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DEVELOPMENT OF TEMPORAL PERCEPTION IN CHILDREN: INFLUENCE OF AUDITORY AND VISUAL INTERVAL-FILLERS

City University of New York PH.D. 1980

DEVELOPMENT OF TEMPORAL PERCEPTION IN CHILDREN: INFLUENCE OF AUDITORY AND VISUAL INTERVAL-FILLERS

by

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A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, the City University of New York.

1980

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

August 1980 — date

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Abstract
Development of Temporal Perception in Children:
Influence of Auditory and Visual Interval-Fillers.

Adviser: Professor Tina Moreau

Temporal perception research has tended to focus, in a partisan manner, on either the evidence for an innate, sensory, "biological clock" explanation, or, on the other hand, on time perception as an acquired mental ability. The theory underlying the present study is that there is a primary organic choronometer, and that this interacts at later developmental stages with more cognitive concepts of time and measurement of intervals. It was hypothesized that pre-school children are more dependent upon an internal clock and would therefore be less influenced by externally imposed time-fillers in reproducing brief intervals, as compared with older children and adults who use more cognitive time perception processes.

In the present study, two groups of pre-school children, aged 3 and 4 years, were compared with two groups of school-aged children, 8 and 9 years old. They were all tested for accuracy of reproduction of a 15-second interval. Subsequently, they were tested on the reproduction of the same interval with a presto metronome time-filler in the visual and auditory modes.

The mean reproduction time of the 3 year old children as a group was closest to the 15" standard interval, but they were also the most variable children with some of them underreproducing and some overreproducing the time interval. Generally, the older groups of children underreproduced the interval. The 4 year olds were the least accurate group, and the 8 and 9 year olds were more accurate and approximately equivalent to each other. The two groups of older children were influenced to underreproduce the interval by the experimental insertion of presto auditory beats or visual flashes of light, whereas the two groups of younger children did not demonstrate such an effect. A comparison of the auditory with the visual mode of presentation of the presto metronome did not indicate a significant difference. Neither racial background nor gender were significant factors influencing accuracy in any group.

These results are consistent with the hypothesis that the younger children rely more heavily on an internal pacing in reproducing brief time intervals, and that their performance is resistant to the speed illusion of time-fillers. The older children have accumulated more experiences that are regulated by clocks, have developed counting skills, and have become more influenced by the rate of flow of events occurring within an interval, and their temporal reproductions are therefore more susceptible to the tempo of external visual and auditory stimuli.

Acknowledgements

Gratitude is extended here to my parents, family and friends for support and encouragement of my project. I also express deep appreciation to my dissertation committee, Professor Daniel Caputo, Professor Mitchell Kietzman, and especially my chairperson, Professor Tina Moreau, for guidance and patience over the years, and for their example of dedication to scientific inquiry.

Development of Temporal Perception in Children: Influence of Auditory and Visual Interval-Fillers

Estelle R. Friedman

Table of Contents **Page no.**

List of Tables

List of Figures

Development of Temporal Perception in Children: Influence of Auditory and Visual Interval-Fillers

This study is based on the broad hypothesis that both an internal, biologically-based chronometer as well as the capacity to cognitively deduce the passage of intervals of time co-exist in varying degrees and relationships at different developmental stages. Differences between pre-school and school-aged children in the basis of temporal judgments are examined here by assessing age differences in the effect of experimental visual and/or auditory stimulation on the accuracy of reproduction of a brief interval of time.

There has been a general tendency for the research on time perception to focus on one or the other side of the nature-nurture controversy, aimed at defending either the viewpoint that the experience of temporal duration is an organic sensitivity based upon inner timing mechanisms (Dmitriev & Kochigina, 1959; Fitzgerald & Brackbill, 1976; Holubar, 1969), or on the opposing notion that time perception is an acquired mental ability dependent upon cognitive factors (Gorman & Wessman, 1977; Chap. 1; Ornstein, 1969; Piaget, 1971).

"Time-Sense" Protagonists

'Biological clocks'

The microscopic diatom, *Hantzschia Virgala*, exudes a mucousy substance that propels it up between grains of sand to the surface of the beach, where it remains in photosynthesis through ebbtide. It slides down under the sand again just before the tide returns (Palmer, 1975). Even when the sand is transported to a laboratory 27 miles away, this regular, punctual behavior persists, and has been descriptively termed a 'biological clock'. This terminology has been applied freely to any regularly recurrent activity of organisms, even though the mechanism is not understood.

Von Frisch (1953) has provided empirical evidence for a biological clock in the honeybee *Apis mellifera*, as he trained them to forage for food with temporal precision. At 4 P.M., for several consecutive days, he placed a dish of syrup in the field. The insects quickly learned to arrive punctually, and continued to do so even when the empty dish was finally left in the field. The training of these insects was also successful when the food dish was placed several times within a 24-hour cycle (e.g., at 10 A.M., 1 P.M. and 7 P.M.). But Von Frisch could not train them to a non-circadian cycle such as to every 18 hours, or every 48 hours. The bees were conditioned to collect the food at a particular hour, not to eat it, but to store it inside the hives. In order to demonstrate that this temporal accuracy was not based upon visual awareness of the sun's position, he successfully replicated the study with the same results indoors under conditions of constant illumination. Although the behavioral phenomenon reported was replicated many times subsequently, Von Frisch was unable to identify the physiological mechanisms underlying this time precision. He concluded, "It is now clear that we are dealing here with beings who seemingly without needing a clock, possess a memory for time, dependent neither on a feeling of hunger nor an appreciation of the sun's position, and which like our own application of time seems to defy any further analysis" (p. 143).

Innumerable subesequent replications and variations of these studies of time sensitivity in

honeybees have confirmed similar results in birds, crabs, cockroaches, ants and flies. These organisms have all been trained to respond at a specific hour of the day. Transportation from natural habitats, across time zones and into constant light or dark conditions were not found to interfere with the maintenance of a conditioned twenty-four hour food-gathering schedule (Luce, 1971; Ward, 1972).

Pavlovian temporal conditioning

Stemming from the Kantian philosophical tradition researchers advocating a time sense have strongly emphasized the intuitive and fundamental nature of timing. Undeniably, regular, organic, rhythmic and cyclic functions are observed in the biological events of pulse, heartbeat, respiration, menses, in spontaneous awakening from sleep, and in jet lag. The conditioning of autonomic responses to an interval of time itself has been well-known since Pavlov's original temporal conditioning research on dogs fifty years ago (1928). In his work, the repeated presentation of meat to laboratory animals at regular intervals resulted in subsequent salivation at the moment when the food was next expected. A specific temporal interval was being utilized as the effective conditional stimulus.

A series of studies in the Pavlovian tradition conducted by Russian investigators with reptiles, birds and monkeys successfully conditioned to time was reviewed by Dmitriev and Kochigina (1959). Tortoises were trained to make a withdrawal reaction by the repeated application of carnation oil every three minutes. In that experiment, the unconditioned reflex to the aversive stimulus was transferred to the time interval (Nikiforovskii, 1951, cited by Dmitriev and Kochigina, 1959). Long-eared hedgehogs and monkeys were trained by artificial reversal of light/dark schedules to change their established patterns of activity and gastric secretions (Filatova, 1949, cited by Dmitriev and Kochigina, 1959). Periodic ear temperature changes in the rabbit were trained to a new pattern by temporal control of their feeding regimen (Isaakian, 1953, cited by Dmitriev and Kochigina, 1959). The effects of drugs were also considered, with caffeine and cocaine being found to stimulate experimental dogs and monkeys to respond

earlier (Bolotina, 1953, cited by Dmitriev and Kochigina, 1959). Alcohol often abolished the conditioned reflex in pigeons, whereas sodium bromide and chloral hydrate generally did not affect temporal conditioning (Baiandurov, 1937, cited by Dmitriev and Kochigina, 1959). The theoretical explanation offered by Dmitriev and Kochigina is that time is reflected in a change in the state of the brain cells, with each separate moment of time offering from all preceding and all subsequent times. These hypothetical changes in cellular state record time's passage within the central nervous system. Various drugs may delay or expand the time sense via alterations in internal biochemistry. These authors are presumably referring to changes in neurotransmitter substances such as norepinephrine, serotonin and acetylcholine levels, but are not specific about this, or about just how such changes might actually control the animal's timing: these are mean to be theoretical schema rather than concrete, identifiable facts. However, this formulation has some logical appeal, as the stability and persistence of a time regimen is reflected in such measureable circadian metabolic periodicities as the number of leucocytes in the blood increasing at the usual, anticipated eating hour, or the urinary electrolyte level, or the body temperature (Brackbill and Koltsova, 1967).

Fraisse's inner timing concept

Fraisse (1963) reviewed the literature on several types of animal experiments in which he found incidental evidence of time perception, or accurately timed motor reactions without any access to external metering devices or other cues. For instance, Fraisse points out that a basic assumption by any experimenter who tests rats in mazes is that the rats will choose the shorter of alternative routes to a goal box, learn to eliminate blind alleys, and select the route which takes *less time* as the preferred or more efficient way. Learning studies are routinely designed with varied intertrial intervals unless specifically studying time as the conditional stimulus, because of this compelling assumption. Fraisse also points out that monkeys have often been trained to stay on one grid for ten seconds, then on another for ten more seconds, accurately timing their movements in order to avoid shock. It is common knowledge, supported by empirical, systematic observations (Wolf, 1967), that human infants are soothed by rhythmic

rocking, and that behaviors such as sucking and crying have a rhythm which can be seen in sound spectrograph analysis and polygraph recordings. These behavioral functions and events are all considered by Fraisse to be controlled by subcortical timing centers, although he has not provided definitive supportive data.

Temporal conditioning in the human infant

Using the Pavlovian temporal conditioning paradigm, Fitzgerald, Lintz, Brackbill and Adams (1967) and Fitzgerald and Brackbill (1976) have demonstrated the success of time as the conditional stimulus for pupillary responses in one to three month old human infants. In their experiments, a four-second light flash repeatedly administered to the subject every twenty seconds resulted in subsequent constriction of the pupil on test trials in which the light was not presented. The consistencey and low variability of conditioning among infants was striking. These investigators concluded that time was a basic sensory dimension. Their results reinforced their viewpoint that neural temporal organization is a primary and essential event in human ontogeny, controlling the periodicities of such biorhythms as are involved in the regulation of body temperature, heartbeat and NaK content of the urine. They considered that they were studying the inborn ability of organisms to perceive the objective passage of time accurately. They speculate that there are two possible mechanisms. The first is that time perception is processed by a separate sensory system. The second is that temporal sensitivity is a property common to all sensory modalities, as Pavlov postulated. The latter case would be analagous to the orienting response: that is, time perception might utilize visual, aural, kinaesthetic and taste cues, but not be specific to any one of them.

