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AUDITORY-VISUAL EQUIVALENCE MATCHING IN MENTALLY RETARDED AND INTELLECTUALLY AVERAGE CHILDREN

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AUDITORY-VISUAL EQUIVALENCE MATCHING

IN MENTALLY RETARDED AND INTELLECTUALLY

AVERAGE CHILDREN

by

Shelly Botuck

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

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Date

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Abstract

AUDITORY-VISUAL EQUIVALENCE MATCHING IN MENTALLY RETARDED AND INTELLECTUALLY AVERAGE CHILDREN
by
Shelly Botuck

Advisor: Professor Gerald Turkewitz

Intra- and interensory auditory-visual information equivalence as well as transposition (temporal-spatial equivalence) was examined in 24 mentally retarded pre-adolescents and adolescents and 72 intellectually average children.

Subjects of average intellect showed no differences in accuracy between intra- and intersensory tasks, although older children were more accurate than younger children. Mentally retarded subjects were more accurate on intra- than on intersensory tasks, in all chronological age groups and across all levels of mental retardation. Independently of whether tasks involving transposition were intra- or intersensory, they were more difficult for the mentally retarded subjects than tasks not involving transposition. The intellectually average subjects in all age groups behaved similarly on intrasensory tasks but showed a reverse effect on intersensory tasks, i.e., they were more accurate when transposition was involved.

Another finding was an influence of direction on intersensory transfer for the subjects of average intellect but not for the mentally retarded subjects. That is, for the children of average intellect, presenting a visual

pattern first facilitated matching, whereas presenting an auditory pattern first increased matching errors. However, accuracy of matching for the mentally retarded subjects was not influenced by the direction of transfer.

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Through out my university education, my sister, Wendy Botuck, has edited and typed my papers, corrected both spelling and grammar and been an ongoing source of support and encouragement.

My husband, John Pittman, painstakingly edited the dissertation under rather pressured circumstances. That was the least of the ways in which he helped me.

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Introduction

Much of the research on mentally retarded individuals is based on the notion that mental retardation is a condition of low intelligence (House, 1977), intelligence regarded as a trait or set of traits underlying mental and/or intellective ability. The concept of mental retardation was considered a special case of the developing construct of intelligence until it became apparent that the traits and properties characteristic of retardation could not be satisfactorily measured solely by indices of general intelligence. Subsequently those traits were deemed to be both grounded in and yet to transcend the construct of intelligence.

Thus, the diagnosis of mental retardation can be seen as evolving historically. Originally, the sole criterion for being diagnosed mentally retarded was low intelligence as measured by standardized intelligence tests. The present definition includes indices of adaptive behaviors. According to the American Psychiatric Association (1980) an individual can be diagnosed as mentally retarded if (1) the individual has subaverage general intellectual functioning, 70 or below on a standardized IQ test (2) concurrent deficits or impairments in adaptive behavior (3) with onset before the age of 18.

Intelligence tests were designed initially to select individuals who would benefit from public education. Intelligence tests have been and continue to be used to indicate what an individual can in fact do as well as to predict what he or she will be able to do in a predefined context, e.g. modern technological society. Therefore it comes as no surprise that IQ together with some measure of adaptive behavior successfully distinguished those individuals who could learn in school, and that it proved to be a reliable criterion for the selection of research subjects for studies designed to differentiate between groups of individuals on the basis of a specific trait or behavior. As long as public education maintained an exclusionary policy by not educating those individuals whose scores were below the pre-established norm, the underlying assumptions were sufficient.

However, as a consequence of recent court decisions and federal legislation, schools in the United States are faced with the challenge of providing a free and appropriate education for all children in the least restrictive environment. Introducing the concept of zero-reject to our educational system, Public Law 94-142 has become the impetus for redefining what was previously deemed a homogeneous population of uneducables. If we are to respond to the demand for an appropriate education in the least restrictive environment, we need to identify possible areas of impaired functioning and understand the various processes underlying performance. We cannot rely on classifications primarily based on IQ score to determine school placements. Only by identifying the bases on which mentally retarded individuals are functioning can we develop specific modes of instruction and remediation.

One of the most basic requirements for flexible adjustment to environmental demands is the acquisition of sensory information. In humans the development of complex adaptive behaviors depends in part upon the capacity to respond to simultaneous multimodal stimulation. The ability to integrate various kinds of sensory inputs e.g. olfactory, auditory, tactile and visual is required for object identification and concept formation and is fundamental to many of our daily activities. For example, learning to read involves the ability to establish equivalence between temporally distributed auditory stimuli (speech sounds) and spatially distributed visual stimuli (letters and words). Counting, initially, involves the integration of tactile (finger counting), visual (the number symbol), and auditory (the word) information.

So fundamental is intersensory integration to higher level functioning that it has been shown that an organism's status within the phylogenetic scheme is a good indicator of its ability to use intersensory functioning in adapting to environmental demands. In Principles of Animal Psychology (1935), Maier & Schneirla give numerous examples of animal studies which demonstrate that the types of cooperation between the sense systems change from relatively independent functioning of the individual sense systems in invertebrates to a more interrelated functioning in vertebrates. For example, in the octopus, modification of a chemically mediated response does not alter behaviors which are tactually mediated. When vertebrates are considered, increasing levels of cooperation between the sense systems can be seen. A stimulus to one modality can serve as a cue for behavior in another modality. Or, under special circumstances, if one sensory system becomes incapacitated another sensory system may take over. An example of this can be found in the blinded frog: a visually mediated response can be mediated by olfaction.

Contemporary research has shown that even mammals below the level of primates (bushbabies, rabbits, cats) are capable of transferring a learned discrimination from one sensory system to another. However transfer is only achieved under very limited and specific conditions (John & Kleinman, 1975; Ward, Yehhle, & Doerflein, 1970; Yehle & Ward, 1969, 1970). That is, transfer between the auditory and visual systems has been achieved when the discriminations are based upon quantitative aspects of auditory-visual stimulation such as more or less, loud or soft, fast or slow, and not on qualitative aspects such as pattern of temporal distribution or rhythm.

