# VISUAL AND AUDITORY DURATION DISCRIMINATION: A COMPARISON OF INDIVIDUALS WITH AND WITHOUT MILD MENTAL RETARDATION

JOHN KEVIN DEFORD

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Charles B. Woods, Ph.D. Major Professor

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# VISUAL AND AUDITORY DURATION DISCRIMINATION: A COMPARISON OF INDIVIDUALS WITH AND WITHOUT MILD MENTAL RETARDATION

A Thesis

Presented for the

Master of Arts

Degree

Austin Peay State University

John Kevin DeFord

May 1996

## DEDICATION

This thesis is dedicated to

James E. DeFord and Senora L. DeFord

for their love, patience, and support.

## ACKNOWLEDGMENTS

Gratitude is extended to Dr. Charles B. Woods for his time, patience, guidance, and knowledge. I would also like to thanks Dr. Anthony Golden and Dr. Stuart Bonnington for their comments and assistance. My appreciation is also extended to Dr. Charles Grah for his assistance in the statistical analysis. Dr. Stephen Oross' comments, assistance, and direction was greatly appreciated. The participation of the clients and the staff at the sheltered workshop was also appreciated. I cannot express enough appreciation to Dr. Charles B. Woods and Dr. Stephen Oross for their dedication and guidance. I will always consider them as my mentors. The help and encouragement from my fellow graduate students is appreciated. Leilani Talley's assistance was appreciated during the course of the year, as well as the advice provided from Ritzi Forren.

I would like to thank all my family and friends from Knoxville, TN. who gave me encouragement and motivation. Special thanks are sent to my brother, James E. DeFord III. I would also like to thank the following people for their contributions, whether direct or indirect; these are Randy Smith, A.J and Misty Caulineau, Lesli Love, Aaron Love, Scott Pierce, and Mike Doyle.

# ABSTRACT

The following study explored visual and auditory duration discrimination in individuals with and without mild mental retardation. Duration discrimination is the ability to discriminate between two stimuli of unequal duration. Participants were presented with two stimuli and asked to respond whether the stimuli were the same or different in duration. The base duration (t) of the stimuli was 50 milliseconds (msec). Several comparison stimuli ($t+\Delta t$) were chosen and compared to the base duration in order to measure the just noticeable difference in duration discrimination. The data were analyzed with traditional and signal detection theory methods to examine the differences in performance between individuals with and without mild mental retardation. The results indicated that individuals with mild mental retardation performed poorer on both duration discrimination tasks. Signal detection analyses showed differences in sensitivity. There were no statistical differences in bias between the two groups.

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# CHAPTER I

## INTRODUCTION

Several recent studies have attempted to identify the perceptual and physiological deficits associated with the developmental disabilities such as dyslexia, mild mental retardation, and Alzheimer's disease. Previous literature has shown that temporal processing deficiencies are associated with these developmental disabilities (Ali, Khaleque, Khanam, Al-shatti, & Ahmed, 1994; Tallal & Piercy, 1973; Watson, 1992; Woods, Sarwar, DeFord, & Oross, 1995). Studies of temporal processing may eventually lead to causal explanations of many of the behaviors associated with developmental disabilities. The results of these studies may also provide information leading to diagnosis and treatment interventions in these conditions.

The present study compared the temporal processing abilities of individuals with and without mental retardation using two tasks: a visual duration discrimination task and an auditory duration discrimination task. The present literature led to the hypothesis that individuals with mental retardation would have a low level temporal processing impairment, operationally defined by performance on these duration discrimination tasks. Specifically, individuals with mental retardation were expected to need a larger difference in the durations of the two stimuli in order to discriminate between them. Deficiencies of these types would be consistent with other reports in the literature about the temporal processing abilities of individuals with developmental disabilities.

The organization of the introduction will begin with a discussion of the background on mental retardation. This discussion will include behavioral and physiological deficits observed in individuals with mental retardation. The next section will consist of a brief review of duration discrimination. This section will review duration discrimination performance, theoretical models, and implications.

## Background on Mental Retardation

### Behavioral Deficits

The following is a brief discussion of the behavioral deficits that are observed in individuals with mental retardation when performing perceptual tasks. Only those deficits associated with the auditory and visual systems are discussed. The cognitive and motor abilities of these individuals will not be reviewed.

Auditory System. Individuals with mental retardation have been shown to have impairments in processing auditory information. Marcell and Cohen (1992) report that individuals with retardation show a higher prevalence of hearing loss, middle ear problems, and deficits in processing auditory information. Also, Mazzoni, Ackley, and Nash (1994) reported that there was a significantly higher degree of individuals with sensorineural hearing loss in individuals with mental retardation. Finally, Reynolds and Reynolds (1979) found that individuals with more severe mental retardation were more prone to hearing impairments. Individuals with mental retardation show a high degree of variability on these hearing assessments.

The auditory perceptual abilities of individuals with mental retardation have been studied using a variety of tasks. Soraci, Barlean, Haenlein, and Baumeister (1986) found that individuals with mental retardation demonstrated a lower sensitivity when determining the differences in the relationship of a sequence of auditory tones. Lovitt (1968) found that individuals with mental retardation preferred a slower or faster rate of narration, where individuals without mental retardation showed a preference for 180 words per minute ("normal") (Lovitt, 1968). These findings may be due to auditory temporal processing deficits.

McNutt and Melvin (1968) examined the ability of individuals with mental retardation to estimate the duration between onset and offset of auditory stimuli. They asked participants to reproduce auditory signals ranging from 1-29 seconds. McNutt and Melvin (1968) found that individuals with mental retardation underestimated durations of time at 13 and 29 seconds when compared to individuals without mental retardation. Laine and Baumeister (1985) performed signal detection analysis on a perceptual task for a pure-tone stimulus. Results showed that individuals with mental retardation were less likely to alter their response strategy when task requirements changed. Mulhern, Warm, and Clark (1974) found that reproduction of acoustic signals was underestimated more in individuals with mental retardation when stimulus duration increased.

Visual System. Previous research involving basic visual assessment of individuals with mental retardation using the illiterate E Snellen chart to measure acuity and using the Pelli-Robson and Vistech wall charts to measure static contrast sensitivity shows that individuals with mental retardation perform similarly to individuals without mental retardation (Fox & Oross, 1988, 1990, 1992). Individuals with mental retardation showed no impairments in acuity (O'Dell, Harshaw, Abernathy, Pool, & Boothe, 1988) or static contrast sensitivity (Woods et al., 1995).

Several tasks have been used to measure the temporal processing abilities of individuals with mental retardation. Several of these studies have investigated visual persistence, the time between the offset of a stimulus and the termination of the sensation (Nisly & Wasserman, 1989). Martos and Marmolejo (1993), in a study of individuals with mental retardation and individuals with dyslexia, reported that visual persistence was different (longer) for individuals without mental retardation. Saccuzzo, Kerr, Marcus, and Brown (1979) found that individuals with mental retardation required longer stimulus durations and longer masking durations when compared to individuals of equal chronological and mental age. Saccuzzo and colleagues (1979) reported these results as a deficit in the speed of information processing. Consistent with this, Thor and Thor (1970) found that individuals with mental retardation required longer intervals between stimuli to perceive two succeeding flashes. Spitz and Thor (1968) used a visual backward masking task and found that individuals with mental retardation performed poorer than individuals without mental retardation. Hill and Silverman (1978) examined participants' ability to match an auditory click to the onset and offset of visual stimuli. Individuals with mental retardation reported a 50 millisecond (ms) pulse as shorter than individuals without mental retardation. These deficiencies suggest that individuals with mental retardation and individuals with dyslexia may have deficits in temporal processing of visual information.

The temporal processing abilities of individuals with mental retardation have also been studied using the critical flicker fusion (CFF) paradigm. This paradigm is characterized by determining the highest rate that a light can be perceived as flickering, that is, when the light is rapidly being turned on and off. Rosicki (1970) found that on a CFF task individuals with mental retardation performed poorer than individuals without mental retardation. Individuals with mental retardation had significantly higher thresholds (lower CFF's) than individuals without mental retardation. Ali, Khaleque, Khanam, Al-shatti, and Ahmed (1994) found that individuals with mental retardation demonstrated a lower sensitivity to flicker when compared to individuals without mental retardation. This is additional evidence that suggests that temporal processing in individuals with mental retardation may be impaired.

Several other perceptual abilities have been studied in individuals with mental retardation. Fox and Oross (1988) found that individuals with mental retardation showed deficits in depth perception when compared with individuals without mental retardation. These researchers have also shown that individuals with mental retardation have deficits in motion perception (Fox & Oross, 1990), detecting motion defined forms (Fox & Oross, 1992), and differences in the serial and parallel processing of visual search (Sarwar, Woods, & Oross, 1995).

The deficits observed in individuals with mental retardation are presumably higher in the visual system. These deficits may occur in the visual pathways or in cortical regions of the brain. Evidence suggests that there is not a global deficiency, rather a group of selective deficiencies in individuals with mental retardation. A sample of individuals with mental retardation may include subgroups who performed poorer on some tasks than other individuals with mental retardation, independent of age and IQ (Woods et al., 1995).

A Methodological Concern in Evaluating the Perception of Individuals with Mental Retardation. Previous research has explored perceptual abilities of individuals with mental retardation using signal detection theory. These studies have evaluated the response bias in individuals with mental retardation on perceptual tasks. The present study used signal detection analyses to gain more insight on the performance of individuals with mental retardation perceptual sensitivity and response criterion on a duration discrimination task. The use of signal detection theory to evaluate perception in individuals with mental retardation is not unique. The use of signal detection theory allows the experimenter to evaluate the sensitivity of the participant as well as the criterion used by the participant. This criterion is the standard for an individual's response when discriminating differences in the duration of two stimuli.