Temporal conditioning in older children

Apparently, no studies of temporal conditioning in older infants and young children have been reported. However, Dmitriev and Kochigina (1959) published the results of their work with children between the ages of 8 and 14 years. The children had to make a motor response to a tone which was repeated at regular 25 to 30 second intervals. The instructions were to

press a button when they heard the sound every 25 seconds. The older group of "middle school aged children" were more accurate and more quickly conditioned to the time interval than the "early school age" children. This was evidenced by the finding that the older children reached criterion in 5 to 13 repetitions, whereas the younger group required 29 to 82 repetitions. The investigators suggested that the age differences occurred because the older children had been further reinforced by the concommitant verbal instructions to "press the button at 25 seconds", and that this "second signal system" of language was superimposed onto the ontogenetically earlier "first signal system" of awareness of the passage of the brief intervals of time. The same verbal instructions were held to be less meaningful for younger children. Dmitriev and Kochigina's overall conclusion is congruent with the Pavlovian model which refers to the brain cell changes in a general manner, i.e., that such conditioning to time was only possible in the presence of some form of exact reflection of the time intervals in the children's brain cells.

EEG and the time sense

Wiener (1948) had suggested that alpha EEG rhythms might be fundamental reference rhythms in the brain for time perception. This hypothesis was inspired by the closeness of the characteristic 8 to 12 cps waves of alpha to the .1 seconds of the "perceptual moment". This brief .1 second period has been considered by White (1963) and others to be the unit on which all time perception is built.

Holubar (1969) experimentally pursued the notion of EEGs being related to time perception with 29 college students. By changing the rate of flicker of light, he produced marked changes in the alpha rhythms and corresponding changes in the subjects' perceptions of time intervals. Thus, lengthening the interstimulus intervals resulted in increases in alpha cycles per second by the "rule of octaves". These increases were correlated with an increase in the judgments of duration of an objectively unchanged total interval. This direct correspondence of the brain's electrical activity in a quantitative manner with the experience of a time interval is an impressive foundation for the biological clock theory and for the notion of a perceptual mo-

ment. Holubar considered his results to be consistent with the view that the sense of time is the capacity of humans and other organisms to perceive the passage of time, to appreciate time and to be aware of the temporal aspects of all sensory perceptions, with only the aid of intrinsic means of temporal measurement.

Time Perception as a Cognitive Faculty

Deduction of the passage of time

In spite of the abundant evidence pointing to some sort of organic chronometer, the currently prevailing viewpoint is that there is no direct temporal perception. Within this framework, timing is not thought to be a sensory capacity as are vision, hearing, taste, touch or smell. Protagonists of this view propose that there are only observations that things change, with consequent deductions that a certain amount of time has passed. For instance, a bird is seen flying from east to west across the horizon. As it moves from one position to another, the observer judges that a time interval has elapsed. Gorman and Wessman (1977, chaps. 1 and 7) contend that there is no direct apprehension of time, that it is not an elementary characteristic of experience, and that we have no intrinsic sense of duration. While they do not deny the evidence for periodicity at all levels of organic life, they question the significance of "biological clocks" in human temporal judgments. Instead, they argue that the perception of time is an abstract mental process involving imagery, language and complex mental schemata, reflecting our externally imposed notions of underlying rules and systems in the universe. They even question whether there is any independent temporality apart from the observer. Instead they view time as a construct system we gradually develop in order to comprehend phenomena and organize our actions.

Ornstein (1969) concurs with this view that there is no real time independent of us, and he insists that if timing was a sensory process like vision, then we would have to have an organ system of time perception analagous to the visual system. He does not refer to any of the research on temporal conditioning and biological clocks, but dismisses any evidence for a biological chronometer as irrelevant to the psychological experience of time. He also rejects

the concept of an inner time sense on the basis that it is not subject to scientific scrutiny, and is therefore not productive of empirically testable hypotheses.

Studies of "mental fillings" of time intervals

The results of numerous studies of "mental fillings" of time intervals suggest that such factors as variations in the number and complexity of stimuli, and the level of mental tasks (e.g., the sound of a clock ticking, flashes of light, arithmetic tasks, cancellation of letters) influence the subjective estimation of time. In general, the results of these studies with children and adults indicate that the greater the complexity or number of stimuli or tasks, the longer the judgment of the time interval (Frankenhaueser, 1959; Axel, 1924; Ornstein, 1969). Ornstein offers a "metaphorical storage size" explanation of the duration experience. He supports this with the results of his experiments with college students, where, for example, 80 tones per minute led to longer temporal estimates than did 40 tones per minute. According to Ornstein, more stimulus events take more storage space, figuratively speaking, and lead to impressions of a longer time interval. In another experiment, the presentation of more lines and angles in the Attneave geometric figures led to longer judgments of temporal duration than did the simpler figures. According to Ornstein, this indicates that the cerebral registration, coding and information processing mechanisms regulate temporal estimation, as opposed to any sensing of the passage of time. Although Ornstein does not explain or specify what this larger "storage space" means, we could speculate that it might be reflected in the firing of more neurons, in more frequent neural firing, and/or in a greater number of biochemical changes occurring as a result of the increased input of information.

If the greater number of stimuli received and stored leads to increased storage size and thence to the experience of longer durations, then the opposite should also be true; i.e., when there is a paucity of stimulus input, time should appear to be briefer because less storage space is being utilized in the brain. However, Ornstein's storage size explanation has difficulty accounting for the proverbial "watched pot that never boils" phenomenon. The "watched pot" is the paradoxical phenomenon wherein an interval appears subjectively unduly long to an indi-

vidual who is anxiously awaiting an anticipated event. Ornstein describes this as a situation of expectancy and heightened vigilance, one in which there is a theoretically lowered threshold to all sorts of minimal, but unspecified, stimuli. According to this assessment, the lengthened duration experience results from the sharpened awareness of this minimal input, and therefore it fits well with Ornstein's theory.

James (1892), however, advanced exactly the opposite interpretation of the "watched pot" phenomenon. Referring to the odiousness of bare time, he argued that the paucity of stimuli is boring, and therefore this unfilled time appears to be longer. This explanation implies a human need for stimulation, the absence of which causes time distortion.

Frankenhaueser (1959) seems to agree with James. She refers to the waiting time period as a period of passivity and monotony, which appears long as it is passing. She gives the example of a convalescence in bed when there is nothing to do but wait for the next meal, with heightened awareness of the empty passage of time rather than of minimal stimuli. She also points out that this time seems to collapse and to become shorter in retrospect years later.

Still another possible explanation of the "watched pot" phenomenon could be that it is due to impatience, such as when one becomes frustrated by any delay in obtaining a sought after goal. When you are driving in a hurry, e.g., eager to get somewhere, the red lights never seem to turn green, and any delay is intolerable and therefore seems to be long. These are all speculations and general observations, with no actual experimental studies known to the present author in this area. Therefore, the "watched pot" cannot at this point be used to support either of the opposing viewpoints concerning time perception.

Time as secondary to space

Ornstein used college students as subjects in his studies, but Piaget (1969), investigating time perception in children, formulated a similar cognitive temporal theory. Like Ornstein, Piaget rejects the concept of a primary time sense, as well as any of the arguments that the perception of time is based upon reception and processing in a specific sensory system. He argues that time judgments or estimations (in contrast to perceptions) are linked to and formed

by memories, and are derived from our understanding of complex physical causal processes such as movements, speed, simultaneity, and successiveness. Time is seen as a cognitive faculty. The amount of work completed, changes in the environment, the numerosity of events, are all information which must be processed in order to determine the way that an interval of time is experienced by a child or an adult, rather than any sense of the passing of time. Like Ornstein, Piaget categorically rejects any role of intuition or of a biological clock. According to his view, pre-operational children (a developmental stage covering the age range 2 to 8 years) have not yet "decentered" or sequenced the concept of time. This means that they have not yet developed the notion that time is universal, objective, and evenly paced second by second, minute by minute. In this view of time as an objective, regular passage of a series of intervals, Piaget apparently differs from Ornstein and from Gorman and Wessman (1977) who have proposed that time does not really exist independent of our experiences of events occuring therein.

In the Piagetian epistemological approach, the awareness of space and number are the primary elements upon which temporal concepts are subsequently superimposed and constructed. In his empirical studies of children, Piaget found that accurate judgments or conceptions of time intervals were not present in children younger than 8 years of age. In one of his classic and most imaginative experiments, Piaget reported that before 8 years, children consistently judged that one of two simultaneously moving toys (such as miniature cyclists, trains or snails) on parallel tracks travelled a longer time if it went faster and covered more territory (although both toys were actually in motion for the same amount of time). Children above age 8 recognized that the two objects were travelling for equal time periods. Piaget interpreted the error of the younger children to mean that the concept of time was secondary to the concepts of space and speed, and was a function deriving from them. Additional studies conducted by Voyat (1977) yielded similar results to those reported by Piaget.

Goldstone and Goldfarb (1966) are among the researchers in time perception who follow the Piagetian tradition and tenets to a great extent, and who have presented empirical evi-

dence in support of Piaget's interpretations. These investigators worked with children as young as five years of age, as well as with adolescents and adults. Utilizing a modified method-of-limits procedure, they required the subjects to make absolute judgments of one-second time intervals demarcated by tones in ascending and descending series. They found that children over 8 years of age overestimated clock seconds, i.e., they identified intervals of less than one second as being one second. There was a decrease in the overestimation with increase in age from 8 to adulthood. Thus, with increase in age, there was an improvement in accuracy. More than half of the children under 8 years completely failed to identify the time intervals, and the remaining children of this age performed quite variably and did not benefit from the feedback when they were told the correct response.

Goldstone and Goldfarb concluded that under the age of 8 years, as originally propounded by Piaget, children cannot perceive, judge or conceptualize duration directly, but must equate time intervals with the amount of action, effort, speed and distance of objects and/or events contained therein. They considered that their results confirmed the hypothesis that the capacity to render absolute judgments of time intervals based on short clock units (seconds) first emerges at 8 years and develops slowly throughout adolescence. However, since the methods and procedures used by Goldstone and Goldfarb involved knowledge of the clock and experiences which are probably beyond the comprehension level of their younger subjects, they may have been tapping mental skills such as time-telling rather than simple temporal perception. Pre-school children may be able to match time intervals before they are able to label them verbally.