It appears that some nonhuman primates are capable of intersensory information processing such as matching shapes across modalities. However, even at this advanced phyletic level, such intersensory relationships require either very specific experimental conditions (Cowey & Weiskrantz, 1975a, 1975b) or the highest level of functioning of which the animal is capable. For example, Davenport (1976), Davenport & Rogers (1970) and Davenport, Rogers & Russell (1973) have found that apes are able to recognize a visually presented stimulus as an object that was previously felt. Ettlinger & Garcha (1980) have found that monkeys were able to achieve visual-tactile shape recognition. However, in all of these studies, thousands of training trials were required and in the Ettlinger & Garcha study (1980), only a few animals reached criteria on crossmodal shape recognition. Cowey & Weiskrantz (1975a, 1975b) have found that modifying the experimental procedure by providing gustatory cues accompanying tactile information and making the nonrewarded stimuli aversive, made visual-tactile shape recognition much easier for monkeys, i.e. far fewer trials were needed to learn.

Based in part upon the view that species evolution has involved increasing integration between the senses, Birch & Lefford (1963) hypothesized that intersensory functioning changes during human development, with integration among the separate sense systems increasing with age. In studies of the development of intersensory functioning in humans, investigators have demonstrated that children's abilities to respond equivalently to inputs in different modalities increases with age (Birch & Lefford, 1963, 1967; Birch & Belmont, 1965a; Blank & Bridger, 1964; Jones & Robinson, 1973). Furthermore the ability of school age children to equate auditory-visual information has been found to be strongly related to reading achievement and to general intellectual performance (Birch & Belmont, 1964, 1965b; Kahn & Birch, 1968; Sterritt & Rudnick, 1966; Rudnick, Sterritt & Flax, 1967). In fact, the evidence of over twenty years of research in intersensory functioning in vision and touch and in hearing and vision, indicates a strong association between poor performance on intersensory tasks and poor cognitive skills and competencies in school-age children.

A close examination of the existing data on interensory functioning in both humans and animals reveals some confusion because of a failure to identify the nonunitary character of intersensory organization (Botuck, Harawitz & Turkewitz, 1985; Lewkowicz & Turkewitz, 1980). That is, intersensory functioning involves multi-level processing ranging from simple crossmodal quantitative summations to complex information abstractions. The failure to differentiate between types of intersensory functioning may be responsible for the apparent discrepancy between finding evidence of intersensory equivalence in infants and animals, and the above noted increase in intersensory integrative ability with increase in age in later childhood.

There are, in fact, at least two ways of abstracting information concerning amodal properties e.g., location, extent, duration, texture, and shape (Bryant, Jones, Claxton, & Perkins, 1972; Lewkowicz & Turkewitz, 1980). One is based upon sensitivity to amount of stimulation: sensitivity to the total amount of stimulation provided by a given object. Organisms of all phyletic levels are sensitive to variations in amount of stimulation. It is not surprising that responsiveness to those amodal properties of stimulation which can be specified by the amount of stimulation they provide appear to be characteristic of even very young organisms (Schneirla, 1935; 1959).

A second manner in which amodal information may be obtained involves responsiveness to the organizational attributes of an object or an event. For example, the abstraction of shape and or rhythm requires a response to the relationship between the parts. Responsiveness to the organizational attributes of objects is by no means phyletically universal, and, as stated previously does not appear to occur except at relatively advanced phyletic levels. We would not expect this type of intermodal equivalence to characterize very young human infants.

These two manners of abstracting information are mediated by different mechanisms which require different levels of organization (Bryant, Jones, Claxton & Perkins, 1972; Schneirla, 1959; Turkewitz, Lewkowicz & Gardner, 1983). Intensity-based intersensory equivalence appears to be a low level process whose persistence might indicate poorer cognitive functioning, whereas organizationally-based equivalence is a relatively high level process which is likely to be associated with more advanced cognitive functioning. Organizationally-based auditory-visual and visual-tactile equivalences are often referred to as intersensory equivalence or intersensory integration. The remainder of this dissertation focuses on studies of intersenory relations on this level of functioning unless otherwise indicated.

Difficulties in equating auditory-visual intersensory information have been found in retarded readers (Birch & Belmont, 1964, 1965b; Kahn & Birch, 1968), brain damaged children (Birch & Belmont, 1965a), psychiatrically disturbed adolescents (Hertzig & Birch, 1966, 1968), schizophrenic children (Walker & Birch, 1970), malnourished children (Cravioto, DeLecardie & Birch, 1966; Cravioto, Gaona & Birch, 1967) and mentally retarded adolescents and older children (Botuck & Turkewitz, 1984; Botuck, Turkewitz & Moreau, 1986). Difficulties in matching visual to tactile stimuli have been found in studies of brain damaged and emotionally disturbed children (Conners & Barta, 1967), economically disadvantaged children (Conners, Schuette & Goldman, 1967), mentally retarded children (Jones & Robinson, 1973; Zung, 1971) and premature infants (Rose, Gottried & Bridger, 1979).

The results of these studies suggest that damage to the central nervous system, regardless of etiology, may cause a general disordering of brain-behavior relationships of which impaired intersensory functioning and cognitive/intellective limitations are representative manifestations. Because intersensory integration is a high level of responsiveness, phylogenetically (Maier & Schneirla, 1935) and ontogenetically (Birch & Lefford, 1963), any insult to the nervous system or to the sense systems might result in difficulties with intersensory relationships.