Ryan and Jones (1975) used signal detection theory and found that individuals with mental retardation did not raise their criteria when strict instructions were given. Individuals without mental retardation showed a rise in criteria. A rise in criteria would indicate a more conservative criteria due to the "strict" instructions. Ryan and Jones (1975) reported that individuals with mental retardation demonstrated more variability on the visual backward masking task than individuals without mental retardation. Laine and Baumeister (1985) used signal detection theory to examine short term memory in individuals with mental retardation. They found that individuals with mental retardation did not change response strategies when task demands are changed. Sensitivity ($d^1$) was significantly different between individuals with and without mental retardation on the short term memory task.

Anatomical and Physiological Deficits

The anatomical and physiological differences observed in individuals with mental retardation and individuals without mental retardation are briefly discussed below.

There is evidence that suggests individuals with mental retardation have external, middle and internal ear pathologies. Mazzoni, Ackley, and Nash (1994) found more pinna defects in individuals with mental retardation. They reported that individuals with mental retardation have, on average, 2.5 pinna defects per ear. Marcell and Cohen (1992) found that individuals with mental retardation frequently have middle ear problems. These middle ear problems were observed by poor mobility of the tympanic membrane. Mazzoni and colleagues (1994) reported that individuals with mental retardation showed a higher incidence of sensorineural hearing loss when compared to individuals without mental retardation.

Individuals with mental retardation also have a higher prevalence of ocular pathology than individuals without mental retardation (Levy, 1984). These ocular pathologies include strabismus ( i.e. when the coordination of the two eyes is upset due to an imbalance of the eye muscles). O'Dell, Harshaw and Boothe (1993) reported that most ocular deficiencies are refractive problems that are often correctable by eyeglasses.

There is a small proportion of individuals with mental retardation that show general brain pathology. This general brain pathology appears to be minor and variable, indicating that no general structural pathology is evident in all individuals with mental retardation (Shaw, 1987). However, there are some anatomical deficits that seem to be characteristic of individuals with mental retardation. Purpura (1974) found that individuals with mental retardation have long and thin dendritic spines, but appeared to show an absence of short and thick dendritic spines. Huttenlocher (1991) also reported that individuals with mental retardation show a dysgenesis of dendritic spines and impaired growth of dendritic trees of cortical pyramidal neurons. The proportion of individuals with mild mental retardation that show these abnormalities is still unclear.

These impairments are not fully understood, but recent evidence suggests that these dendritic abnormalities may influence the processing of temporal information. Casseday, Ehrlich, and Covey (1994) reported that neural mechanisms that play a role in perceiving auditory duration. Auditory duration is perceived by the inhibition and excitation of neurons in the inferior colliculus (Casseday et al., 1994). Rose and Call (1993) reported that aspiny and spiny neurons appear to be important in the processing of temporal information. This evidence, taken with evidence indicating dendritic pathology, may suggest a deficit in duration discrimination.

Gasser, Pietz, Schellberg, and Kohler (1988) showed that individuals with mental retardation demonstrated longer visual-evoked response latencies and that certain visual-evoked response components were found to be underdeveloped. The researchers suggested that their results were indicative of a physiological developmental delay in individuals with mental retardation (Gasser et al., 1988).

The visual system processes information in multiple parallel channels. Transient (magnocellular) and sustained (parvocellular) pathways broadly divide the retinogeniculostriate visual system. Transient pathways are more selectively activated by tasks that require the detection or discrimination of abrupt onsets and offsets of stimuli (Merigan & Maunsell, 1994). Behavioral studies have evaluated the performance of individuals with mental retardation on tasks that indirectly measure possible selective deficits of these systems. Fox and Oross (1988, 1990, &1992) found impairments in motion and depth perception in individuals with mental retardation. These results, along with the above, are consistent with physiological deficits in the magnocellular pathway of the retinogeniculostriate visual system.

## Background on Duration Discrimination

Duration discrimination is defined as an observer's ability to discriminate differences in the duration of stimuli. Duration discrimination tasks are a common measure of temporal processing and serve as part of the foundation for the study of the perception of time. The duration discrimination paradigm has been studied extensively in the areas of audition and vision.

### Auditory Duration Discrimination.

Previous studies have investigated various aspects of auditory duration discrimination. Creelman (1962) found that duration discrimination was influenced by base duration, signal intensity, and the increment difference (amount of time added to the base duration to determine threshold). Abel (1972) found that threshold (75% correct performance) was proportional to the base duration. She also found that performance was not affected by bandwidth (the frequencies that characterize a signal). Grondin (1993) used a variety of duration discrimination tasks to evaluate the differences in performance with variations in stimuli. He reported that the just noticeable difference (JND) for a 50 ms auditory tone was 11.3 (Grondin, 1993). The JND is an increment difference added to the base duration and the observer can perceive a difference in the base duration. Rammsayer (1994) found that with a standard duration of 50 ms, individuals without mental retardation showed difference thresholds of 13.5 ms. Rammsayer (1994) also explored the effects of practice on duration discrimination and concluded that performance was not affected by practice.

Visual Duration Discrimination

Several studies have investigated visual duration discrimination. Allan, Kristofferson, and Wiens (1971) found that visual duration discrimination was not affected by type of presentation (single presentation or two alternative forced choice), interstimulus interval, or luminance. Allan, Kristofferson and Rice (1974) reported that the length of the interstimulus interval between successive stimuli did not affect duration discrimination performance.

Getty (1975) reported that the Weber fraction holds true when stimuli were between 200 ms and 2 seconds, a Weber fraction of about .05. This falls outside the realm of the present study, however, Grondin (1993) has reported that the JNDs for a 50 ms visual stimulus is about 25.7 ms. The present study is methodologically similar to Grondin's (1993) study.

Models of Duration Discrimination Performance.

Many of the earlier studies attempted to provide a theoretical explanation for duration discrimination performance. Reviews of this literature can be found in Allan (1979), Killeen and Weiss (1987), and Ivry and Hazeltine (1995). Creelman (1962) developed the first quantitative model for duration discrimination. Other models included the Quantal counting model (Allan & Kristofferson, 1974), Onset-Offset model (Allan et al., 1971), parallel-clock model (Eisler, 1975), real-time criterion theory (Kristofferson, 1977), and optimal timing (Killeen & Weiss, 1987). These models centered around the idea of an internal counting mechanism. The various models explained this counting device in many different ways. Creelman's (1962) model suggested that an internal counting mechanism accumulates pulses when the stimulus is presented. This accumulation occurs when the internal mechanism begins "counting" as soon as the stimulus is presented. The subject's judgment depends on the number of pulses accumulated during the stimulus event.

Implications

The importance of studying duration discrimination is briefly discussed below. This section explores the implications that may be considered if duration discrimination is impaired.

Auditory System. Auditory duration discrimination plays a major role in speech perception. Repp, Liberman, Eccardt, and Pesetsky (1978) found that the duration of a sound can influence an individuals perception of speech. Speech comprehension may be affected by the inability to discriminate auditory durations. Schwartz and Tallal (1980) reported that the accurate detection of rapid changes in sounds contributed to the perception of speech. Speech comprehension and speech perception are affected by auditory temporal processing. Previous research suggests that individuals with mental retardation show deficits in speech perception and comprehension. Lovitt (1968) found that individuals with mental retardation preferred a rate of narration to be either slower or faster than Lovitt's "normal" rate of narration. Merrill and Mar (1987) reported that individuals with mental retardation demonstratd poorer performance on a speech comprehension task. These studies may indicate possible impairments in auditory duration discrimination.

Visual System. Visual duration discrimination and temporal processing are important to visual-motor coordination. For example, the ability to process visual temporal information of an object moving toward you would affect the motor actions needed to move from the path of the object. Henderson, Morris, and Frith (1981) found that individuals impaired in manual tracking had problems coordinating motor actions and sensory input. Individuals with mental retardation appear to show deficits when performing reaction time tasks, where stimuli are presented and a motor response is required (Nettelbeck & Brewer, 1981). Kerr and Blais (1987) reported that individuals with mental retardation performed poorer on manual tracking task than individuals without mental retardation. Individuals with mental retardation appear to show deficits in visual-motor coordination tasks. These task deficits may indicate deficits in visual duration discrimination.

The present study compared the temporal processing abilities of individuals with and without mental retardation using two tasks: a visual duration discrimination task and an auditory duration discrimination task. Duration discrimination performance for individuals with mental retardation was expected to be poorer in comparison to individuals without mental retardation. Individuals with mental retardation show behavioral (time perception deficits) and physiological (dendritic abnormalities) deficits that may indicate impairments on temporal processing tasks. The duration discrimination models mentioned above give theoretical explanations of the internal counting mechanism involved on these types of tasks. The results of the present study may provide further insight into the speech perception and visuo-motor coordination of individuals with mental retardation.

# CHAPTER II

# METHODS

## Participants

The participants included 9 individuals with mental retardation: four white males, two black males, two white females, and one black female. The participants with mental retardation were classified as having mental retardation of unknown etiology and an I.Q. between 50-70 (M = 63, SD = 3.61). Having an IQ in this range defines the mild mental retardation subgroup (Grossman, 1983). The age of individuals with mental retardation ranged from 26 to 63 ( M = 39.6, SD= 14.83). The individuals with mental retardation were volunteers from a local sheltered workshop and were capable of giving informed consent. All testing took place at Austin Peay State University and the experimenter provided transportation. Each participant received four dollars for each visit. Two to three visits were required to complete the tasks.