Despite their findings and conclusions, Goldstone and Goldfarb introduce their chapter on time perception with a discussion of time as a "complex perceptual abstraction derived from sensory attributes" in which they presume a "delicate, sensitive human clock" which is essential for adjustment and survival. They consider our perceptual world to be a temporal world, wherein everything perceived is within a time scheme or framework. They state that at birth, timing is a biological metronome regulating the basic bodily rhythms such as hunger, breathing

and heartbeat. But they do not attempt to reconcile this postulated internal clock with the time judgment faculty that they see emerging separately and distinctly at the age of 8 years. The reader is left to guess whether the presumed biological metronome disappears sometime after birth, is considered to be irrelevant to the later emergence of cognitively based temporal perception faculty, or is modified by the knowledge and cognitive skills that develop with age.

Voyat (1977) generally follows the Piagetian tradition in his numerous studies of time and velocity interactions, extending and concurring with the principal findings and interpretations of Piaget. Voyat amplifies the fundamental division of time perception at the critical age of 8 years, as does Piaget. But, to his own surprise, Voyat also found in one study that if the factor of speed of objects is masked, then children as young as 5 years of age come "precociously" to correct temporal estimations. This crucial part of Voyat's experiments (masking of the speed of movement of objects) hinges upon what he calls an "enclosed interval". The procedure used involves a toy train which both departs after and arrives at a goal before another toy train. The second train therefore "encloses" the first one temporally because it departs first and arrives last. Eleven out of 18 children between the ages of five and six years made correct time judgments, showing their capacity to focus on an ordinal referrent; they successfully judged that the second train took more time despite the greater speed of the first train. Despite the involvement of speed here, the pre-operational children are not influenced to call the faster train the one which takes more time. Voyat indicates that this study therefore conflicts with the Piagetian view, and states that Piaget would have to admit here to a set of early intuitive timing operations.

Several other reports have challenged Piaget's view that children neither perceive nor conceive of abstract independent time before the age of 8 years. In a recent study, Levin (1977) found that nursery school children, as well as first and second grade children, correctly equated the length of time that two dolls were "asleep". The procedure used was to put two dolls into two beds side-by-side, and either remove them simultaneously, or one before the other. These young children correctly identified equal or different amounts of sleeping time.

However, it was also found that they were then misled by irrelevant movernent cues such as toys rotating on spindles at different rates, or moving along parallel tracks at different speeds; they associated greater velocity with longer time durations. Therefore, these young children (as well as those in Voyat's special case) actually do perceive and conceive of time in some basic manner independent of external spatial cues. As a matter of fact, they deal most successfully with temporal concepts when space and speed are not involved.

The findings of these studies suggest that young children are vulnerable in their temporal perceptions to movements of objects at various velocities, which act as countersuggestions to them. An alternative postulation to that of Piaget emerges. From Levin's results it becomes clear that it is tempero-spatial coordination and resolution which is lacking, or not yet developed, in the young children. Although they understand the simple concepts of "more time" and "same time", they also confuse "faster" and/or "greater distance" with "more time" when motion and space are added.

The results of at least two other studies of time perception in pre-school children challenge Piaget's denial of time perception in young children, and his conclusion that this capacity does not emerge until the age of 6 years. Crowder and Hohle (1970) found that 5 year olds performed as well as 9 year olds in a temporal reproduction task. The experimenters demonstrated the pulling of a toy lion across a two-foot space into a "cave" in either a 2.7 or a 5.4 second interval. The subjects had to reproduce that action. All of the children tended to underestimate the intervals on the early trials, and all of them who were corrected (half of each age group) benefited from that feedback.

An important methodological difference between the Crowder and Hohle (1970) and the Goldstone and Goldfarb (1966) study can be noted. In the Crowder and Hohle experiment, the 5 year old children could reproduce the two standard durations demonstrated, but could not have been expected to label them properly as 2.7 or 5.4 seconds, because they are not sufficiently familiar with the clock units of time (seconds, minutes) or with numbers. This was not taken into consideration in the Goldstone and Goldfarb research. The difference in task re-

quirements in these two studies were matching time intervals vs. verbal identification. Therefore, the failure of young children in the latter case may be an artifact of their lack of familiarity with clock time, and lack of verbal facility with numbers and counting.

Friedman (1977) set out to test Piaget's contention that children under 8 years of age are unable to accurately judge and conceive of time because correct time estimation must derive from prior knowledge of the speed and distance relationships of moving objects, which is not attained until about 8 years of age. The 22 pre-schoolers tested in the Friedman study ranged in age from 2½ to 5½ years, and they all reproduced a 15-second interval that had previously been demonstrated for them by the examiner on a stopwatch. In one group, the children were given feedback after their first responses, showing them how close their reproductions were to the 15-seconds model unit of time. The mean estimation time for this group of children was 15.5 seconds (S.D. = 4.47), which was significantly more accurate than the mean time reproductions of 11.1 seconds (S.D. = 3.58) in the control group which received no feedback. Since none of the children in this study could count or tell time by the clock, it would seem that the most parsimonious explanation of their ability to reproduce the standard 15-second interval is that some form of organic clock or inner timing mechanism was involved in the memory of the brief interval. The finding that all of the children reproduced the interval fairly accurately challenges Piaget's notion that very young children have not yet de-centered or sequenced time, or understood that durations are repeated and evenly paced. In neither the Friedman nor the Levin experiments were space or movement cues involved. From this viewpoint, there could be no speed or movement complications to confuse the children. It was also demonstrated in the Friedman study that children benefited from knowledge of their own performance, where they had stopped the clock in relationship to the model interval. These findings suggest that the young children had a means of "tuning" their internal clocks—some form of biofeedback.

The studies of Levin (1977), Crowder and Hohle (1970) and Friedman (1977) all demonstrated the feasibility of doing time perception research in children as young as 2½

years, and pointed to the importance of this developmental stage for an understanding of how time perception changes with age.

Thus, although the results of these studies do not provide support for Piaget's thesis, the impetus for the present research derived from Piaget's provocative formulations on the development of time perception in children.

Developmental Studies of Time Perception

Research on temporal perception in different age groups throughout the life span is reviewed here separately in order to provide coverage of those relevant studies which did not focus directly on the question of whether time judgments can best be explained in terms of a biological clock or in terms of cognitive factors. These developmental studies have compared the accuracy of time judgments in school children, college students and middle-aged adults. It should be noted that because of their differences in methodology, terminology and units of time, it is difficult to compare and coordinate them directly and systematically.

In one extensive and unusual study, Crawford and Thor (1967) tested time perception in a variety of ways in 17 children aged 7 to 12 years. The children were isolated (experimentally) for six days and nights in a fallout shelter, and lacked such external temporal synchronizers as changes in the sun's position, watches, clocks and ordinary daily routines. However, neither the eating and sleeping arrangements, nor the activities other than those experimentally-induced were specified in the article, so that the presence of time-related events cannot be ascertained from this publication. One of the required tasks was to estimate visual and auditory stimuli of 4, 8, 12, 16 and 20 seconds twice a day. Although all of the children overestimated these time intervals, the magnitude of the overestimation significantly decreased with increase in age. Thus, the older children were more accurate than the younger children. It was also found that the estimates made in the morning of the three days were more accurate than estimates made in the afternoon: but this difference did not persist during the last three days of the study. No significant differences were found in time estimation of intervals presented via visual vs. auditory signals, and there were no sex differences found in time estimates.

The California Short Form Test of Mental Maturity had been administered to the subjects before their confinement in the shelter, and the six lowest scoring children (I.Q.'s 68 to 93) were compared with the six highest scoring children (I.Q.'s 111 to 137). The children with higher I.Q.'s were more accurate in judging the hour of the day, but there were no significant differences between the groups in the estimations of the 4 to 20 second intervals. This might have been due to the small n (six children in each group) so that high variability might obscure real differences. Twenty-eight paid volunteers started out with this group, but 11 of them dropped out and were not included in the analysis of results. This suggests that considerable stress was involved, and the study may be demonstrating the persistence of accuracy of time perception under highly stressful circumstances.

A similar age range of children was studied by Davids (1969) in an experiment in which second, fourth and sixth grade pupils were required to reproduce a 30-second interval on a stopwatch. He found that although every child responded too soon (under-estimating the 30-second intervals) the magnitude of the error was greater in the younger children. These results were consistent with, and in the same direction as those of Crawford and Thor (1967). Davids also compared the performance of these children with that of 7 to 12 year old institutionalized children with various diagnoses of behavioral disorders, neuroses and psychoses. The institutionalized group overestimated more, and in general were less accurate than their normal age peers at each age level. Davids postulated that a well-developed ego structure, a strong sense of self within the environment, was essential to the accurate perception of time. However, it is apparent that there might be other explanations of the poorer performance of institutionalized children. Living in an institution may itself be a factor influencing perception of time, without consideration of the psychopathology.

In an extensive study of more than 700 boys in the third to eighth grades, plus 68 male and female college graduate and undergraduate students, Axel (1924) found some significant differences in estimations of brief intervals of time (15, 20 and 30 seconds). In 20 seconds of "unfilled time" in which no specified task was assigned other than making the temporal judg-

ment, there was a marked increase in the accuracy of judgment as age increased over the entire range studied. However, when 15 and 30 second intervals were filled with a mental task such as letter cancellation, then the estimates of the 9 to 14 year old children were as accurate as those of the university group. The women students overestimated time (e.g., labelled a briefer period as 15 seconds) more than men, and were more variable in their responses. This finding confirmed those obtained in an earlier study of sex differences in time perception in college students reported by Yerkes and Urban (1906). Axel did not attempt to account for the differences in the accuracy of estimating "filled" versus "unfilled" intervals, but it appears that the older and more accurate one becomes in time estimation tasks, the more readily one can be deceived about a temporal duration when the attention is directed to a mental task. Axel reported large individual differences for all intervals and all fillings studied; he also found that there was a tendency to estimate in five and ten second time units.

McGrath and O'Hanlon (1968) reviewed several studies of changes in the rate of subjective time (RST), i.e. whether an interval seems longer or shorter than the objective interval as measured by clock, as it correlates with aging in older adults. They further presented the data obtained from their own experimental studies. Completely reversing the traditional view in the literature they surveyed, which states that the RST grows slower with increasing age, their own results showed that brief units of time subjectively shorten in a systematic way, by .03 seconds per year between the ages of 20 to 52. The briefer the test interval (from several seconds through 8 minutes duration) the stronger the correlation between age and RST. Although these changes appear to be miniscule, they may have some practical meaning in daily life such as the rate of counting. McGrath and O'Hanlon extrapolated, and speculated that days, months and years seem subjectively shorter as we grow older because of increased number of experiences. Therefore, a week seems to be longer to a child because it is a larger percentage of his life experience, and it seems shorter to his or her parents. Following this reasoning, there may be no relationship between age and RST at 1 hour, but brief clock intervals seem to be longer with aging (shorter RST).

