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SPEED AND PATTERN OF VOCAL AND MANUAL RESPONDING TO SINGLE AND DUAL LIGHT DISPLAYS

by

Howard Charles Eisner

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Psychology)
in The University of Michigan
1972

Doctoral Committee:

Professor J. David Birch, Chairman
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CHAPTER I

THEORETICAL BACKGROUND

Introduction

The variety of activities exhibited by man is almost limitless. Among these activities, language stands out as the most distinctive aspect of human behavior; and yet no feature of human behavior has proved more difficult to analyze than that of the meaning and function of language. One of the most crucial aspects in this analysis of language is to determine what, if anything, is special about man's linguistic capacity. Hebb (1966), for example, defines three broad levels of communication. The most basic level is that of reflexive communication. This is the form of communication in evidence when an organism shows an innate responsiveness to stimulus inputs from some other organism. Thus, certain ants utilize odor to determine whether an approaching organism shall be allowed access to the colony. One odor "communicates" to the ant guarding the entrance that the new arrival is a member of the colony and should be admitted, while another odor "communicates" a message of danger. The latter typically evokes a reflex of hostility and attack by the guardian ant upon the approaching organism.

Hebb's second level of communication is what he calls purposive communication. The critical distinction between this and the more primitive type of communication is "whether the 'sender' acts in such a way as to affect the 're-

ceiver's' behavior, and modifies the communication according to its effect on him (or lack of effect). In purposive communication the sender remains sensitive to the receiver's responses" (Hebb, 1966, p. 296). A dog may, for example, bark at its master when it wants its bedtime treat. Depending on the success of such activity, the dog will either run toward the cupboard where the treat is kept if its master gets up and starts in the direction of the cupboard or may begin some new activity such as begging or whining if the initial message does not produce the desired effect.

In man, one can see instances of both the primitive reflexive level of communication (as in the smile when a long awaited friend is finally spotted in the distance) as well as the purposive level. This second type might be demonstrated by someone pointing to where another person should look when the latter is searching for some missing item. In addition, however, man attains a third level of communication which Hebb sees as uniquely human. Man possesses true language which Hebb defines as "the <u>varied combination</u> of the same signs...for different purposes" (p. 297, italics in the original) and which Carroll (1964) has called "a socially institutionalized sign system."

More specifically, this means that man possesses a set of signs and symbols by which he can create thoughts and ideas, either for his own use or for the purpose of imparting information to others. The symbols can be in verbal, written, or gestural form. What is unique about such a sign system is that the units can be combined and recombined

in what amounts to an infinite number of ways to create new meanings (see Mowrer, 1954).

DeLeguna (1927) makes the same point in a slightly different manner. She sees true language as dependent on predication. As the need for coordinated activities among individuals increases, one word communications no longer are sufficient. Man has had to develop different sign classes to refer to objects, to qualities describing these objects, and, more crucially, to acts involving these objects. Predication aids in the communication of needs that extend beyond the immediate present or which are too complex to be conveyed through a single word utterance. The invention of multiple classes of signs provides the mechanism for transmitting more precise and sophisticated forms of information. It is also the case that by substituting one word member of a class for another an entirely different idea can be created.

Such a definition of language is not without difficulties, however. Parrots, for instance, can produce a complete sentence in verbal form. In addition, a psychologist could point to the reinforcement record of the animal and claim that the animal was producing the verbal sequences because of its past history of training and reinforcement. And yet, one does not want to term such behavior linguistic. The parrot cannot, for example, replace one word in its utterance with another in order to change its meaning. Furthermore, no parrot has been shown to understand such symbolic usage when it is the receiver rather than the sender of the information.

Even this qualification of what is language is not entirely adequate. Marler (1970) has investigated the development and functions of birdsongs. He has been able to identify five to 14 different sounds. These sounds can be arranged into highly organized patterns or songs. These songs may be so specific that a local dialect used by one group of birds may be recognizably different from that of another flock separated from the first by only a few miles (Marler and Tamura, 1962). Here, one sees a very specific form of communication that can be used to obtain a mate or give notice of a territorial boundary to other males. Its symbols are specific and understood by other members of the species. Furthermore, the songs are learned through interaction with other members of the flock rather than being purely innate responses. Why then are birdsongs not considered a true form of language? The answer probably lies in the limited number of sound arrangements actually generated and the fact that the songs are usually produced only for the purposes of protection and propagation of the species. In this latter respect, they seem to resemble Hebb's more primitive, reflexive level of communication--although it might be hard to maintain this argument in the situation where there is no specific social stimulation present but instead the birdsong appears to occur spontaneously.

In looking for parallels as well as differentiating features between human language and communication systems employed by the remainder of the animal kingdom, it is nat-

ural to investigate the possibilities of teaching language to other primates. An early attempt by one couple to teach English to a chimpanzee proved largely unsuccessful. The animal was capable of responding to many different commands, but never was able to speak (Kellogg and Kellogg, 1933). More recently two psychologists tried to shape an infant chimpanzee to emit speech sounds. After six years of intensive training, the animal had learned only four sounds which were recognizable English words (Hayes and Hayes, 1951).

This previous work led some psychologists to conclude that man may be biologically endowed with a unique ability to acquire language. Lenneberg (1964, 1967) has made an extensive study of morphological and functional specialization from which he has inferred that man's vocal apparatus is peculiarly suited for the production of verbal behavior. He further states that "Language is the manifestation of species-specific cognitive propensities. It is the consequence of the biological peculiarities that make a human type of cognition possible" (Lenneberg, 1967, p. 374).

This hypothesis that man is biologically unique in his linguistic endowment can be criticized on several grounds. It does not follow that because scientists have been unable to teach primates to speak that these animals are incapable of any form of linguistic behavior. Certainly, if such an animal were to write recognizable sentences, this could be taken as satisfactory evidence that it had acquired language.

Furthermore, there are many deaf people who never learn to speak but communicate through manual gestures. This fully developed signaling system certainly qualifies as a language. Perhaps a chimpanzee could learn this form of language behavior, particularly since chimpanzees typically use their hands in many activities.

To test this latter hypothesis, Gardner and Gardner (1969) attempted to teach American Sign Language (the form of sign language employed in North America) to Washoe, an infant female chimpanzee. Through imitation, prompting, and instrumental conditioning, the Gardners were able to get Washoe to learn signs for objects in her environment. After 22 months, Washoe had learned 30 to 34 signs. The criterion was "at least one appropriate and spontaneous occurrence each day over a period of 15 consecutive days" (Gardner and Gardner, 1969, p. 670). Several interesting analogues to language acquisition in infants have been noted such as an exponential increase in the number of signs learned over successive time periods and over-generalization of signs to inappropriate contexts followed by successful differentiation of context.

Language, however, involves putting together combinations of signs. The most significant finding from the Gardners' research is that as soon as Washoe had learned 8 or 10 signs, she began to use them in combinations. She has emitted many two, three, and occasionally even four word strings. Often one word such as "More" would be used in different contexts with several other words such as "More

Sweet" and "More Tickle." This is very reminiscent of Braine's (1963) classification of children's two-word sentences, with a small group of words (pivot words) appearing frequently in combination with a larger class of less frequently used words (open words). Further, many of Washoe's word strings have been her own invention and thus cannot be attributed to mere imitative behavior.

Does this mean that another organism besides man has learned to use true language? Unfortunately, no clear answer to this question is available. The Gardners were very careful to indicate that the determination of whether Washoe had mastered language was not their intent. Roger Brown (1970) has made a careful analysis of the written and photographic records of Washoe's behavior. He concludes that Washoe has made remarkable semantic accomplishments, but he feels that she has not yet demonstrated syntactic capacity. For example, she does not yet consistently show understanding of agent-object relationships. Signs in a particular combination tend to occur in all possible orders. Brown, however, further concludes that it has not been demonstrated that Washoe lacks this capacity. There is, for instance, little pressure on Washoe to use only the proper word order when she communicates. It is also true that Washoe is developmentally still very young. Perhaps with time, more appropriate and complex word strings will appear.

What the work with Washoe does imply is that part of Lenneberg's hypothesis which postulates man's linguistic uniqueness is clearly open to question. An organism other

than man has demonstrated the ability to understand signs and to use them appropriately both individually and in novel combinations. This satisfies what many have defined as the essence of linguistic competence. Defenders of man's linguistic uniqueness have been continually forced to make a more fine-grained analysis of the essential attributes of language. It has become necessary to be much more precise in the description of semantic and syntactic structure. This serves the beneficial purpose of advancing our understanding of language. It has also highlighted the difficulties in determining what there is about man's linguistic behavior that is unique.

The discussion so far has been centered around what are the basic elements of language and which of these elements, if any, are unique to man. It is also possible to adopt an altogether different approach to the investigation of man's linguistic behavior. Rather than being concerned with linguistic units per se, one could look at the behavioral side of the question and attempt an analysis of how language acts as a regulator of human behavior. The central core of such an analysis involves a shift from a concern primarily with the structure of language to an exploration of how language functions and interacts with other forms of human behavior.

The remainder of this paper will examine the latter type of question. It will investigate the nature of "verbal control"--the role of speech in the regulation of human behavior (Luria, 1961; Birch, 1966). This examination will

attempt to discover whether language furnishes mankind with intellectual capacities that are somehow different from the type of function exhibited in other forms of intellectual activity. Is man's superiority a result of new abilities or is this only a reflection of the kinds of advantages that might follow from an augmentation of functions that already exist in other organisms? In other words, is man's language and language-related behavior a qualitative or a quantitative step up from behavior in the rest of the animal kingdom?

Soviet Studies of Language

In an attempt to answer these questions, this paper will specifically examine one systematic "theory" which has been developed in Russia to explain the role of speech in controlling human behavior. The Russian system has been chosen because its development is based on the control functions of language and because a large body of literature has been produced in the Soviet Union which purports to show the unique nature of human language. The next section of this paper will look at the historical roots of the present day Russian theory of verbal control. This will be followed by a detailed analysis of the ideas of A.R. Luria, who is generally considered the leading exponent of the Russian system. Subsequent sections will deal with contributions of other Russian investigators to verbal control theory and will attempt a reevaluation of the Russian position and of the more general problem of language and intellectual ability.

Historical Background

Pavlov. A great deal of the impetus for Soviet research on the role of speech in the regulation of behavior has resulted from the theoretical contributions of the Russian physiologist-psychologist, Ivan Pavlov. Pavlov is best known by psychologists for his "discovery" of the conditioned reflex. In reality, as Pavlov himself acknowledged, his contribution to psychology lies in the discovery of an objective method for the study of the reflex--which had already been known for 300 years or more and which had already been theorized about in Russia by Sechenov a half century earlier (see Sechenov, 1863). Pavlov understood that all the earlier theorizing was mere conjecture. "The time was ripe for a transition to the experimental analysis of the subject--an analysis which must be as objective as the analysis in any other branch of natural science" (Pavlov-Anrep, 1960, p. 5). Insofar as this meant a dismissal of subjective speculation about "higher nervous activity," the widely accepted view that Pavlov was opposed to psychology is correct. But on another level, "Pavlov's refusal to use psychological terminology was nothing more than the act of a man of genius, a brilliant discoverer who clearly saw that the law of the conditioned reflex is the law governing objectively developed nervous processes in the human and animal brain" (Anokhin, 1968, p. 131).

Pavlov's conception of higher nervous activity in man embodies three distinct levels of behavior. At the core is a set of adaptive reactions which are genetically determined and common to all members of the species. During their lifetime, organisms develop a more advanced mode of adaptation based upon conditioned reflexes. Pavlov postulated that both animals and man possess this system of signaling reality that is based upon stimuli from the environment. Pavlov named this the "first signaling system" and stated that:

> The developing animal world on reaching the phase of man acquired an exceptional supplement to the mechanism of nervous activity. To an animal, reality is signalled almost exclusively merely by the stimulations--and the traces that they leave in the cerebral hemispheres--conveyed directly to the special cells of the visual, auditory, and other receptors of the organism. This is what we likewise possess in the form of impressions, sensations, and conceptions of the environment, both of the general natural environment and of our social environment, with the exception of words--visible and audible. This first system of signaling reality is the same in our case as in the case of animals. But words have built up a second system of signaling reality which is peculiar only to us, being a signal of primary signals. The numerous stimulations by word have on the one hand, removed us from reality.... On the other hand, it was nothing other than words which have made us human... (Pavlov-Gantt, 1941, p. 179).

This basic idea of a second signaling system has been refined by various Russian physiologists and psychologists until today it is viewed as providing a qualitatively different system in man from anything possessed by animals. Pavlov himself insisted that the innova-

tion of speech introduced "a new principle of nervous activity..., the abstraction and generalization of innumerable signals." It is this "new principle which enables the second signaling system to become the highest regulator of human behavior"(Pavlov, quoted by Luria, 1957, p. 116).

The second signaling system widens immensely the reality which man can experience. It reshapes the first signaling system and is, in turn, affected by this more primitive system until the two systems form an integrated unit. Pavlov felt that the same fundamental laws operated in both systems. His contributions to psychology and to the study of language thus include the objectification of the investigation of human verbal activities and the suggestion of a method whereby one can experimentally study language in a manner similar to the way one studies more primitive conditioned reflexes.

Moreover, Pavlov's introduction of the concept of the second signaling system as a qualitatively unique system of reflecting reality has become the cornerstone of Russian theorizing and experimentation on verbal behavior. It is the universal given from which all later work has derived. This is not to imply that psychology in the Soviet Union is nothing more than classical conditioning. As Cole and Maltzman (1969) have pointed out, psychology in the

U.S.S.R. has never been exclusively restricted to Pavlovian principles of conditioning; and, in fact, at the present time there is very little work being done in the Soviet Union on classical conditioning. Rather, what Pavlov's major influence has been is to provide literally a Weltanschauung from which to pursue problems in psychology and verbal behavior.

Vygotsky. The other major contributor to early Russian theorizing about language was L.S. Vygotsky. Vygotsky was a contemporary of Pavlov and was familiar with the latter's work on higher nervous activity. Vygotsky accepted the idea that psychology was dependent upon a firm physiological foundation for its development. He even granted that the conditioned reflex was the basic process underlying mental activity (see Leontiev and Luria, 1968). Vygotsky, however, saw the need to go beyond this elementary analysis when examining human behavior. To understand human behavior he felt that one needed a new unit of analysis--that of "word meaning," which is the unit which contains thought and speech interrelated.

Thought and speech were viewed by Vygotsky as arising from different roots. Thus, there can be a prelinguistic phase in the development of thought and a preintellectual period prior to the development of speech. These two functions can follow along

different developmental paths which are not necessarily parallel. At some point, however, these paths converge and the unit of word meaning evolves, wherein thought becomes verbal and speech rational (Vygotsky, 1962).

In order to understand how this higher form of psychological activity evolves, Vygotsky found it necessary to move beyond the analysis of a person's individual history and adopt a socio-historical analysis of human development. Such an analysis begins with the assumption that man lives through the process of work. He not only reacts directly to the environment; he also invents mediators to intervene between himself and this environment. These mediators take the form of tools and language. They are the products of the history of man's development. Originally, an individual uses these means to affect his external environment, but with time these means and in particular language become internalized.

Vygotsky gives as an example of this process his interpretation of the manner in which man remembers. In the most primitive stage, a young child relies on his natural memory for subsequent recall. At a more advanced stage, he may tie knots in a string thereby affecting his environment in a way that can be useful later in aiding his inner thought processes in what is to be recalled. As this process becomes more and more refined, external signs become replaced by in-

ternal signs in the form of language, which then takes the lead in the direction and regulation of man's thinking and remembering (Vygotsky, 1929).

This gradual interiorization shapes and then reshapes man's mental processes. It is in this way that man's "real consciousness" arises--not from a blooming from within but from the interiorization of something which was once external. Furthermore, the external means of controlling the environment are at first shared between the individual and society. Then as the individual cooperates with others in joint work activities, and as he engages in social interactions with those around him, he begins to develop a separate consciousness. What was once shared by two people evolves into the mechanism for the internal regulation of one person's behavior.

Such an analysis must also then signify that language and word meanings are the products of social interchange. The primary function of speech in young and old alike is for communication. Thus, the young child's earliest speech is a shared activity. In this manner, too, the child can incorporate the wisdom of those around him, although at first he may only dimly understand what he hears. Gradually, however, with maturation and through an unspecified dynamic change in his own mental processes, the child begins to attach meaning to what he hears. One also begins to see an emer-

gence of egocentric speech. The child comes to use speech first to accompany and then to regulate his own behavior. Egocentric speech takes on "a directing, planning function and [raises] the child's acts to the level of purposeful behavior" (Vygotsky, 1962, p. 17). Finally, in the last stage of language development, egocentric speech disappears, but its function is maintained by inner speech. The latter assumes the role of regulating adult autistic and logical thinking. Vygotsky thus theorized that language shifts from a social to an individual activity and that its purpose, in turn, shifts from a simple communicative labeling device to, first that of an accompaniment to activity, and then in its final form to the initiation and regulation of human behavior. It is in this fashion that language becomes Pavlov's "highest regulator of human behavior."

Ideology and Philosophy

The third significant influence in the development of Russian thinking about language is the network of people, ideas, and actions which constitute Soviet ideology and philosophy. Although one seldom encounters explicit references to politics and although philosophical references are so general as to mute the tone of what is really implied, it is nonetheless true that what is written in the Soviet Union about language or any other topic in psychology must closely conform to the official Soviet conception of man (see Bauer, 1952; Tucker, 1963; Wozniak, 1972. For a slightly different

but not entirely contradictory viewpoint, see the Editor's Introduction in Cole and Maltzman, 1969). Since this official conception of man has shifted from time to time since the 1917 Revolution, one can see corresponding shifts in Soviet psychological theorizing. These changes in theory over time should not be viewed in the same manner that one can discern changes over the years in theorizing about the nature of reinforcement. While the latter are usually a reflection of increased knowledge about the nature of the problem derived through experimentation, the former are most oftentimes reactions by professional psychologists to ideological shifts arising largely outside the realm of psychological research. In order to fully understand Soviet thinking about language, it is, therefore, necessary to examine briefly the dominant concepts which have emerged or been imposed upon Soviet psychology over the past half century.

The period from 1917 to 1929 was one of great activity and experimentation in Soviet psychology (see Chapter 4, in Bauer, 1952). Several different schools of psychology coexisted--Pavlov's theory of the conditioned reflex, Bekterev's "Reflexology," Kornilov's "Reactology," and even an offshoot of American behaviorism had its devoted followers. Certain trends such as a strong commitment to the objective method (as exhibited in the work of Pavlov) and an emphasis on determinism could be detected; but, in general, researchers were free to write and think as they wished. By 1930, however, a search had begun to determine what kind of psychology was the correct view as interpreted from Marxist principles.

The different schools of psychology gradually disappeared from sight.

A turning point in Soviet psychology was reached in 1936 with the issuance of the Decree against Pedology. Although it was principally directed toward education, the Decree also shaped the course of future psychological thought in the Soviet Union. The test movement was abolished. Industrial psychology was greatly curtailed. A new model of man emerged which was based upon the importance of the socio-economic environment. The influence of training was emphasized and set apart from the rest of man's environmental influences. Consciousness became the fundamental principle in Soviet psychology. It is the "highest most specifically human level of development of the psyche" (Smirnov, quoted in Bauer, 1952, p. 132). In addition, consciousness is intimately connected with action. Consciousness both directs man's actions and is, in turn, shaped itself by the result of these actions. Man is viewed as purposefully striving for the achievement of goals (Bauer, 1952).

The period from 1936 to 1950 saw a continual refinement of these concepts of training, action, consciousness, and purpose. The science of psychology deteriorated as investigators spent most of their energy making certain that their statements accorded with the Marxist-Leninist party position. Psychology journals disappeared and the field largely became subsumed within the discipline of education.

In 1949 yet another ideological shift occurred. September of that year marked the one-hundredth anniversary of the

birth of Pavlov. A national conference was convened the next summer to reevaluate the theories of Pavlov. The result was the Pavlovianization of Russian psychology, probably as a direct result of official political pressure from Stalin (Tucker, 1963). Whereas before 1950 Pavlov had always been greatly admired, after this date his writings became the bible for all Soviet research in psychology. The second signaling system, which is only cursorily mentioned in Pavlov's books and notes, became the central focus of all subsequent research on language and is the major theme of the material discussed in the remainder of this paper.