Ten individuals without mental retardation, selected from undergraduate psychology classes, took part in the study. The participants without mental retardation consisted of six white females, two black males, and two white males. The participants without mental retardation ranged in age from 23 to 57 (M = 36.2, SD = 2.89). These participants were selected to provide approximate chronological age matches. Participants without mental retardation received extra credit for their participation.

## Apparatus

Auditory Stimulus Generation. A personal computer and National Instruments Corporation timer-counter board (PC-TIO-10) generated the digital signals used to drive the visual and auditory stimuli. The tone stimulus was a 2000 Hz square wave presented at 64 dB SPL, as measured at the one meter distance from the speaker. A 200-watt Pioneer amplifier model number SA 7500 and a 40-watt Realistic speaker (catalog number 40-2030C) were used to amplify and present the auditory stimuli. Observers sat with their head in a chin rest, one meter from the speaker. A green light emitting diode (LED) mounted on the top of the speaker was used to provide feedback for correct responses.

Visual Stimulus Generation. The same personal computer and timer-counter board generated the visual stimuli. Participants placed their head in a chin rest and viewed a red LED. This LED was made by Hewlett Packard corporation (HLMP-3301) and had a 626 nm peak dominant wavelength. Participants viewed the light through a 632 nm peak wavelength interference filter (Edmund Scientific, # 643,081). The luminance of the LED was 12.6 cd/m$^2$ and had an angular subtense of 1.27°. All subjects viewed the visual stimulus with their natural pupils. The computer generated a tone for feedback, identifying both correct and incorrect responses.

Procedure

All observers participated in both duration discrimination tasks. Participation required each observer to perform at 70% on a criterion task. The criterion requirement was to insure that each observer understood the task. The order of participation in the two tasks was counterbalanced across participants. A same-different method of constant stimuli paradigm was used to present the stimuli (See Figure 1).

In the method of constant stimuli paradigm, stimuli are presented randomly in blocks of trials. A block of trials was set at a fixed stimulus level and consisted of 40 individual trials. Each task required five trial blocks. Stimuli had base durations of 50 ms.

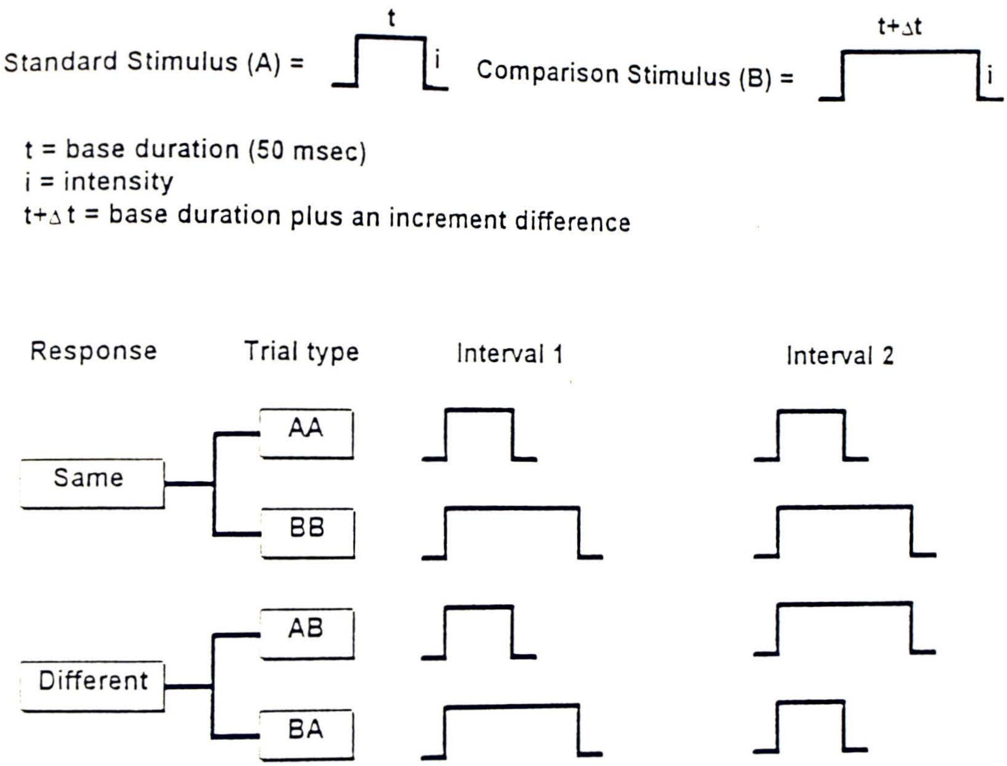


Figure 1. A same-different method of constant stimuli paradigm was used to present the stimuli. The figure shows each of the stimulus and trial types.

Five different increment difference (Δt) comparison stimuli were chosen, based on pilot data. The largest difference was chosen to be well above the participants' discrimination threshold and the smallest was chosen to be well below the threshold. The increment differences (Δt) for the auditory task included 10 ms, 20 ms, 40 ms, 80 ms, and 160 ms for individuals without mental retardation and 20 ms, 40 ms, 80 ms, 160 ms, and 320 ms for individuals with mental retardation. The increment differences (Δt) for the visual task included 20 ms, 40 ms, 80 ms, 160 ms, and 320 ms for individuals without mental retardation and 40 ms, 80 ms, 160 ms, 320 ms, 640 ms for individuals with mental retardation.

The trial-by-trial procedure was as follows: A trial began when a key was pressed, the first stimulus was presented, then a 500 ms delay, and the second stimulus immediately followed the delay. The experimenter asked the participant whether the two stimuli presented were the same or different in duration. The observer responded, then the experimenter entered the response into the computer and feedback was provided. The experimenter controlled the intertrial interval and allowed the participant time to get ready for the next trial.

The stimuli were either the base duration (t) of 50 ms or t plus an increment (Δt). A hit was defined as the situation where a participant responded "different" after the stimuli {t+Δt, t} or {t, t+Δt} were presented. A correct rejection was defined as the situation when a participant responded "same" after the stimuli {t, t} or {t+Δt, t+Δt} were presented (See Figure 1). Ten presentations of each combination were presented in a random order.

The trial blocks were used to determine the individual's duration discrimination threshold. Percent correct at each $\Delta t$ was used to describe the psychometric function for each participant. The point where the participant discriminated 75% of the stimuli on the psychometric function was defined as threshold. Percent correct was calculated by adding total number of hits and correct rejections and dividing by 40 (total number of trials). The order of presentations was balanced by a Latin Square design in order to eliminate practice or order effects. All procedures (except $\Delta t$'s) were identical for the visual and auditory duration discrimination tasks.

# CHAPTER III

# RESULTS

## Inferential Statistical Analyses

Group differences in percent correct were analyzed using a 2 x 4 (groups x Δt's) repeated measures analysis of variance, using the conditions tested in both groups. Also, the difference threshold or just noticeable difference (JND) was computed for each individual. This was defined as the point were an individual performed at 75% correct in discriminating the two stimuli. Psychometric functions were graphed for each participant by plotting percent correct at each value of Δt (See Figures 2 and 3). Percent correct for each participant was calculated by adding total number of hits and correct rejections and dividing by 40 (total number of trials). A hit is defined as the situation where a participant responded "different" when the stimuli presented ({t+Δt, t} or {t, t+Δt}) were different in duration. The definition of a correct rejection is when a participant responds "same" after the stimuli presented ({t, t} or {t+Δt, t+Δt}) were equal in duration. Mean psychometric funtions were graphed to show group performance and standard error at each Δt. Interpolation was used to determine each participant's threshold, which was defined as 75% correct performance. The two Δt's that bracketed threshold were used to caluculate the point where the performance reached 75% correct. Mean threshold differences between groups were analyzed using t-tests for unequal sample variances.

Auditory Duration Discrimination. The results of a 2 x 4 ANOVA revealed that performance of individuals with mental retardation was significantly different than the performance of individuals without mental retardation, $F(1, 17) = 33.13, p<05$. A separate analysis of variance was computed excluding the individuals who never achieved