Goldstone and Lhamon (1958) also found that when asked to count to 30 at the rate of one count per second, 69 year old subjects counted significantly faster than 20 year olds. These findings (Goldstone and Lhamon, 1958; McGrath & O'Hanlon, 1968) suggest a decline in time perception accuracy with increase in age from middle to later adulthood, in the estimation of brief intervals. The peak accuracy, then, appears to be at the young adult level, since it has been shown that accuracy of time perception improves from middle childhood to adulthood (Axel, 1924; Goldstone & Goldfarb, 1966). Proponents of a biological clock theory might see here a "winding down" affecting time perception, due to physiological aging, to the lowering of the metabolic rate, modification of skin and hair, and bodily changes in the rate of wound healing (Carrel, 1931; Raskin & Jarvik, 1979).

Summary, Conclusions and Unanswered Questions

In evaluating all of the foregoing empirical findings, it would seem that there is considerable evidence for the existence of both some form of inner clock or time sense, as well as of temporal knowledge or learned pacing of brief intervals of time. Examination of the results of temporal perception studies suggests that at different age levels or developmental stages there are changing relationships in the contribution of the innate, sensory and the learned, cognitive aspects to the process of judgment of time intervals. Possibly, there is a developmental shift in time perception from an ontogenetically-earlier biological basis, to an ontogenetically-later cognitive basis. According to this formulation, some primitive form of organic clock allows for the temporal conditioning of animals and human infants as seen in the work of Pavlov (1928), Von Frisch (1953), as reviewed by Dmitriev and Kochigina (1959), and the studies of Fitzgerald and Brackbill (1976). Since preschool children are capable of making judgments or reproductions of brief intervals of time even when they have not yet acquired counting or clockreading skills (Levin, 1977; Crowder and Hohle, 1970; Friedman, 1977), it is possible that they are still relying primarily on internal temporal mechanisms. It does not seem logical that this capacity would be entirely lost, as has been suggested by the cognitive theorists (e.g. Piaget, 1971; Ornstein, 1969).

Increasing accuracy of time perception has been found through childhood to the young adult level (Axel, 1924; Goldstone & Goldfarb, 1966). Concurrently, over this period there is also an increasing susceptability to distortions of RST of event-filled time such as to rapid beats or to mental tasks assigned. Theoretically, biological and physiological maturation correlates with the development of a more cognitive approach to time estimation, improving skills in temporal judgments, but also more vulnerability to other events and external manipulations that can speed up or slow down the perception of an interval. Further, studies have demonstrated a decrease in the accuracy of temporal perception from young adulthood to middle age (McGrath & O'Hanlon, 1968; Goldstone & Lhamon, 1958). This could be due directly to physiological aging or deceleration of the biological clock, or indirectly due to cognitive losses consequent upon the biological changes.

It must be stated that time perception is a complex function which cannot be completely accounted for only by sensory and cognitive processes. Emotional factors may override both; pleasure or pain may make the perception of time subjectively slower or faster. Albert Einstein was supposed to have said that sitting with an attractive member of the opposite sex can make two hours seem like two minutes, while sitting on a hot stove can make two minutes seem like two hours (Luce, 1971). Time orientation and perception can also be distorted by psychopathological factors or drug reactions (Densen, 1977; Frankenhaueser, 1959; Rabin, 1957). Many biological, mental and emotional factors interrelate to affect the accuracy of time perceptions and susceptibility to temporal illusions and distortions.

There is no reason to promote either the biological clock or the cognitive learning viewpoint of time perception by invalidating or discrediting the evidence for the other. At this point in the long history of time perception studies, it would be more profitable to examine the complex interrelationships of both factors and to put an end to the partisanship in the literature. It seems more likely that there are dynamic shifts in the relative efficacy of internal and cognitive components, and in the ability to switch back and forth when extraneous stimuli or mental tasks are imposed on the task of time estimation. Despite the extensive history of

philosophizing and experimentation, there is no generally accepted neuropsychological explanation, no indication of specific receptors or nervous system pathways, and no direct or compelling evidence for either the innate-organic or the cognitive-learing interpretation of temporal perception.

Since there are indications that both biological and cognitive factors operate, one of the questions that requires exploration is whether or not it is valid to associate the organic rhythmicities, the primitive, internal pacing and autonomic conditioning in animals and human infants to time, with time estimations of brief intervals in human children and adults. Are these biological mechanisms available to children and adults and used by both in the judgments of passages of temporal durations? Can we sense that time intervals are passing, analagous to the way we sense a colored light or a musical tone? How does an individual alone in a dark, quiet room judge the passage of time? Is it purely a cognitive function, as deemed by Gorman and Wessman, Ornstein and Piaget? Must one figure out the passage of time by observing alterations in the environment? Or could it be that the perception, estimation and judgment of time involve higher level cognitive organization and integration that is built up out of ontogenetically earlier, more primitive biological rhythms? In this way, one could put the temporal conditioning studies on animals and human infants and the verbal time estimation findings in children and adults into a heuristic developmental framework, If one views the phenomenon of time perception developmentally, it can be hypothesized that in early post-natal life, the basis for time perception is internal, physiological/organic rhythms, and that as the child acquires cognitive skills such as counting and regulation by timepieces, external stimulus events become increasingly important in the time estimation and judgment.

Within this framework, time perception could be seen as comparable to the other senses. What we are basically equipped to sense visually, for example, is contour, color, contrast, shading, movement, etc., and then we learn by experience that it is a dog, with brown fur, four legs, a wagging tail, and maybe some emotional reaction such as fear because it has teeth and might bite. Within a developmental framework, our basic sensory equipment initially enables

the identification of specific aspects of stimuli, and only after considerable experience does stimulation become organized into patterns enabling the perceptual identification of a recognizable object (Hebb, 1949). Analagously, over the course of development, we might build upon experiences of basic internal rhythmicities, to cognitive, socio-culturally determined time periods and conceptions of past, present and future. In that way, we might learn to "wait just a minute", or how long it takes us to get to work, eat lunch or sing a song. One of the problems, then, would be to understand how (and if) the sensing of brief passages of time intervals is related to more extensive time periods such as tomorrow, last week, next summer. The units that we utilize socially and culturally must be imposed upon an inner rythm for logic, coherency and order.

The present experiment derives from this viewpoint that there is a primitive, organically-based, ontogenetically early "internal clock" on which, over the course of development, are superimposed cognitive skills such as counting, reading mechanical clocks and watches, and factors such as the cumulative experiences of successive occurrences. According to this view, time perception in infants and young children would be based upon inner, biological mechanisms, whereas that of older children would be based upon cognitive, numerical experiences and knowledge.

In this experiment, we are accepting the Newtonian concept of time as real, regular, mathematical and flowing universally at a steady pace, in contradistinction to those who have claimed that there is no real time (Ornstein, 1969) apart from the observer.

Present Experiment

The purpose of the present study was twofold: first, to compare pre-school and school aged children in the accuracy of reproduction of a 15-second interval; and second, to ascertain age differences in the effects of timed auditory, visual and auditory/visual stimulus events on reproduction accuracy. The theoretical rationale underlying the study is that a developmental shift from a primary "time sense" in early childhood to a learned pacing in middle childhood takes place between these years. The pre-schooler has less experience with time, less

acquantance with various clock and calendar units, no capacity to tell time by a watch, and no skills or fluency with counting or measuring. In reproducing a brief interval of time, the younger child is probably perceiving the quality of duration more directly trying to match an observed segment without cognitive guidelines, and more reliant on an internal, sensory basis. It is hypothesized therefore, that pre-schoolers would be less influenced than older children by "mental fillings" or simultaneously imposed external environmental events such as the beat of a metronome or a flashing light. In the older children, we expect to have the beginnings of the more adult, cognitive time-telling techniques and perceptions, and therefore temporal judgments and estimations would be more affected by the number and kind of stimulus events within a time unit, as has been shown in several studies of college students (Axel, 1924; Frankenhaueser, 1959; Ornstein, 1969).

The present experiment is a direct outgrowth of previous work with young children (Friedman, 1977) and is an exploration of differences between 3 and 4 year old pre-schoolers and 8 and 9 year old school children. It is also an extension downward in age of the work with older children and adults in which both age and accuracy have been correlated with susceptibility to distortions of speed with stimulus fillers (Axel, 1924: Frankenhaueser, 1959; Ornstein, 1969). Therefore, we are specifically hypothesizing that the older children will overestimate time more in the presence of presto speed auditory and visual signal than will the younger children.

Since younger children have difficulty in estimating and verbally labelling a short time interval (Crowder and Hohle, 1970; Danziger and DuPreez, 1963), the method of reproduction was used in this study as the most feasible in working with 3 and 4 year olds.

There has been some difference of opinion in the literature about the relative temporal efficiency of one sensory channel over the other. Goldstone and Goldfarb (1966) have reported that in older children, auditory stimuli are judged to be significantly longer than visual stimuli in estimating one to four second intervals. The results of Crawford and Thor (1967) did not concur, and they suggested that modality differences might be specific to durations under 5 sec-

onds. In order to explore this question further, auditory and visual stimuli were employed in the present study as the time-fillers for the 15-second interval to be reproduced. An auditory/visual combined condition was also utilized in order to assess possible additive effects.

Method

Subjects

A total of 84 children participated in this experiment. There were 21 subjects in each of the following four age groups: 3, 4, 8 and 9 year olds. The distribution of children by sex and racial background is presented in Table 1.

The 3 and 4 year old children were selected from the populations of two private nursery schools in the city of New Haven, Connecticut. Although there was a tuition fee in both of these schools, there were also numerous scholarship students. A relatively homogeneous lower middle class SES characterized this group, as determined by neighborhood of residence and discussions with teachers.

The 8 and 9 year old children were selected from the third and fourth grades of a public school in the city of New Haven. The school is located in a relatively homogeneous lower middle class neighborhood.

Permission to conduct the study in the schools was obtained from the Superintendent of Schools, principals, directors and teachers. In addition, written consent for the child to participate was obtained from the parents. Copies of the permission forms and approval letters are included in the appendix. Children who refused or were reluctant to participate, despite parental consent, were not tested.