What all of this ideological influence has meant for Soviet psychology is that professional investigations and theorizing have been shaped by forces other than those normally effective in scientific research. Vygotsky's sociohistorical approach to language plays a dominant role in Russian theorizing not just because of the brilliance of his ideas, but because such a concept fits the official conception of man. Other scientists whose ideas were not so compatible with ideology were simply removed from their positions and their work disclaimed. Consciousness and action are the distinguishing characteristics of man because this is what Russian leaders want their people to believe. And Pavlov's second signaling system based upon conditioned reflexes is the theory tying together all the work on language because Stalin decreed it to be this way. This is not to say that thinking about language would have been any differ-

ent without ideological influence. It does, however, explain why other approaches such as a behavioristic analysis have not been developed. It also explains why the same basic concepts and terms are employed by all of the people working on a particular topic.

Luria

For the last forty years, the major Russian theoretician has been A.R. Luria (1928, 1932, 1957, 1959, 1960, 1961, 1969; Luria and Yudovich, 1959). Luria displays in his work both the influence of Vygotsky with whom he was closely associated before the latter's death in 1934 and that of Pavlov whose formulation of the second signaling system guides so much of the Russian research. To all of this, Luria has added his own unique conception of how the child uses language to regulate its behavior.

Luria accepts the socio-historical approach to language. He takes the position that mental functions are not inherent properties evolving within the individual. Rather, one must look to the child's social condition to understand human mental development. The child from birth is in the closest contact with its mother who is the source of satisfaction of his biological and psychological needs. These contacts which at first are direct and emotional later come to be mediated through speech. The speech of the mother and others surrounding the child is at first a mechanism of communication with the child. It is in this fashion that the child acquires in a ready-made form the experience of

others. These include both the specific experiences directly related to the infant and a history of general human experience.

These contacts with adults do more, however, than just provide a way to acquire experience. As the child learns the meaning of words, his complex mental processes are being formed and then constantly reformulated. Functions such as memory, perception, and attention are developing not just in a vacuum, but in conjunction with the whole process of mastering human experience. This is followed by the origin of those "higher psychological functions" which include voluntary attention, active memory, and voluntary action "whose sources are to be sought not in the depths of the mind but in the forms of the child's relationships with the adult world" (Luria, 1961, p. 16).

Luria places great stress throughout his writings on the concept of action. A child does not just acquire mental functions; rather, these "result from a lengthy evolution in a child's actual behavior" (Luria, 1961, p. 15). It is further true that "even the most complex manifestations of mental life are formed in the process of active reflection of reality" (Luria, 1969, p. 122). The mind itself is even treated as a form of activity which at first was shared by two people (e.g., arose through communication) and later becomes a form of behavior within a single person (Luria, 1969, p. 143). It is in this way that a child's consciousness is manifested. Activity "socializes" the original autistic consciousness of the newborn child.

As the child actively constructs his own mental structure, other changes occur as well. Speech is used first to describe an activity already accomplished. With time, the role of speech shifts to that of an accompaniment of action and finally to that of planning and regulating the child's behavior. At the same time, fully expressed overt speech becomes gradually transformed into shortened, covert form. This internal speech, however, fulfills the same function of characterizing the nature of previous experience and mobilizing all necessary functions in the planning and regulation of future activity. The child's inner speech is thus indissolubly linked with his thinking and activity, just as his overt speech was at an earlier stage of development. The next portion of this paper will describe the stages of development in a child's speech as its function matures from the overt, descriptive level to the covert, regulative level.

Stages of Development. During the first half year of life a child will begin to show responses to verbalizations of adults in the form of smiles or even turning of the head. Kol'tsova (in Luria, 1969) has demonstrated that at this stage, however, the word should not yet be considered a part of the child's second signaling system. At this earliest stage, the word appears to be only one of a number of features such as visual appearance and texture which are associated with the specific object indicated by

the word. Furthermore, the word will only produce the appropriate reaction if it has a specific intonation, is accompanied by specific gestures, and is produced by a specific individual in a specific situation. If any of these conditions are eliminated, the word ceases to have meaning for the child. It is only during the next half year that the word becomes freed of the conditions under which it is uttered. At this same time, with the increase in the child's experiences and activities, the word ceases to be associated with only a single reference object (e.g., "Ball" with a specific ball) and gradually generalizes to a number of similar objects. It now begins to resemble what Pavlov termed a "signal of signals."

It would still be wrong, however, to think that, by the start of the second year, the words in a child's vocabulary have the same meaning for him as they do for an adult. While the child can recognize and pick out the correct object designated by such simple words as "Dog," "Cat," and "Fish," the pragmatic, directive function of speech is still weak. If a toy fish and toy dog of equal attractiveness are placed an equal distance from the child and he is asked to get the fish, he easily performs the correct response. The same experiment is then repeated several times. If the child is then asked in the same tone of voice to get the dog, he frequently will get the fish. Similarly, if a child

of 1:2 is commanded to "Put the ring on the stick!," he can usually carry out the instruction correctly. If, however, while the child is putting rings on a stick, he is commanded to "Take off the ring!," the effect of the directive fails and the child only intensifies his activity of putting rings on the stick (experiment of Poljakova, reported in Luria, 1959). Adult speech can thus initiate activity in the year-old child, but the directive function of the word is effective only when it does not conflict with the inertial buildup of connections from the earlier instructions.

Luria's own research examines the conditions which are necessary for the development of verbal control of behavior by the child. He begins by instructing a child of 18 months to squeeze a rubber balloon. These instructions will reliably produce the required action, but the child cannot stop additional squeezes once initiated. The additional verbal instruction "That's enough" will not inhibit further responding. Instead, it often intensifies the activity in progress. Thus, speech can initiate but not inhibit behavior at this early point in development.

Even more difficult is what Luria calls the preparatory or regulating function of speech. This is illustrated by instructing the child "When you see the light, squeeze the bulb!". Such a command requires the child to set up a preliminary plan regulating a subsequent

course of action. Yakovleva (in Luria, 1961) has shown that it is impossible to establish such a contingency plan in a child of 18 months or even two years. Upon hearing "When you see the light," the child begins to look for the light. When he next hears the words "...squeeze the bulb!,"he immediately begins pressing the rubber balloon even though no light is present. If the light does now come on, he produces a second orienting response which frequently inhibits the very reaction of pressing which was the intent of the original command. Here again, it is seen that the nominative function of the word is present in the very young child. The child understood the meaning of "Light," "Squeeze," and "Balloon." He can even initiate a pressing response to a simple command, but inhibition and regulation of the occurrence of responses cannot be directly achieved.

The conditional responding of the child upon the occurrence of the light <u>can</u> be accomplished through indirect methods. One solution is to approximate the desired behavior much like one trains a rat by building the response link by link, using extensive practice at each step. Even then the reaction remains unstable, and extra-signal responses are frequent. An alternative procedure is to modify the experiment such that the child is instructed when he sees the light to press the balloon <u>and</u> then to place his hand

on his knee. Moving the hand to the knee is incompatible with pressing the bulb and thus serves to inhibit all but the first bulb squeeze. The child who has been thoroughly trained to obey the instruction "When you see the light, press the bulb!" easily masters this new set of instructions and thus learns to inhibit the first action through a second. The distance to be moved after pressing the bulb can then be reduced until, at last, the second action can be dispensed with entirely (Luria, 1961).

Another way of achieving indirect control of a child's behavior is to make external feedback from the response achieve the desired inhibitory effect. After preliminary training, the young child is instructed to press the bulb when he sees the light and then he will hear a bell sound. This exteroceptive signal serves to indicate the completion of the activity; and, in a majority of children aged one and one-half to three, this change resulted in the elimination of all but the first press to the appearance of the light (experiments of Yakovleva, reported in Luria, 1960).

To summarize, at the earliest stage of verbal control in the child, extending from the beginning of the child's second year to the end of his third year, the child can initiate activity upon command but cannot inhibit activity once it is in progress. The child cannot readily adopt a program for regulating his sub-

sequent activity. Such a program can only be approached by lengthy step-by-step training; while inhibition of response can be achieved only by the performance of a response incompatible with the to-be-inhibited act or through external feedback signifying completion of the designated response. Self-regulation at this time is therefore at a very primitive level.

The next stage of development begins near the end of the child's third year and extends until nearly the end of the fifth year. Experiments described by Luria which cover this age range utilize first the speech of adults and later the child's own speech to develop a more sophisticated control over the child's behavior. The first thing which Luria notes is that for the child of three to three and a half the conditional nature of the command "Press only when the light comes on!" is easily understood. The child will make the required conditional response, but is still unable to inhibit extra intersignal responding. Experiments by Tikhomirov (in Luria, 1959) show further that the more complex instruction to press the bulb every time a red light comes on but not to press when the blue light appears, again produces appropriate conditional responding to the red light; but the positive response still remains diffuse, often producing more than one bulb squeeze. Moreover, after the first few trials, the child is unable to inhibit responses to the blue

light. It thus appears that by three or three and a half, the child can momentarily carry out the instruction of the adult, but his responding is still not well controlled.

An experiment by Paramonova (in Luria, 1959) shows that correct responding by the same three year old child can be achieved if each occurrence of the red light is accompanied by the verbal command "Press!" and each blue light is accompanied by the experimenter's command "Don't press!". What could not be consistently achieved through a single preliminary presentation of a set of rules is readily accomplished when correct instructions are repeated by the experimenter on every trial.

Luria (1961) also reports studies of children this age in which the child's own speech is used to regulate his responding. In the first study, the child is instructed to react to each signal with the words "Go!" "Go!". The three or four year old child quickly and consistently coordinates its vocal response with the light signals. "In contrast to the experiments demanding motor reactions, these experiments resulted in practically no perseverating verbal behavior produced independently of the signal, nor on the other hand did the responses become extinct. All the data obtained showed that the neurodynamics of simple verbal reactions at this age become much more perfect than the

neurodynamics of the motor reactions..." (Luria, 1961, p. 75, italics in the original).

In a related experiment by Peskovskaya and Tikhomirov (in Luria, 1961), the child is instructed to say "Go!" and simultaneously press the bulb at each flash of light. The task is correctly performed as long as the self-produced verbal signals continue. With their cessation, the light signal no longer consistently controls the performance of the manual (bulb press) response alone.

It might then appear that the child of three or four has at last achieved self-regulation of his behavior. This, however, is only partially correct. First, it is clear that motor responses unaccompanied by verbal reinforcement still are performed erratically and cannot be inhibited for signals where no response is required. It is also the case that verbal reinforcement by the adult or the child must accompany each trial. The child cannot preset his behavior by a single repetition of a rule at the start of the experiment and then correctly carry out the task in silence.

Finally, further experimentation showed that the vocal function of the child's own speech had not yet achieved full significative, semantic control of his behavior. The child of three or four can respond to each light flash with the verbal responses "Go!" "Go!" and two

simultaneous hand squeezes on the bulb. If the experiment is now altered slightly, however, so that each flash of light is to be followed by the self command "I shall press twice!" and two manual responses, a different result follows. The child usually accompanies this command with a single extended squeeze on the rubber bulb (experiment of Tikhomirov, in Luria, 1961). An even more significant experiment by the same author demonstrated that a child could respond to a positive light signal with the word "Press!" and a single motor reaction, but the verbal response "Don't press!" to a negative signal produced an intensified squeeze of the bulb. Only if the child remains silent on the negative trials will bulb squeezes remain inhibited.

From these last experiments, Luria (1961, p. 91) concludes that "it is perfectly possible for a child of three to four years of age to regulate his motor reactions with the help of his own speech.... However, at this early stage--at least in conditions of our laboratory experiments--this regulatory influence proceeds from the non-specific, impulse aspect of the child's own speech rather than from its elective, significative aspect" (italics in the original). It is only beginning at four and a half to five and a half that this significative role of speech begins to appear in the child's own speech.

Several distinguishing characteristics are typical of

the significative stage. The child can now formulate a system of motoric responses by verbal instruction only. He can even learn at once to obey a command such as "Press to the red light but not to the green light!". The child can also inhibit his manual response to a conditioned negative signal even if he does verbalize the command "Don't press!" because words have developed significative rather than impulsive control over behavior. Behavior begins to be regulated by internal rules, as external forms of speech become greatly diminished. Only in very difficult tasks such as where the presentation of the signals is greatly speeded up must the child return to overt vocalization to regulate his behavior.

This internalization of speech is viewed by Luria (see Luria, 1961, p. 95) as another and final stage in the development of the child's control of its own behavior. Thought and voluntary action are now regulated by this internal speech and the child begins to use this verbal system to analyze his problems and to formulate rules for their solution. It is a process which continues to be refined even during the adolescent years and which only then truly resembles Pavlov's highest regulatory system.

Finally, it should also be noted that for all stages of mental development, Luria specifically attributes the causal role to speech organization and not to gen-

eral maturation. As proof, Luria relies heavily on a study he did on a pair of five-year-old twins whose speech development was greatly retarded (Luria and Yudovich, 1959). This retardation was due to a number of genotypical factors. It was further aggravated by what Luria termed the "twin situation"--the very close contact between the twins which allowed them to understand each other's primitive speech and which made more highly developed speech unnecessary. Their speech consisted of only a small number of words, many of which had special forms and meanings that were unintelligible to the outside observer. It was further true that the twin's understanding of speech of others was very limited and that all of their behavior, especially play, was very primitive for normal children of that age.

Luria's solution of the problem was to separate the two children for three months. Each was placed in a separate kindergarten group. In addition, the twin with the more primitive speech development was given special speech training. Within three months, the twins showed substantial improvement in their speech. Simultaneously, "The whole structure of the mental life of both twins was...sharply changed. Once they acquired an objective language system, the children were able to formulate the aims of their activity verbally and after only three months we observed the beginnings of

meaningful play; there arose the possibility of productive, constructive activity in the light of formulated aims, and to an important degree there were separated out a series of intellectual operations which shortly before this were only in an embryonic state" (Luria and Yudovich, 1959, p. 122).

Other Russian Theorists

Although Luria is the best known of the Russian psychologists working on speech and the control of human behavior, it would be unfair to presume that other Russian scientists have not also made substantial contributions to this topic. It would be impossible to give credit to all of these workers, but this section attempts to present in brief form the views of certain other psychologists whose ideas have been influential in the Soviet literature.

Zaporozhets. A.V. Zaporozhets (1957, 1961, 1969) has concentrated his research on the origin and development of voluntary activities in man. He has noted that the way a child approaches a motor task is very different at various stages in development. Like other Russian psychologists, Zaporozhets acknowledges that the acquisition of voluntary control of movements derives from social models. The regulating role of images in shaping and carrying out activities also gains increasing importance. And, "At the same time, because of the existence of the second signal system, the

images that are created in man acquire a generalized and conscious character,...[as are the] movements executed on the basis of these images..." (Zaporozhets, 1961, p. 275).

Great stress is placed on the role of orienting and investigatory activities in this mastery of motor acts. There are really two different components involved in a particular motor task. First are the activities which, while not leading directly to the performance of the task, greatly aid the person in orienting toward those factors which are critical for accomplishing the task at hand. Secondly, there are the executive movements which achieve the desired end result.

Zaporozhets has noted that a critical developmental change occurs in the manner in which the child performs the initial orienting activities toward the task. In children of three or four, acquaintance with a new object or unfamiliar task comes about through tactile exploration. At first, this exploration may take the form of haphazard, global touching movements. With time, however, these exploratory manipulations become more systematic. The child begins to trace the contours of the new object, or he develops the ability to traverse the correct pathway through some unfamiliar maze. The child begins to actively learn about his environ-

ment. The adult's role is viewed as that of a tutor. He calls attention to characteristics of the problem which must be oriented toward for an efficient solution, and he may guide the child's hand in systematic exploration of the critical features of this situation.

At a later stage of development, one notes a transition from a tactile orientation to the problem to that of a visual familiarization with the critical features. It is as if "...the eye, which earlier had followed the hand as it felt objects, [borrows] as it were on its accumulated experience and [becomes] able to fulfil the orienting function independently" (Zaporozhets, 1961, p. 279). This transition is particularly pronounced if one compares the behavior of four-year-old children to that of children of six or seven. In the former, visual orientation alone cannot lead to an accurate image of the situation. On the other hand, by age seven, children can use a single glance to structure the whole task and set up an image of the motor sequence needed to perform the task correctly.

In conjunction with Luria, Zaporozhets also notes the increasingly important role of speech in this regulation of voluntary activity. In the same manner that the visual orientation replaces tactile exploration, so too does the role of verbal control of behavior in-

crease in absolute and relative amount. At first, the verbal system may only act along with the visual system to familiarize the child with the conditions of the task. At a later stage, verbal control may replace visual orientation altogether.

Here, verbal instruction can give a complete picture of the object or task without any need for its immediate presence. Words may not only give an accurate representation of the problem, but also provide a method for executing the requisite motor activity. The child thus progresses from a direct exploration of his environment to an abbreviated, interiorized verbal method of orientation. Words not only have an informational role,but they provide for planning subsequent activity; and, in this manner, they become the mechanism for the true conscious control of human behavior.

Galperin. A similar regulatory role is envisioned for language in the formation of more complex mental acts. Galperin (1957, 1969; Galperin and Talyzina, 1961) has developed the most systematic Russian approach to this problem. He has looked at the way children learn mathematical concepts such as that of the meaning of the bisector of an angle in geometry. Learning of concepts is considered to be an activity similar in its initial stages to any of the more elementary motor acts that Zaporozhets investigates.

Each mental act can be characterized by its stage of development along four relatively independent pathways. A mental act first differs in the degree of generalization. The more the critical properties of a concept are distinguished from unessential properties, the higher the degree of generalization. A second measure of the development of mental capacities is concerned with the abbreviation of an activity. A child who, for example, performs an addition problem by counting all the operations out on his fingers is less advanced than is one who abbreviates the task to a single, simple mental act. The third parameter is loosely defined as mastery and measures how familiar a task is to the child and how facile he is in performing the required mental act by the same well-practiced method. Finally, the fourth measure of a mental act refers to the level at which it is carried out. Actions carried out at the level of inner speech, for example, are more advanced concepts than are those performed on the plane of external objects.

Galperin has been principally concerned with the last of these measures. He has made a careful analysis of the levels an activity passes through before it becomes a truly "mental act." In the initial stage, a child is unable to perform the act even in crude form. He gains a preliminary conception of the task through the explanations and demonstrations of the teacher.

This training facilitates orientation toward the important aspects of the task without necessitating any activity by the child. Once the training period is completed, the child begins to master the activity through his own execution of the task using external objects. In counting, for example, he grasps blocks separately and builds up the number by adding more and more units to the pile in front of him. This is carried out by the child under the continual encouragement and instruction of the teacher. Inasmuch as this is a joint activity, it resembles very much Vygotsky's proposals regarding how a child learns to use speech. It also closely resembles the course of action Zaporozhets found in learning voluntary control of motor movements.

When the action is sufficiently well practiced using material objects, the child can then transfer it to the plane of audible speech. The function of speech switches at this stage from that of a mere guide to perceptual and tactual familiarization with the task. Language now emerges as a separate vehicle for the performance of the activity. The role of speech has also switched from a regulator of the actions of others to that of the controlling agent in the child's own behavior. Its function has further changed "from an accompaniment of material action to an independent plane of action; a new context for the action is creat-

ed and the child learns to use this new tool" (Galperin, 1969, p. 261). In the child's counting behavior, this stage is manifested by replacing the handling of the blocks by counting aloud without need of the objects.

Once the activity can be carried out through verbalization aloud, the transfer to an entirely mental activity begins. The verbalization is reduced first to a whisper and then to silent rehearsal. The action is now performed "in the head." It is still a real activity, but its resemblance to the original external copy is quickly reduced. With increasing mastery of this internal regulation of mental acts, the child counts in abbreviated and automatic form. At this final stage, the child can go at once from the initial instructions to the final result. This direct route is facilitated in the child because of his frequent past repetitions of the activity on both the external and internal planes. In addition, the roles of speech and motoric activity become reversed. Whereas at first speech development depended on experience with material objects, now speech develops and guides the course of future actions, both motoric and mental.

Liublinskaya. The regulatory function of speech in mental acts has been further clarified by several other authors. Liublinskaya (1957) has concentrated on the role of the second signal system in developing sensory discriminations. The infant at the age of six months

is already distinguishing different objects in its environment and by the end of the first year can form simple conditioned responses. The introduction of speech into the child's mental abilities provides a fundamental reorganization of the discrimination and conditioning processes. A child aged one and a half to three years can learn to select a paper cup of a particular color or size in order to obtain a reinforcement. Such a connection requires a great amount of practice and proves very unstable.

Liublinskaya has found that if a verbal label (e.g., "Red" for a color discrimination task) accompanies each trial, the speed with which a child learns a task doubles or triples. Once formed, the learning proves highly resistant to extinction. The conditioned reflex can be generalized to other objects of the same color, and transfer to tasks requiring discrimination of a new color is greatly speeded relative to a control group which does not employ verbal denotation of the distinguishing features of the object. The significant role speech plays in abstraction and generalization of critical features is given credit for the significant increase in discrimination and learning abilities.