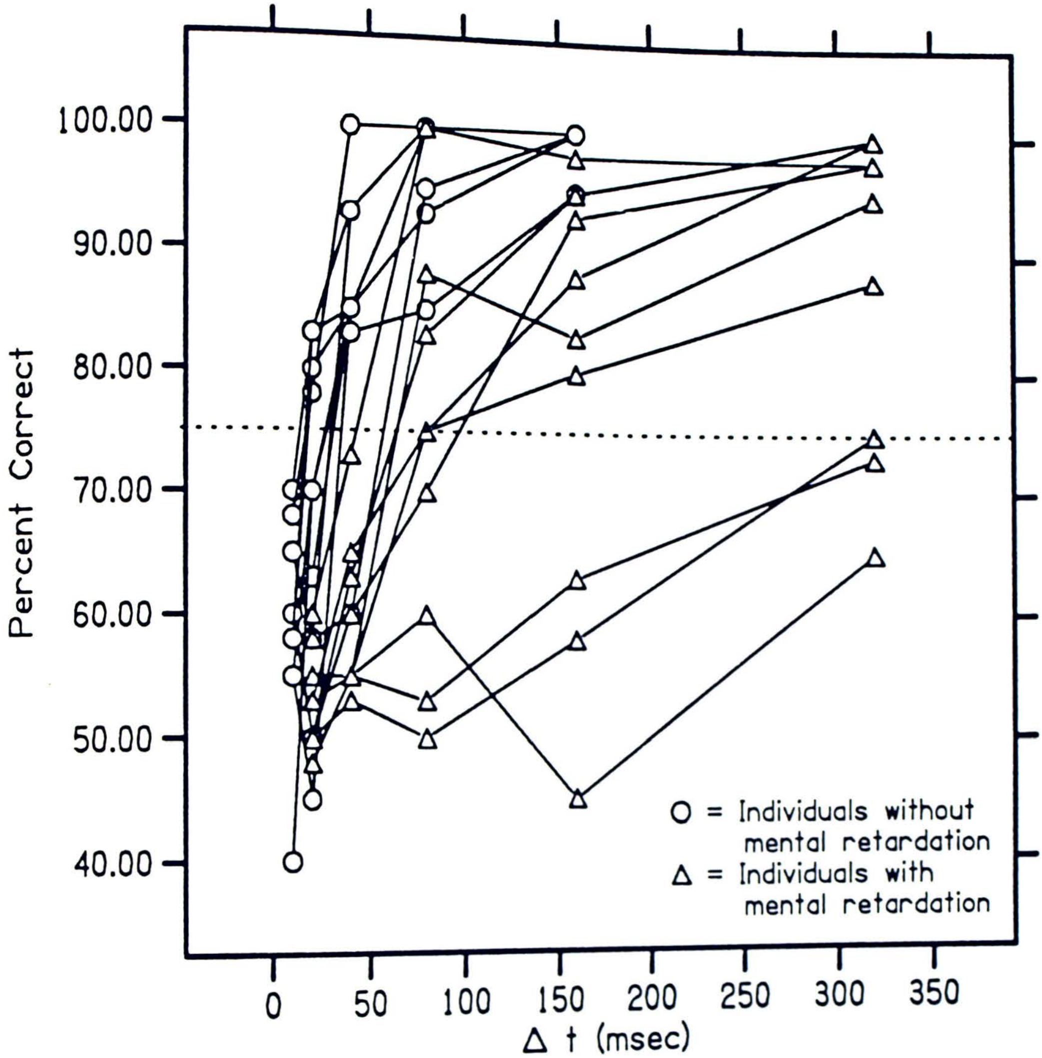


Figure 2. The figure shows individual psychometric functions for the auditory duration discrimination task. Percent correct performance is plotted at each value of Δt. Circles represent individuals without mental retardation and triangles represent individuals with mental retardation. The dotted line represents the discrimination threshold (75% correct performance).

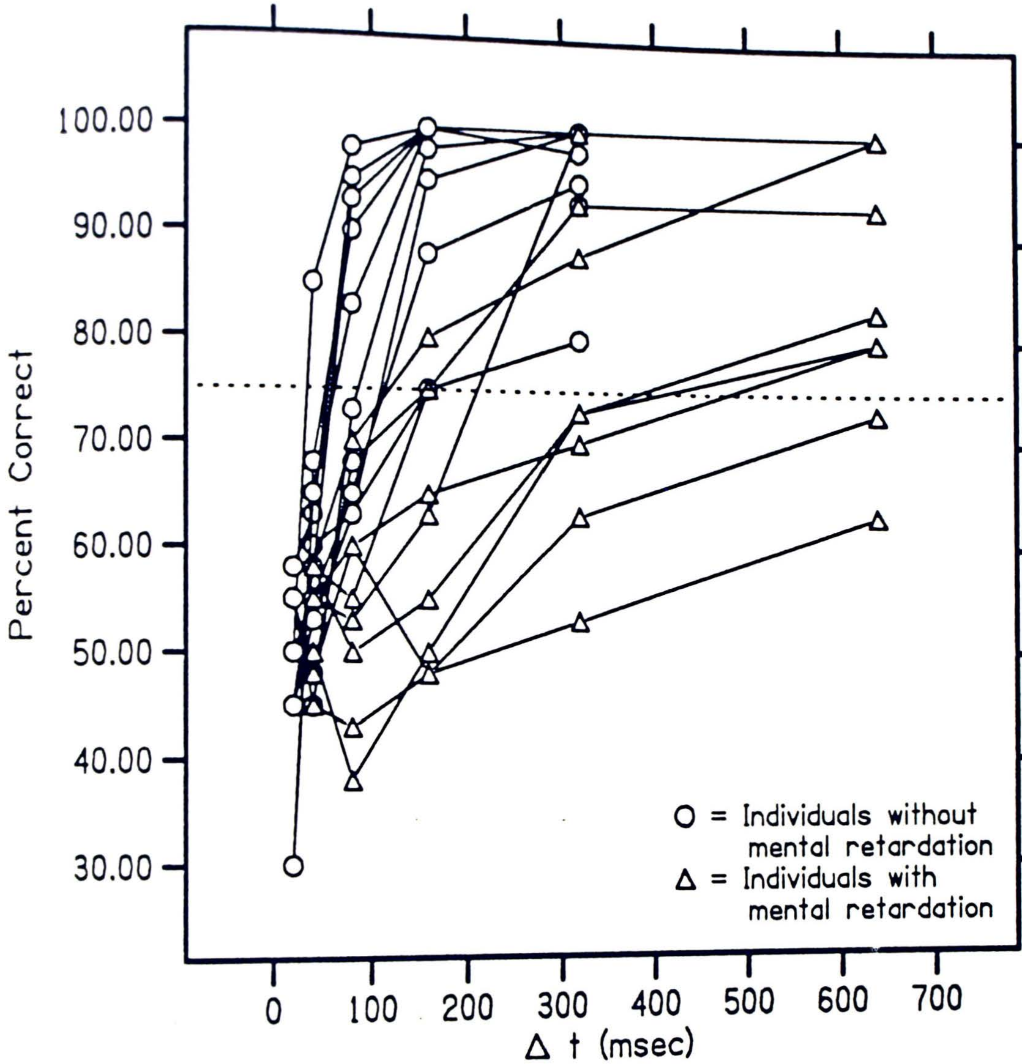


Figure 3. The figure shows individual psychometric functions for the visual duration discrimination task. Percent correct performance is plotted at each value of $\Delta t$. Circles represent individuals without mental retardation and triangles represent individuals with mental retardation. The dotted line represents the discrimination threshold (75% correct performance).

75% correct, at the largest Δt. These results also indicated that the performance of individuals with mental retardation was significantly lower than individuals without mental retardation, $F(1, 14) = 26.04$, $p<.05$.

The individual thresholds were used to find a mean threshold value for each group. Mean psychometric functions were plotted to show mean group differences (see Figure 4). A t-test for unequal sample variances was performed on the mean thresholds. Results of the auditory task showed that the thresholds of individuals with mental retardation were significantly higher when compared to the thresholds of individuals without mental retardation, $t(8) = 2.87$, $p<.05$.

Visual Duration Discrimination. The results of a 2 x 4 ANOVA revealed that performance of individuals with mental retardation was statistically different than individuals without mental retardation, $F(1, 17) = 26.65$, $p<.05$ A separate analysis of variance was computed excluding the individuals who never achieved 75% correct, at the largest Δt. These results indicated that individuals with mental retardation had significantly higher thresholds than individuals without mental retardation, $F(1, 15) = 19.54$, $p<.05$.

The individual thresholds were used to find a mean threshold value for each group. Mean psychometric functions were plotted to show mean group differences (see Figure 5). A t-test for unequal sample variances was performed on the mean thresholds. The visual duration discrimination task results indicated that individuals with mental retardation had significantly higher thresholds than individuals without mental retardation, $t(8) = 3.35$, $p<.05$.