The examiner went to each classroom a week before the testing to distribute the parent permission forms and to make an announcement to the children about coming back to see them individually for a study of how children learn about time.

The criteria for the selection of children were as follows: first, the school medical records did not indicate any mental retardation, sensory handicap, neurological disorder or emotional

Table 1.

Distribution of children by age, sex and racial background

Age Group (yrs)	Mean Age (yrs)	Age Range (yrs - mos)	Sex		Racial background	
			Female	Male	White	non-white
3	3.4	3-2 to 3-8	10	11	12	9
4	4.6	4-2 to 4-10	9	12	11	10
8	8.5	8-4 to 8-8	15	6	8	13
9	9.6	9-3 to 9-11	11	10	7	14

illness; second, the teacher's evaluation of the child as functioning within the normal range of behavior.

Apparatus

An Aristo stopwatch was used for this experiment, with a side switch to start and stop the hand, and a top button to return the hand to zero.

A Seth Thomas electronic metronome was used to provide the auditory and visual time-fillers. The model was E 962-000, 115 V.A.C., 60 cycles, 7 watts, presented throughout at a presto speed of 192 beats and/or flashes per minute.

Procedure

A separate, quiet room, furnished and decorated in keeping with the other rooms, was provided at each of the three schools in which the testing was conducted. All tests took place between 9 A.M. and 12 P.M. The rooms were illuminated by daylight coming through the windows. The child was taken individually from his/her classroom and seated alongside the examiner, facing a metronome. Except during demonstration trials, the face of the stopwatch was hidden from both the child and the examiner.

The following four conditions were investigated: 1) A Baseline Condition, 2) An Auditory Condition, 3) A Visual Condition and 4) An Auditory/Visual Condition. The Baseline Condition was always administered first to each child, and the other three conditions then presented in random order.

In the Baseline Condition, the following instructions were given to the child: "I am going to show you 15-seconds of time on this stopwatch. Pay close attention. After, you'll have a chance to guess when it is 15 seconds." The examiner then demonstrated the 15 second interval immediately by starting the stopwatch manually and stopping it when 15 seconds had elapsed, calling the child's attention to it by pointing. The examiner then said, "Alright? Understand? Pay attention again." The demonstration was then repeated.

After the second demonstration, the examiner hid the watchface by turning it down, and said, "Now, I'll start the stopwatch and say 'go', and you tell me to 'stop' when you think it is

15 seconds, okay?" The examiner then started the stopwatch and said "go" simultaneously. When the child said "stop", the examiner stopped the watch and recorded the elapsed time. After the first recorded trial only, the examiner showed the child where the watch's hand had been stopped, to provide feedback. This was accompanied by an appropriate comment, such as "see, you needed to wait a little bit more", or, "You waited too long", or "That was very good. Very close!" No further feedback was provided. Five more trials for a total of six test trials were administered and the child's responses recorded.

After testing under the Baseline Condition, the child was told, "Now we are going to see how you would guess the same time, 15-seconds, while this metronome is on." The Auditory, Visual and combined Auditory/Visual conditions were then each presented, and the order of presentation of these three conditions was counterbalanced within each of the four age groups. There were six test trials in each of the three conditions. In the Auditory Condition, the metronome was set at 192 beats per minute, and an aluminum foil cover masked the metronome lamp. In the Visual Condition, the metronome lamp flashed at the rate of 192 times per minute with the sound turned off. The metronome remained at the same presto speed with lamp flashing and beating sound simultaneously for the combined Auditory/Visual condition. Before testing under these conditions, the child was verbally reminded to watch the light and listen to the sound in accordance with which modality was being presented. No feedback was provided. The examiner recorded the time reproductions made, by stopping the watch when the child said "stop".

Although there may be bias in the data relating to the reaction time of the experimenter, the bias would be expected to be the same for all trials and all children since the same experimenter conducted the entire procedure.

The procedures and manipulations were kept as simple as possible in order to accommodate the youngest children. The method of reproduction was utilized throughout the entire experiment. Each child was given six trials under each of the four conditions for a total of 24 reproductions.

Following testing, in order to assess their numerical skill, the younger children were asked to count as high as they could, and the responses were recorded. Then there were brief inquiries of all of the children to see if they could explain how they had made the time judgments. They were asked, "How did you guess?" or "Did you count?" The responses to these questions as well as spontaneous comments were recorded.

The total testing time for each child ranged from ten to fifteen minutes.

Data Analysis

The six time reproductions of the 15-second interval made by each child were averaged for each of the four conditions (Baseline, Auditory, Visual and Auditory/Visual). Geometric, rather than arithmetic, means were computed because the former are ordinarily used in time perception work in order to compensate for individual variability (Guilford, 1954; Reuder, 1979, personal communication). Arithmetic means of the individual geometric means were then computed for each of the four age groups (3, 4, 8 and 9 year olds) under each of the four conditions.

We proceeded first to the statistical evaluation of age differences under Baseline Condition, to test the hypothesis of developmental differences in time estimation. Secondly, we compared the effects of Auditory, Visual and Auditory/Visual Conditions on the pre-school and school-age children to test our hypothesis of a differential due to new, cognitive factors available to the older children. Thirdly, we assessed possible modality differences between conditions of presto stimuli on the judgment of time intervals.

Results

The data presented in Figure 1 provide an overall summary of the experimental results. Examination of this graph indicates that the mean time reproductions of the 3 year olds was closest to 15-second standard under all four conditions. The mean reproduction times of the 4 year olds was the furthest from the standard, the least accurate, under all conditions, compared with those of children in the three other age groups. The time reproductions of the 8 and 9 year olds are quite similar to each other under each of the four conditions, with both age

Figure 1.

Time reproductions of a 15 second interval for four age groups of children under Baseline (B), Auditory (A), Visual (V), and Auditory/Visual (A/V) Conditions. Standard Deviations indicated by vertical lines.

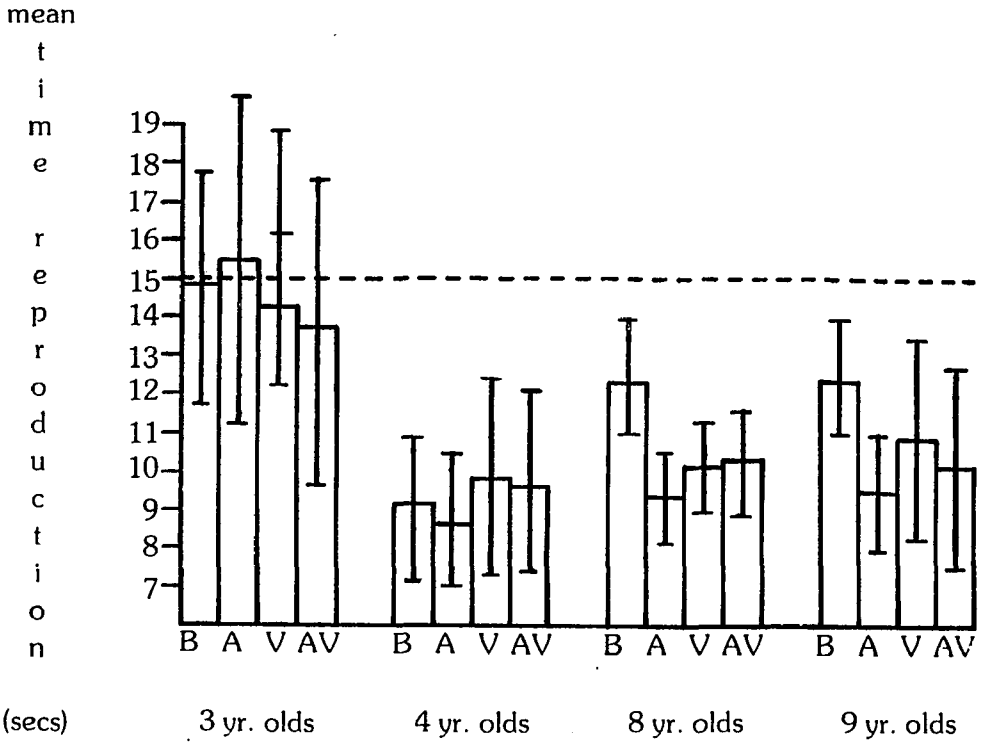
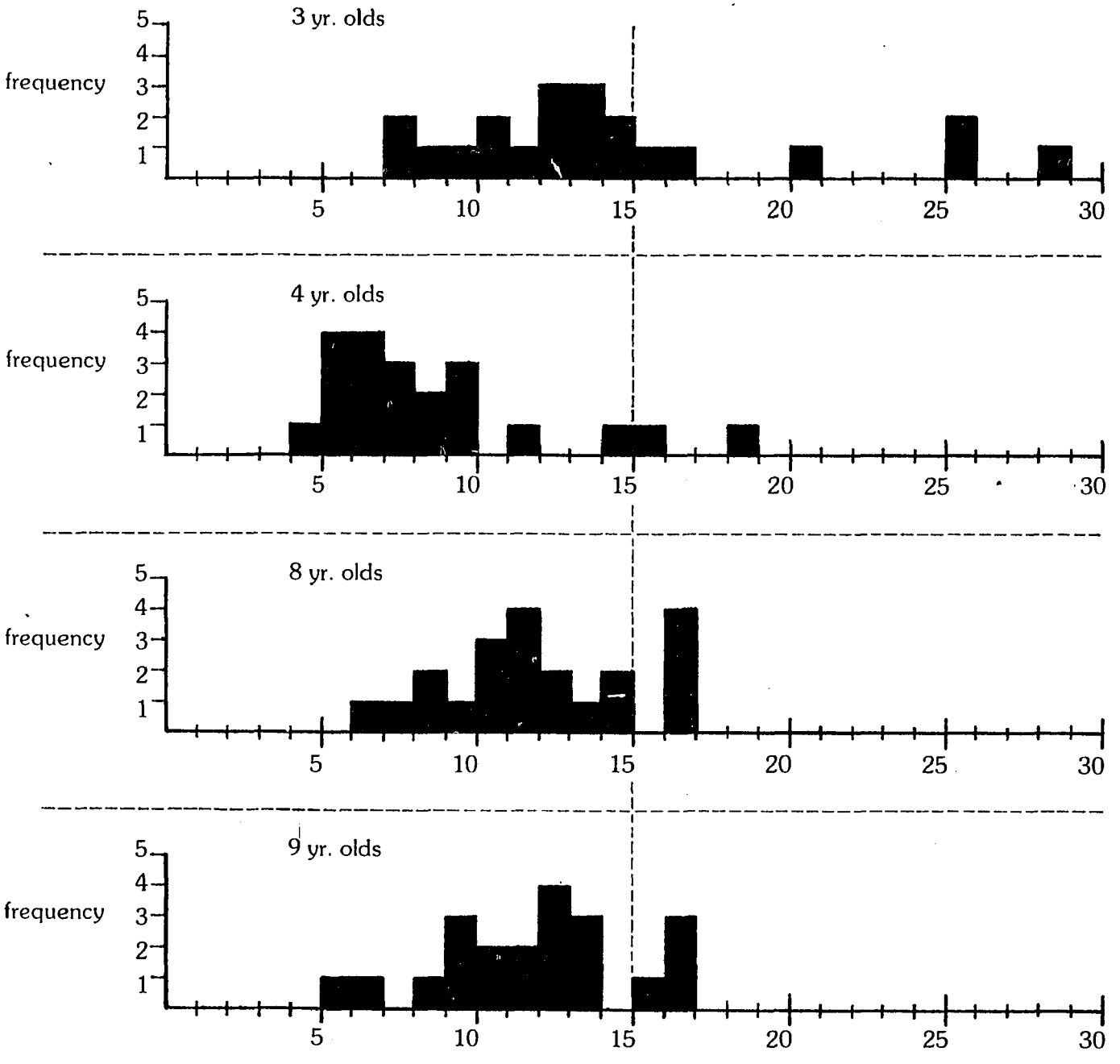


Figure 2.