A further example of the role of speech in abstracting critical variables is cited in the same paper. Children were required to acquaint themselves with a particular butterfly and then to identify this butterfly

from among a number of similar ones on the basis of the pattern of spots and stripes on the butterfly's wings. Without verbal labeling, the task proved impossible. Children would concentrate only on the insect's color. The inclusion of a verbal description reorganized the perceptual differentiation at once. Even the youngest children could now compare the patterns and make proper discriminations. "The introduction of language into the process of visual discrimination [restructured] the whole activity of the analyser and the whole process of sense perception" (Liublinskaya, 1957, p. 200).

Liublinskaya (1957) also found that further development of the child's mastery of grammar signaled even more accurate understanding of the perceptual relationship between objects. Instruction was given in the proper usage of prepositions and adverbs denoting the location and spatial relationship between objects ("On," "In," "Behind," "Above," etc.). Compared with control subjects, children in the instruction group were able to describe more fully whole pictures rather than identifying single objects. The subjects with grammar training could also more accurately state the relationship of the objects represented in the picture. Here, speech was not only singling out objects for identification, but actually

restructuring the child's analysis of how the objects are connected and related in the physical world.

Martinoskaya. Speech can even change the relative strengths of the different components of a complex stimulus. Martinoskaya (in Luria, 1969) displayed to children aged three to five visual stimuli such as a red circle on a gray background and a green circle on a yellow ground. The child was to react with his right hand to the first figure and with the left hand to the latter picture. Test trials employing a red circle on a yellow background and a green circle with a gray ground demonstrated that the dominant part of the complex was the circle. The child still pointed to the red circle with his right hand and to the green circle with his left hand. Martinoskaya then accompanied each picture with vocal reinforcement of the background component. This proved ineffective for children of three to four years, but for children of five or six the verbal instruction shifted the dominant character to the background.

Abramyan. Further work by Abramyan (in Luria, 1969) showed that if meaningful lables were attached to pictures similar to the ones employed by Martinoskaya even the younger children could successfully

react to the background component of the stimulus. The circles were replaced by airplanes and the child was told to respond with his right hand to the yellow background ("Because the airplane can fly in good weather, when the sun is shining") and to use the left hand with the gray background ("Because in bad, gray weather the airplane cannot fly"). "In this case the attribute reinforced by color became dominant and, even when the airplane was a different color, even the youngest children began to react to this physically weak but verbally established critical attribute" (Luria, 1969, p. 148).

Leontiev. A final mental function which has been carefully studied by the Russians is human memory. A.N. Leontiev (1961, 1964; Leontiev and Rozonova, 1957) has been particularly influential in this area. As is so frequently the case in Russian theorizing, Leontiev's analysis of memory is in terms of man's cultural and social development.

Man is considered to be innately endowed with a "biological" memory which is also found in lower animals. The uniquely human memory function is to use tools to supplement this memory. The most primitive type of indirect memory aid relies on objects in the environment. A knot is tied in a string or a stone is placed in one's pocket, and this item is

later used as a tool for remembering. Even at this level, however, memory is mediated. Man actively adapts the environment to meet his needs. But this use of indirect memory aids is no accidental innovation. "It cannot be explained exclusively by the requirements which the environment makes on man; being included in the previous biological forms it can be understood only in connection with the general [socio-historical] history of their development" (Leontiev, 1964, p. 83).

At a more advanced stage of development, man not only employs objects as cues to remember, he may invest these tools with particular meanings. An example cited by Leontiev is the Peruvian "knotted writing" in which the quipu or knots can take on symbolic meanings for the writer. He uses the knots to recall specific ideas, but the meaning of the knots is arbitrary and can be interpreted only by the writer who made them.

Because of work and socio-cultural requirements, man's need to communicate and remember becomes more critical. He can no longer rely on symbols which have arbitrary meanings for a single individual. He must develop a system where the symbols can be understood by all the members of the group. For this reason, first picture writing and then the more conventional symbolic system of written speech evolved.

> At the final stage of human advancement, the employment of external memory aids is replaced by internal cues, especially language. "In this process of formation of inner experience in man the central role undoubtedly is played by speech; specifically in speech are the associations present which are necessary for mediate memory and are the intentions created. It may be supposed that the very transition, made from externally mediate memory to internally mediate memory, is most closely associated with the transformation of speech from a poorly [sic] external function into an internal function" (Leontiev, 1964, p. 89).
>
> Man thus has reached a stage where he is master of his own mental functions. Activities which once were shared by the group become the basis, at first for externally mediated tools for the control of a single individual's behavior; and, at man's highest level of achievement, these tools become the basis for the internal, verbal control of our own private mental lives.

Evaluation and Conclusions

Stages of Development

An initial problem in evaluating the Russian treatment of language arises when one considers Luria's analysis of the manner in which a child develops verbal control. Luria clearly states his belief that development occurs in stages:

> One of the basic tasks of this young science is to make a thorough study of the qualitative changes in a child's higher nervous activity from the moment speech begins to affect his active behavior, and an equally thorough analysis of the main developmental stages in the regulatory role of speech (Luria, 1961, p. 49, italics added).

It is equally apparent in the Russian writings, from Vygotsky to the present, that the changes in the pattern of verbal control occur through the interaction of the child with those around him. Yet even Luria is less than precise in demarcating when these qualitative shifts occur. Nor is there concrete proof that the abilities manifested at later stages are not already present in primitive form at some earlier point.

It was pointed out earlier, for instance, that a primitive stage of development appears soon after the first year when speech has a simple impellant or initiating control over the child's behavior. Luria adds that at this stage adult speech can initiate an action but cannot inhibit or shift a child from one action to another. An example has been cited wherein an instruction to take off a ring while a child is putting rings on a peg only intensifies the behavior in progress. Unfortunately, Luria does not report experiments where the child at this stage is commanded to do something else entirely different such as take off his shoes while he is engaged in putting rings on the stick. The ring experiment may have failed not because the words lacked the directive function for the young child, but because the phrases "Put the ring on the stick!" and "Take the

ring off the stick!" are not readily discriminable by the child, particularly when uttered in the same tone of voice. It might also be the case that "On" and "Off" are not well understood by the child. Or it could be attentional deficits that would best explain the effect. It is also true that adult speech did initiate the activity of putting rings on the peg. Furthermore, the child was doing something before he began the activity with the rings. So, in a very real sense the verbal command did produce a shift in activity. It might be better to conclude that adult speech can produce shifts in certain kinds of activities for an 18 month old child, but that there are limits to the kinds of behavior that can be initiated or shifted into or from.

To cite another example, Luria maintains that a child of two and a half is unable to make use of the regulatory role of his own speech. To obtain even simple vocal responses to conditioned signals is apparently impossible. Luria goes on to state:

> It is true that in these experiments children at the age of two or two-and-a-half at first reacted to the signals with the word 'Go!'...; however, these reactions proved very unstable: the child soon showed himself unable to pronounce the word 'Go!' and simultaneously to press the bulb. The verbal reactions either became rapidly extinct, or were produced stereotypically, without any connection with the signal...(Luria, 1961, p. 71).

It seems remarkable that the apparent early success of the child is dismissed because of its instability. Since

the task was initially performed with some degree of skill, it seems more appropriate to credit the child of two and a half with some form of self-regulation. One then needs to inquire how this regulatory system is different from self-regulation in an older child. Is it the question of whether the child can maintain the behavior without any further accompanying instructions from the experimenter and is this a difference of kind or degree? It might be better at this point to adopt an alternative position and challenge the whole notion of a qualitative deficit in the verbal control system. It is then necessary to inquire into why the system fatigues so rapidly or otherwise becomes inactive without constant accompanying reinforcement from another person. This is a different question, however, from a denial of any self-regulation capacity in a child of this age.

Finally, at the highest stage of development, the regulatory function of speech is viewed as shifting from an impulsive character to that of an analytic, significative system of connections. Concomitantly, control shifts to the internal speech of the child at this stage, which begins between the age of four and a half and five and a half. The child can now further regulate his behavior according to some internally retained rule. Here again, however, it can be argued that the child of 18 months is following a rule when it puts rings on a peg.

Liublinskaya's experiments (1957) demonstrate further that very young children can use a verbal label as a primitive rule for discriminating one butterfly from another and

can ignore salient but conditioned negative signals as cues for the discrimination. Without additional experimentation, therefore, one might want to question Luria's notion of qualitative stages of development. Instead, one could adopt a position similar to the production deficiency hypothesis of Flavell, Beach, and Chinsky (1966). It would then be argued that even very young children possess capabilities postulated by Luria to reside only in older children, but that younger children fail to make use of certain of the skills they possess as verbal human beings.

Distinctive Features of Speech

The problem remains then to examine which qualities of speech are deemed by Luria and the other Russians to be paramount in distinguishing man's control of his behavior from that of other animals. It is at once apparent from his writings that Luria agrees with Pavlov that, with language, "a new principle of nervous activity is introduced, the abstraction and generalization of innumerable signals" and that it is this "new principle which enables the second signal system to become the highest regulator of human behavior" (Pavlov, quoted by Luria, 1957, p. 116).

And yet clearly there are difficulties in utilizing such a statement to attribute special qualitatively different properties to speech. The fact remains that animals can generalize and abstract certain concepts. Pavlov (1960), in fact, developed his ideas on generalization and differentiation of responses from studies of the salivary reflex in

dogs. Similarly, little doubt remains that a highly sophisticated concept such as "oddness" can be learned by some higher organisms. Harlow has utilized his learning set paradigm to train monkeys to differentiate that one of three stimuli which is unlike the other two. In such a problem, both position and perceptual cues are ambiguous; and the animal must learn to "abstract" the principle of oddness. A monkey given 400 training trials can make more than 90% correct responses on this type of task (Harlow, Meyer, and Settlage, 1951). More impressive yet is data reported by Herrnstein and Loveland (1964) that even such a concept as "humanness" can be abstracted. Pigeons were highly accurate in differentiating between positive and negative instances of the concept of the human figure in colored pictures.

Of course, the position could be adopted that speech enables us to notice and give labels more readily to those elements of the problem which are most crucial to a correct solution. Such a position might be put forth by a Russian psychologist such as Zaporozhets or Liublinskaya. This labeling process might indeed direct us more rapidly toward a correct solution; but this in no way detracts from the fact that animals can accomplish this same type of abstraction. There also remains the further possibility that the final result is not accomplished in the same manner in humans and in animals. Nevertheless, since language has been shown to affect only the rate of acquisition of certain types of abstract concepts, it seems premature of Luria and

other Russians to attribute to it qualitatively different capacities from those possessed by animals.

Similar objections can be raised regarding other features of verbal control which the Russians see as distinctively human. Luria argues, for instance, that speech removes the necessity of gradually developing connections between the conditioned stimulus and the conditioned response. In animal conditioning, connections may only be formed after many repetitions and may require prolonged practice at each of a series of consecutive stages. Through the mediation of speech, however, a new connection can be included in an already existing system of connections and is established at once. An example of the latter would be a case in which a human subject was instructed to "Press the rubber bulb when you see a green light!". Such a connection should be formed at once without any necessity of preliminary training. Except, of course, all human subjects have undergone extensive training in language prior to their participation in the experiment. If this practice is included, learning to press the bulb is not really faster than an experiment in animal conditioning. If such practice is disregarded, it might still be argued that the learning in such an experiment is more a matter of transfer of training than new learning. The expanded opportunities for transfer through utilization of the second signaling system would confer an advantage on human beings in terms of more rapid learning. This need not imply, however, that learning is taking place in any new manner. Finally, since the differ-

ences here between human and animals can only be represented in terms of speed of acquisition, it once again seems parsimonious to attribute these differences to quantitative augmentation from speech rather than to postulate some new, specifically human feature.

Once a connection has been established in animals, it usually needs constant reinforcement in order to maintain a given level of strength. If this reinforcement is withheld, the connection begins to weaken. Luria argues that connections formed with the aid of the verbal system are not subject to this rule. The experimenter can formulate the task once for the subject and then discontinue further verbal reinforcement both in terms of repeated instructions ("Press!") and in terms of social reinforcers such as "Good" or "That's right." Yet, it is clear Luria understands the human capacity for self-reinforcement: "A verbal formulation of a system of connections (in the shape of a rule which specifies each reaction) itself acts as a constantly operating reinforcement, sufficient to preserve the stability of a connection" (Luria, 1957, p. 122). It follows that humans may be indulging in nothing more than secondary social reinforcement, and it is already known that this is a powerful maintainer of behavior in human and animal subjects alike.

Language connections are also seen as very much more labile than those restricted to the first signaling system. The former are easily replaced or the meaning of an instruction is quickly reformulated under new circumstances accord-

ing to the demands of the organism and its environment. It is further argued that connections of the second signaling system are more stable and are less easily disrupted by interference from such things as external inhibition. Once again, however, it must be noted that human subjects do not always show faster relearning on such problems as non-reversal shifts (Kendler and Kendler, 1962). And humans are subject to external inhibitions or distractions as anyone who has tried to read a technical paper over the blare of his daughter's transistor radio can readily vouch for. One is again led to the conclusion that such arguments are talking about differences of degree rather than kind. It still remains then to be demonstrated that any of the above features of the second signaling system are really unique features distinctive to man.

Regulatory Functions of Speech

If one cannot readily demonstrate ways in which speech is a qualitative supplement to intellectual functioning, it nevertheless is readily apparent that the human being with his language potential is in some fashion superior to other species. The Russian approach to language seems to serve its most beneficial purpose in calling attention to factors which, for whatever reason, aid human thought and reasoning. This seems to be the true contribution of Soviet psychological investigations of the verbal mechanism as a regulator of behavior.

Inhibition. Wozniak (1972) has made a very thorough, recent analysis of such factors in verbal control. His analysis of the philosophical tenets which underlie Soviet scientific thought leads him to conclude that there is an implicit set of constructs (such as the law of transformation of quantity into quality and the law of mutual penetration of opposites) which form an underpinning for the development of human mental functions. It is difficult to evaluate such constructs because they are only tacitly alluded to in Russian psychological writing. They certainly will not satisfy the need to identify obvious, critical principles involved in verbal control. Wozniak seems on firmer ground when he examines the explicit aspects of a verbal control theory. He is particularly effective in utilizing basic Pavlovian concepts, especially those related to inhibition, as a means of explaining the gradual development of verbal self-regulation in the growing child.

It was pointed out above that Luria's model of speech development falls short of the qualitatively distinctive system he makes claims for. One salient factor which does stand out, however, is that the child is continually improving his ability to inhibit extraneous responses. Regulation comes to mean the ability to drop out of the response system those acts which do not produce the proper response or which are superfluous to

the response once it has been correctly performed. Insofar as Wozniak has underlined the significance of this principle, he has made a valuable contribution to the understanding of the Russian system and to the mechanism of verbal regulation.

It seems equally clear, however, that regulation implies more than just inhibition. One principle which is revealed time and again in the Russian writing is the active nature of man. Inhibition may only appear to play a major role in verbal control because it has to act as a buffer against the increasing tendency of the human organism to seek out information and then devise new ways of acting on this information.

Orienting Activity. This is clearly seen in the emphasis the Soviets place on the orienting response (OR) (Sokolov, 1960, 1969; Lynn, 1966). A great deal of stress is given to the role played by organisms in searching out sources of information. The organism, especially the human with its verbal capacities, addresses questions to an object or event. The information obtained from an OR provides a basis for further decisions about behavior. Learning, in contrast to the standard American representation in terms of a passive pairing of stimulus and response, takes on an active role as well. Russian research has indicated, for instance, that the OR does more than just inhibit performance of a condi-

tioned response. It also appears to play a significant role in the elaboration of this same conditioned response (see Gray, 1966). The optimal situation for learning appears to be one where the OR has been performed several times as a basis for the discovery of the essential attributes of the environment. Orientation has further utility in identifying any changes in the stimuli or the relations between stimuli.

Here is one place where verbal processes would appear to provide a clear advantage. Through verbalization, the organism can frame questions about the environment in a precise manner. Speech can efficiently tag those aspects of the environment which are essential for the conditioning process. In addition, language allows us to label concisely stimulus attributes. It, therefore, is easy to discriminate changes in critical attributes as the environmental situation changes.

Planning. Closely related to the Russian emphasis on activity and the OR is a concomitant development of the concept of planning. At an elementary conditioned reflex level this concept is apparent in Anokhin's work on the acceptor of effect (Anokhin, 1961, 1969). In such a system, a group of cells are continually stimulated upon each introduction of first the conditioned stimulus and then the unconditioned stimulus.

In this manner, an expectancy is built up of what should follow upon the presentation of the conditioned stimulus. If the unconditioned stimulus follows, as is usually the case, the return afferentation arising from its effect matches the pre-set expectancy. If something unusual occurs, a mismatch occurs. The animal displays an OR, and it maximizes the activity of the cerebral cortex to organize a new plan or expectancy of what is occurring in the environment.

Further experiments by Anokhin have led him to conclude that "every instance of decision making intended to produce results is invariably accomplished by the formation of an acceptor of effect" (1969, p. 847). Bernshtein (1969) also emphasizes that the organism is always acting on the world. Action necessitates the formation of a physiologically encoded model of what is expected to occur in the future. All human skilled movements are viewed as requiring a plan in the brain of what conditions are necessary to bring about the required correct response.

When one turns to the higher human functions, the role of planning becomes increasingly apparent. Zaporozhets cites the critical developmental change in skilled voluntary movements from random tactile orientations to a fully developed verbal program of action. Galpe-

rin's work on the development of higher mental functions emphasizes the role of the verbal system in formulating a conception of a problem and a rule or plan for carrying out a solution to the problem.

Luria also discusses the central role of planning in the development of verbal self-regulation:

> When [the child] establishes verbally the complex connections and relations between perceived phenomena he introduces essential changes in the perception of things influening him; he begins to act according to verbally elaborated influences by reproducing the verbal connections reinforced by earlier adult instructions, and thereafter modifies them, isolating verbally the immediate and final aims of his behavior, indicating the means of achieving these aims and subordinating these aims to verbally formulated instruction (Luria and Yudovich, 1959, p. 14, italics added).

Luria's twin study also showed that with the introduction of speech projects are formulated ahead of time and with a specific goal in mind. Play activity becomes elaborated from originally diffuse behavior into formation of a goal, preparation for the achievement of the goal, and the accomplishment of the specified end result. In productive and constructive activity alike, the advent of speech signals a shift from description of what has already happened to a verbal elaboration of what needs to be done beforehand, even when this requires a program of action which goes beyond what is perceptually salient in the environment.

Social Relationships. A final theme which has already been noted is that not only is human behavior an active, structured process, but that it only arises through interaction with other people. Vygotsky stated this position many years ago and emphasized how it contrasted with the Piagetian theory that speech behavior arises in the individual and only in time is socially directed. The Russians strongly support the position that work is the precept that organizes activity and that with the specialization of our advanced culture a strong pressure is created for language. Only a verbal system provides the precision of description and planning that a complex society demands. Leontiev has made a similar point in his recognition of the human use of speech as a tool for the remembrance of specific events and ideas necessary for the well-being of the culture. Luria demonstrates an equal indebtedness to the socio-historical approach to language in his theory of verbal control. Social relationships are seen as playing an integral role in restructuring human functions such that they provide man with a mechanism for going far beyond the restraints of his physical environment.

Russian Contributions to Language

This leads to one final critique of the Russian system. It has been indicated that the characteristics which Soviet psychologists see as qualitatively unique to language or to a theory of human development upon closer examination seem

to be only extensions of capacities displayed by lower organisms. An alternative suggestion has been put forth that the Russian contribution lies primarily in the emphasis upon certain key concepts such as activity, planning, and the socio-historical approach to language attainment. These are envisioned as the reasons for the greater abilities in the human race.

Even here, however, the Russians cannot be credited with an altogether unique approach. Soviet scientists may have consistently emphasized these key concepts for a long period of time, but American scientists have recently become more and more concerned with replacing passive black-box theories of learning with systems which stress the role of the organism actively pursuing and selecting information (Bruner, 1957; Neisser, 1967). Miller, Galanter, and Pribram's (1960) book on planning has focused the attention of Western psychologists on the breadth and flexibility that such an approach offers for describing human behavior. Equally apparent is the crucial role verbal activity plays in the elaboration of such planning:

> In man we have a unique capacity for creating and manipulating symbols, and when that versatility is used to assign names to TOTE units, it becomes possible for him to use language in order to arrange the symbols and to form new Plans. We have every reason to believe that man's verbal activities are very intimately related to his planning abilities (Miller, Galanter, and Pribram, 1960, p. 38).