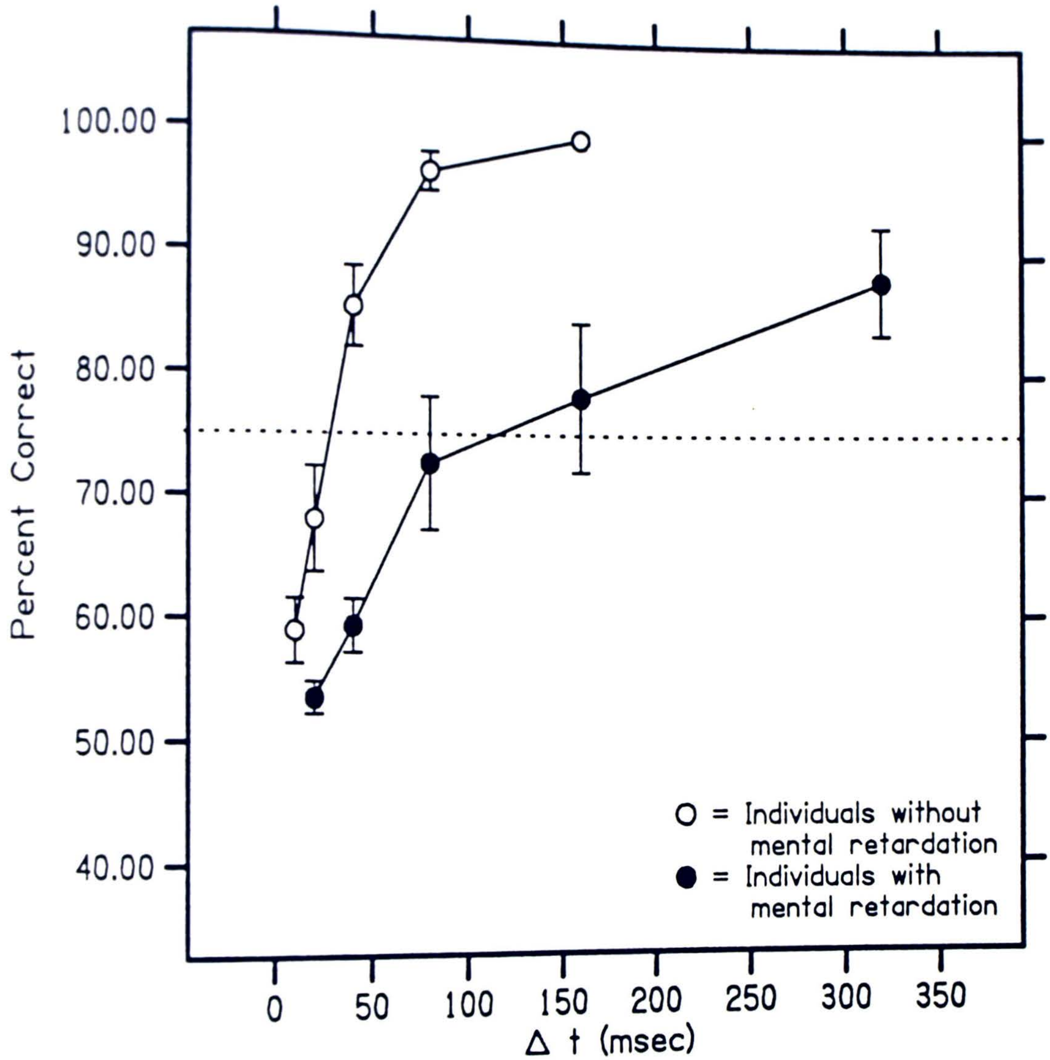


Figure 4. The figure shows the mean (and standard error) psychometric functions for the auditory duration discrimination task. Mean percent correct performance is plotted at each value of $\Delta t$. Open circles represent individuals without mental retardation and filled circles represent individuals with mental retardation. The dotted line represents the discrimination threshold (75% correct performance).

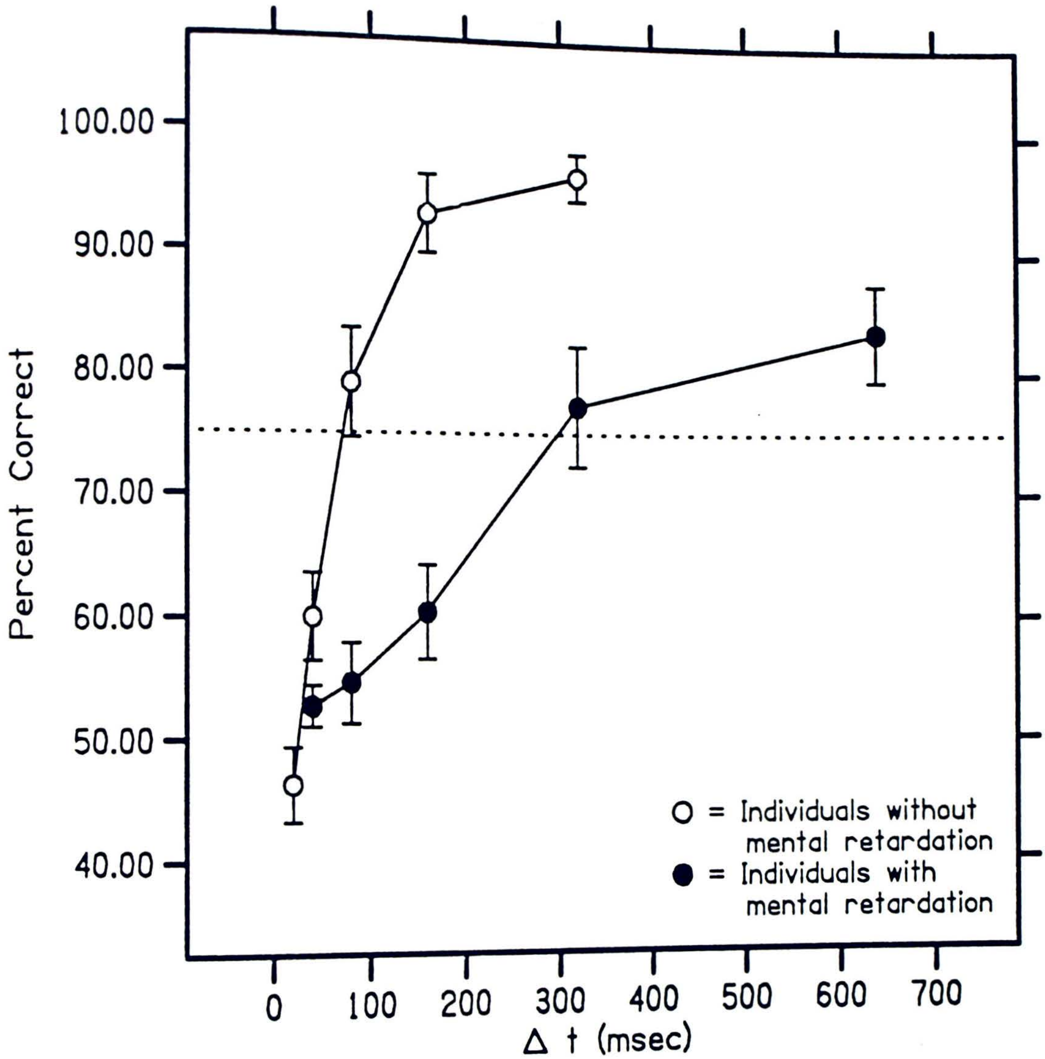


Figure 5. The figure shows the mean (and standard error) psychometric functions for the visual duration discrimination task. Mean percent correct performance is plotted at each value of Δt. Open circles represent individuals without mental retardation and filled circles represent individuals with mental retardation. The dotted line represents the discrimination threshold (75% correct performance).

Signal Detection Analysis

Signal detection analyses were performed on the data to evaluate response bias and sensitivity. Response bias is an individual's preference for saying "same" or "different" independent of stimulus configuration (qualities). The hit rates and false alarm rates were transformed into z-scores. Bias was evaluated by plotting z hits and z false alarms in receiver operating characteristic (ROC) space. These results appear in Figure 6 for the auditory task and Figure 7 for the visual task. $\beta$ measures of bias were calculated and analyzed for differences using t-tests. Sensitivity is the individuals ability to discriminate if the two stimuli are the same or different. The sensitivity to the stimuli was measured by calculating $d^1$ for each participant.

Auditory Duration Discrimination. Bias was calculated for $\Delta t$ values that were immediately above and below the difference threshold (75% correct performance). There were no significant differences in bias between the two groups, $t(8) = 1.20$, $p > .05$.

Figure 8 shows each individual's sensitivity at the given $\Delta t$ and Figure 9 shows mean sensitivity and standard errors at each value of $\Delta t$ for the two groups. Thresholds were interpolated by calculating the increment required for an observer to perform at a $d^1$ of 2.1. A $d^1$ of 2.1 represents a hit rate of 75% and a false alarm rate of 25%. Z-scores for these percentages were found and $d^1$ was determined. A t-test for unequal sample variances was performed on the mean $d^1$ threshold differences. This analysis of $d^1$ indicated that individuals with mental retardation had significantly higher thresholds when compared to thresholds of individuals without mental retardation, $t(17) = 2.87$, $p < .05$.