Despite the apparent importance of intersensory functioning for optimal cognitive functioning, a number of problems in interpreting available evidence have been identified. Blank and Bridger (1966) argued that difficulties in tasks requiring the identification of auditory-visual equivalence are really difficulties in equating information that has been transposed from a temporal to a spatial mode. They found that nursery school children were able to equate temporally distributed auditory patterns and temporally distributed visual patterns but had difficulty equating temporally distributed auditory patterns with spatially distributed visual patterns (Blank & Bridger, 1964). Therefore, they argued that for young children the difficulty lies not in auditory-visual integration but in the transposition from a temporal to a spatial mode. Intersensory integration studies have also been criticized for failure to employ intrasensory controls, i.e. auditory-auditory, visual-visual, and haptic-haptic matching (Bryant, 1968;

Freides, 1974). This criticism was based on evidence from studies of visual-haptic integration which indicated that limitations in visual-haptic matching could be attributed to limited functioning in one or both of the sensory systems without necessarily involving any special difficulty with intersensory integration per se (Milner & Bryant, 1968). In addition, interpretation of the findings of studies of auditory-visual equivalence must be tempered by an awareness that some very different procedures, especially in the presentation of stimulus patterns, have been used. (For a more detailed discussion, see Freides, 1974, and Jones, 1981).

In an attempt to address some of these issues, as well as to examine the performance of mentally retarded individuals on tasks of auditory-visual matching, I conducted two studies. In the first study, Botuck & Turkewitz (1984) examined the performance of mildly and moderately retarded adolescents on tasks of auditory-visual information equivalence, using a multiple choice matching procedure, which included intra- and intersensory tasks which did and did not require transposition from a temporal to a spatial mode (and vice versa). The most striking finding was that intersensory matching, whether requiring transposition or not, was more difficult for the subjects than comparable intrasensory matching. In addition, it was found that intersensory tasks requiring transposition were more difficult than intersensory tasks not requiring transposition, whereas this was not the case for intrasensory tasks.

In a second study, Botuck, Turkewitz & Moreau (1986) examined auditory-visual information equivalence and its relation to IQ score in mentally retarded and intellectually average 12-and-13-year-olds. Intra- and intersensory auditory-visual information equivalence as well as spatial-temporal equivalence was examined by the use of a forced choice matching procedure. This was more comprehensive than the procedure used in Botuck & Turkewitz (1984), due to the inclusion of two additional tasks: visual spatial - visual spatial, and visual temporal - visual temporal. The mentally retarded subjects made more errors on inter- than on intrasensory tasks, and both intra- and intersensory matching accuracy dropped when transposition was required. This finding was different from that of the first study when transposition was found to increase the number of errors made on intersensory but not intrasensory tasks.

The difference in the findings may be due to more accurate matching by the adolescents in the 1984 study. Given the homogeneity of the two samples on all relevant variables except chronological age, it is possible that differences in transposition are due to greater accuracy with increase in age. On the other hand, it is also possible that the more complete design of the second study allowed difficulties in temporal-spatial equivalence to become manifest. In either case, identification of the cause of the discrepant results is important for understanding auditory-visual equivalence in mentally retarded individuals.

Another finding of this study was the absence of correlation between IQ score and intra- or intersensory performance. To the extent that performance on tasks of auditory-visual equivalence indicates the capacity for cognitive skills, the fact that IQ score is not correlated with scores on tasks of auditory-visual equivalence is somewhat surprising. After all, IQ is a major index for placement decisions of mentally retarded children in special education classes. The failure to find evidence of a correlation between performance on tasks of intersensory equivalence and IQ raises disturbing questions about the legitimacy of IQ as an index of developmental potential for mentally retarded individuals.

The purpose of the first dissertation study was to examine auditory-visual equivalence matching in mentally retarded pre-adolescents and adolescents. The study was designed to accomplish four task: to improve the experimental procedure by "computerizing" the stimulus patterns thereby increasing the uniformity of task presentation; to resolve the discrepancy between the two earlier studies regarding transposition and chronological age; to determine if there was a relationship between level of mental retardation and intersensory task performance;

and to identify the source of impairment in auditory-visual matching.

Study 1

Method

Subjects.

The subjects were 24 mentally retarded adolescents and young adults, 14 males and 10 females (See Table 1).

Sixteen of the subjects were participants in the Catholic Guardian Summer Experience, an educational/recreational summer day program owned and operated by Brooklyn Catholic Guardian Society, and eight of the subjects were residents of Catholic Guardian Society Group Homes. Ten of the subjects who participated in the summer day camp lived at home.

The criteria for the selection of subjects were as follows: 1) a primary diagnosis of mental retardation, 2) no recorded behavior problems and no recorded physical or sensory limitations, 3) age 12 to 21 years, 4) a passing score on the pretest.

Of the 44 mentally retarded individuals originally considered, only 24 were selected, as 20 did not pass the pretest and were eliminated from the experimental sample. Initial analyses, (t-tests), indicated that those individuals who passed the pretest and served as subjects and those individuals who failed the pretest and were excluded from the sample, did not differ on level of mental retardation or chronological age.

Table 1

Distribution of Age and Level of Mental Retardation

CA	Level of Mental Retardation			
	Severe IQ=20-34	Moderate IQ=35-49	Mild IQ=50-70	Total
12.25-14 yrs	2	3	4	9
16-18.5 yrs	2	1	3	6
19-20 yrs	1	6	2	9
Total	5	10	9	24

Design

To examine intra- and intersensory auditory-visual information equivalence, as well as spatial-temporal equivalence, nine matching tasks, developed for a previous study (Botuck, Turkewitz & Moreau) were used and are listed in Table 2. There were five intra- and four intersensory matching tasks. Four of the tasks required the subject to match a temporally distributed pattern with another temporally distributed pattern, one task required matching a spatially distributed pattern with another spatially distributed pattern, and four tasks required transposition from a spatially to a temporally distributed pattern or vice versa. Because sound is essentially a pattern in time, all of the auditory patterns differed with regard to their temporal rather than their spatial distribution.