And DeLeguna (1927) was long ago aware of the possibilities of a socio-cultural analysis of the origins and

functions of speech. She envisioned language as "the peculiar instrument for controlling the indirect behavior of tool-using men in a highly organized social group" (p. 273). In another passage, it is acknowledged that "the characteristic structure of language has evolved from the animal cry in order to meet the needs of expanding group life" (p. 37).

Such examples could be supplemented by many more. One is left then with a much more modest evaluation of the Russian representations about language. Their system has identified no unique capacities of language. Nor is the Russian verbal control theory a Weltanschauung which is indigenous only to the Soviet Union. What the Russians have provided, however, is an integrative, coherent system in which certain principles are highlighted and which only now are fully appreciated by Western psychologists. Vygotsky, Luria, and their colleagues have shown us an approach. They have recognized the virtues of a naturalistic method of investigating language and behavior which points out the central characteristics of verbal behavior. Perhaps the future goal of psychologists is to amalgamate this approach with the more statistical, neo-behavioristic methods favored by American researchers in the pursuit of some ultimate understanding of the nature of human verbal behavior.

CHAPTER II

INTRODUCTION TO THE EXPERIMENT

In spite of the large amount of research and theorizing on the nature of language, many questions about the mechanisms involved in the verbal control of behavior remain unanswered. It is unclear, for example, whether language functions as a qualitative or quantitative supplement to the performance of human activities. The more general premise that language acts as some form of regulator of human behavior is, however, widely acknowledged; and many important relationships between verbal activities and the performance of either cognitive or skilled motoric responses have begun to be revealed.

In the previous chapter, several instances were cited in which verbal behavior aided in the accomplishment of a complex cognitive act. Liublinskaya (1957) demonstrated that a verbal label accelerates the rate at which a color discrimination task is mastered by the young child. Martinoskaya (in Luria, 1969) found evidence that vocal reinforcement by a teacher effects shifts in the salience of various components of a visual scene for most five-and-six-year-old children. Galperin (1957, 1969) has shown that verbal control produced through the instructions of a teacher results in the earlier and more firmly established mastery by the child of scientific concepts. Furthermore, this verbal control can pass on to the child himself, who

is then more effective in shaping his own future mental and physical activities. Finally, the work of Leontiev (1961, 1964) has pointed to the significance of language cues for the formation and retrieval of information from memory.

Many other tasks remain, however, where the researcher is not directly concerned with a comparison of performance when language is operative versus situations when it is absent. Rather, many investigators whose primary interest is in human performance attempt to determine how the verbal system acts in conjunction either with some other cognitive system or with a motoric system to bring about effective control of behavior. These investigators are interested in how the vocal system interacts with a second response system when both systems must operate upon one or more stimulus inputs. Are there specific relationships in terms of speed, accuracy, or rhythmic sequences which are established when two systems are jointly active?

An experiment conducted by Samsonova (1960) demonstrates one such pattern of relationships when a vocal response and an arm movement are required upon presentation of visual stimuli. The observer's task was to determine whether two visual stimuli were equidistant from him. In the initial condition, S was instructed to respond by a bulb squeeze response with one hand and a 50° abduction of his other arm to stimuli that were equally far away. If the stimuli differed in their distance from S, the correct response was a 14° abduction of the forearm and no accom-

panying press on the rubber membrane. A second condition maintained the forearm response, but pressure on the rubber membrane to equidistant stimuli was replaced by the verbal response "Equal."

Results indicate that the condition in which a vocal response and a manual response were performed frequently produced a lower threshold for distance discrimination when compared to the condition where both response components were body movements. Two groups of Ss could be differentiated in terms of the temporal sequence in which responses were performed. Some Ss performed both motor responses simultaneously during the initial condition. A second group of Ss executed one response and then performed the second motor response. The most significant finding for investigators interested in verbal control, however, is that when one motoric component was replaced by a verbal response, all Ss performed the verbal and motoric responses simultaneously. It is unclear, however, what exactly is meant by the reported simultaneity of the verbal and motoric responses since no distinction was made between the initiation and termination of the arm movement. Furthermore, Samsonova provides no statistical treatment of the data so that even means and variability measures on the difference scores are unavailable.

It comes as no great surprise, however, that in certain situations Ss are capable of making more than one response simultaneously. Norrie (1964) found that Ss were quite accurate when they were required both simultaneously

to initiate and simultaneously to terminate movements of the right and left hands that were of equal distance and complexity. Differences in the starting times and differences in contact times were greater for tasks of greater complexity. Insofar as deviations from simultaneity were observed, a consistent pattern in which the right hand moved first and made contact last was apparent in all tasks except the one requiring the same movement patterns for both hands.

A second study by Norrie (1967) replicated the relative simultaneity of starting and termination times for identical hand responses. Findings also indicate that when the two hands had to move different distances, the hand which had to travel the longer distance moved first and finished later. A similar pattern is evident when times are compared in a task where one hand traveled a long distance and one foot moved a shorter distance. It should be noted that Norrie's Ss were instructed to perform the initiation and termination portions of the two responses simultaneously. Furthermore, she did not include a condition in which one of the two activities was a vocal response.

Luria (1961) has reported that initially children of two or two and a half years of age, when specifically instructed to synchronize, reacted to signals with a simultaneous bulb squeeze and vocalization. Such simultaneity extinguished rapidly or became a stereotype which had no connection to the signal. In children of three or four

years of age, simultaneity of vocal and manual reactions to signals was maintained. It is again the case, however, that without any reported means or variances, a satisfactory interpretation of simultaneity remains impossible.

There is a noticeable paucity of published reports in which Ss are required to make a verbal and a motor response to stimulus signals, but where no instructions are given with respect to the precise patterning of the two responses. In addition to the Samsonova (1960) study, Schvaneveldt (1969) has carried out an experiment in which S was required to make a verbal response to a numeric display and a manual response to the location of the numeral in the display. The primary finding is that reaction time increased with increasing stimulus uncertainty and with the introduction of an indirect S-R code for either response. Timing relationships between the two responses are difficult to determine since the data are reported in terms of group medians. It was found, however, that when one task involved a simple reaction and the other required a choice, the simpler task slowed down relative to a single-task control condition while the choice task was facilitated.

What is still needed is an explicit formulation and testing of hypotheses about the interaction of the vocal and motoric response systems on an individual trial basis. One hypothesis is that the verbal and motor systems act independently of each other. This would mean that it should take the same amount of time to perform a response

when it is performed together with a second response as when it is performed alone. This hypothesis would also predict no difference in the manner in which a response is performed as a function of whether or not some second response is being carried out coterminously with the first. Data from the Schvaneveldt (1969) study demonstrate that speed of performance may increase or decrease when a second task is added. Samsonova (1960) has shown synchronization of responding when an arm movement and a vocal response are made to the same stimuli. These two experiments thus make the independence hypothesis appear highly unlikely.

A second hypothesis states that the vocal and motoric response systems compete whenever both must act upon the same input at the same time. This competition hypothesis would be most readily demonstrated if it could be shown that two responses could not be initiated at the same time or if one response could not be initiated at the same time a second response is being terminated. Data from a series of studies conducted by Birch and his associates (Birch, 1971; Birch and Eisner, 1968; Susman, 1971) provide very little support for this competition hypothesis. Birch (1971) found a higher than expected number of trials on which young children called out the color of a light at the same time they hit a target grid. Birch and Eisner (1968) found a similar set of results using college students. The data from this study show a significant number of instances in which hitting a target occurred at the same

time as either calling out the color of a stimulus light (the light was either red or blue) or calling out the alternative color to the one that appeared. Finally, Susman (1971) using situations involving choice on both the vocal and manual responses, found a large amount of synchrony of vocalizing with initiation of a motor response in six out of the seven conditions tested.

It appears then that some form of coordination hypothesis best describes the relationship between the verbal and motor systems--at least for the situations so far investigated. The implication of such a coordination hypothesis is that patterning of responses occurs. This can be manifested in the synchronous initiation of the vocal and motor responses, simultaneity between production of a verbal response and completion of a motor response, or some other pattern where one response consistently occurs at a fixed place in time relative to the initiation or termination of the other response.

The experiment to be reported in this dissertation was designed to examine more precisely the speed and pattern of responding when vocal and manual responses are performed when two visual stimuli come on together, but where a single response or no response is to be made when only one light comes on. Ss in a configuration group are instructed to make both a verbal and a manual response to a visual display consisting of the simultaneous onset of two lights. If only the left or right light comes on alone, this is considered to be a different perceptual unit

to which no response is required. Ss in the components group are instructed that each light in the display is a separate cue with its own associated response. The right light is a signal for S to make a manual response, the left light is associated with the vocal response. If both lights come on together, components Ss are instructed to make a vocal response in association with the left light and a manual response in conjunction with the onset of the right light. Differences in speed and timing patterns are predicted for the two groups depending on whether the two light display is organized as a single perceptual unit with two associated responses or as two perceptually distinguishable cues, each of which calls for its associated response. It is predicted that responding to a display as a single perceptual unit (configuration task) should produce faster vocal and manual response times than responding to the same display in terms of its separate parts (components task). It is also predicted that the representation of the display as a single unit in the configuration task should result in a greater amount of synchronous responding than the amount produced by representing the same display in terms of its different parts as is true of the components task.

CHAPTER III

METHOD

Subjects

Ss were 48 right-handed male students at the University of Michigan. Ss were paid $1.75 plus a bonus for a 1 hour and 15 minute experimental session. Twelve Ss returned for an additional 40 minute session for which they received $1.50 and a bonus.

Apparatus

S was seated at a small metal table which had on it the primary components for a reaction time task. The piece of equipment nearest S was a black, lectern-shaped wood platform 13-1/2 inches wide x 24 inches long. The height of the platform at the point nearest S was 2 inches, and the platform slanted up and away to a final height of 7 inches. Set into the platform 1 inch from the edge closest to S was a plastic "home button" measuring 1 inch in diameter. The platform also contained a 2-1/2 inches x 3-1/4 inches felt covered, wood target grid whose closest edge was located 6 inches beyond the home button. Five feet from S was a raised, tan wood display panel 7-1/2 inches high and 6 inches wide. In the center of the display panel were three blue plastic disks arranged in the form of an equilateral triangle, measuring 2-1/4 inches on a side. Lights with near-

ly zero rise time could be illuminated behind each disk to provide appropriate stimuli. Only the bottom two display lights were used in the experiment to be reported. A tiny white square was positioned midway between these two lights and functioned as a fixation point. S wore headphones through which an auditory warning signal could be presented. The headphone set also contained a voice microphone into which S could speak during those parts of the experiment in which a vocal response was required. E sat behind S with a control button which could be pressed to rerun trials on which errors occurred. Stimulus presentations and sequences were controlled by a PDP-4 computer located in an adjacent room. A model 5211A Hewlett Packard electronic counter was used to measure response times to the nearest millisecond.

Procedure

Ss were randomly placed into either a configuration or a components treatment group. In the initial part of the configuration task, S was instructed to make both a manual and a vocal response as quickly as possible after the simultaneous onset of both stimulus lights. (Complete instructions for the two treatment groups are included in Appendix I.) If only one of the two stimulus lights came on, S was instructed to make no response at all. For the initial part of the components task, S was instructed to make a vocal response as quickly as possible after the onset of the left-hand blue light. If the right-hand blue

light came on alone, S was required to perform the manual response as quickly as possible. If both lights came on together, S's task was to perform each of the two responses as quickly as possible. For both groups, the vocal task was to call out as rapidly as possible the color "Blue." The correct manual response for S was to move his finger from its initial location on the home button as quickly as possible to the target grid.

Six blocks of 32 trials were run, with two minute rest intervals between blocks. On block one, the initial task appropriate for the particular condition was introduced to S. A buzzer served as the auditory ready signal and was a cue to S to fixate the white square. After a random delay of 2,3,4 or 5 seconds one or both stimulus lights came on. Foreperiods were counterbalanced with the appearance of the lights such that for each of the four foreperiods there were six trials when both lights came on, one trial when the right light came on alone, and one trial when only the left light came on. A different stimulus sequence of 32 trials was presented for each block.

Before block two, medians corresponding to S's baseline vocal and manual times were computed, based upon the response times for the last 15 trials of block one when both lights had been presented. S was informed that his task on block two was still to turn off the lights as quickly as possible. He was told, however, that he would earn or lose points on each trial as a function of how fast each response was in relation to S's baseline times. Bonus earnings were

regulated in terms of the total number of points amassed for the entire session. Separate bonus payoffs were computed for the motor and vocal responses. S could win or lose up to an additional $ .75 on each of the two responses. (Point values and the payoff schedule are included in Appendix II.) He was assured, however, that he would always earn at least his base pay of $1.75 for the session.

Blocks 2, 3 and 4 were then conducted in the same manner as block one but with the payoff schedule in effect. On block five, S was informed that his task was to perform just the vocal part of the task he had just been doing. For Ss in the configuration group, this meant calling out the color "Blue" as fast as possible when both lights came on. If a single light appeared, no response was to be made. Ss in the components group were instructed to make the vocal response when either the left light or both lights came on. If the right light appeared alone, they were to make no response. Block six was conducted in a manner similar to block five except only a manual response was required. Ss in the configuration group performed the manual response if both lights came on, and Ss in the components group made a manual response if either the right light or both lights came on. The same point system and payoff schedule continued in effect for blocks five and six.

Twelve Ss were brought back for a second experimental session about one week later. Components group Ss were given instructions appropriate for the configuration task,

and Ss previously in the configuration group received instructions for the components task. S was then run through four blocks of trials of the type where both vocal and manual responses had to be performed when both lights came on. The bonus system based upon response baselines from S's previous session was in effect for all four blocks of trials.

CHAPTER IV

RESULTS

Reaction Time Data

Mean response times for lifting the finger off the home button, hitting the target, and vocalizing are shown for each block of trials in Figure 1. Each point represents a mean response time based on 576 observations; that is, it is an average of the 24 Ss in a particular group each of whom received 24 trials per block on which both lights came on. For all three response measures, the general finding is that the components Ss have longer response latencies than the configuration Ss. There is also a general decrease in Ss' response times over blocks. In addition, an analysis of variance performed on movement time (target time minus lift time) on blocks 2, 3 and 4 for the two groups yields no significant groups main effect, F (1,46) = 2.75, $p < .20$ (see Table 1 in Appendix III for an overall summary of the statistical findings from the analysis); and, because of this, this measure will not be discussed further in this section. The remaining three response measures will be discussed in the order--lift, target, and vocal.

Lift Data

Data for the lift measure are depicted in the bottom

two curves in Figure 1. These graphs show that Ss in the components group have consistently slower lift times for each of the blocks of trials than do Ss in the configuration group. The first block of trials was primarily employed for familiarizing Ss with the task. In blocks 2, 3 and 4, the payoff schedule was in effect and both a manual and a vocal response were required. A two dimensional analysis of variance was performed on the data from blocks 2, 3 and 4 comparing the two groups of Ss (Table 2 in Appendix III). Ss in the configuration group are significantly faster than Ss in the components group, F (1,46) = 7.54, $p < .01$. Both groups show a small but consistent and significant decrease in latency between blocks two and four, F (2,92) = 6.98, $p < .01$. The interaction between groups and blocks is not significant.

For the first four blocks of trials, the manual and vocal responses were both performed when the two stimulus lights came on together. Block six is a "singles" block in which a manual response only was to be carried out in response to the joint occurrence of the two lights. Figure 1 shows that there is an additional decrease in lift time latencies when Ss go from the first four blocks of "combined" trials to the "singles" requirement in block six. A two dimensional analysis of variance (Table 3 in Appendix III) compares lift times on block four with lift times on block six. Both the groups, F (1,46) = 6.01, $p < .025$, and blocks, F (1,46) = 58.20, $p < .001$, main effects are significant. The interaction of groups and blocks

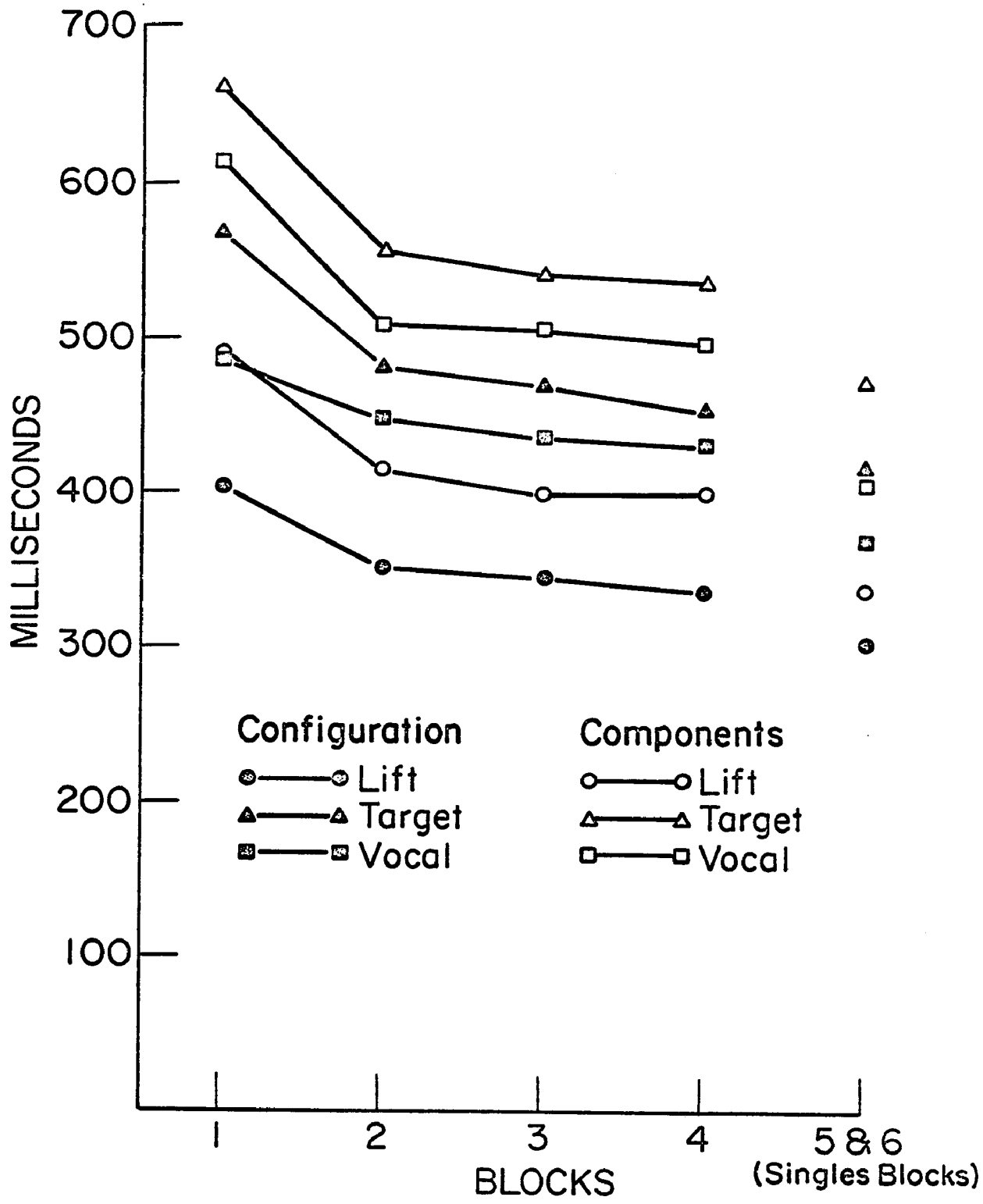


Fig. 1. Mean lift, target, and vocal times on blocks one to six for the two experimental groups.

is also significant, F (1,46) = 5.20, $p < .05$. This latter result reflects the greater decrease in lift response times for the components Ss when moving from the combined to the singles condition.

Target Data

The lines representing the target measure data in Figure 1 display a pattern of results very similar to that shown for the lift measure. For each block of trials, the target times for the components Ss are slower than the times for Ss in the configuration group. A two dimensional analysis of variance (Table 4 in Appendix III) performed on the data from blocks 2, 3 and 4 shows the difference between groups to be highly significant, F (1,46) = 8.13, $p < .01$. The decrease in target latencies from block two to block four is also significant, F (2,92) = 9.83, $p < .001$; but the groups x blocks interaction is not.