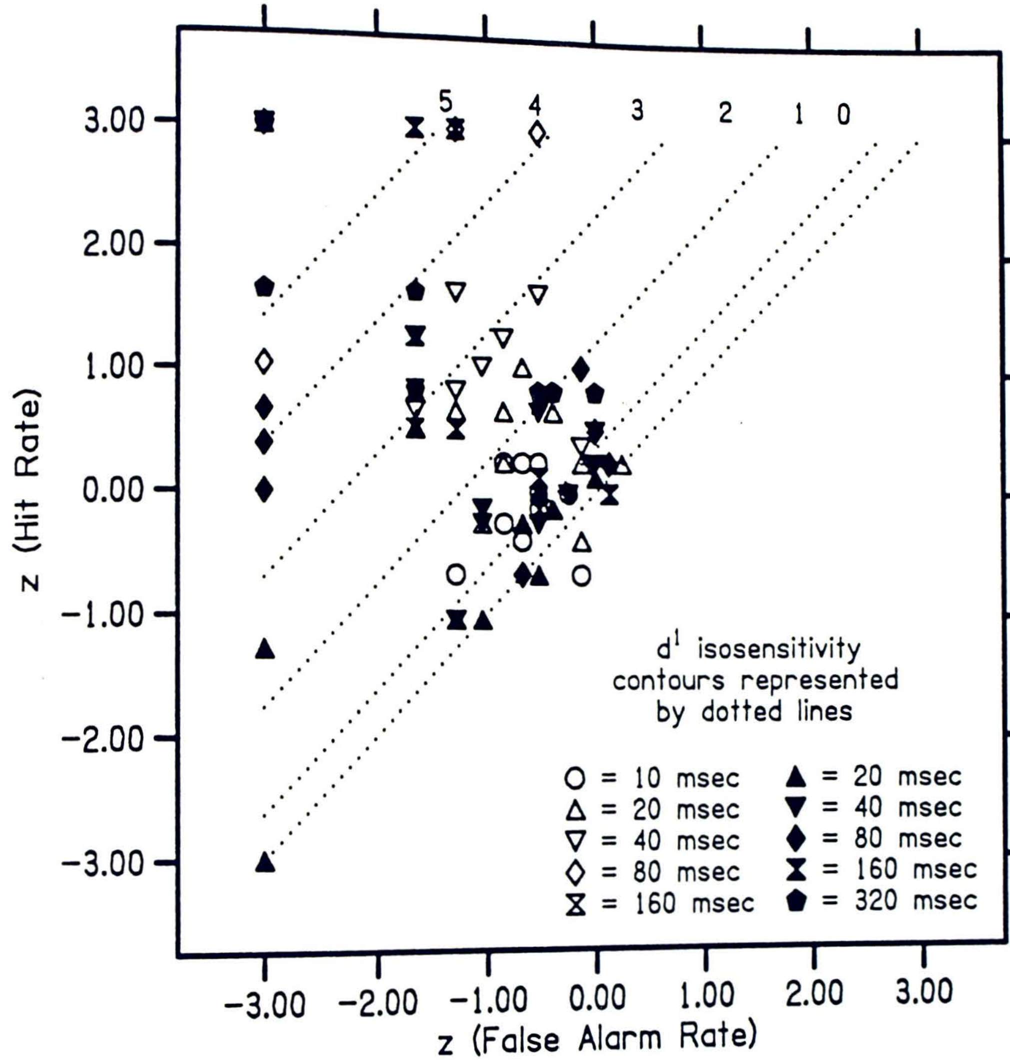


Figure 6. The figure shows signal detection analyses for each individual on the auditory duration discrimination task. Z-score for Hit rate and false alarm rate at each Δt were plotted in ROC space. Open symbols represent individuals without mental retardation and filled symbols represent individuals with mental retardation.

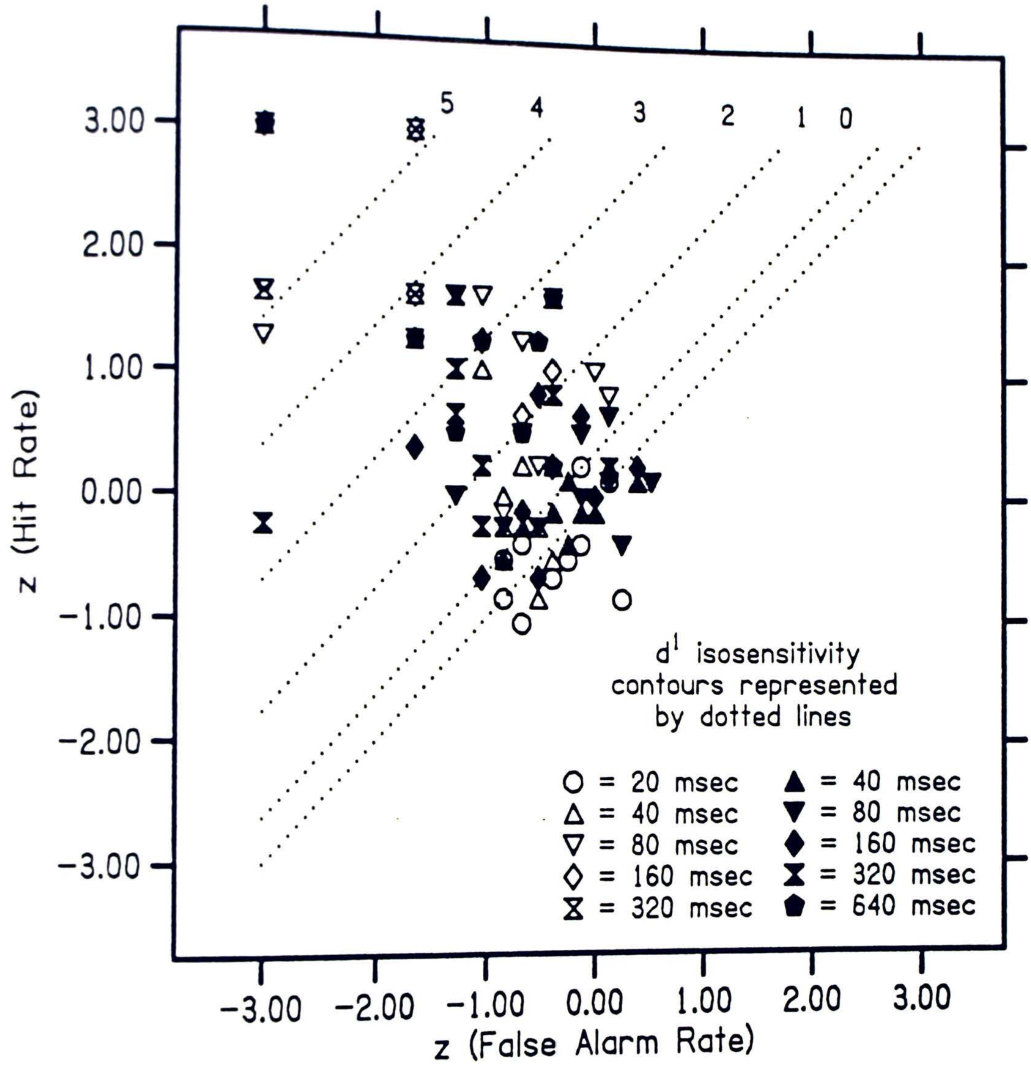


Figure 7. The figure shows signal detection analyses for each individual on the visual duration discrimination task. Z-score for Hit rate and false alarm rate at each $\Delta t$ were plotted in ROC space. Open symbols represent individuals without mental retardation and filled symbols represent individuals with mental retardation.

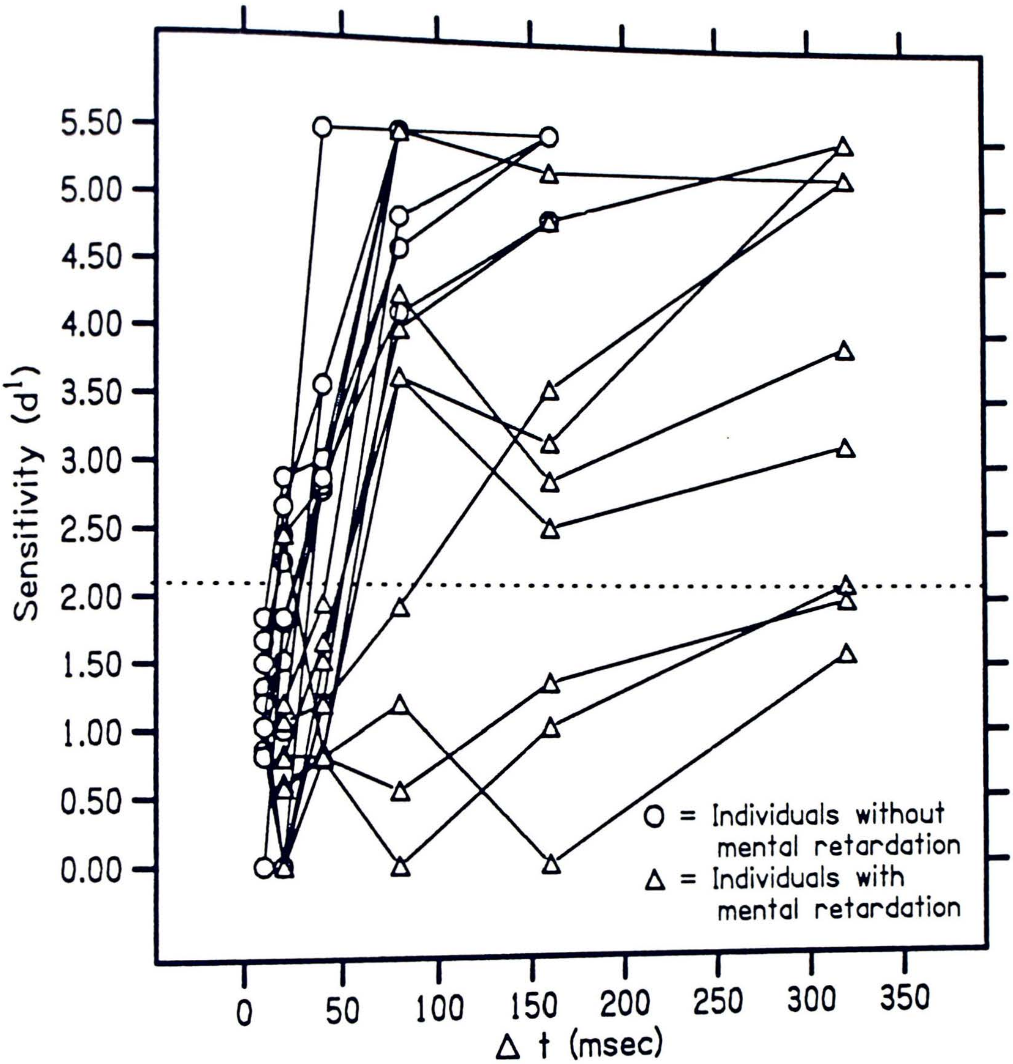


Figure 8. The figure shows each individuals measure of sensitivity on the auditory duration discrimination task. Sensitivity ($d^1$) was plotted at each value of $\Delta t$. Circles represent individuals without mental retardation and triangles represent individuals with mental retardation. The dotted line represents the discrimination threshold ($d^1$=2.1).