The combinations of various tasks resulted in four experimental conditions: intrasensory transposition, intersensory transposition, intrasensory nontransposition and intersensory nontransposition. These variables formed the basis for examining intra- and intersensory equivalence and spatial temporal equivalence (transposition).

To study the facilitation-interference of an auditory or a visual stimulus pattern presented as the "standard" on intersensory matching, referred to as direction of intersensory transfer, the intersensory tasks were analyzed according to whether they began with an auditory or visually presented pattern first.

Table 2
Intra- and Inter Matching Tasks

Intrasensory Tasks	Intersensory Tasks
Auditory Temporal- Auditory Temporal	Auditory Temporal- Visual Temporal
Visual Temporal- Visual Temporal	Visual Temporal- Auditory Temporal
Visual Spatial- Visual Spatial	--------------- ---------------
Visual Temporal- Visual Spatial	Auditory Temporal Visual Spatial
Visual Spatial- Visual Temporal	Visual Spatial- Auditory Temporal

Each of the nine tasks was presented to each subject. Two different orders of task presentation were used (see Table 2a), each order for 12 of the 24 subjects. For each task there were six trials. Each trial consisted of the presentation of a standard stimulus pattern followed by a comparison stimulus pattern. For half of the trials the standard and the comparison were the same and for half of the trials they differed.

Apparatus and Stimuli.

The equipment for stimulus pattern generation consisted of a Commodore 64 Computer, a Commodore Disc Drive (#1541) and a Commodore Video Monitor (#1702). Stimulus patterns were entered into a specially written program and generated under software control.

The auditory stimuli were sequences of 300 ms 1000 Hz tones presented at a comfortable sound level well within the normal hearing range.

The visual temporal stimuli were 300 ms flashes of 2.54 cm by 2.86 cm black and white checkered rectangle displayed on a white screen. The checks were 1.59 mm by 2.38 mm.

The visual spatial stimuli were a series of 2.54 cm by 1.88 cm black and white checkered rectangles displayed on a white screen. The checks were 1.59 mm by 2.38 mm.

A seven interval pattern was used for both auditory and visual stimuli. In all patterns five stimuli were distributed over the seven intervals and the first and the

Table 2a

Orders of Task Presentation

Presentation A	Presentation B
1. VS-VT	1. VT-VS
2. AT-AT	2. VS-VS
3. VS-AT	3. AT-VS
4. VT-VT	4. VT-VT
5. AT-VT	5. AT-AT
6. VT-VS	6. VS-VT
7. VS-VS	7. VT-AT
8. AT-VS	8. AT-VT
9. VT-AT	9. VS-AT

seventh interval were always filled. There were three stimulus patterns: 0*000*0, 000*0*0, 00*0*00. The total duration of the auditory temporal and visual temporal pattern presentation was 2.1 seconds. The duration of the visual spatial pattern presentation was two seconds. For each task, interpattern interval, i.e. time between the presentation of the standard and the comparison, was two seconds. The intertrial interval, the amount of time allotted for the subject to answer, was flexible to meet the demands of the subject but never exceeded one minute. Intertask interval was approximately one minute.

Procedure.

Each subject came with the investigator to a test room, either a quiet, empty classroom in the school where the day camp was held, or an office in the group homes. The subject had been told that he/she would be playing matching games on a computer.

Before the experimental procedure a pretest of six matching exercises was given to familiarize each subject with the matching procedure as well as to screen out any subjects who did not understand the matching concept. The exercises required determining whether the following did or did not match: (1) two groups of three pencils (2) two groups of four pieces of the same candy (3) one square on a flashcard with two squares on another flashcard (4) three handclaps in rapid succession followed by two hanclaps with a longer time between them (5) two squares on a flashcard and three handclaps. After the presentation of each pretest trial the investigator asked the subject if the patterns were the same or different. Following the subject's response, the investigator informed him/her of the correctness of his/her judgement. (However, no corrections or affirmations were given during experimental testing.) If a subject answered 1, 2, 3, 4 correctly but was unable to answer exercise 5 correctly, a sixth exercise, one square on a flashcard and one handclap was introduced. Only those subjects who answered 1, 2, 3, 4, and 5 or 6 correctly were considered to have passed the pretest and remained in the experimental sample (N=24).

The subject then moved to a chair facing the keyboard and computer screen and the investigator sat about .3 meter to the right of the subject. Each subject was familiarized with the equipment before being tested. Using a different stimulus pattern than any appearing during the actual testing, the investigator showed the subject what each of the three stimulus patterns looked (sounded) like.

The subjects were told to say whether the standard and the comparison patterns were the same or different. However, I accepted "yes" and "match" for same and "no" for different as we found in two previous studies that mentally retarded subjects often use "yes", "match", and "no" instead of "same" and "different." The subjects were told that some of the tasks might be very difficult and that it was "OK to guess."

After testing, each subject was told that he/she did a "great job".

Subjects were tested in a single session which lasted between 25-35 minutes. Only initial responses were accepted and no changes in answers were permitted. In some instances the subjects said " I don't know," "I missed that" or "Can I see (hear) it again." All such responses were recorded as "don't know."

Scoring

There were nine scores for each subject, one score for each task. Each score was the number of correct choices made on the six trials. A response of "don't know" was always scored as incorrect. However, in some cases a correction for guessing was used. That is, any task for which the subject's responses were either all same or all different was scored as zero - number of correct responses (three) minus number of incorrect responses (three). Scores for tasks AT-AT, VS-VS, VT-VT, were combined to obtain a score for intrasensory-nontransposition; scores for VT-VS, VS-VT were combined to obtain a score for intrasensory-transposition; scores for tasks AT-VT, VT-AT were combined to obtain a score for intersensory-no transposition, and AT-VS, VS-AT were combined to obtain a score for intersensory-transposition.