Distribution of reproduction times under Baseline Condition in each age group (n = 21)



groups underreproducing the interval, particularly under the three presto metronome conditions. The school-age children underreproduced the 15-second interval more in the Auditory Condition than in both the Visual and the Auditory/Visual Conditions.

The distributions of mean reproduction times for the four age groups, under the Baseline Condition, are shown in Figure 2. This figure clearly displays the tendency for more of the youngest group of children to overreproduce the interval, and by larger amounts, than the 4, 8 and 9 year olds. More of the children in the older groups underreproduce the interval. The means of the 3 year olds range most widely, from 7 to 29 seconds. More of the 4 year olds underreproduced the interval than any of the other groups: in Figure 2 it can be seen that the means were concentrated in the 4 to 10 second range. The distribution of means for the 8 and 9 year olds are similar to each other.

Baseline Condition

Although examination of the mean reproductions of the four age groups under Baseline Condition indicates that the youngest group was the most "accurate", i.e. closest to 15 seconds (see Table 2), it is also seen that the SD of this group is the largest. The variability of the 3 year olds is larger than that of the other children, as evidenced by the SD and greater range. The Hartley test was applied, comparing the largest variance of the 3 year olds with the smallest variance of the 8 year olds (see Table 2), and F-max of 3.9 is statistically significant at the .03 level. Thus we conclude that 3 year olds are significantly more variable in time reproductions of brief intervals than are older children.

ANOVAS are considered to be robust with respect to moderate departures from homogeneity of variance (Winer, 1971), particularly when the number of subjects is as large as 21 in each group (Ramsey, 1979, personal communication). Therefore, in order to determine whether there were age group differences in reproduction time, a one-way ANOVA was applied to the data from the Baseline Condition. Tabel 3 summarizes the ANOVA results, and indicates that the group differences in mean reproduction times is significant at the .01 level.

From Table 2 we can compute the largest difference of 5.8 seconds between the 3 and 4

Table 2.

Time reproductions (secs.) in the Baseline (B) Condition for four age groups (n = 21)

	Age group (years)			
	3	4	8	9
Mean	14.9	9.1	12.4	12.4
S.D.	6.0	3.6	3.1	3.1

year olds; in decreasing order, the next largest difference is between the 4 and 8 year olds, a smaller difference between the 3 and 9 year olds, and no difference between the two oldest groups.

Post hoc orthogonal comparisons were conducted to ascertain which age groups differed significantly (see Table 4). The difference between the scores of the 3 and 4 year olds was found to be statistically significant at the .01 level. Neither of the other two comparisons were statistically significant. It is apparent from Figure 1 that the low mean reproduction time of the 4 year olds balanced out the higher mean of the 3 year olds, and accounts for the failure to find a difference between the pre-school (3 and 4 year olds) and the school-age (8 and 9 year old) children.

Effects of Auditory, Visual and Auditory/Visual Conditions

The data presented in Figure 1 indicate that the various presto metronome conditions did not markedly affect the time reproductions of the 3 and 4 year olds. In contrast, the Auditory, Visual and Auditory/Visual Conditions resulted in briefer reproduction times for the two older groups. The time reproductions of the four groups of children under the three presto metronome conditions are presented in Table 5.

There were marked disparities in variability for different age groups under the Auditory, Visual and Auditory/Visual Conditions (see Table 5), ranging from an SD of 9.2 for 3 year olds to an SD of 2.5 for 8 year olds. Applying the Hartley test for homogeneity of variance resulted in a significant Fmax of 5.67 ($p = .02$). Therefore, we conclude that the 3 year old children are again more variable under all of the presto metronome conditions than any other age group. as they were under the Baseline Condition.

The effects of presto visual and auditory stimulation on time reproductions were assessed by comparing the mean reproduction time under each stimulus condition with the mean reproduction time in the Baseline Condition. First the data were converted to ratio scores, by dividing the individual means under the Auditory, Visual and Auditory/Visual Conditions by the corresponding mean under the Baseline Condition, then summing them for each age

Table 3.

One-way ANOVA of age differences in time reproductions of a 15-second interval (Baseline Condition)

Source of Variation	SS	df	MS	F	D
Between Groups. . .	359.6	3	119.87	6.97	.01
Within Groups. . .	1374.63	80	17.18		
Total. . .	1734.23	83			

Table 4.

ANOVA for orthogonal comparisons of age group differences in time reproductions of a 15-second interval (Baseline Condition)

Source of Variation	SS	df	MS	F	D
cf 1 (3 vs 4 yr olds)	355.83	1	355.83	20.71	.01
cf 2 (8 vs 9 yr olds)	.02	1	.02	.001	n.s.
cf 3 (3+4 vs 8+9 yr olds)	7.50	1	7.50	.44	n.s.

Table 5.

Time reproductions (secs) in the Auditory, Visual and Auditory/Visual Conditions for four age groups (n = 21)

Condition		Age group (yrs.)			
		3	4	8	9
Auditory	Mean	15.5	8.6	9.4	9.5
	S.D.	9.2	3.5	2.5	3.1
Visual	Mean	14.3	9.9	10.2	10.95
	S.D.	9.2	5.3	2.6	5.6
Auditory/ Visual	Mean	13.8	9.7	10.3	10.1
	S.D.	8.7	4.8	2.8	5.2

group separately (sum $\frac{A}{B}$, sum $\frac{V}{B}$, and sum $\frac{A/V}{B}$), and finally, dividing by the n of 21 to obtain the mean. As can be seen in Table 6, the ratio scores range from .77 through .88 for the school-aged children, and from .90 to 1.09 for the pre-school children, and there is no overlap between the two groups. The effect of the presto metronome, therefore, was to decrease the reproduction times of the older school-age children, but not having this effect on the means of the two groups of younger children, 3 and 4 year olds.

The results of a two-way ANOVA (4 age groups X 3 Conditions) on these ratio scores are presented in Table 7. There is a significant age group difference at the .01 level. There was no significant difference as a function of Auditory, Visual or Auditory/Visual Conditions, and there was no significant interaction between age and condition.

In order to determine specifically which age groups differed in the effects of presto metronome "interval-fillers", a post-hoc Newman Keuls test was conducted evaluating the sets of means in the four age groups under the three metronome conditions. Table 8 shows that each of the differences between age groups is significant at the .01 level. The two younger groups ranked consistently and significantly first and second (least influenced by metronomes) as compared with the two older groups which ranked consistently third and fourth (most influenced). Looking back at Figure 1 then, we may have a high level of confidence that the three presto metronome conditions caused significant underreproduction of the time interval in the 8 and 9 year olds, but not in the 3 and 4 year olds.

The differences noted in Figure 1 among Auditory, Visual and Auditory/Visual Conditions are probably due to chance, since the F score was below the tabled critical value (Table 7).

Sex Differences

The mean time reproductions made by the boys and the girls in each of the four age groups, under each of the four conditions are presented in Table 9. There are small, unsystematic differences within age groups and across conditions. The overall difference between boys and girls is only .40 seconds, and is not statistically significant.

Table 6.

Mean ratio scores under Auditory, Visual and Auditory/Visual Conditions for four age groups

Age groups (yrs.)	Condition		
	A	V	A/V
3	1.03	.98	.90
4	1.00	1.09	1.08
8	.77	.84	.85
9	.79	.88	.81

Table 7.

Two-way ANOVA: Differences in effect of three conditions of time reproductions (A, V and A/V) in ratio scores in four age groups of children (3,4,8 and 9 years)

Source of Variation	SS	df	MS	F	p
Between Subjects:	17.79	83			
A (age group):	2.65	3	.88	4.89	.01
subjects within:	15.14	80	.19	4.04	
Within Subjects:	6.80	44			
B (condition):	.13	2	.065		
A × B (age × condition):	.37	2	.185	.35	ns
subjects within:	6.30	40	.16	1.15	ns

Table 8.

Newman Keuls post-hoc analysis on the two-way (4 x 3) ANOVA
Differences between 4 age groups under 3 conditions in ratio scores

AUDITORY CONDITION:

age groups	rank	S
8	4	5.58
9	3	5.22
4	2	.70
3	1	

VISUAL CONDITION:

age groups	rank	S
8	4	5.37
9	3	4.54
3	2	2.43
4	1	

AUDITORY/VISUAL CONDITION:

age groups	rank	S
9	4	5.97
8	3	4.92
3	2	3.91
4	1	

Table 9.

Sex differences in mean time reproductions of a 15-second interval

Age Group (yrs.)	Condition	Girls	Boys
3	Baseline	14.8	15.0
	Auditory	16.4	14.7
	Visual	13.9	15.7
	Auditory/Visual	13.4	14.0
	total	14.6	14.8
4	Baseline	8.4	9.5
	Auditory	8.6	8.7
	Visual	9.2	10.3
	Auditory/Visual	8.4	10.6
	total	8.7	9.8
8	Baseline	12.7	11.8
	Auditory	9.7	8.5
	Visual	10.1	10.3
	Auditory/Visual	10.1	10.8
	total	10.6	10.3
9	Baseline	11.8	13.0
	Auditory	8.8	10.2
	Visual	11.3	10.5
	Auditory/Visual	10.0	10.1
	total	10.5	11.0
	GRAND MEAN	11.1	11.5

Racial Background

Racial background was not a significant factor in performance on the time reproduction task. Table 10 presents the data obtained from white and non-white children in all age groups under each of the four conditions. Differences are small and not consistent. The difference in total time is only .21 seconds, and is not statistically significant.