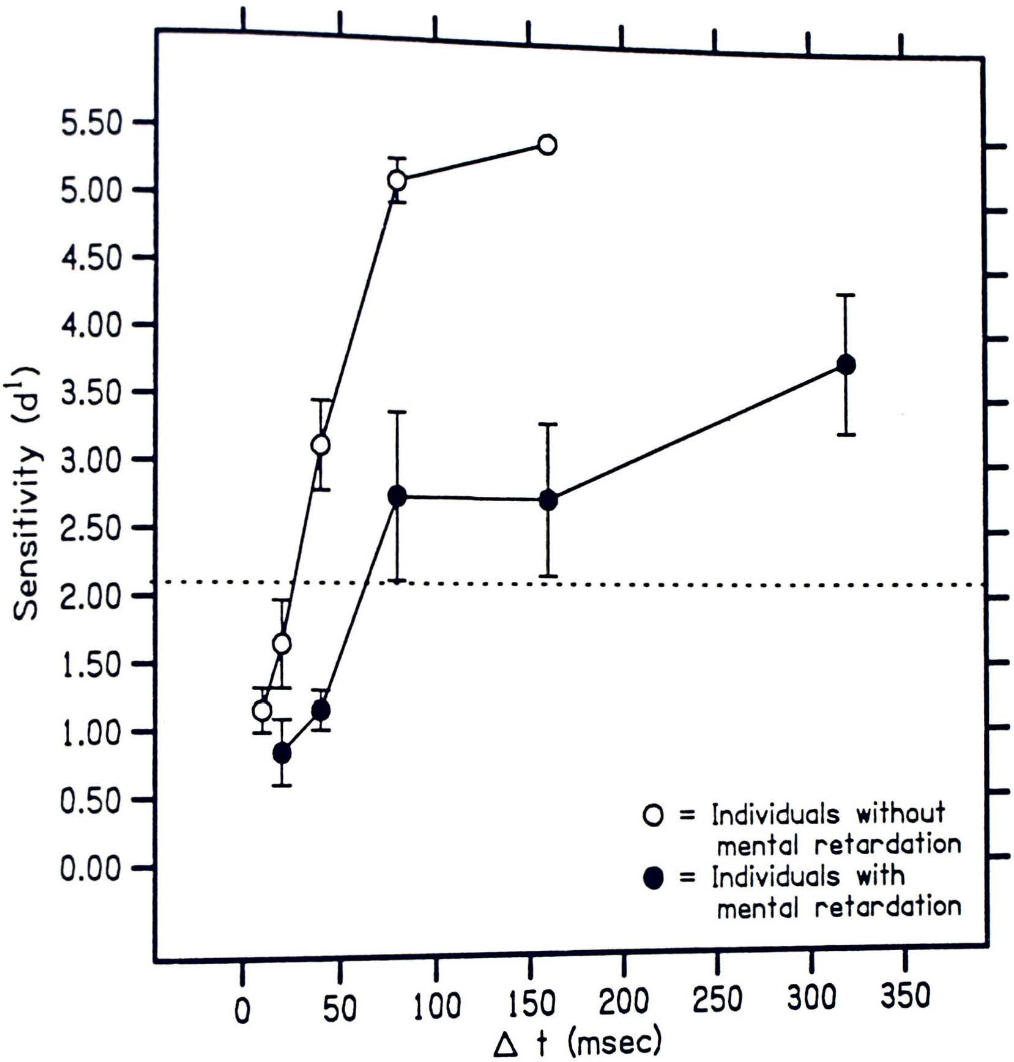


Figure 9. The figure shows mean (and standard error) sensitivity measures for the auditory duration discrimination task. Mean sensitivity measures ($d^1$) were plotted at each value of Δt. Empty circles represent individuals without mental retardation and filled circles represent individuals with mental retardation. The dotted line represents the discrimination threshold ($d^1$=2.1) for a group.

Auditory duration discrimination mean discrimination thresholds (JNDs) and Weber fractions ($\Delta t/t$) for individuals with and without mental retardation are represented in Table 1.

Table 1

Auditory Duration Discrimination JNDs and Weber Fractions for Individuals with and without Mental Retardation

| | Individuals without mental retardation | Individuals with mental retardation |
|---|---|---|
| JND M (SD) | 26 (11) | 153 (146) |
| Weber Fraction | .51 | 3.1 |

Visual Duration Discrimination. The same procedures were used to analyze bias in the visual task as were used in the auditory task. There was no significant difference in response bias between groups on the visual task, $t(8) = 1.76$, $p > .05$.

Threshold $d^1$ values were interpolated using the same procedures described in the auditory task. A t-test for unequal sample variances was performed on the mean threshold $d^1$ differences. The visual duration discrimination task results indicated that individuals with mental retardation had significantly lower sensitivities when compared to thresholds of individuals without mental retardation, $t(17) = 3.35$, $p < .05$. Figure 10 shows each individual's sensitivity at the given $\Delta t$ and Figure 11 shows mean sensitivity and standard error for the two groups. Visual duration discrimination mean JND thresholds (in ms), standard deviations, and Weber fractions ($\Delta t/t$) for individuals with and without mental retardation are represented in Table 2.

Table 2

Visual Duration Discrimination JNDs and Weber Fractions for Individuals with and without Mental Retardation

| | Individuals without mental retardation | Individuals with mental retardation |
|---|---|---|
| JND M (SD) | 85 (43) | 366 (290) |
| Weber Fraction | 1.7 | 7.3 |

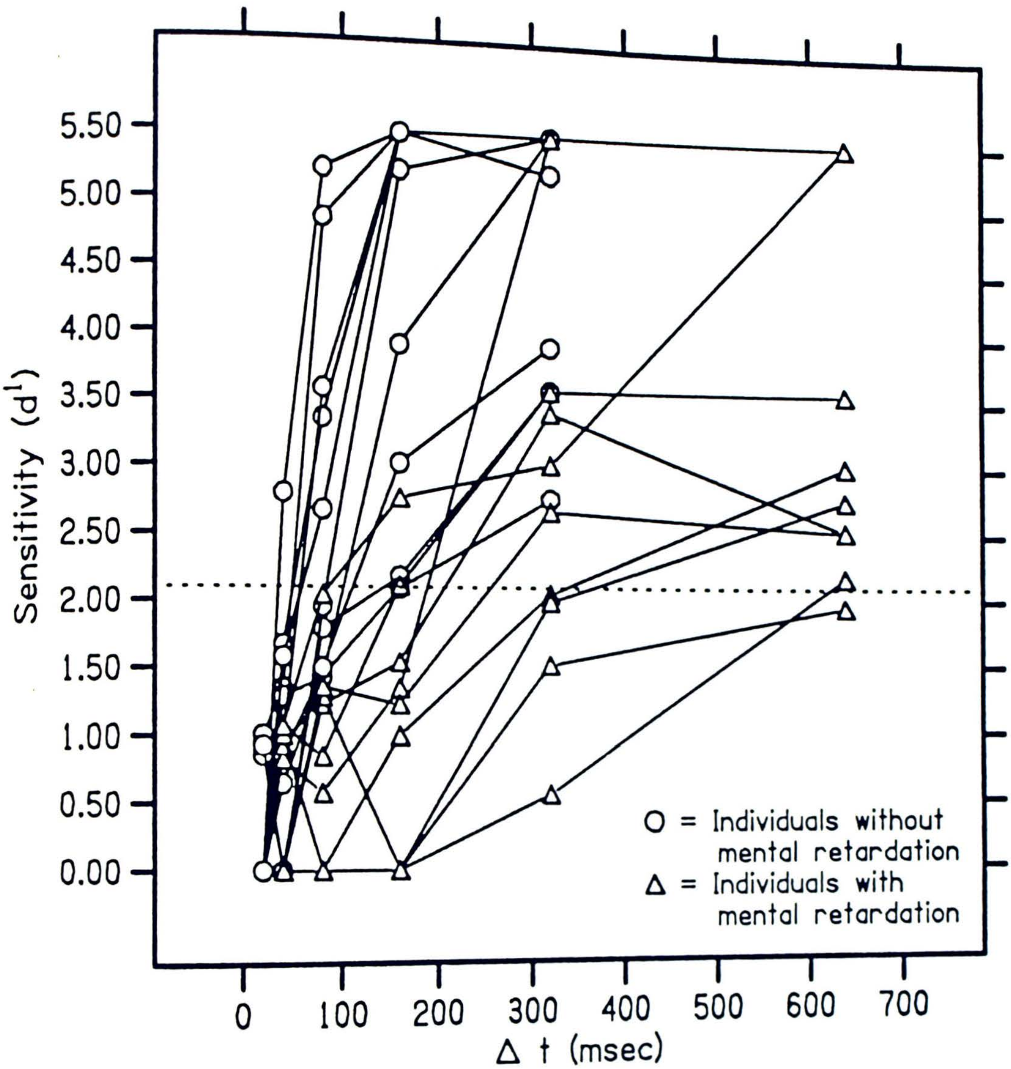


Figure 10. The figure shows each individual's measure of sensitivity on the visual duration discrimination task. Sensitivity ($d^1$) was plotted at each value of $\Delta t$. Circles represent individuals without mental retardation and triangles represent individuals with mental retardation. The dotted line represents the discrimination threshold ($d^1$=2.1).