Results

To examine the effect of the two different orders of task presentation on the accuracy scores an ANOVA was performed. No difference was found between the scores of the two orders of task presentation. Therefore, order of task presentation was ignored for all subsequent analyses.

Because of the possibility that the correction for guessing distorted the data, the analyses which appear below were also computed using the data without the correction for guessing. The F Tables for these analyses can be found in Appendix A. On the whole the reported analyses using the correction for guessing resulted in more conservative statistical probabilities than would be the case without the correction for guessing.

The overall performance of the sample is summarized in Tables 3 and 4. As may be seen from these data, the mentally retarded subjects scored higher on intrasensory tasks than on intersensory tasks, and were much more effective in matching patterns which did not require transposition than they were matching patterns requiring transposition.

A 3x3x2x2 repeated measures analysis of variance was performed with the following factors: level of mental retardation - severe, moderate, mild; CA - 12-15 years, 16-18, 19-20 years; task - intra- and intersensory; and transposition - nontransposition. The subjects were more accurate on intra than on intersensory matching tasks (see Table 3), resulting in a statistically significant main effect for task, $F(1,15)=8.18$, $p<.01$. They were also more accurate on tasks not requiring transposition than on tasks

Table 3

Mean Number of Correct Responses out of six on Intra- and Intersensory Matching for Mentally Retarded Subjects (n=24)

Matching Task	Mean	SD	Number of Subjects With Zero Scores	Number of Subjects With Scores of six
Intrasensory				
Auditory Temporal-Auditory Temporal	3.9	1.75	2	5
Visual Spatial-Visual Spatial	5.0	1.23	0	11
Visual Temporal-Visual Temporal	2.4	1.91	5	2
Visual Temporal-Visual Spatial	3.0	1.85	4	2
Visual Spatial-Visual Temporal	2.9	2.07	5	1
Intersensory				
Auditory Temporal-Visual Temporal	2.9	2.07	5	3
Visual Temporal-Auditory Temporal	2.9	1.91	4	3
Auditory Temporal-Visual Spatial	2.5	2.02	7	1
Visual Spatial-Auditory Temporal	2.8	2.30	7	2

Table 4

Mean Number of Correct Responses out of six on Intra- and Intersensory Matching Involving and Not Involving Transposition for Mentally Retarded Subjects

	Intrasensory		Intersensory		Total	
	M	SD	M	SD	M	SD
Transposition	2.8	1.52	2.5	2.15	2.6	1.85
No Transposition	3.8	1.05	2.9	1.85	3.3	1.45
	3.4	1.29	2.7	2.00		

which required transposition (see Table 3), resulting in a statistically significant main effect for transposition, $F(1,15)=13.55$, $p<.002$. Whether the task was intra- or intersensory, subjects in all three age groups across the three levels of retardation found matching not requiring transposition easier than matching requiring transposition. This finding is indicated by the lack of statistically significant interactions between: task and transposition; level of retardation, task, and transposition; and level of retardation, CA, task, and transposition.

There was a significant difference between the means of the four experimental condition (see Table 4), $F(3,23)=5.55$, $p<.005$. The subjects made fewest errors when the matching was intrasensory and did not require transposition, while in the remaining three conditions, there was no appreciable difference in the number of errors made. T-tests between the six pairs of means revealed that subjects were more accurate on intrasensory tasks not requiring transposition than they were on the three other tasks: $t(23)=2.89$, $p<.008$ intrasensory transpositon; $t(23)=3.88$, $p<.001$ intersensory transposition; $t(23)=2.76$, $p<.01$ intersensory no transposition.

There were significant differences among the means of the nine tasks (see Table 3), $F(8,184)=7.89$, $p<.001$. Scheffe tests revealed that, except for auditory temporal - auditory temporal, visual spatial - visual spatial matching was superior to all other tasks at the 0.05 level. There were no significant differences between the means of any other tasks.

The fact that four of the five intrasensory tasks required matching a visually presented standard with a visually presented comparison and only one task involved matching an auditory standard with an auditory comparison, raises the possibility that it was not intra- and intersenory matching which was examined but visual-visual intrasensory matching and auditory-visual, visual-auditory intersensory matching. Therefore, intra- and intersensory auditory-visual equivalence was also examined by a 3x3x2 repeated measures ANOVA using the following factors: level of mental retardation, CA, and modality - within (AT-AT, VS-VS) and cross (AT-VS, VS-AT). In all age groups and across the three levels of mental retardation, subjects were more accurate on intrasensory than on intersensory tasks, $F(1,15)=23.38$, $p<.0002$.

To determine whether intersensory matching was influenced by the direction of presentation, i.e., auditory or visual pattern first, a 3x3x2 repeated measures ANOVA was performed using the following factors: level of mental retardation, CA, and direction (auditory first, visual first). Intersensory matching was not affected by whether the first pattern presented was auditory or visual, and no main effect of direction was found. No effects of level of mental retardation, or CA were found, and there were no interactions between either of the subject factors and direction of presentation.

Discussion

Botuck & Turkewitz (1984) have suggested that one of the ways that mentally retarded individuals differ from intellectually average children is in their difficulties in equating auditory-visual stimuli; with the emphasis on the intersensory aspect of the difficulty rather than the transposition aspect. This was because teenage subjects in that study (1984) were just as accurate when matching intrasensory tasks requiring transposition as they were matching intrasensory tasks not requiring transposition, whereas intersensory matching was considerably poorer when transposition was required.

Botuck, Turkewitz & Moreau (1986), using a more comprehensive experimental procedure, were unable to replicate this effect in 12 - 13 year old mentally retarded children, finding more errors in both intra and intersensory auditory-visual matching when transposition was required. The discrepancy between the results of the two studies appeared to be the result of either increased matching accuracy by the 14-18 year old subjects in the first study or more accurate data due to the more complete experimental design of later study.

