C	D	E	F
1	-18	23	03	21	00	44
2	39	52	-07	-12	-09	18
3	-08	84	-15	18	13	-03
4	03	65	15	05	18	-32
5	-12	02	70	17	-03	-08
6	13	-07	67	-03	06	00
7	08	36	-06	03	52	02
8	07	-19	11	-10	39	-06
9	-04	10	14	00	57	-04
10	29	-18	01	23	27	23
11	19	-04	02	41	25	27
12	33	-06	-19	26	19	01
13	21	-04	-05	47	12	03
14	55	02	02	16	11	-05
15	03	-01	-01	62	08	-14
16	57	-02	10	13	09	-04
17	03	10	01	69	-04	15
18	66	-05	08	02	03	-19
19	10	06	09	65	-17	-16
20	67	03	-08	-01	02	-03
21	00	-13	00	61	-17	-20

Note.-Decimal places have been omitted.

Table 38

Means for All Variables
in Six Conditions

Variable	Condition					
	Normal	Placebo	Atropine	Dexedrine	Chlorpro-mazine	Physostig-mine
1	199.30	195.20	199.65	191.60	185.35	196.10
2	22.95	22.70	22.45	23.30	22.70	23.05
3	14.25	14.35	15.00	13.95	13.70	14.55
4	19.05	19.75	19.60	19.20	18.50	19.70
5	45.45	45.35	44.55	44.35	43.85	43.30
6	61.55	66.30	66.75	67.70	68.25	66.65
7	43.60	47.70	44.25	48.05	45.85	44.30
8	39.00	39.25	38.60	39.25	37.45	39.95
9	136.85	135.30	135.70	133.00	130.70	135.75
10	7.60	7.42	7.88	7.55	7.81	7.75
11	15.79	14.53	15.27	14.90	16.74	15.81
12	15.18	15.37	16.30	15.46	16.54	15.72
13	15.81	14.92	15.40	15.14	16.71	15.91
14	22.39	22.83	24.76	22.56	24.21	22.86
15	16.80	16.74	17.78	16.12	18.24	17.35
16	7.50	7.56	7.96	7.94	7.89	7.82
17	16.18	15.27	15.24	15.90	17.68	15.85
18	15.22	14.95	16.15	15.57	16.08	15.89
19	15.47	14.66	15.32	15.55	17.51	15.02
20	22.49	21.88	23.30	22.88	24.02	22.85
21	16.21	15.93	16.41	16.58	18.27	16.36

Table 39

Standard Deviations for All Variables
in Six Conditions

Variable	Condition					
	Normal	Placebo	Atropine	Dexedrine	Chlorpro-mazine	Physostig-mine
1	43.62	43.86	41.54	57.27	45.56	47.06
2	3.17	3.40	2.70	2.36	2.54	2.50
3	4.49	3.65	4.18	3.49	4.40	3.86
4	3.76	3.43	3.63	3.64	4.60	3.66
5	14.50	14.81	16.36	16.33	15.23	12.94
6	32.66	33.39	32.01	29.32	32.14	29.97
7	11.55	10.87	8.32	12.12	15.25	13.62
8	16.22	14.03	10.82	12.48	13.96	11.54
9	38.49	41.94	36.84	45.20	44.18	41.64
10	2.41	2.18	2.57	2.08	2.03	2.60
11	6.29	4.95	5.14	5.17	6.33	5.73
12	4.76	4.65	5.22	4.40	4.33	4.94
13	5.38	5.64	5.01	4.87	6.33	5.19
14	7.17	7.73	8.53	6.73	7.80	7.94
15	7.00	6.94	6.77	6.80	7.79	5.12
16	2.15	2.20	2.53	2.04	1.90	2.44
17	6.87	6.15	5.35	5.94	6.98	5.51
18	4.26	4.12	5.08	4.41	4.18	4.46
19	6.05	6.05	5.35	6.06	7.70	4.27
20	5.84	5.81	6.82	6.92	7.01	6.49
21	6.77	6.10	5.32	6.56	8.51	4.12

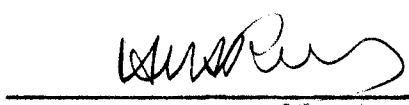
APPROVAL SHEET

The dissertation submitted by James B. Erdmann has been read and approved by five members of the Department of Psychology.

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the dissertation is now given final approval with reference to content, form, and mechanical accuracy.

The dissertation is therefore accepted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

JANUARY 20, 1966
Date



Signature of Adviser