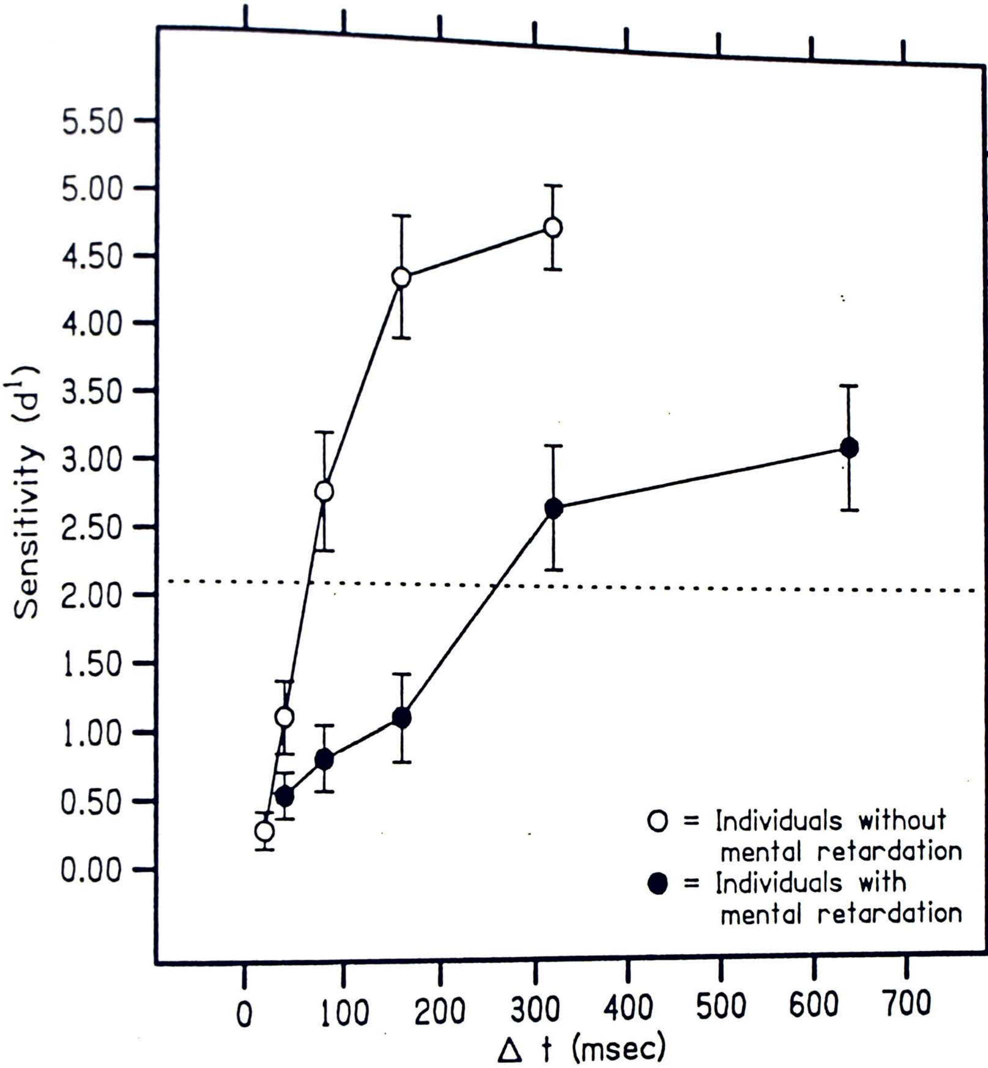


Figure 11. The figure shows mean (and standard error) sensitivity measures for the visual duration discrimination task. Mean sensitivity measures ($d^1$) were plotted at each value of Δt. Empty circles represent individuals without mental retardation and filled circles represent individuals with mental retardation. The dotted line represents the discrimination threshold ($d^1$=2.1) for a group.

# CHAPTER IV

# DISCUSSION

The present study examined temporal processing in individuals with and without mental retardation. The study found significant differences between the two groups on both duration discrimination tasks. These findings are consistent with other reports in the literature that have shown that individuals with mental retardation show temporal processing deficits. Individuals with mental retardation needed a larger duration difference to discriminate the two types of stimuli (lights or tones) when compared to individuals without mental retardation.

Auditory Duration Discrimination. Individuals with mental retardation were found to have large discrimination thresholds. The use of signal detection theory permitted an evaluation of sensitivity and response bias. Response bias was defined as the observer's preference for saying "same" or "different" independent of stimuli characteristics. Response bias can be characterized as having two forms: a conservative criterion exists when observers are less willing to respond "different" unless they are sure there was a difference in duration and a liberal criterion is evident if the observer is more willing to respond the two stimuli are different, independent of the stimuli. On these tasks, individuals with mental retardation showed similar response bias to individuals without mental retardation.

The calculated measure of sensitivity was $d^1$. This measure of sensitivity describes the ability of an individual to discriminate the difference of the two stimuli. The individuals with mental retardation showed a lower sensitivity to the differences in the stimuli. The lower $d^1$ of individuals with mental retardation suggest that auditory duration discrimination in individuals with mental retardation is impaired.

These findings of auditory duration discrimination deficits in individuals with mental retardation have implications in the areas of speech comprehension and perception. The duration of sounds has a dramatic effect on the comprehension of speech. Speech perception is dependent on the duration of the sounds (Schwartz & Tallal, 1980). If these durations are altered, then the perception of the speech is also altered (Repp, Liberman, Eccardt, & Pesetsky, 1978). Individuals with mental retardation have an apparent deficit in the auditory duration discrimination and these may partially explain the speech comprehension impairments that are evident in individuals with mental retardation (Merrill & Mar, 1987). Merrill and Mar (1987) found that individuals with mental retardation demonstrate slower, less efficient processing on a speech comprehension task.

Visual Duration Discrimination. Individuals with mental retardation demonstrated higher JNDs and Weber fractions than individuals without mental retardation on the visual task. Although individuals with mental retardation tended to have a conservative criterion when performing the visual duration discrimination task, there were no significant differences in bias between the groups. The individuals with mental retardation showed a lower sensitivity to the differences in the stimuli. The lower $d^1$ of individuals with mental retardation suggest that visual duration discrimination in individuals with mental retardation is impaired.

These results are consistent with the previous literature. Deficits in processing information specific to the magnocellular pathway is supported by previous literature (Fox

& Oross, 1988, 1990, &1992). The magnocellular pathways are characterized by information concerning the discrimination of abrupt onsets and offsets of stimuli (Merigan & Maunsell, 1994). Performance on the visual duration discrimination task is behavioral evidence in support of a deficit in the magnocellular pathway.

Impairments in visual duration discrimination have implications in visual-motor coordination. These implications are discussed with regard to the duration discrimination performance of individuals with mental retardation. Previous literature has shown that individuals with mental retardation show impairments in motor coordination on a tracking task (Henderson, Morris, & Frith, 1981). There is a direct link between perception and motor activities. The ability to successfully track an object through space will reflect an individual's performance on a visual duration task. The visual duration impairments associated with individuals with mental retardation may interfere with performance on tasks that involve motor coordination when visual stimuli are to be perceived and attended to by a motor action. Impairments in visual temporal processing of the object may interfere with motor coordination.

General Findings

Duration discrimination performance on the two tasks appeared to show differences in within-group variance. This variance resulted in some overlap in the distributions of the individual data points (See Figure 2 and 3). It is apparent that deficiencies occur in individuals with mental retardation, however the magnitude of the impairment was found to be larger in some cases than other cases.

All individuals with mental retardation completed the criterion task, however some individuals never achieved 75% correct responses on any of the trials. In each task two individuals with mental retardation never exceeded 75% correct at the largest Δt. The individuals with mental retardation who failed to reach 75% correct on the visual task were not the same individuals who failed to reach 75% correct on the auditory task. These individuals remained in the sample because of their ability to complete the criterion.

All participants' performance showed an increasing slope with the increase of the increment difference, with the exception of one individual with mental retardation. This individual's psychometric function demonstrated a general rise in performance with the exception of one datapoint. This increase in performance and success on the criterion task suggests a comprehension of the task.

It should be noted that the performance of the individuals without mental retardation was not consistent with the results of previous studies. Grondin (1993) found lower thresholds for individuals without mental retardation on visual and auditory duration tasks. Grondin (1993) used well practiced subjects and a forced choice adaptive procedure to estimate threshold. In the present study, to better compare the individuals with and without mental retardation, each group had no previous experience with this type of psychophysical task and were untrained. This may have resulted in poorer performance by the individuals without mental retardation, as compared to other studies.

In conclusion, these findings suggest that individuals with mental retardation show impairments on tasks involving duration discrimination. These results are consistent with further deficits that occur in individuals with mental retardation when processing temporal information. These deficits found on the duration discrimination tasks may provide behavioral evidence for means of further classification of individuals with mental retardation. Further investigations of similar deficits may lead to a more accurate classification for individuals with mental retardation.

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# APPENDIX

# RESEARCH INVOLVING HUMAN SUBJECTS



TITLE OF PROPOSAL: Temporal Processing and Developmental Disabilities

Principal Investigator: Dr. Charles B. Woods, Yasmin Sarwar & Kevin DeFord (Psychology)

Sponsor (if student):

Action of the human Research Review Committee:

XXX A. Approved as described. Researcher is responsible for obtaining approval from the Committee prior to introducing any changes in protocol; for keeping signed consent statements for the duration of the project and 3 years thereafter; and informing the Committee of an unexpected physical or psychological effects on subjects.

____ B. Approved with recommendations as follows:

Researcher may revise the project in accordance with recommendations and communicate in writing the changes which have been made; discuss the action with the Committee; or withdraw the proposal.

____ C. Proposal deferred for additional evidence as follows:

Further action is contingent on the investigator supplying the Committee with appropriate information.

____ D. Proposal not approved for the following reasons.

Researcher may revise the project or discuss the action with the Committee.

Reviewed by: X Chairperson, Human Research Review Committee [signature] 9/27/94
Signature

____ Membership, Human Research Review Committee ____________
Signature

Copies to: 1. Investigator
2. File with proposal