A two dimensional analysis of variance (Table 5 in Appendix III) was carried out on the target latencies for blocks four and six. The decrease in latency in moving to the singles block is highly significant, F (1,46) = 59.60, $p < .001$. The groups main effect, F (1,46) = 7.82, $p < .01$, and interaction, F (1,46) = 4.11, $p < .05$, are also significant. These latter two results reflect the faster response times for the configuration group Ss and the greater speed-up for the components Ss on the target measure when moving from block four to the singles block.

Vocal Data

The lines in Figure 1 representing the vocal reaction times for the two groups show that the components Ss again have consistently longer latencies for each block of trials than do Ss in the configuration group. A two dimensional analysis of variance (Table 6 in Appendix III) on the vocal times for the two groups on the last three combined blocks yields a significant groups effect, $F(1,46) = 6.50$, $p < .025$. Furthermore, as is the case for the start and target measures, the decrease in vocal response times over blocks 2, 3 and 4 is significant, $F(2,92) = 3.27$, $p < .05$; and the interaction of blocks and groups once more fails to reach significance. Finally, a two way analysis of variance (Table 7 in Appendix III) was performed comparing groups on the last combined block with singles block five where only a vocal response was required. In a pattern similar to that found for the lift and target response times, configuration group Ss have shorter latencies, $F(1,46) = 5.66$, $p < .025$. The decrease in vocal response speed on moving to the singles block is also highly significant, $F(1,46) = 89.91$, $p < .001$. In contrast to the results found with the lift and target measures, the interaction of groups and blocks for the vocal measure is not significant.

Latency Data Comparing Trials With One and Two Lights

All of the preceding analyses compare times for trials

where two lights come on simultaneously. For the configuration Ss no response was required when only a single light came on. Ss in the components group, on the other hand, were to make a vocal response only when the left light came on alone and a manual response only to the appearance of the right light. Figure 2 depicts for each block the two sets of trials with the lift, target, and vocal response times arranged separately for trials on which a single light came on and trials presenting a dual light display. It is immediately apparent that responses to the two light situation are generally faster than are responses for the single light "catch trial" situations.

Averaging over blocks 2, 3 and 4, a mean lift response time for each of the 24 Ss in the components group was computed separately for single and dual light trials. A t test for paired observations was carried out on these data. Lift response times to a dual light stimulus are significantly faster than lift response times for single light presentations on the combined blocks of trials, $t\ (23) = 5.41$, $p < .001$. Further inspection of Figure 2 shows that the difference in lift response speed for two and one light presentations disappears on block six where only a manual response was required. A t test for paired observations computed for lift response times on block six is not significant, $t\ (23) < 1$.

A similar overall mean difference response time averaged over blocks 2, 3 and 4 was computed for target response times for trials where one and two lights appeared.

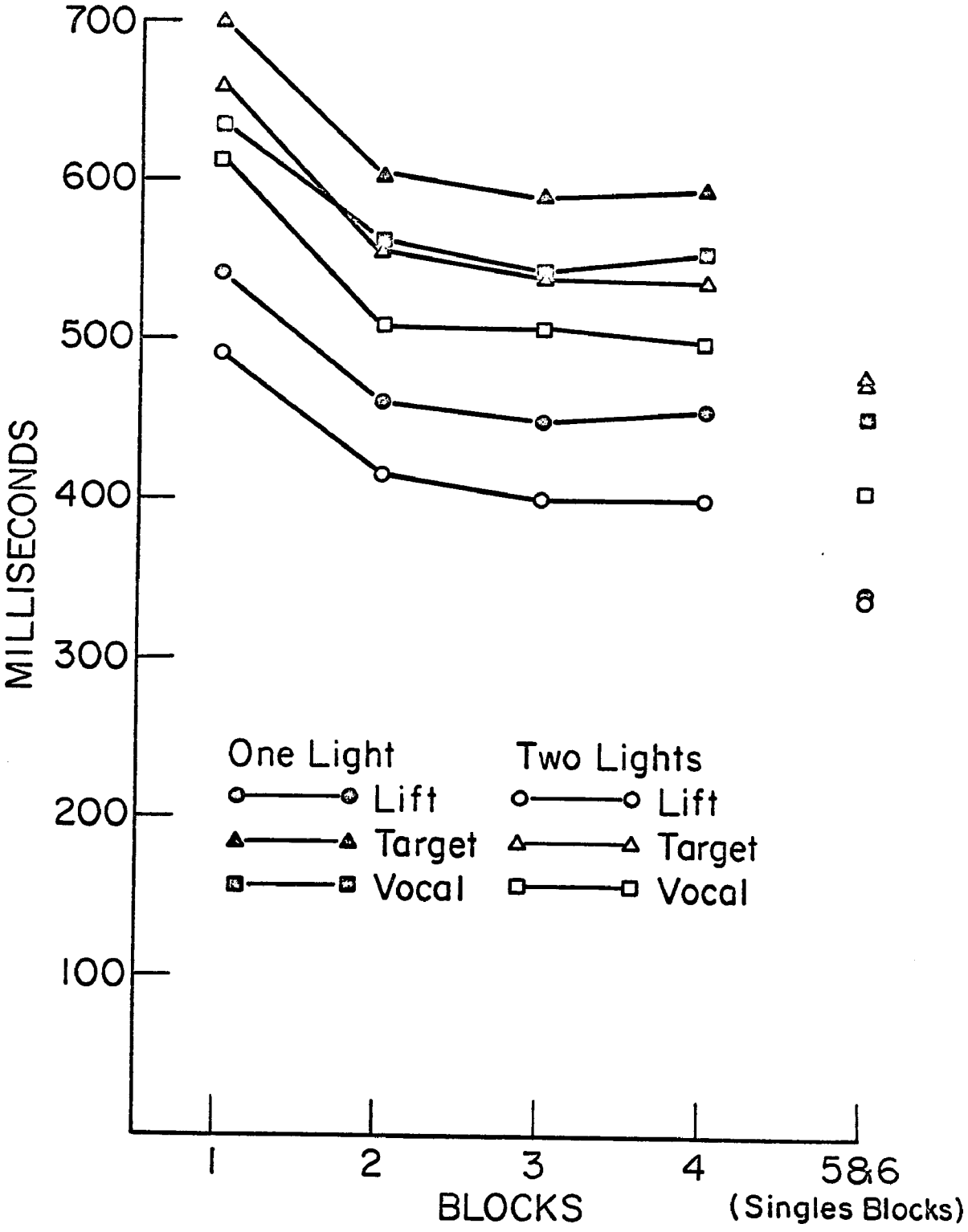


Fig. 2. Mean lift, target, and vocal times to one and two light displays on blocks one to six for the components group.

When a *t* test for paired observations was carried out on these data, it was found that target latencies are significantly shorter for the trials where both lights came on, t (23) = 4.93, $p < .001$. Again, the difference in target response times to a single light versus two lights disappears on block six when only a manual response is called for, t (23) < 1.

Finally, the same type of comparison was made for vocal latencies averaged over blocks two through four for the trials on which *S* was presented with a single light versus trials when both lights appeared. Vocal responses are much faster for the two light case, t (23) = 4.05, $p < .001$. In contrast to the findings for the manual response measure, however, this superiority in vocal response speed in the two light situation is maintained on block five when *S* was required to perform only a vocal response, t (23) = 4.60, $p < .001$.

Synchrony Data

The previous sections provide summary data on response latencies for each of the blocks of trials. A second meaningful feature of the data involves the extent to which *S* coordinates the performance of the manual and the vocal responses. The question can be asked: on what proportion of the trials does the vocal response occur at the same time as lifting the finger off the home button? Similarly, one can ask about the proportion of

trials on which the vocal response occurs at the same time as hitting the target button.

S's responses are defined as synchronous with respect to the lift measure if the time at which S vocalized and the time at which he lifted his finger from the home button differ by less than 25 milliseconds. In a similar manner, target synchrony is defined for a trial on which vocalization occurred no more than 24 milliseconds before or after the time at which S hit the target.

Tables 8 and 9 in Appendix III show the number of lift and target synchronies for each S separately for each of the four blocks of trials on which S made both a manual and a vocal response. Calculations from the data in Table 8 show that for blocks 2, 3 and 4, during which the payoff schedule was in effect, Ss in the components group synchronize their vocal and lift responses on 14.5% of the trials and their vocal and target responses on 22.0% of the trials. Analysis of the data in Table 9 reveals that on 11.6% of the trials Ss in the configuration group synchronize their vocal and lift responses; and on 24.2% of the trials, configuration Ss synchronize vocalizing with hitting the target. The total proportion of synchronizing, summing over both lift and target measures, for all 48 Ss on the last three combined blocks is 36.1%.

A comparison was made of the amount of synchronizing for the two groups by a two dimensional analysis of variance (Table 10 in Appendix III) performed on the number of lift synchronies for components and configurations Ss

on blocks 2, 3 and 4. There is no difference in the number of lift synchronies between groups, F (1,46) < 1. The blocks main effect and blocks x groups interaction also fail to reach significance. A two way analysis of variance (Table 11 in Appendix III) was also carried out on the amount of target synchronizing on blocks two through four for the two groups. Once again, there is no difference in the amount of synchronizing between groups, F (1,46) < 1; and the blocks effect and blocks x groups interaction are also not significant. Finally, a measure of the total amount of synchronizing on each of the last three combined blocks was computed for each S by summing the number of his lift and target synchronies. The two dimensional analysis of variance (Table 12 in Appendix III) shows no difference in the total number of synchronies for Ss in the components and configuration groups, F (1,46) < 1. The blocks effect and interaction once again fail to reach significance.

Types of Synchronizers

From the data reported in Tables 8 and 9, it is apparent that there are sizable individual differences in the extent to which S synchronizes his vocalization either with lifting his finger off the home button or with hitting the target button. A decision was made to categorize each S as either a lift synchronizer, a target synchronizer, or a non-synchronizer. Three criteria were employed to determine the category into which S was placed.

First, separate distributions were constructed which listed the total number of lift and target synchronies for each of the 48 Ss summed over blocks 2, 3 and 4; and each distribution was examined to determine a point in the distribution which seemed to separate Ss naturally into synchronizers and non-synchronizers. Second, the point chosen had to indicate a relatively large amount of synchronizing when compared to the average amount of synchronizing obtained from all Ss. Third, no S could be categorized as both a lift and target synchronizer.

S is considered a lift synchronizer if he synchronizes his lift and vocal responses on at least 20 out of the 72 trials (which corresponds to a cutoff point of just under 28% of the trials). In a similar manner, S is classified as a target synchronizer if at least 20 out of 72 trials result in synchrony of the times at which S vocalizes and hits the target. All remaining Ss are classified as non-synchronizers.

Table 13 summarizes the number of Ss falling into each of the six categories created when Ss are classified both by groups and by type of synchronizer. Nine Ss are categorized as lift synchronizers, 22 are target synchronizers, and 17 are non-synchronizers.

A chi-square test carried out on the frequencies in Table 13 is not significant, X^2 (2) < 1. Lift and target synchronizers were then combined and compared against non-synchronizers for the two groups. Once again, the chi-square test is not significant, X^2 (1) < 1.

TABLE 13

NUMBER OF Ss IN EACH OF THE SIX EXPERIMENTAL SUBGROUPS

Group	Type of Synchronizer: Lift	Target	Non-Synchronizer
Configuration	4	10	10
Components	5	12	7

Reaction Time Data II

Figures 3, 4 and 5 depict the mean lift, target, and vocal latencies for Ss in the six subgroups formed when components and configuration Ss are also categorized according to synchrony type. These figures are based on the same set of observations as those represented in Figure 1. In a similar manner, the results that will be reported in subsequent analyses are based on the same data as those reported in the previous section on reaction time, except that now the data are analyzed both by experimental group and by type of synchronizer. The figures show that components Ss have longer response latencies than configuration Ss. It is also apparent from the figures that non-synchronizers generally have the slowest response times while target synchronizers have the fastest response times. Mean lift, target, and vocal response times averaged over blocks 2, 3 and 4 and means for the

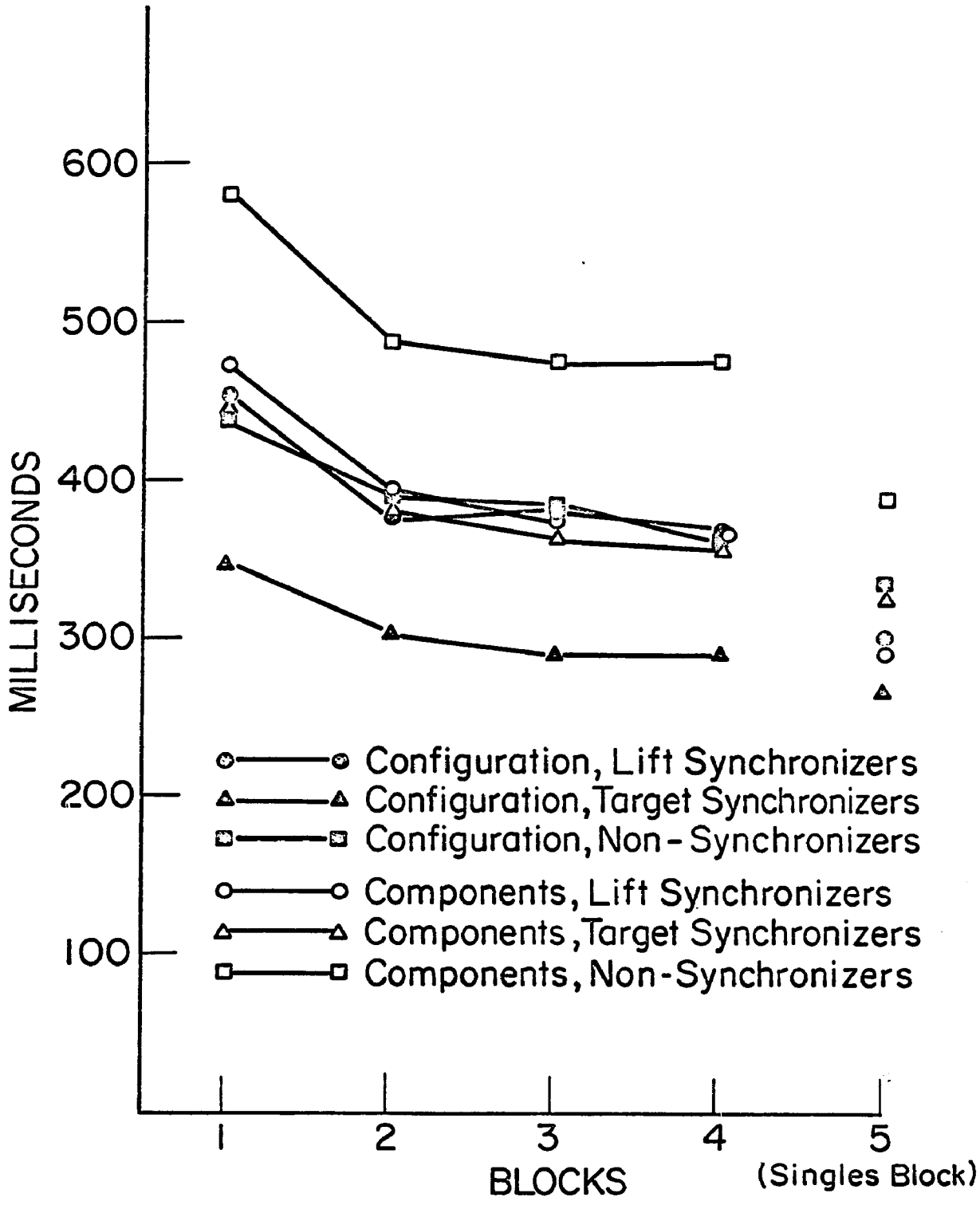


Fig. 3. Mean lift times on blocks one to four and block six for the six experimental subgroups.

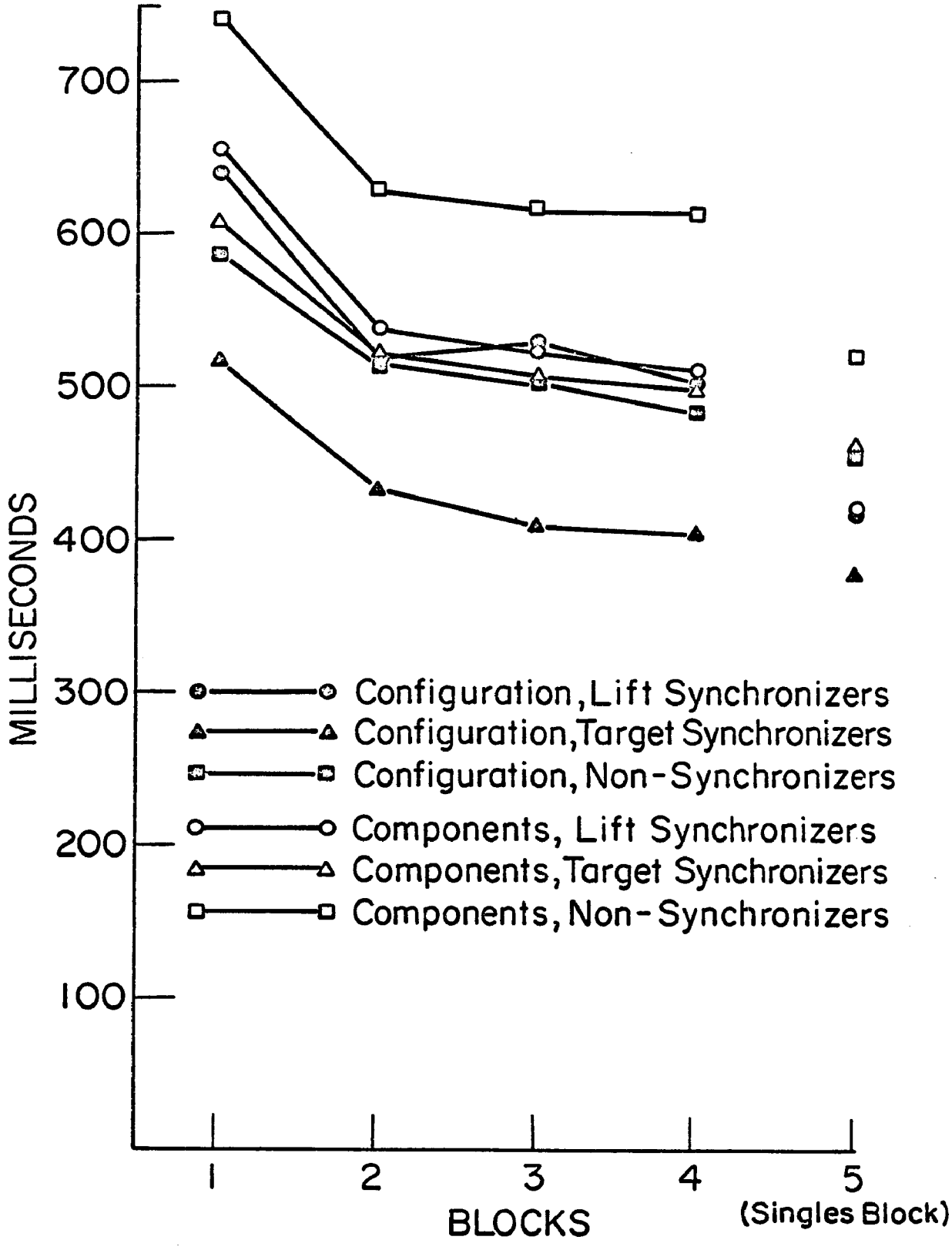


Fig. 4. Mean target times on blocks one to four and block six for the six experimental subgroups.