Additional Responses

During post-testing inquiry, most of the pre-school children could not count corrrectly upon request. Only one 4 year old counted correctly and fluently up to 15, and six of the 3 and 4 year olds counted with some errors up to ten or twelve. It was noted that one of the 4 year olds used a unique technique throughout the testing in that he held up a finger and moved it around in the air in imitation of the watch hand, clockwise to the 15-second position. Another pre-schooler tapped his foot. Any tactics used by the child in accomplishing the task was accepted. No instructions were given to any of them as to how to make the judgment. None of the children asked the experimenter how it was to be done.

All of the school-aged children counted correctly up to 15 when asked to do so after the experiment proper. From observation of the 8 and 9 year olds during the testing, it seemed that most of them utilized some variation of a counting technique in their estimations of the time intervals. For example, most could be heard to count aloud from one to fifteen, others counted by twos up to thirty, or by fives up to 100, and then by tens to 100. Still others counted three times to 15, or from one to thirty-five during the task. Twenty of these school-age children also stated explicitly that counting was the method they used in the judgment of durations. When specifically asked, seven of the older children said that they did not count. In addition, it was observed that in those who did count aloud, they sped up their number progression under the presto metronome conditions. Counting was prominent if not universal in the two groups of older children.

Table 10.

Race differences in mean time reproductions of a 15-second interval

Age Group (yrs.)	Condition	White	non-White
3	Baseline	15.0	14.8
	Auditory	14.8	16.3
	Visual	14.0	14.7
	Auditory/Visual	13.5	13.7
	total	14.3	14.9
4	Baseline	9.3	8.6
	Auditory	8.9	8.4
	Visual	9.2	10.3
	Auditory/Visual	8.5	10.4
	total	9.0	9.4
8	Baseline	12.7	11.7
	Auditory	10.0	8.4
	Visual	9.9	10.6
	Auditory/Visual	11.2	9.6
	total	10.6	10.4
9	Baseline	11.4	13.2
	Auditory	9.1	10.0
	Visual	9.9	10.6
	Auditory/Visual	11.2	9.6
	total	10.7	10.9
	GRAND MEAN	11.2	11.4

Discussion

The results of the present experiment reaffirm recent research findings that pre-school children can reproduce a 15-second interval, and therefore can be said to have a conception and a perception of time. In addition, the present results replicate more generally established findings of time perception and judgment of intervals reported in young school-age children. This study indicates that the accuracy of temporal estimation is related to developmental stage (chronological age) in a more complex manner than simply, "the older, the better". In the two pre-school groups it was found, unexpectedly, that the mean reproduction time of the 3 year olds was significantly closer to the 15-second standard than was the case for the 4, 8 and 9 year olds. However, the youngest children were also found to be more variable in their reproductions. The 3 year olds have overreproducers of the brief interval as well as under-reproducers, whereas most of the older children are underreproducers.

The age differences in variability and accuracy obtained in the present study are corroborated by the reanalysis of the results obtained in an earlier study (Friedman, 1977). In that previous study, the method of testing was somewhat different, and all pre-schoolers of 3, 4 and 5 years had been grouped together regardless of age (which was not considered to be critical at that time). The means and SD's in reproduction times of a 15 second interval for each age from that earlier study are presented in Table 11, and can be directly compared with the data from the present experiment (Table 2). In the 1977 study, the reproduction time of the 3 year olds are more variable than those in the 4 and 5 year groups, with their means closer to the standard (more "accurate"). In addition to the similarity between the present and prior study for the results of the 3 year olds, the means for the 4 year olds in the two experiments are also similar, strongly attesting to the reliability of these results. These findings suggest a change in the process of temporal perception taking place between the third and fourth year of life.

One possible explanation of this age difference is that the youngest children are still more reliant on intuitive, biological temporal mechanisms which have been reported to control reactions of infants (Fitzgerald & Brackbill, 1976). Organic rhythms vary widely between in-

Table 11.

Time reproductions (secs.) of a 15 second interval in three age groups (Data extracted from Friedman, 1977)

	Age group (yrs.)		
	3 (n = 9)	4 (n = 7)	5 (n = 5)
Mean	15.1	11.1	13.1
S.D.	6.08	3.06	2.07

dividuals when unguided by a learned, social unit of pacing the passage of temporal units. By the age of 4 years, children may be in a stage of preparation of transition for the more mature, cognitive approach to time perception, breaking away from the earlier internal, personal, biological approach, but without the more advanced counting or metering techniques yet available to them. The postulation of a transitional period at approximately four years of age, in which the more primitive approach is less utilized and the more advanced techniques unavailable, is supported by the finding that the 4 year olds were the least accurate in the Baseline Condition, and in the presto metronome conditions, as well as in the 1977 Friedman study. The 4 year olds may be developing some kind of mental image of the time interval which may include a representation of the watch hand going around the face to the 15-second point.

The 5 year olds in the 1977 study were more accurate than the 4 year olds, so that the cognitive skills may be beginning to be effective in approaching this task.

These speculations are also supported by the results obtained from the 8 and 9 year old children under the Baseline Condition, who apparently using cognitive numerical skills, have a clearly greater accuracy than the 4 year olds. The differences between these older groups and the 3 year olds are confounded by the greater variability of the latter group. The significant differences between the 3 and 4 year olds merit further exploration. The present results confirmed the hypothesis that school-age children, 8 and 9 year olds, are significantly more affected than 3 and 4 year old pre-schoolers by the imposition of a presto metronome "time-filler" during the 15-second interval. The older subjects were more influenced to underreproduce the interval (Figure 1). The difference between the school-aged and pre-school children occurred whether the metronome was presented in the Auditory, Visual or combined Auditory/Visual modalities. The pre-schoolers were less affected and maintained a more stable (if not more accurate) perception of the 15-second model throughout the three presto metronome conditions, in contrast to the older children. The underreproductions of the older

children were in keeping with the findings of several researchers that a greater number of stimuli in an interval leads to longer judgments of the same time interval (Axel, 1924; Frankenhaueser, 1959; Ornstein, 1969).

We have postulated that both an ontogenetically earlier and/or biologically more primitive timing mechanism exists in humans which underlies the maturation or evolution of more cognitive forms of time perception based upon counting, measuring, reading clocks and experiencing duration. The differences between pre-schoolers and school-age children in time reproduction of a brief interval under conditions involving a presto metronome time-filler in the present experiment supports the view of a dynamic developmental change in the basis of temporal perceptual processing in children. Although we do not know "how" the 3 and 4 year olds did it, or why the two groups differed, we do know that they have a stable memory of a demarcated period of time, 15-seconds, which is impervious to the speedup illusion of a presto metronome which affect older children (and adults).

Friedman (1978) has defined experiential time as independent of logical cues and well-developed in young children. This "sense of time" is thought to occur even though logical time is not yet comprehended by pre-schoolers, and even though conventional time has little influence on the thought of children under 5 years of age. Thus, we can again relate the capacity for time perception of the pre-school children in this study to the maintenance of the more primitive timing devices demonstrated in lower animals and human infants.

Most of the older children in this study were observed to use counting techniques under the Baseline Condition, and to increase the speed of this activity when there was an externally imposed presto visual or auditory beat. This suggests that the acquisition of cognitive skill may be associated with a concurrent susceptibility to the illusory temporal effects of presto interval-fillers. It would be expected that lento time-fillers would have the opposite effect, causing slowed counting and overreproduction of the time interval. The cognitive approach may require focused attention to the time judgment task, which is diffused by the "interval-filler". This

possibility could be explored by examination of the effects of simple distraction on time judgments, such as looking at pictures, rather than the imposition of fast or slow beats which has the additional factor of numerosity or speed.

It is interesting to compare the present findings which revealed the older children to be more vulnerable to the effects of presto time-fillers leading to underreproduction of intervals, with the results obtained in the Piagetian studies (see pp. 9-11) where it was the pre-schoolers who were influenced by speed and distance into temporal inaccuracies. Thus, there seems to be a reversal of the age groups which are most susceptible to the different kinds of temporal illusions. When Piaget's subjects, 5 and 6 year olds, were presented with two moving objects, they judged the faster one to be taking more time although they were both objectively synchronous. The school-age children in Piaget's study were not deceived into making such temporal errors by the factor of coverage of more distance or increased velocity (Piaget, 1971). The major difference in the two types of externally imposed 'deceptive cues' (i.e. the presto metronome in the present experiment versus Piaget's speeding objects) seems to be that the Piagetian tasks also involved space; so that a temporal-spatial coordination could be the critical factor as far as the younger children are concerned. It is this coordination which, according to Piaget's results as well as those of Levin (1977), emerges at about the age of 8 years. In the present study, it is the presto beats or flashes, their increased number, which seems to result in the significant underreproduction of the brief interval in the older children, but which did not have an effect on the 3 and 4 year olds. The lack of numerical skills in the pre-schoolers may render them less responsive to increased number of beats; they are less knowledgeable regarding numbers and therefore less affected by them. Tentatively, it can be argued here that the younger children have a more direct and intuitive response to the unit of time as a whole, which is unaffected by the rapid changes of stimuli events imposed within it.

It is important to note that some "correction" or "compensation" was apparently made by the older children in estimating the time with the presto filler; otherwise, they would have

tripled their estimates by an exact 1:1 counting of 192 beats per minute. This clearly was not the case. Ornstein (1969) also reported that one of his subjects estimated the 40 beats per minute condition as 3 minutes long, 80 beats per minute as 4 minutes long, and 120 beats per minute as 5 minutes long. There was not enough data presented, however, to determine how this "adjustment" worked. This adjustment raises the possibility of the timing "sense" balancing out some of that residual difference. It would seem that this could be a valuable direction for future research to take in this area: to analyze the balance of a baseline rate of counting and the imposed speed-up presto beat (or, of course, conversely, the lento rate effects).