It is possible that the age range in this study (12-20 years), was insufficient to detect any developmental changes in accuracy due to increase in chronological age or to chronological age - level of mental retardation interactions. However, the fact that the present data did not reflect effects of chronological age on the accuracy of matching makes it unlikely that the discrepant findings in the two previous studies were due to the age differences of the subjects. It seems, instead, that the inclusion in the later study of the two intrasensory nontransposition tasks, visual spatial - visual spatial and visual temporal - visual temporal, resulted in the discrepant findings.

The results of the present study are in agreement with those previously obtained (Botuck & Turkewitz, 1984; Botuck, Turkewitz & Moreau, 1986) concerning auditory-visual equivalence in mentally retarded adolescents and young adults, indicating more accurate matching on intrasensory than on intersensory tasks. They further indicate that, for such individuals, transposition requirements pose added difficulties so that performance on both intra- and intersensory matching tasks drops when transposition is required. It appears that, for many mentally retarded individuals transposition is an additional demand in the processing of both intra- and intersensory information. While one could argue that for many mentally retarded individuals equivalence within the auditory and within the visual systems is not fully intact, the results of this study indicate that the concomitant deficits in intersensory equivalence, especially intersensory transposition equivalence, would not be expected from the scores on the intrasensory tasks. There is the possibility, that the intrasensory tasks which are predominantly visual, have resulted in inflated intrasensory matching scores. However, the fact that an amended definition of intrasensory (AT-AT, VS-VS) and of intersensory (AT-VS, VS-AT) yielded the same results, i.e., more accurate performance on intrasensory than on intersensory matching, increases the liklihood that deficiencies in auditory-visual equivalence have their roots in intersensory transpositional processing and not intrasensory equivalence, or transposition equivalence.

The fact that whether an auditory or a visual stimulus pattern was presented first did not affect the accuracy of matching may be due in part to the pervasive difficulties which the subjects experienced in intersensory matching. Even so, the finding was somewhat surprising, because presenting a visual pattern first seems to enhance accuracy in young children of average intellect. (This will be discussed in more detail below.)

The findings of the present study suggest certain deficiencies in auditory-visual integration in mentally retarded individuals. However, the data show that performance was not affected by level of mental retardation. The failure to find a relationship between levels of mental retardation and deficiencies in auditory-visual equivalence is in agreement with an earlier study (Botuck, Turkewitz & Moreau, 1986) which failed to find evidence of a correlation between IQ score and performance on auditory-visual equivalence matching in mentally retarded 12 and 13 year olds. The importance of auditory-visual integration for complex human behavior has been detailed in the introduction. The fact that level of mental retardation (IQ), is unrelated to auditory-visual intersensory performance suggests that IQ itself is not a useful measure of this aspect of adaptive behavior.

While the present findings help to elucidate a pattern of auditory-visual equivalence matching in mentally retarded pre-adolescents and adolescents, it is also necessary to understand how their pattern of equivalence matching compares with children of average intellect, specifically mental and chronological age peers. A comparison between mentally retarded individuals and those of average intellect on tasks of auditory-visual equivalence is not an attempt to compare the two groups on the quantitative aspects of performance such as rate of responding, time to learn discrimination etc. Rather, by delineating the developmental course of auditory-visual equivalence in children of average intellect, differences and similarities in patterns of responding can be defined.

Most empirical studies of intersensory integration in children have examined visual-haptic matching and not auditory-visual matching (Jones, 1981). Studies of auditory-visual matching, the majority of which were undertaken in the 1960's, were the result of a search for explanations of reading disability. By presenting "good" and "poor" readers (usually children between the ages of 5 to 11 years) with auditory-visual equivalence matching tasks, correlations between reading ability and auditory-visual integration were revealed. Evaluation of the utility of this approach for understanding reading disability is well beyond the scope of this project; for an excellent review of the these studies see Freides (1974). Jones (1981) is less thorough but includes some more recent studies on visual-haptic equivalence. The most relevant of these studies and their result were enumerated in the introduction, and the most potent criticisms were detailed there.

To review, the criticisms of these studies are: (1) Difficulties in auditory-visual matching may be the result of equating information that has been transposed from a spatial to a temporal mode (Blank & Bridger, 1966). (2) Difficulties in intersensory matching could be the result of intrasensory deficiencies (Bryant, 1968; Freides, 1974). It was also noted that the differences in experimental design and procedure, i.e. stimulus pattern presentation - type, duration. etc., make comparative interpretations of the studies (especially studies from different laboratories) tentative.

The findings concerning symmetry in the direction of auditory-visual transfer are conflicting (Freides, 1974; Jones, 1981; Mann, 1974) and to a large extent can be attributed to differences in design and procedure. For example, as Freides (1974) points out, Birch & Belmont's studies (1964, 1965a, 1965b) seem to assume symmetry, i.e., all standard patterns were auditory temporal and all comparison patterns were visual spatial. However, Muehl & Kremenak (1966) report that subjects were more accurate when the standard was visual spatial. Rudel & Teuber (1971) maintained that visual spatial was superior to auditory temporal when the comparison was auditory temporal, but auditory temporal was superior when the comarison was visual temporal.

Botuck, Turkewitz & Moreau (1986) examined auditory-visual equivalence in 13 year olds of average intellect and found no difference in accuracy between intra and intersensory matching. However, intrasensory matching involving transposition proved to be more difficult than intrasensory matching not involving transposition, while intersensory matching was more accurate when transposition was involved. This finding was different from that reported by Blank & Bridger (1964) and was interpreted as indicating a change in the role that transposition might play during development.