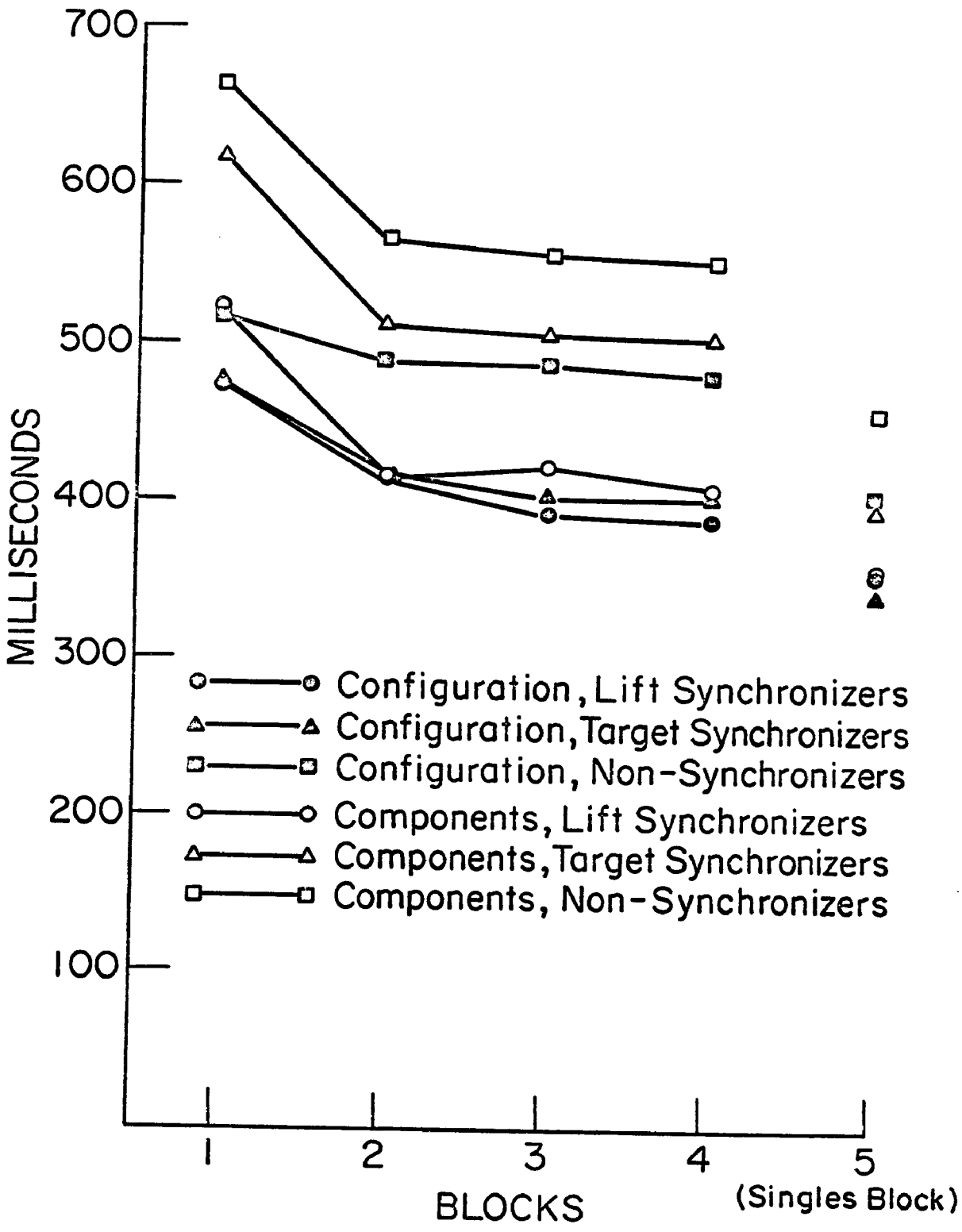


Fig. 5. Mean vocal times on blocks one to five for the six experimental subgroups.

singles blocks are given in Table 14 in Appendix III. Two dimensional analyses of variance, corrected for proportionality by the addition of the appropriate number of scores at a value equal to the cell mean, consistently show significant differences in cell means between the configuration and components groups and significant differences among means for the three types of synchronizers. A two dimensional analysis of variance (Table 15 in Appendix III) performed on movement times for the six subgroups averaged over blocks 2, 3 and 4 shows no significant difference between groups, F (1,42) = 2.82, $p < .20$, or among types of synchronizers, F (2,42) < 1. As a result, further discussion of movement time data will be omitted. A more detailed discussion of the remaining response data will be presented in the order--lift, target, and vocal.

Lift Reaction Time Data

Mean lift latencies for the six sets of Ss are represented in Figure 3. The figure shows mean lift response times for each block of trials for Ss jointly classified by type of synchronizer and group. In addition to the difference in lift response times already reported to exist between components and configuration Ss, it is apparent from Figure 3 that Ss who are non-synchronizers tend to have longer lift latencies than do Ss who are target or lift synchronizers. A two dimensional analysis of variance (Table 16 in Appendix III) carried out on lift latencies averaged over blocks 2, 3 and 4 shows that Ss in

the components group have longer latencies than Ss in the configuration group, F (1,42) = 17.27, $p < .001$ and that there are significant differences in mean lift latencies among the three types of synchronizers, F (2,42) = 13.12, $p < .001$. The interaction of groups and types of synchronizers is not significant.

Figure 3 also indicates that the differences between groups and among types of synchronizers are maintained on block six where only a manual response was performed. When analyzed by a two dimensional analysis of variance (Table 17 in Appendix III), the differences in lift latencies between the configuration and components groups, F (1,42) = 6.82, $p < .025$, and among the three types of synchronizers, F (2,42) = 6.99, $p < .005$, are both highly significant. The groups x types of synchronizers interaction fails to reach significance.

Finally, Figure 3 shows that the components and configuration Ss and the three types of synchronizers differ in the amount they speed-up in moving from the last of the combined blocks to block six. The two dimensional analysis of variance (Table 18 in Appendix III) performed on the difference in lift latencies on blocks four and six shows a greater speed-up for the components Ss, F (1,42) = 8.23, $p < .01$ and differential speed-ups for the three types of synchronizers, F (2,42) = 5.33, $p < .01$. The interaction of groups and types of synchronizers is not significant.

Target Reaction Time Data

Figure 4 depicts mean target latencies on each block of trials for Ss in the six subgroups formed by subdividing components and configuration Ss according to type of synchronizer. Ss in the configuration group who are target synchronizers have the shortest target latencies, while Ss in the components group who are non-synchronizers have the slowest target response times. Averaging over blocks 2, 3 and 4, a two way analysis of variance (Table 19 in Appendix III) was carried out on mean target latencies. Components Ss are slower than configuration Ss, F (1,42) = 14.82, $p < .001$; and there are significant differences in mean target latencies for the three types of synchronizers, F (2,42) = 7.92, $p < .005$. The interaction is not significant.

It is also clear from Figure 4 that the difference in target latencies between groups and the difference in times among types of synchronizers are maintained on block six when the manual response only had to be performed. Target latencies on block six were analyzed by a two dimensional analysis of variance (Table 20 in Appendix III). Components Ss are again slower than configuration Ss, F (1,42) = 9.35, $p < .005$. The difference in mean response times among types of synchronizers is significant, F (2,42) = 5.05, $p < .025$, while the interaction is not.

From Figure 4, it is also apparent that the six sets of Ss differ in the amount they speed-up in going from

block four to block six. These differences in target latencies obtained by subtracting the mean for block six from the mean for block four for each S were tested by a two dimensional analysis of variance (Table 21 in Appendix III). Components Ss again speed-up more in going from block four to block six than do Ss in the configuration group, F (1,42) = 6.60, $p < .025$. There are also differential speed-ups among the three types of synchronizers, F (2,42) = 6.43, $p < .005$. The interaction between groups and types of synchronizers is not significant.

Vocal Reaction Time Data

Vocal response times for the six subgroups are represented in Figure 5. Components Ss who are target synchronizers or non-synchronizers have the slowest vocal response times on blocks 2, 3 and 4, while configuration Ss who exhibit lift or target synchrony have the shortest vocal latencies on these three blocks. A two dimensional analysis of variance (Table 22 in Appendix III) performed on the data from blocks 2, 3 and 4 yields a highly significant groups main effect, F (1,42) = 12.30 $p < .005$. Type of synchronizer is also highly significant, F (2,42) = 8.03, $p < .005$, while the interaction effect fails to reach significance.

Differences among Ss on the vocal response measure are also apparent in block five. Components Ss and Ss who are non-synchronizers have slow vocal response times on the

vocal singles block. Ss in the configuration group and Ss who are lift synchronizers have fast vocal response times on block five. Both the groups main effect, F $(1,42) = 8.03$, $p < .01$, and type of synchronizer main effect, F $(2,42) = 8.70$, $p < .001$, are highly significant when tested by a two dimensional analysis of variance (Table 23 in Appendix III). No significant interaction is obtained.

Finally, Figure 5 indicates that Ss with slow vocal response times on block four speed-up more on moving to the singles task on block five than do Ss whose vocal response times on block four are already relatively fast. A two dimensional analysis of variance (Table 24 in Appendix III) was performed on the difference in vocal latencies for blocks four and five. Components Ss show more of a speed-up on block five than do Ss in the configuration group, F $(1,42) = 4.58$, $p < .05$. The main effect for synchrony type and the groups x types of synchronizers interaction fail to reach significance.

Return Subject Data

Twelve Ss, five from the components group and seven from the configuration group, were brought back for a second experimental session. Two of the Ss retested were lift synchronizers; six were target synchronizers; and four were categorized as non-synchronizers on the basis of their performance on session one. Ss in the configuration group on session one were presented in session two with instruc-

tions for the components task; Ss originally in the components group received instructions for the configuration task in session two. Ss were run through four combined blocks employing the new task instructions. The payoff schedule was in effect for all four blocks of trials.

Latency Data

Figure 6 depicts mean lift latencies for each block of trials and for both sessions. Latencies are represented separately for Ss who switched from the components to the configuration condition and for Ss who switched from the configuration to the components task. There is a large increase in lift response latency for Ss moving from the configuration to the components condition. Six out of seven Ss who began in the configuration condition show consistently longer lift response times across all four combined blocks when switching to the components task. Figure 6 also indicates that Ss who began in the components condition have faster lift response times upon switching to the configuration task. This difference is particularly noticeable on blocks one and two and is exhibited by four of the five Ss tested.

Mean target latencies for the 12 Ss are represented for each group and session in Figure 7. On all four combined blocks, mean target latencies are longer in session two than in session one for Ss moving from the configuration to the components condition; and target latencies are shorter for session two than for session one for Ss moving

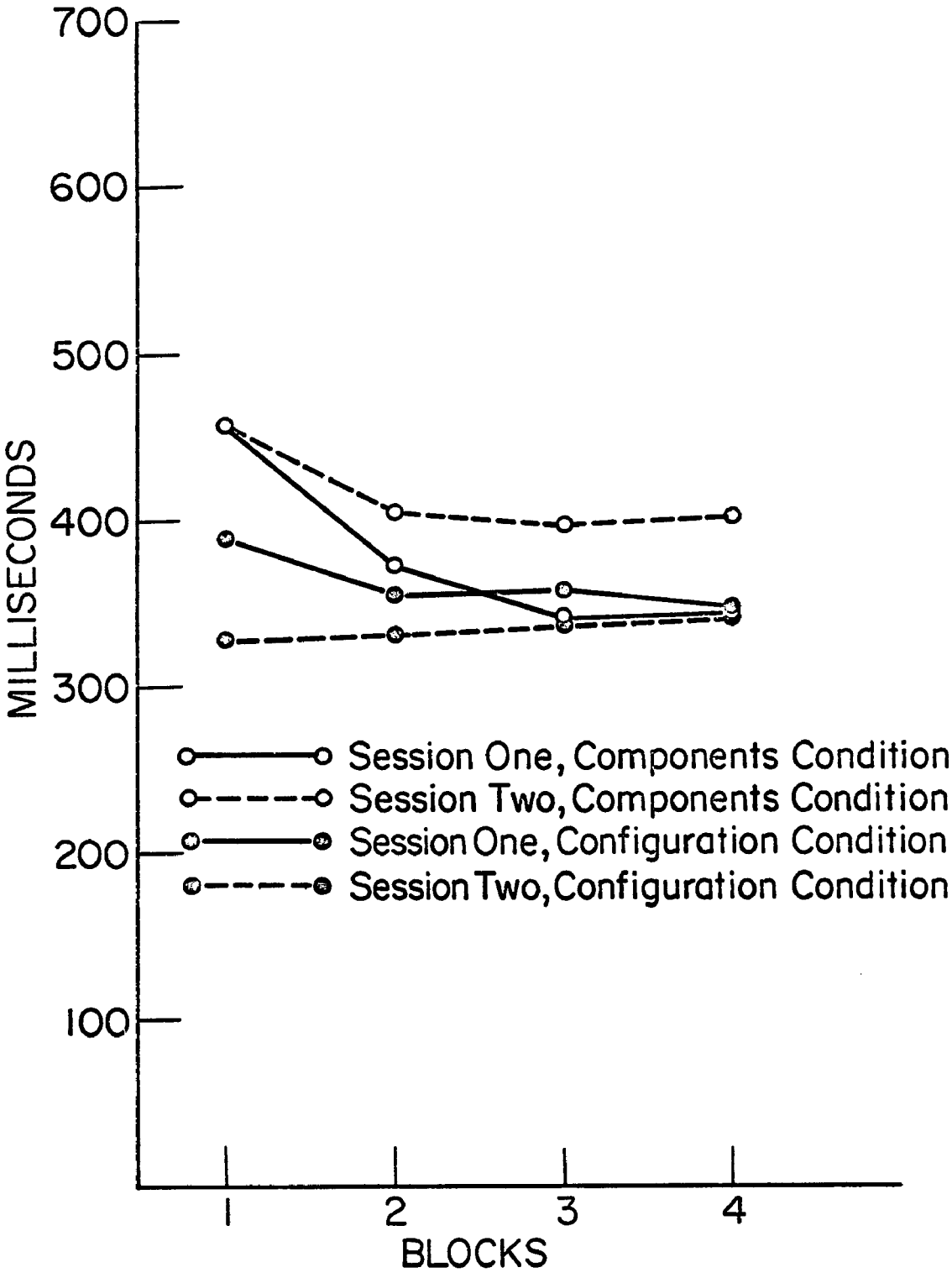


Fig. 6. Mean lift times on blocks one to four for Ss participating in both sessions and both experimental conditions.

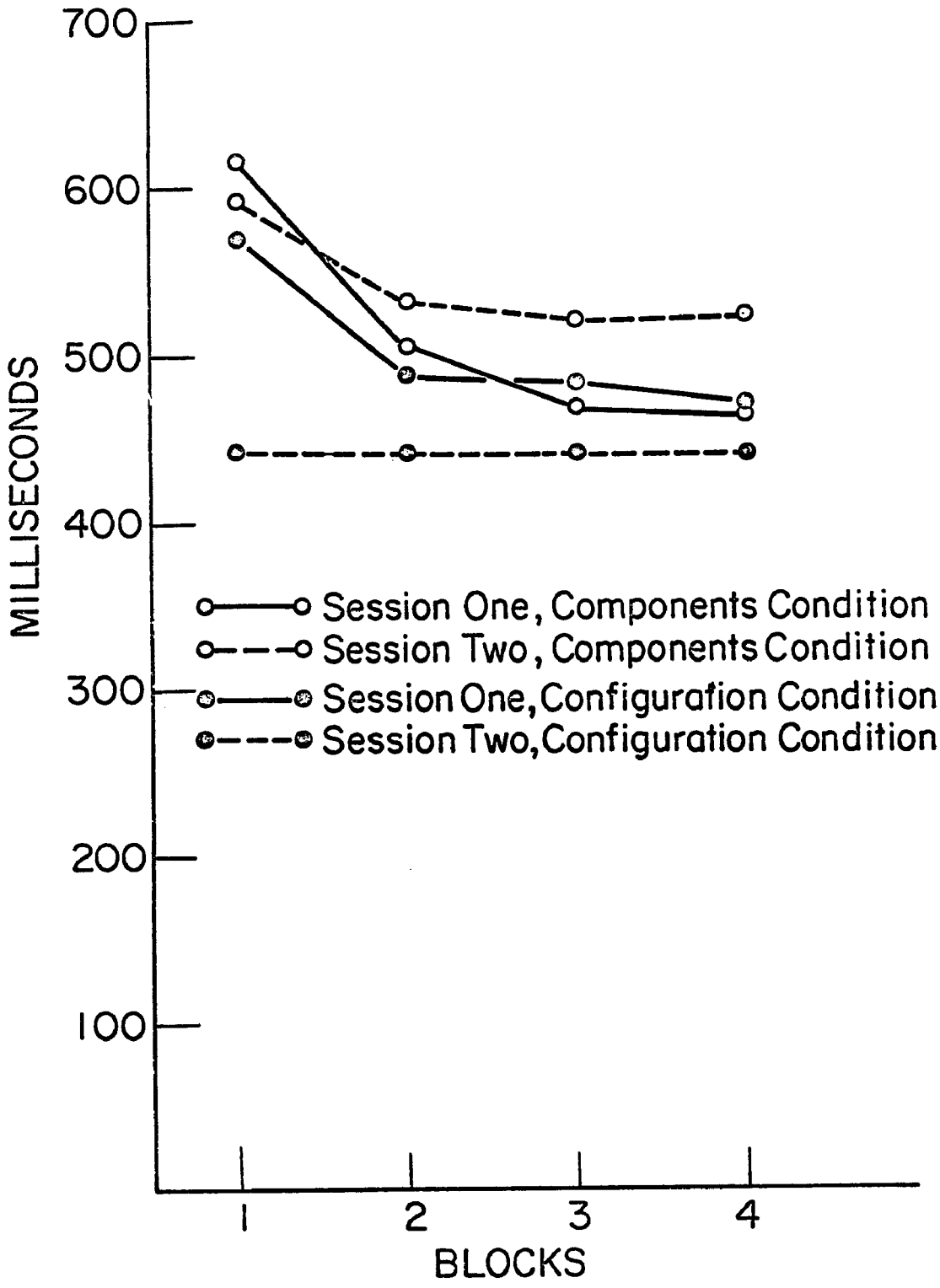


Fig. 7. Mean target times on blocks one to four for Ss participating in both sessions and both experimental conditions.

from the components to the configuration task. All seven Ss starting in the configuration condition show increases in target response times when switching to the components task. Four out of five Ss show corresponding decreases in target latencies when switching from the components to the configuration task.

Figure 8 portrays the mean vocal response times on sessions one and two for Ss beginning in the configuration and components conditions. Large speed-ups in vocal latencies are apparent for all four combined blocks of session two for Ss who began in the components condition. Only two of five Ss, however, show consistently shorter vocal latencies for all four blocks of session two. The other three Ss show longer latencies on blocks three and four of session two relative to their mean times for these blocks on session one. Figure 8 also indicates slower vocal response times on session two for all four combined blocks for those Ss going from the configuration to the components condition. This difference is attributable to slower vocal times for four Ss in the second session. The remaining three Ss actually decrease their vocal latencies upon moving to the components task.

Synchrony Data

Table 25 in Appendix III gives the number of lift and target synchronies for each S on all four combined blocks of session one and for each of the four combined blocks of

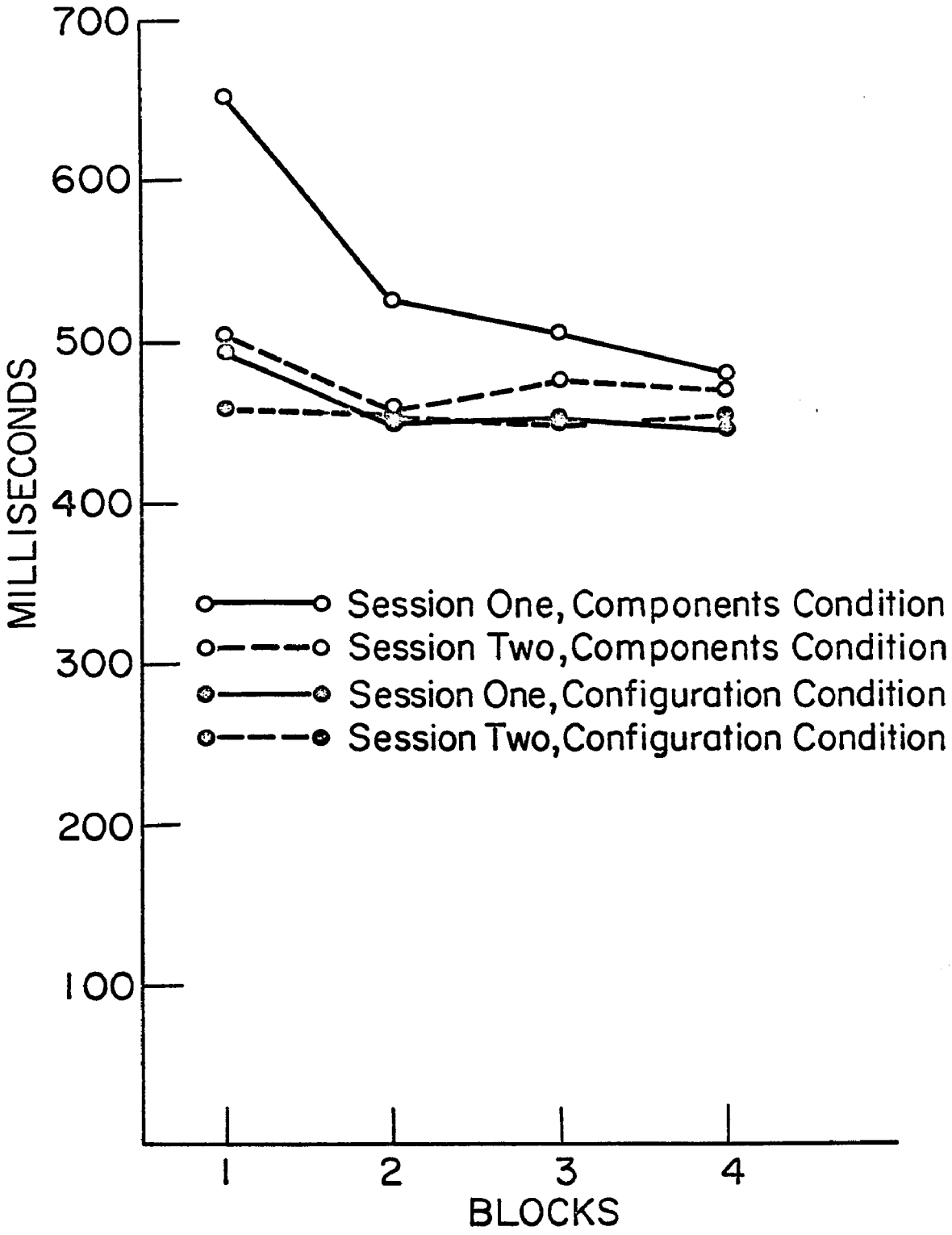


Fig. 8. Mean vocal times on blocks one to four for Ss participating in both sessions and both experimental conditions.

session two. Five of the six target synchronizers remain target synchronizers upon switching to a new condition on session two. The remaining target synchronizer is classified as a non-synchronizer for session two. Three of four Ss who are classified as non-synchronizers in session one are also classified as non-synchronizers in session two. The remaining non-synchronizer becomes a target synchronizer for session two. One S is categorized as a lift synchronizer for sessions one and two, and one S switches from a lift synchronizer to a non-synchronizer when moving from session one to session two.