In this study, there were no differences found between the Auditory, Visual or Auditory/Visual combined metronome conditions imposed during the reproductions of the time interval. Whether one sensory system is more involved than another in temporal perception has been controversial in the literature. Hirsh and Sherrick (1961) found no auditory-visual difference in their time perception studies with adults, in agreement with the present findings. They argued that there is a time organizing system which is independent of modality, yet central to all sensory systems. Also, in the experiments of Crawford and Thor (1967) with 7 and 12 year old children, there were no differences between visual and auditory presentations of the 4, 8, 12, 16 and 20 second intervals. However, Goldstone and Goldfarb (1961) found that their school-aged children judged 1 to 4 second auditory stimuli to be temporally longer than visual stimuli of the same actual duration. In explaining the conflicting results of the different experiments, Crawford and Thor speculated that modality differences may be specific to intervals shorter than five seconds. According to these authors, different time perception systems may be used for briefer and for longer intervals (analagous to short and long term memory systems), so it does appear to be at least possible that such intermodal differences might be expected to emerge in briefer and more accurately timed situations. Furthermore, it is not at all clear how the actual demarcation of an interval by either a tone or a light relates to the visual or aural presentation of a presto interval-filler. If a 3-second interval is judged to be

longer for auditory than for visual stimuli, would it necessarily follow that presto metronome beats within that interval also lead to more underestimation than flashes of light within that same interval? That relationship is another direction for future research to take.

No significant sex differences were found in the present study, in agreement with the results presented by Crawford and Thor (1967). Axel (1924) and others did find sex differences between men and women college students, with the males underestimating 15 to 30 second intervals, and the females overestimating. There are, therefore, possibilites worth pursuing that culturally or hormonally based sex differences may emerge at adolescence or in adulthood, although the reasons for this are not apparent. Although the possibility of small differences (in the order of milliseconds) could not be examined in the present experiment because of the imprecision of the measurements (stopwatch, and manual RT of the examiner), Axel's sex differences were found with the same procedures and methods.

The method of reproduction was found to be ideal for the exploration of time perception in pre-school children, as is the simplicity of the response required (saying "stop"). These findings confirm those obtained by other investigators (Friedman, 1977; Crowder and Hohle, 1969; Levin, 1977) and point to the success of young children in time reproduction tasks. No complex manipulations have been required of them, nor time interval labeling, making it possible to work here with children as young as 3 and 4 years. One feedback trial was presented in the Baseline Condition to each child in order to provide uniform assistance on this task. Although the examiner's reaction time is involved, it is unlikely that it was of sufficient magnitude or there was a consistent bias that would differentially affect the age groups. Present procedures had the advantage of allowing some quantification within a guessing game atmosphere, thus perhaps sustaining the interest and attention of even the youngest children. A more automated system would have enabled us to obtain more precise scoring, but would have involved more training time, a probable loss of the youngest subjects' willingness and capacity to persist at the task, or their comprehension of the requirements. Sustained attention

is difficult for pre-schoolers, and it is therefore preferable to use a test that is quick, interesting and simple.

In general, the findings of this study are congruent with results of previously published time judgment studies, extending and filling in the developmental curve of temporal perception. Human infants have been shown to have an extremely accurate inner clock, as evidenced by the successful conditioning of pupillary constriction to a 20-seocnd interval (Fitzgerald, Lintz, Brackbill, and Adams, 1967). Although there is no direct evidence that the mechanism is the same, our 3 year old pre-schoolers in the present study as a group had a mean reproduction time of the 15-second interval (though highly variable) which may be a reflection of this accuracy in a different kind of test. We have noted a significant change or shift at the age of 4 years, where underreproduction of the interval is the rule as it is for older children. At the age of 8 and 9 accuracy has improved and variability decreased. A slow rise in accuracy through the young adult years has been charted by Goldstone and Goldfarb (1966) and by Axel (1924). Subsequently, there appears to be a slow decline in accuracy of temporal perception into middle age, according to McGrath and O'Hanlon (1968), who find that within the age range of twenty to fifty years, the older the person, the faster his rate of subjective time. Thus, in summary, the developmental curve of time perception appears to be S-shaped, with shifts at certain developmental stages. This accuracy curve depicts a high accuracy level in infancy, dipping at age four, rising again to age 8 and 9 and indicates gradual acquisition of more accuracy through young adulthood, after which the curve begins a gradual decline again.

In terms of the directions of future research, the area of developmental changes in time perception and the factors contributing to these changes has barely been tapped. Further investigation may have important applications. Physiological studies of body time and body rhythms are proliferating (Luce, 1971; Ward, 1972; Brady, 1979), with a goal of finding best times for surgery and other treatments, and for solving the problems of jet lag, night work, insomnia and the stress effects of artificial light-dark illumination.

Temporal perception work with young children, especially between the ages of 3 and 8 years, may be a fruitful area to explore further. Differences between estimations of brief and longer intervals at all ages are not widely known, and merit more attention with possible analogies to short term and long term memory processes. Memory is certainly involved in the reproduction of an interval, as the task occurs after the stimulus has terminated, and has to be remembered. In addition, different susceptabilities to various kinds of time-fillers or environmental stimuli need to be studied from the developmental veiwpoint in order to enhance our understanding of age changes in time perception and that which is entailed in the development of that ability.

It should be further noted that individual differences in time estimation would be an important area to study for possible applied value. Cappella, Gentile and Julian (1977) tested the judgements of brief intervals of 7, 15 and 30 seconds in 100 school-aged children and found significant overestimation of time in those children who had been diagnosed as hyperactive by other tests. This suggests that standardized time perception tests at a pre-school level might be useful as a diagnostic and predictive tool. A standardized time perception test for young children could also have potential benefit for providing a generally accepted operational definition of hyperactivity with a brief attention span. Presently, different clinicians often disagree since this diagnosis is difficult to make without a quantitative measure. In our study, we can observe individual differences within each age group; these could be related to personality differences. Especially in the 3 year olds, comparisons of characteristics of overestimators and underestimators could be of interest.

To summarize, despite a great many studies (60 items in the bibliography of Friedman's recent 1978 review article on time perception in children) we have only scratched the surface as far as understanding age differences in time estimation, and there are several directions for future research.

Our study has examined age differences in time reproduction in two preschool and two early school-age groups of children. The discrepancy between the high "accuracy" and wide variance of the 3 year olds and the low accuracy and under-reproduction of the 4 year olds, and the apparent lack of susceptibilities in both of these groups to the illusion of increased time that affected the older groups studied (via presto speed of interval-fillers) suggests that there is a different process of time perception in the older and younger groups. The younger children may be more reliant on an inner clock, whereas the older children may be learning to judge intervals by cognitive techniques. Between 3 and 4 years of age, verbal and motor skills are maturing rapidly and may account for the differences in time reproduction found here. Finally, it would also be important and instructive to test temporal perception in the age groups between 4 and 8 in order to fill in the developmental curve and to directly test the hypothesized developmental shift from reliance on an inner clock to judgment of time intervals by cognitive techniques.

Appendix

1. copy of letter to school describing research plan
2. copy of request to parents of nursery school children for permission to participate
3. copy of request to parents of public school children for permission to participate.

Original request to conduct a psychological study in New Haven Schools

Early Developmental Study of Relationships Among Chronological Age, Mental Age and the Rate of Subjective Time.

The origins of our capacity to perceive time intervals has long been controversial topic. It raises basic biological and social questions: where in the brain is this skill located? Is it a sense? How does it develop? Can we train it? There are unequivocal indications of organic rhythms and timing mechanisms- e.g. conditioning to pure time demonstrated by Pavlov, and the phenomenon of awakening to one's "internal alarm clock". In addition, it is known that cognitive and emotional factors effect our time judgments. Thus, "waiting" makes time appear to pass slowly. Piaget's experiments indicated to him that preoperational children (below age 8) could not have any objective temporal ideas, but Friedman has already demonstrated accurate time judgments in preschoolers. Most time perception work has been done with older children, college students and middle-aged adults, but not with younger children. Some recent research has suggested that individual differences in time perception correlate with clinical conditions such as hyperactivity, and might therefore provide a test for prediction, detection and amelioration, an obvious benefit to children and to the schools.

The present study is a comparison of age groups of children in a simple time perception task that takes less than ten minutes per child, and is to conducted in a separate room at the school. A 15-second interval will be demonstrated to the child on a stopwatch. The examiner will then say "go" starting the watch, and the child is to say "stop" when he thinks the 15 seconds have elapsed. This is in the nature of a guessing game, and is repeated for 6 trials. The task is then repeated with a metronome at presto speed in the background. A statistical analysis will indicate which group of children is more accurate in performing the task and which is more susceptible to the efforts of the distortion by the background interval-filler of the metronome.

Pilot work has already been done with young children in the New Haven area nursery schools. The test is interesting and enjoyable to the children, and would not interfere with their education. Results of that work are to be published in the December issue of Perceptual and

Motor Skills. This present study is to be my dissertation research in the Psychology Department at Queens College of C.U.N.Y. I would like to add that I have been a Clinical Research Psychologist employed by the Connecticut State Health Department with twenty years of experience with normal and retarded children.

I have read your GENERAL POLICIES for studies in the schools, and agree to abide by these and not to publish results prior to approval by your designated representative.

Estelle R. Friedman
419 Norton Parkway
New Haven, Ct. 06511
776-8324

September 26, 1977

November, 1977

Dear Parent,

On _____ _____ _____, I plan to be at the _____ Nursery School to conduct a study of the way young children develop a perception of time. I'll be in a separate, quiet area with each child, for about ten minutes, playing a guessing game with a stopwatch. My earlier work has indicated that children usually find this enjoyable and educational. This research is part of my doctoral studies in psychology at the City University of New York.

However, if you have any objections, please return this form immediately so that your child will be excluded from the project. In any case, I thank you for your consideration.

Estelle R. Friedman.

I do not wish to have my child participate _____.

signed: _____

November, 1977

Dear Parent,

On November 22 and 23 I plan to be at the Roger Sherman School to conduct a study of the way young children develop a perception of time.

I'll be in a separate, quiet area with each child, for about ten minutes, playing a guessing game with a stopwatch and metronome. A 15-second interval is to be demonstrated,and then the child is to attempt to reproduce the interval and let the examiner know when he or she thinks that 15-seconds is up. The task is then repeated with a metronome at presto speed in the background. My earlier work has indicated that children usually find this enjoyable and educational.

This research is part of my doctoral studies in psychology at the City University of New York,and has been approved by Dr. Riello of the New Haven Public School Department of Pupil Personnel.

I would like to have your approval for your child's participation, immediately, or your objection if that is the case. Please sign and return this slip with your child. Thank you for your consideration.

Estelle R. Friedman.

My child may participate in this project:

YES_____ NO_____

signed: _____

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