Study 2

The purpose of the second dissertation study was: to provide CA and MA comparisons for interpreting the findings regarding mentally retarded individuals, to replicate Botuck Turkewitz & Moreau's findings concerning transposition, and to examine the influence of direction of transfer on intersensory tasks, i.e. whether the presentation of an auditory or visual pattern first facilitated or interfered with intersensory matching.

Method

Subjects. The subjects were 72 children and adolescents of average intellect, 30 males and 42 females, who were pupils in racially integrated Catholic schools located in a working class New York City neighborhood. The names of pupils with school grade averages between B- and B+, with no recorded behavior problems and no recorded physical or sensory limitations were given to the investigator. Subjects were chosen at random within each age and sex category from this list of names.

There were three age groups, with 24 subjects (10 males, 14 females) in each group. The ages of the three groups were: (1) 7 years, CA ranged from 6 years 9 months to 7 years 9 months, M = 7.0 years, sd = 4 months, (2) 13 years, CA ranged from 12 years 6 months to 13 years 5 months, M = 13.0 years, sd = 5 months, (3) 17 years, CA ranged from 16 years 7 months to 17 years 6 months, M = 17.1 years, sd = 6 months.

Design. The design of Study 2 was identical to that of Study 1.

Apparatus and Stimuli. The equipment for stimulus pattern generation and the stimuli were identical to those in Study 1. However, the intertrial interval, the amount of time the subject needed to answer, was shorter (approximately 40 seconds) than in Study 1, as was the intertask interval which was approximately 30 seconds. The children of average intellect were "ready to continue" faster than the mentally retarded children.

Procedure. The procedure used with the seven-year-olds was the same as was used for the mentally retarded subjects in the first study. Of the 25 subjects originally considered, one seven-year-old subject did not pass the pretest and was eliminated from the experimental sample.

For the 13- and 17-year olds, the procedure was as follows: Each subject entered the test room, a quiet empty classroom. The subject had been told that he/she would be participating in a study involving a home computer. The subject sat down facing the keyboard and computer screen. The investigator sat about .3 meters to the right of the subject. The subject was told that the study involved matching patterns, that the investigator would not be giving any instructions and that feedback would be postponed until the end of the testing. Each subject was familiarized with the equipment before being tested. Using a different stimulus pattern then any appearing during the actual testing, the investigator showed the subject what each of the three stimulus patterns looked (sounded) like.

After testing, each student was told that he/she did a good job and was asked if the matching became easier as he/she went along and if any task was particularly easy or difficult.

As was the case in the first study, the subjects were told to say whether the standard and the comparison pattern were the same or different, and I accepted "yes" and "match" for "same" and "different." The subjects were told that some of the tasks might be difficult and that it was "OK to guess".

Subjects were tested in a single session which lasted about 15 minutes for the 17-year-olds, 20-25 minutes for the 13-year-olds, and 25-35 minutes for the seven-year-olds.

Scoring

Scoring was identical to Study 1. Only seven-years-old subjects ever used the "all same", "all different" response pattern.

Results

To examine the effect of the two different orders of task presentation on the accuracy scores an ANOVA was performed. No differences were found between the scores of the two orders of task presentation. Therefore, order of task presentation was ignored for all subsequent analyses.

The overall performance of the sample is summarized in Table 5. As may be seen from these data, the development of intra- and intersensory equivalence matching is reflected by improvement in the accuracy of matching with age. As may be seen in Table 5, the performance of the 17-year-olds was uniformly high with means on all tasks of five or more correct responses out of a possible six. In

Table 5

Mean number of Correct Responses on Intra- and Intersensory Matchings for Subjects of Average Intellect (n=72)

Matching Task	7 yrs (n=24)		S´s With a Score of Six	13 yrs (n=24)		S´s with a Score of Six	17 yrs (n=24)		S´s With a Score of Six
	M	SD		M	SD		M	SD	
Intrasensory									
AT-AT	3.6	1.41	1	5.1	1.42	14	5.3	1.49	18
VS-VS	5.2	1.02	13	5.8	0.53	20	5.5	1.25	18
VT-VT	1.8	1.80	0	4.6	1.32	8	5.0	1.14	9
VT-VS	2.6	1.64	0	4.6	1.53	8	5.2	1.15	14
VS-VT	2.8	2.16	2	5.1	1.59	15	5.2	1.71	16
Intersensory									
AT-VT	2.3	2.01	2	4.1	1.79	8	5.6	0.93	18
VT-AT	2.6	1.67	0	5.0	1.00	8	5.6	0.82	19
AT-VS	3.0	1.83	1	5.4	0.93	16	5.7	0.86	20
VS-AT	4.1	1.80	6	5.8	0.66	21	5.7	0.87	19

view of the liklihood that a ceiling effect was operating in this group and producing an artificial restriction in variability, the results from this age group were eliminated from further analyses.

As was the case for the analyses of the data from the mentally retarded subjects, the data for this study were also analysed without the correction for guessing. The results of these analyses which are presented in Appendix B, were identical to those obtained with the correction.

A 2x2x2 repeated measures analysis of variance was performed with the following factors: chronological age - seven and thirteen, task - intra- and intersensory; and transposition - nontransposition.

The 13-year-olds were more accurate than the 7-year-olds on both intra- and intersensory tasks resulting in a statistically significant main effect for CA, $F(1,46)=51.93$, $p<.001$. There was also a statistically significant effect of transposition, $F(1,46)=4.22$, $p<.05$. For both age groups accuracy was greatest on intersensory tasks involving transposition, followed by intrasensory tasks not involving transposition, resulting in a statistically significant interaction between task and transposition, $F(1,46)=30.44$, $p<.0001$.