Error Data

Table 26 in Appendix III gives error data on each of the six blocks for each S in the configuration group. An error occurred when S made a vocal or a manual response on a "catch trial" on which the left or right light was presented alone and on which the response produced was not called for. An error was also recorded if S made an anticipatory response on a trial where both responses were required.

There were 152 errors made by Ss in the configuration group. Virtually all errors occurred on catch trials. Altogether, there were 1152 of these catch trials, which corresponds to an error rate of 13.2%. If both catch trials and combined (dual response) trials are included, the error rate is 3.3%. There were 68 errors made by configuration Ss on blocks 2, 3 and 4. This corresponds to

an error rate of 11.8% if only catch trials are included or a rate of 2.9% if both catch trials and dual response trials are included. The data in Table 26 also reveal that configuration Ss make more incorrect responses on catch trials in a manual singles block than in a vocal singles block. Ss made only seven errors in the vocal singles block, while they made 52 errors in the manual singles block.

Error data for Ss in the components group is reported in Table 27 of Appendix III. An error occurred if S made a vocal response on a catch trial which presented the right light alone and where only a manual response was called for, or if S made a manual response on a catch trial on which only the left light came on and where only a vocal response was required. An error was also recorded if S made an anticipatory response on a trial where both responses were to be performed.

There were 110 errors committed by components Ss, virtually all of which occurred on catch trials. This corresponds to an error rate of 9.5% if only catch trials are considered or a rate of 2.4% if both catch trials and dual response trials are included. Seventy-three errors were committed on blocks 2, 3,and 4,which corresponds to an error rate of 12.7% if catch trials are included or 3.1% if all trials are considered. Only four errors were made in the vocal singles block, and ten errors were committed in the manual singles block.

CHAPTER V

DISCUSSION

The experiment reported in this dissertation was designed to examine speed and patterning of responses when both a manual and a vocal response had to be performed upon the joint presentation of two visual stimuli. For Ss in the configuration group, the simultaneous onset of the two lights was to be considered a unitary perceptual display to which two responses were to be made. The onset of only the right or left light was a different perceptual display to which no response was required. Ss in the components group, on the other hand, were instructed that different parts (lights) in a display were to be associated with individual responses. Thus, the right light signaled a manual response, and the left light signaled a vocal response. If both lights came on together, Ss in the components group were instructed to perform the manual response in association with the appearance of the right light and the vocal response in reaction to the onset of the left light. It was expected that different response speeds and timing relationships would be identifiable as a function of whether the identical dual light presentation was organized as a single perceptual unit associated with the requirement to make two responses or as two perceptually differentiable stimulus components each of which was a signal for its associated response.

The data support several general conclusions about response speeds to single and dual light displays as well as information about the interrelationships of the vocal and motoric response systems in the two light case. First, it is immediately apparent from Figure 1 that the task instructions produced different response latencies for the two groups. On all six blocks of trials, components Ss had longer response latencies for all three response measures than configuration Ss-- in spite of the fact that both groups were required to make the same responses to the identical dual light display. Presumably, it is more difficult to perform one response in conjunction with a second response when each response is related to its own individual component of a multiple signal display. Multiple responses can be initiated and completed more rapidly when they are jointly evoked by a particular stimulus configuration or display. These statements must be qualified, however, insofar as the differences in response speeds between groups may only appear when the dual light presentations are randomly interspersed with single light presentations which do impose different response requirements for the two groups.

It is also apparent from Figure 1 that Ss improve their response times with practice. There are large decreases in response latencies for the lift, target, and vocal measures in moving from block one to block two. Whether this improvement is a function of practice is confounded by the fact that block two is also the first block

in which the payoff schedule was in effect. Improvement is also evident, however, in the small but consistent and significant decreases in response times for all three response measures across combined payoff blocks 2, 3 and 4.

A much larger and theoretically more significant decrease in lift, target, and vocal response times is apparent when Ss move from the final combined block to the singles requirement on blocks five and six. The speed-up when moving to the singles task is many times greater than the improvement between blocks three and four. It would appear that having to perform only a single response is much easier than performing the same response in conjunction with a second response. Insofar as this is the case, the data clearly refute the hypothesis of independence of performance when two responses are to be carried out upon the presentation of same stimulus display. The dramatic improvement in response times on blocks five and six imply that the vocal and manual response systems are interacting on blocks one through four such that each response is slowed down relative to the speed at which it would have been performed if it were the only response required.

A further conclusion from the data is that for combined blocks 2, 3 and 4 components Ss are faster in performing a response in conjunction with a second response to a dual light presentation than performing that same response alone to a single light catch trial. This might

appear to contradict the conclusion stated just above that a response is faster when performed alone on the singles block than when it is paired with a second response on the combined blocks. The apparent contradiction can be resolved if it is realized that on a singles block S knows that only one response (e.g., the manual response) is required for the whole block of trials. He can essentially ignore the other response. In contrast to this, components Ss on combined blocks one to four cannot ignore either response since on three out of every four trials both responses are to be made. One suggested explanation is that if S prepares to make both responses and a catch trial occurs on which only a single response is called for, it is possible that the need to inhibit the response which is not to be made also inhibits the rate at which the required response is performed. The data would further suggest that this delay in responding is greater than the delay created in dual response trials by the interaction of the two response systems. In this manner, both the faster responding on the singles block and the comparatively slower response speeds to single light catch trials can both be explained.

The difference in response speeds to single light and dual light trials for Ss in the components group disappears for the lift and target measures on the singles manual block. This is readily explainable if it is presumed that on this block S develops a strategy of ignoring the left light entirely since no vocal response is ever called for.

By concentrating on only the right light S should have identical lift and target response times on trials where both lights come on and trials where only the right light comes on.

A similar line of reasoning would predict no difference in vocal latencies on the singles vocal block for trials where only the left light comes on and trials where both lights come on (since S could ignore the right light entirely on this block). A significant difference is found, however, with faster responses to the two light stimulus. This discrepancy in performance on the manual and vocal singles block is puzzling. It might be that since the vocal singles block comes before the manual singles block S only discovers the strategy of ignoring one light after some amount of practice. This is at least plausible since S had been originally instructed to concentrate on both lights. Furthermore, no change in instructions about fixation of attention occurred when S switched to the singles block. Any strategy of ignoring one light would have to be developed by S on his own. In addition to a possible practice effect, it might be that Ss simply adopted different strategies for the vocal and manual singles blocks or that the vocal and manual reaction time tasks differ in some other unidentified manner.

With respect to the synchrony data, there is a sizable amount of synchronizing of the vocal response with either lifting the finger off the home button or hitting the target button. For combined blocks 2, 3 and 4, better

than one out of every three (36.1%) of the trials resulted in synchrony of either the lift or target response with the vocal response. There was no difference between the components and configuration groups, however, in the number of lift synchronies, target synchronies, or on the combined, lift plus target synchronies measure. Although the two groups are differentiable in terms of speed of responding, synchronizing is equally frequent for the two groups--even when instructions to the components group specifically attempted to associate each response with a different aspect of the stimulus display.

Previous investigators (Birch, 1971; Birch and Eisner, 1968; Susman, 1971) have reported a comparable amount of synchronizing when both a vocal and a manual response were to be performed at the onset of a single light stimulus. The present data support these findings and generalize them to the case where the two responses are attached to two different cues. It appears then as if coordination, or, more specifically, synchronization of responses in a multiple response situation, is a reliable characteristic of human performance. Such a finding might have some utility in situations such as training workers for tasks involving sequences of rhythmic activities or for curing stuttering. In the latter case, for example, it might be possible to train a stutterer to synchronize his speech sounds with some simple motor act such as tapping a finger on a table.

The kind of synchronizing exhibited by Ss seems to vary

from one experiment to another. Birch and Eisner (1968) found only synchrony of the vocal and target responses in their experiment. In the study carried out by Susman (1971), six of the seven conditions resulted in synchrony of the vocal and lift responses. Susman suggests that the type of synchronizing may be a function of the specific vocal and manual tasks. The present study further indicates that response patterning may vary among Ss even for the same task. Nine Ss in the present experiment were lift synchronizers, 22 were target synchronizers, and 17 were non-synchronizers. It appears that synchronizing is a function both of the task and of the individual.

The significance of individual differences is further highlighted by a comparison of performances for the 12 Ss who participated in both the configuration and the components task. Nine of 12 Ss were classified as the same type of synchronizer for both experimental sessions. This again signifies that individuals differ in how they organize the patterning of their vocal and manual responses, but that an individual who adopts one type of synchrony pattern is likely to retain this pattern whenever possible if switched to another task which also produces several different types of synchrony patterns among Ss.

It should also be pointed out that the categorization of Ss into lift, target, and non-synchronizers is entirely arbitrary. It could be that each S is coordinating his responses in some fashion. For one S this might take the form of synchrony of lifting the finger from the home button

and vocalizing. Another S may always be making his vocal response at some point in time midway between the time his finger leaves the home button and the time he hits the target grid. A third S could always make the vocal response and afterwards begin his manual response. The latter two Ss would be classified in the experiment as non-synchronizers, yet is is clear that they are coordinating their two responses in some regular manner. For the purposes of this experiment, however, a decision was made to examine just response patterns involving simultaneity of vocalization and the act of lifting the finger from the home button or hitting the target button. Other types of response patterns could and should be examined in future research.

Not only do Ss differ in whether they are classified as lift synchronizers, target synchronizers, or non-synchronizers, but the three types of synchronizers differ in their lift, target, and vocal response latencies. Non-synchronizers, particularly those in the components group, have generally longer response latencies than synchronizers for both the combined and the singles blocks. Put another way, it is the faster responding Ss who are synchronizers. Lift and target synchronizers are further differentiable in that target synchronizers, especially those Ss in the configuration group, tend to have faster lift and target response times than either of the two lift synchronizer subgroups. Both lift synchronizer subgroups tend to have shorter vocal latencies than the target synchronizers who are components Ss.

What emerges is a pattern for synchronizing as follows: Ss who are relatively slow at vocalizing (i.e., Ss from the more difficult, components task) or relatively fast in both vocalizing and making a manual response (i.e., Ss from the easier, configuration task) synchronize the end or target portion of their manual response with the vocalization. Ss who are fast at producing a vocal response but not as fast at making a manual response synchronize the vocal response with the initial or lift portion of the manual response, regardless of which experimental group they are in. Non-synchronizers are Ss from the components group who are slow at both the vocal and manual responses or Ss in the configuration group who are slow at vocalizing and have intermediate manual response times. Such an explanation attributes type of synchrony to relative reaction time latencies. The data do not really permit, however, a substantiation of this type of hypothesis from one that attributes relative reaction times to the type of synchrony. It is only possible to state that certain patterns of response times are connected with a particular type of synchronizing without stating which causes which.

One type of hypothesis which can be tested and rejected is what may be termed a strong verbal control hypothesis. Such a hypothesis would predict that the vocal reaction time remains constant and that the vocal response always pulls the lift or target response time up or down to match it. What is found instead is that vocal response times

differ for different types of synchronizers. Similarly, a strong lift or target hypothesis must also be rejected because both manual response measures differ for the different synchronizer types.

Synchrony data for Ss participating in both the components and configuration conditions have already been cited as evidence that Ss tend to be classified as the same type of synchronizer even when switching from one task to another. The latency data for the 12 Ss brought back for a second experimental session confirm the difference in response times for the components and configuration tasks. Ss originally in the components condition generally speed-up on their lift, target, and vocal response measures when switching to the configuration task. Ss who had participated in the configuration condition in session one show generally slower response times for all three responses when they move to the components task in session two. The return subject data thus lend additional support to the claim that the components task is more difficult in terms of reaction time latencies, but that this difference does not extend to the amount of synchronizing produced by the two tasks. This latter feature of the data seems to be more a matter of individual differences among Ss.

Finally, an examination can be made of the error data for Ss in the components and configuration groups. The 9.5% error rate for components Ss is a lower error rate than the 13.2% reported for configuration Ss. It should

be noted, however, that the latter Ss could commit either a vocal or a manual error on a catch trial. Components Ss, on the other hand, could only make half as many errors since one response (the manual response for the right light and the vocal response for the left light) was always correct on every trial. This would lead to a prediction of twice as large an error rate for the configuration group Ss if the tasks were equally difficult. Since the ratio is smaller than 2:1 this might be interpreted as more evidence that components Ss were performing in the more difficult task.

In summary, the experiment reported in this dissertation supports several conclusions about human performance. Instructions or the set S adopts can influence S's speed of performance. Components Ss had slower vocal and manual reaction times than configuration Ss when an identical stimulus display was presented to both groups and both groups were required to make the identical two responses. It appears that processing information in parts (components) is less efficient in terms of time needed to respond than processing that same information as a single unit (configuration task). The difference in difficulty between the two experimental groups is further supported by the shifts in reaction time for Ss participating in both conditions. Ss speeded-up in session two when they moved from the components to the configuration task, while Ss' response times were slower on session two if they moved from the configuration to the components task. Finally, the

error data also may be interpreted as supporting the claim that processing information in parts is more difficult than processing the same information as a whole. Components Ss had only half as many opportunities to make errors on catch trials as configuration Ss, and yet the total number of errors made by components Ss was more than half the number made by configuration Ss.

The data from this experiment also refute the hypothesis that two responses can be performed independently of each other, when both are to be performed to the same stimulus input. The large decreases in manual and vocal response times when Ss moved from the combined to the singles blocks is strong evidence that there is some interaction between response systems in the combined task.

The nature of this interaction between response systems seems best described by some form of coordination hypothesis. Both experimental groups show a sizable number of trials on which a vocal response occurred synchronously with either the initiation or termination of the motor response. It is interesting that the two groups did not differ in terms of the amount of synchronizing. This is true in spite of the fact that the two groups differed substantially in their vocal and manual response speeds. It appears that coordination and more particularly synchronization of responses is a general characteristic of human performance in multiple response tasks and that this synchronization is generally independent of S's response times. This finding would seem to have applicability to a

large number of situations where training of vocal or motoric performance is required or where there is some congenital or acquired deficiency in either the vocal or motoric system.

Finally, what also seems to be apparent from the data is that there are large differences in the type of synchronizing that is found for different tasks and for different individuals in the same task. Another aim of human performance theorists should thus be a more precise description of the circumstances under which coordination of multiple responses occurs. This should lead, in turn, to even greater application of this finding to natural, real world settings.

APPENDICES

APPENDIX I

CONFIGURATION CONDITION INSTRUCTIONS

Hello. This is an experiment on reaction time. Please be seated in this chair and I will begin giving instructions.

Combined Task

Your task is to respond as quickly as you can following the onset of these stimulus lights. [Point out the appropriate positions on the display apparatus.] Please put on these headphones and adjust them so they fit comfortably. When you hear the ready signal, fixate the tiny white square at the center of the display. The ready signal will be a pure tone that will come on a few seconds before the lights. The lights will both come on together. As soon as the lights come on, turn them off by performing the following two reactions. Call out as quickly as you can the name of the color of the lights. The lights in this experiment will always be blue. Be sure to really call out the color so the microphone picks up your voice. In addition, as soon as the lights come on, you must move your preferred hand (right hand) as quickly as possible from this home button to this target plate. Your task is thus to make two reactions. You respond as quickly as you can by calling out the color "Blue" and you respond as quickly as you can by moving your hand from the starting position to the target grid. Don't try to anticipate the lights because

the interval between the ready signal and the appearance of the lights will vary randomly.

In addition, on some of the trials, only one of the two lights--either the left or right--will come on. On these trials you are not to make any response at all. The light will go off automatically after a few seconds. A short time later a new trial will begin.

Thus let me reemphasize that you should not anticipate the lights. You should avoid all false alarms or incorrect responses. All errors will be penalized and if you make too many of them, we will have to discontinue the experiment.

Are there any questions?

Okay, we'll go through a few practice trials.

Now we will go through a block of 32 trials.

Payoff Combined

Your task is still to turn off the lights as quickly as you can. However, we have decided to pay you a bonus if you can do it particularly quickly. This is how it will work. We have calculated the median time for the last 15 trials separately for your motor and verbal responses. These median times have been designated your baseline times. Now the faster you are able to respond in relation to your baseline time the more money you will earn. By the same token if you respond relatively more slowly you will reduce your earning power. You will receive a separate payoff for each response. Now I will ex-

plain what this all means. Your basic pay for the session is $1.75 and that amount you are guaranteed. If your response time for a particular trial--let us pick, for example, your motor response--is shorter than your baseline time you will earn a certain number of points as indicated on this sheet.[Point to payoff schedule.] If, however, your time is longer than your baseline time, you will lose points. The same thing would, of course, apply for your vocal response time. Wins and losses will be regulated in terms of the total number of points you get as shown in this payoff schedule.

Do you have any questions?

Okay. Remember (1) to go as fast as possible, (2) call out the color loud and clear, (3) perform the motor response the same way on each trial, (4) do not anticipate the lights (5) do not make errors.

Now we will run through a block of 32 trials.

[Blocks 3 and 4 are the same as payoff combined.]

Payoff Single Vocal

This time your task is to perform just the verbal part of the task you have just been doing. That is, you should call out as fast as possible the color "Blue" if both lights come on. If the left or right light comes on alone, do nothing. Do not move your finger off the home button and do not call out the color. The light will go off automatically after a short period of time. And then a new trial will begin. Again you will be earning points toward

extra bonus money as a function of how fast you go relative to your baseline time--so remember to respond as quickly as you can without making any errors.

Do you have any questions?

All right. We will go through a block of trials.

Payoff Single Manual

This time your task is to perform just the motor part of the original task. That is, you should move your hand as quickly as possible from the home button to the target button when both lights come on. If only the left or right light comes on, do nothing. Do not make either a manual or a vocal response. The light will go off automatically.

Once again the same point system and bonus schedule will be in effect.

Do you have any questions?

All right, now we'll go through a block of trials. Remember to go as fast as possible.

COMPONENTS CONDITION INSTRUCTIONS

Hello. This is an experiment on reaction time. Please be seated in this chair and I will begin giving instructions.

Combined Task

Your task is to respond as quickly as you can following the onset of one or both of these stimulus lights. [Point out appropriate positions on the display apparatus.] Please put on these headphones and adjust them so that they fit comfortably. When you hear the ready signal, fixate the tiny white square at the center of the display. The ready signal will be a pure tone that will come on a few seconds before the light or lights. Both of the lights will be blue. If the left-hand blue light comes on, turn it off by calling out the color "Blue" as quickly as possible into the microphone. Be sure to really call out the color so the microphone picks up your voice. If the right-hand blue light comes on, turn it off by moving your preferred (right) hand as quickly as possible from this home button to this target plate. If both of the lights come on together, your task is to perform both of these responses. That is, you must call out the color "Blue" as fast as possible and you must move your hand as fast as possible from the starting position to the target grid.

Don't try to anticipate the lights because the interval between the ready signal and the appearance of the light(s) will vary randomly. Let me emphasize that you

should avoid all false alarms or incorrect responses. All errors will be penalized and if you make too many of them, we will have to discontinue the experiment.

Are there any questions?

All right. We'll go through a few practice trials.

Now we will run a block of 32 trials.

Payoff Combined

Your task is still to turn off the light or lights as quickly as you can. However, we have decided to pay you a bonus if you can do it particularly quickly. This is how it will work. We have calculated the median time for the last 15 trials separately for your motor and verbal responses. These median times have been designated your baseline times. Now the faster you are able to respond in relation to your baseline time the more money you will earn. By the same token if you respond relatively more slowly you will reduce your earning power. You will receive a separate payoff for each response. Now I will explain what this all means. Your basic pay for the session is $1.75 and that amount you are guaranteed. If your response time for a particular trial--let us pick, for example, your motor response--is shorter than your baseline time you will earn a certain number of points as indicated on this sheet.[Point to payoff schedule.] If, however, your time is longer than your baseline time, you will lose points. The same thing would, of course, apply for your vocal response time. Wins and losses will be regulated in

terms of the total number of points you get as shown in this payoff schedule.

Do you have any questions?

Okay. Remember (1) to go as fast as possible, (2) call out the color loud and clear, (3) perform the motor response the same way on each trial, (4) do not anticipate the lights, (5) do not make errors.

Now we will run through a block of 32 trials.

[Blocks 3 and 4 are the same as payoff combined.]

Payoff Single Vocal

This time your task is to perform just the verbal part of the task you have just been doing. That is, you should call out as fast as possible the color "Blue" if the left light comes on or if both lights come on. If just the right light comes on, do nothing. Do not move your finger off the home button and do not call out the color. The light will go off automatically after a few seconds. A short time later a new trial will begin. Again you will be earning points toward extra bonus money as a function of how fast you go relative to your baseline time--so remember to respond as quickly as you can without making errors.

Do you have any questions?

All right, we will go through a block of trials.

Payoff Single Motor

This time your task is to perform just the motor part

of the original task. That is, you should move your hand as quickly as possible from the home button to the target button when the right light or both lights come on. If the left light comes on alone, do nothing. Do not make either a manual or a vocal response. The light will go off automatically.

Once again, the same point system and bonus schedule will be in effect.

Are there any questions?

All right. Now we will go through a block of trials. Remember to go as fast as possible.

APPENDIX II

POINT VALUES

Wins

0-49 msec. faster than baseline = 5 points

50-99 msec. faster than baseline = 10 points

100-149 msec. faster than baseline = 20 points

150-199 msec. faster than baseline = 30 points

200 or more msec. faster than baseline = 40 points

Losses

1-49 msec. slower than baseline = -5 points

50-99 msec. slower than baseline = -10 points

100-149 msec. slower than baseline = -20 points

150-199 msec. slower than baseline = -30 points

200 or more msec. slower than baseline = -40 points

PAYOFF SCHEDULE

Points	Earnings
1-500	5¢
501-1000	15¢
1001-1500	25¢
1501-2000	35¢
2001-3000	45¢
3001-4000	55¢
4001 or more	75¢

APPENDIX III

TABLE 1

ANALYSIS OF VARIANCE OF MOVEMENT TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	176838		
Groups (A)	1	9967	9967	2.75
Ss w. groups	46	166871	3628	
Within Ss	96	14061		
Blocks (B)	2	1632	816	6.37**
A x B	2	698	349	2.73
B x Ss w. groups	92	11731	128	

**p < .01

TABLE 2

ANALYSIS OF VARIANCE OF LIFT TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	912042		
Groups (A)	1	128403	128403	7.54**
Ss w. groups	46	783639	17036	
Within Ss	96	50194		
Blocks (B)	2	6489	3244	6.98**
A x B	2	887	443	< 1
B x Ss w. groups	92	42818	465	

**p < .01

TABLE 3

ANALYSIS OF VARIANCE OF LIFT TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS FOUR AND SIX

Source	df	SS	MS	F
Between Ss	47	501089		
Groups (A)	1	57870	57870	6.01*
Ss w. groups	46	443219	9635	
Within Ss	48	96948		
Blocks (B)	1	51569	51569	58.20***
A x B	1	4606	4606	5.20*
B x Ss w. groups	46	40773	886	

*p < .05 ***p < .001

TABLE 4

ANALYSIS OF VARIANCE OF TARGET TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	1396926		
Groups (A)	1	209916	209916	8.13**
Ss w. groups	46	1187010	25805	
Within Ss	96	83777		
Blocks (B)	2	14602	7301	9.83***
A x B	2	801	400	< 1
B x Ss w. groups	92	68374	743	

**p < .01 ***p < .001

TABLE 5

ANALYSIS OF VARIANCE OF TARGET TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS FOUR AND SIX

Source	df	SS	MS	F
Between Ss	47	792725		
Groups (A)	1	115163	115163	7.82**
Ss w. groups	46	677562	14730	
Within Ss	48	120122		
Blocks (B)	1	65261	65261	59.60***
A x B	1	4496	4496	4.11*
B x Ss w. groups	46	50365	1095	

*$p < .05$ **$p < .01$ ***$p < .001$

TABLE 6

ANALYSIS OF VARIANCE OF VOCAL TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	1225088		
Groups (A)	1	151581	151581	6.50*
Ss w. groups	46	1073507	23337	
Within Ss	96	55190		
Blocks (B)	2	3628	1814	3.27*
A x B	2	470	235	< 1
B x Ss w. groups	92	51092	555	

*$p < .05$

TABLE 7

ANALYSIS OF VARIANCE OF VOCAL TIMES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS FOUR AND FIVE

Source	df	SS	MS	F
Between Ss	47	547434		
Groups (A)	1	60000	60000	5.66*
Ss w. groups	46	487434	10596	
Within Ss	48	222068		
Blocks (B)	1	143221	143221	89.91***
A x B	1	5582	5582	3.50
B x Ss w. groups	46	73265	1593	

*$p < .05$ ***$p < .001$

TABLE 8

NUMBER OF LIFT (L) AND TARGET (T) SYNCHRONIES FOR EACH COMPONENTS S ON BLOCKS ONE TO FOUR

Subject	Type of Synchrony	Blocks 1	2	3	4	Total
1	L	12	11	17	19	59
	T	1	0	0	0	1
2	L	5	1	0	2	8
	T	5	11	16	9	41
3	L	0	1	0	0	1
	T	5	9	11	10	35
4	L	6	2	2	0	10
	T	5	8	12	10	35
5	L	0	3	0	0	3
	T	12	14	14	11	51
6	L	0	0	0	0	0
	T	1	0	0	1	2
7	L	2	5	1	2	10
	T	1	3	5	12	21
8	L	2	3	7	9	21
	T	6	14	3	2	25
9	L	0	0	0	1	1
	T	3	5	10	10	28
10	L	1	0	0	0	1
	T	4	5	12	10	31
11	L	0	0	0	1	1
	T	1	5	7	9	22
12	L	0	0	1	0	1
	T	9	9	13	10	41
13	L	6	6	3	0	15
	T	0	0	3	7	10
14	L	3	12	6	10	31
	T	4	0	1	1	6

TABLE 8 -- Continued

Subject	Type of Synchrony	Blocks 1	2	3	4	Total
15	L	4	8	7	8	27
	T	0	2	1	3	6
16	L	0	3	7	6	16
	T	4	1	2	4	11
17	L	0	1	8	3	12
	T	0	0	0	0	0
18	L	0	0	0	0	0
	T	4	8	11	3	26
19	L	2	2	5	3	12
	T	8	10	7	5	30
20	L	3	6	6	8	23
	T	1	0	2	1	4
21	L	10	8	6	7	31
	T	1	1	2	2	6
22	L	0	4	5	8	17
	T	0	0	0	0	0
23	L	1	3	2	1	7
	T	2	5	8	10	25
24	L	0	0	0	0	0
	T	2	1	0	0	3
Sum	L	57	79	83	88	307
Sum	T	79	111	140	130	460

TABLE 9

NUMBER OF LIFT (L) AND TARGET (T) SYNCHRONIES FOR EACH CONFIGURATION S ON BLOCKS ONE TO FOUR

Subject	Type of Synchrony	Blocks 1	2	3	4	Total
1	L	1	2	2	1	6
	T	0	0	1	0	1
2	L	0	0	0	0	0
	T	4	6	6	8	24
3	L	3	0	0	0	3
	T	0	1	8	13	22
4	L	10	10	10	6	36
	T	0	0	0	0	0
5	L	4	0	0	0	4
	T	2	10	8	10	30
6	L	1	0	0	0	1
	T	9	13	11	1	34
7	L	0	0	0	0	0
	T	3	0	4	4	11
8	L	1	1	3	0	5
	T	9	3	3	9	24
9	L	9	7	7	1	24
	T	1	2	0	1	4
10	L	0	0	0	0	0
	T	0	7	7	2	16
11	L	0	0	0	0	0
	T	0	9	22	20	51
12	L	0	0	0	0	0
	T	6	10	0	0	16
13	L	1	4	2	3	10
	T	1	8	4	5	18
14	L	0	0	0	0	0
	T	3	3	5	4	15

TABLE 9 -- Continued

Subject	Type of Synchrony	Blocks 1	2	3	4	Total
15	L	3	1	6	0	10
	T	0	9	6	6	21
16	L	10	12	12	14	48
	T	0	1	0	1	2
17	L	0	0	0	0	0
	T	9	9	4	6	28
18	L	8	9	14	10	41
	T	0	0	0	0	0
19	L	2	4	5	1	12
	T	5	1	0	10	16
20	L	1	0	0	0	1
	T	5	5	10	15	35
21	L	13	15	16	21	65
	T	2	1	3	0	6
22	L	2	0	0	2	4
	T	1	10	17	3	31
23	L	0	0	0	0	0
	T	5	4	13	10	32
24	L	0	0	0	0	0
	T	6	10	20	16	52
Sum	L	69	65	77	59	270
Sum	T	71	122	152	144	489

TABLE 10

ANALYSIS OF VARIANCE OF LIFT SYNCHRONIES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	2635.82		
Groups (A)	1	16.67	16.67	< 1
Ss w. groups	46	2619.15	56.94	
Within Ss	96	278.67		
Blocks (B)	2	3.01	1.51	< 1
A x B	2	5.68	2.84	< 1
B x Ss w. groups	92	269.98	2.93	

TABLE 11

ANALYSIS OF VARIANCE OF TARGET SYNCHRONIES FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	2729.66		
Groups (A)	1	9.51	9.51	< 1
Ss w. groups	46	2720.15	59.13	
Within Ss	96	1044.00		
Blocks (B)	2	38.10	19.05	1.74
A x B	2	0.09	0.04	< 1
B x Ss w. groups	92	1005.81	10.93	

TABLE 12

ANALYSIS OF VARIANCE OF THE TOTAL AMOUNT OF SYNCHRONIZING FOR THE TWO EXPERIMENTAL GROUPS ON BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Between Ss	47	2198.64		
Groups (A)	1	1.00	1.00	< 1
Ss w. groups	46	2197.64	47.77	
Within Ss	96	1070.67		
Blocks (B)	2	59.18	29.59	2.70
A x B	2	4.63	2.31	< 1
B x Ss w. groups	92	1006.86	10.94	

TABLE 14

MEAN LIFT, TARGET, AND VOCAL TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS AVERAGED OVER BLOCKS TWO TO FOUR AND MEANS FOR THE SINGLE BLOCKS

Measure	Group	Type of Synchronizer	Mean of Blocks 2, 3 & 4	Singles Block
Lift	Configuration	Lift	377.0	302.2
		Target	296.4	270.9
		Non-Synchronizer	380.1	336.5
	Components	Lift	379.1	294.8
		Target	370.7	327.2
		Non-Synchronizer	480.4	389.9
Target	Configuration	Lift	519.1	417.7
		Target	416.1	378.0
		Non-Synchronizer	503.0	455.4
	Components	Lift	526.0	422.6
		Target	510.1	463.4
		Non-Synchronizer	622.0	523.6
Vocal	Configuration	Lift	398.2	355.2
		Target	408.5	344.9
		Non-Synchronizer	486.3	404.0
	Components	Lift	413.9	355.0
		Target	509.6	397.1
		Non-Synchronizer	558.9	457.7

TABLE 15

ANALYSIS OF VARIANCE OF MOVEMENT TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS AVERAGED OVER BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Type of Synchronizer (A)	2	1561	780	< 1
Groups (B)	1	3634	3634	2.82
A x B	2	386	193	< 1
Error	42	54088	1288	
Total	47	59669		

TABLE 16

ANALYSIS OF VARIANCE OF LIFT TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS AVERAGED OVER BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Type of Synchronizer (A)	2	102455	51227	13.12***
Groups (B)	1	67416	67416	17.27***
A x B	2	16322	8161	2.09
Error	42	163953	3904	
Total	47	350146		

***$p < .001$

TABLE 17

ANALYSIS OF VARIANCE OF LIFT TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS ON BLOCK SIX

Source	df	SS	MS	F
Type of Synchronizer (A)	2	52094	26047	6.99**
Groups (B)	1	25436	25436	6.82*
A x B	2	7943	3971	1.07
Error	42	156518	3727	
Total	47	241991		

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

TABLE 18

ANALYSIS OF VARIANCE OF LIFT TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SNYCHRONIZERS WITH RESPECT TO THE DIFFERENCE IN MEANS FOR BLOCK FOUR MINUS BLOCK SIX FOR EACH S

Source	df	SS	MS	F
Type of Synchronizer (A)	2	15794	7897	5.33**
Groups (B)	1	12210	12210	8.23**
A x B	2	6983	3491	2.35
Error	42	62298	1483	
Total	47	97285		

**$p < .01$

TABLE 19

ANALYSIS OF VARIANCE OF TARGET TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS AVERAGED OVER BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Type of Synchronizer (A)	2	108826	54413	7.92**
Groups (B)	1	101834	101834	14.82***
A x B	2	21447	10723	1.56
Error	42	288680	6873	
Total	47	520787		

**p < .01 ***p < .001

TABLE 20

ANALYSIS OF VARIANCE OF TARGET TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS ON BLOCK SIX

Source	df	SS	MS	F
Type of Synchronizer (A)	2	59939	29969	5.05*
Groups (B)	1	55552	55552	9.35**
A x B	2	11607	5803	< 1
Error	42	249455	5939	
Total	47	376553		

*p < .05 **p < .01

TABLE 21

ANALYSIS OF VARIANCE OF TARGET TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS WITH RESPECT TO THE DIFFERENCE IN MEANS FOR BLOCK FOUR MINUS BLOCK SIX FOR EACH S

Source	df	SS	MS	F
Type of Synchronizer (A)	2	22631	11315	6.43**
Groups (B)	1	11616	11616	6.60*
A x B	2	8644	4322	2.46
Error	42	73875	1759	
Total	47	116766		

*p < .05 **p < .01

TABLE 22

ANALYSIS OF VARIANCE OF VOCAL TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS AVERAGED OVER BLOCKS TWO TO FOUR

Source	df	SS	MS	F
Type of Synchronizer (A)	2	98516	49258	8.03**
Groups (B)	1	75488	75488	12.30**
A x B	2	12898	6449	1.05
Error	42	257762	6137	
Total	47	444664		

**p < .01

TABLE 23

ANALYSIS OF VARIANCE OF VOCAL TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS ON BLOCK FIVE

Source	df	SS	MS	F
Type of Synchronizer (A)	2	54297	27148	8.70***
Groups (B)	1	25048	25048	8.03**
A x B	2	5753	2876	< 1
Error	42	131078	3121	
Total	47	216176		

**p < .01 ***p < .001

TABLE 24

ANALYSIS OF VARIANCE OF VOCAL TIMES FOR THE TWO EXPERIMENTAL GROUPS AND THE THREE TYPES OF SYNCHRONIZERS WITH RESPECT TO THE DIFFERENCE IN MEANS FOR BLOCK FOUR MINUS BLOCK FIVE FOR EACH S

Source	df	SS	MS	F
Type of Synchronizer (A)	2	15625	7812	2.57
Groups (B)	1	13920	13920	4.58*
A x B	2	4075	2037	< 1
Error	42	127615	3038	
Total	47	161235		

*p < .05

TABLE 25

NUMBER OF LIFT (L) AND TARGET (T) SYNCHRONIES FOR EACH S ON BLOCKS ONE TO FOUR OF SESSIONS ONE AND TWO

Subject	Session	Type of Synchrony	Blocks 1	2	3	4	Total
1	1	L	12	11	17	19	59
		T	1	0	0	0	1
	2	L	15	6	3	6	30
		T	0	0	2	4	6
2	1	L	5	1	0	2	8
		T	5	11	16	9	41
	2	L	0	0	0	1	1
		T	7	15	10	17	49
3	1	L	0	1	0	0	1
		T	5	9	11	10	35
	2	L	0	0	0	0	0
		T	16	14	5	4	39
4	1	L	0	0	0	0	0
		T	1	0	0	1	2
	2	L	0	0	0	0	0
		T	2	6	4	7	19
5	1	L	0	0	0	1	1
		T	3	5	10	10	28
	2	L	0	0	0	0	0
		T	13	18	15	15	61
6	1	L	0	0	0	0	0
		T	6	10	0	0	16
	2	L	0	0	0	0	0
		T	2	8	2	5	17
7	1	L	0	0	0	0	0
		T	0	9	22	20	51
	2	L	0	0	0	0	0
		T	8	11	14	19	52

TABLE 25 -- Continued

Subject	Session	Type of Synchrony	Blocks 1	2	3	4	Total
8	1	L	0	0	0	0	0
		T	3	0	4	4	11
	2	L	0	0	0	0	0
		T	9	14	8	12	43
9	1	L	4	0	0	0	4
		T	2	10	8	10	30
	2	L	6	8	0	1	15
		T	0	3	9	10	22
10	1	L	10	10	10	6	36
		T	0	0	0	0	0
	2	L	5	6	10	5	26
		T	0	0	0	0	0
11	1	L	3	0	0	0	3
		T	0	1	8	13	22
	2	L	13	8	4	5	30
		T	0	0	0	1	1
12	1	L	1	2	2	1	6
		T	0	0	1	0	1
	2	L	0	3	4	9	16
		T	0	0	0	0	0

TABLE 26

ERROR DATA FOR EACH CONFIGURATION
S ON BLOCKS ONE TO SIX

Subjects	Blocks 1	2	3	4	5	6	Total
1	2	0	0	0	0	1	3
2	2	3	0	1	0	4	10
3	0	0	1	1	0	0	2
4	0	0	0	0	0	0	0
5	0	1	2	0	0	1	4
6	0	0	0	0	0	2	2
7	3	2	3	2	0	0	10
8	5	3	2	0	0	3	13
9	0	2	0	0	0	1	3
10	0	0	0	0	0	0	0
11	2	2	0	0	1	2	7
12	1	0	3	0	0	0	4
13	0	0	0	0	1	3	4
14	1	3	3	2	1	2	12
15	0	1	0	0	1	1	3
16	0	1	1	0	0	0	2
17	2	5	3	5	0	9	24
18	0	0	0	0	0	1	1
19	0	0	0	0	0	4	4
20	2	0	2	0	0	4	8
21	0	0	0	0	2	2	4
22	0	1	1	0	0	3	5
23	3	2	3	3	0	4	15
24	2	2	2	0	1	5	12
Sum	25	28	26	14	7	52	152

TABLE 27

ERROR DATA FOR EACH COMPONENTS S ON BLOCKS ONE TO SIX

Subject	Blocks 1	2	3	4	5	6	Total
1	0	0	0	0	0	0	0
2	0	1	1	0	0	1	3
3	2	0	1	0	0	1	4
4	0	3	0	2	0	1	6
5	0	1	1	0	0	0	2
6	4	0	1	1	0	0	6
7	2	1	0	0	0	0	3
8	1	1	0	0	1	0	3
9	5	3	1	4	1	0	14
10	1	0	1	0	0	0	2
11	0	3	1	1	0	1	6
12	0	1	2	2	0	0	5
13	1	1	0	0	0	1	3
14	0	3	0	3	0	1	7
15	0	1	3	3	0	1	8
16	1	1	0	2	1	1	6
17	0	0	1	0	0	0	1
18	1	2	0	0	0	0	3
19	2	1	3	1	1	0	8
20	1	1	2	2	0	1	7
21	0	0	1	1	0	0	2
22	0	0	0	0	0	0	0
23	2	2	1	1	0	0	6
24	0	2	1	1	0	1	5
Sum	23	28	21	24	4	10	110

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