T-tests between the two age groups revealed statistically significant differences on all nine tasks as well as in all four conditions (see Table 6). To determine whether the predominance of visual-visual intrasensory

Table 6

Mean Number of Correct Responses on Intra- and Intersensory Tasks Involving and Not involving Transposition for 7 and 13 Year Olds (n=48)

CA	Intra- Trans Mean	SD	Inter- Trans Mean	SD	Intra- No Trans Mean	SD	Inter- No Trans Mean	SD
7 yrs (n=24)	2.7	1.66	3.6	1.57	3.5	1.06	2.5	1.53
13 yrs. (n=24)	4.8	1.11	5.6	0.53	5.1	0.77	4.6	1.22

Note: T(46)> or = 5.21 for all four conditions; p<0.0001 matching affected performance, a 2x2 analysis of variance was performed with the factors CA and modality - within (AT-AT, VS-VS) and cross (AT-VS, VS-AT). There was a statistically significant effect of CA, $F(1,46)=35.70$, $p<.0001$; the 13-year-olds were more accurate than the 7-year-olds on both within and cross modality matching. Once again, there was no effect of whether the matching was intra- or intersensory, but there was a statistically significant interaction between age and whether the task was within or cross modality, $F(1,46)=6.40$, $p<.01$. As can be seen in Table 7, the 13-year-olds were equally accurate on intra- and intersensory matching and the 7-year-olds made more errors on intersensory matching.

To explicate these interactions, the performance of each of the two age groups was analyzed separately using a 2x2 repeated measures analysis of variance with task and transposition as the factors.

The 7-year-old subjects made many errors, but showed no differences in accuracy between intra- and intersensory matching, and no differences in accuracy between tasks requiring and not requiring transposition. However, there was a highly significant task by transposition interaction, $F(1,23)=17.75$, $p<.0003$. As can be seen in Table 6, the 7-year-olds were more accurate on intrasensory tasks when they did not involve transposition, but more accurate on intersensory tasks when the tasks involved transposition. To determine whether eliminating visual temporal patterns

Table 7

Mean Number of Correct Responses on Intra- and Intersensory Tasks When Visual Temporal Tasks Were Eliminated

	Matching Task					
	Within		Cross		Total	
CA	M	SD	M	SD	M	SD
7 Years (n=24)	4.5	1.05	3.6	1.21	4.1	1.10
13 Years (n=24)	5.4	0.71	5.6	0.53	5.5	0.62
	4.9	0.88	4.6	0.87	4.8	0.86

affected the findings of no difference between intrasensory and intersensory matching, an analyis of variance using modality - within and cross was performed. When visual temporal patterns were eliminated from both intra- and intersensory matching, the 7-year-olds made more errors and were less accurate on intersensory tasks than on intrasensory ones, $F(1,23)=9.25$, $p<.01$ (See Table 7).

This was not the case for the 13-year-olds who were equally accurate on both intra- and intersensory tasks whether or not visual temporal matching was required. There was also no effect of task when a 2x2 repeated measures analysis of variance was performed with the factors task and transpossition. There was however, a statistically significant effect of transposition, $F(1,23)=4.32$, $p<.05$, and a significant interaction between task and transposition, $F(1,23)=17.64$, $p<.0003$. As may be seen in Table 6, greater accuracy on the intersensory transposition and the intrasensory nontransposition tasks resulted in their being significantly different from the intrasensory transposition and intersensory nontransposition tasks (see Table 8).

To determine whether intersensory matching was facilitated or interfered with by the presentation of a sound or a visual pattern first, a 2x2 repeated measures analysis of variance was performed using the following factors: CA - seven and thirteen; and direction - auditory first, visual first. As may be seen in Table 9, when

Table 8

Statistically Significant t-values for Comparisons Between Intra- and Intersensory Tasks Involving and Not Involving Transposition for 13 Year Olds

Task	Mean	SD	N	T Value	df	p
Intra-Trans	4.8	1.11				
			24	3.37	23	0.01
Inter-Trans	5.6	0.53				
Inter-Trans	5.6	0.53				
			24	4.55	23	0.001
Inter-No Trans	4.6	1.22				
Intra-No Trans	5.1	0.77				
			24	2.58	23	0.02
Inter-No Trans	4.6	1.22				

Table 9

Accuracy Scores of 7 and 13 Year Olds on Intersensory Tasks Where Either Auditory or Visual Patterns Were Presented First (n=48)

	Auditory		Visual	
CA	Mean	SD	Mean	SD
7 yrs (n=24)	2.8	1.61	3.4	1.42
13 yrs (n=24)	4.7	0.94	5.4	0.65
	3.7	1.27	4.4	1.03

judging the equivalence of intersensory patterns, both age groups were more accurate when visual patterns were presented first, resulting in a main effect of direction, $F(1,46)=16.49$, $p<.0002$. However, the older subjects made more correct matches, resulting in a main effect of CA, $F(1,46)=46.14$, $p<.0001$.

Discussion

As was expected, the findings of this study affirm increased accuracy in performance with increased age. This was true for intra- and intersensory matching whether or not transposition was required. Unfortunately, the necessary elimination of the 17-year-olds from the analyses due to a ceiling effect limits any discussion of improvements in auditory-visual equivalence after the age of 13. However, the fact that the accuracy continued to increase after age 13 indicates that future examination is warranted.

The intellectually average subjects showed no differences in accuracy between intra- and intersensory tasks. Both the seven- and 13-year-olds were more accurate on intersensory transposition matching than on intersensory nontransposition matching. However, accuracy on intersensory transposition matching and intrasensory nontransposition matching was equivalent. Thus, it appears that the capacity for correct judgements of auditory-visual intersensory transposition exists by age seven, and continues to improve with age. This is different from

Blank & Bridger's hypothesis (1966) that difficulties in auditory-visual matching may be due to difficulties in transposition from a visual-spatial to an auditory-temporal mode (or vice versa). While this may be true for nursery school children (Blank & Bridger, 1964), the seven-year-olds in the present study demonstrated equivalent performance on both intra- and intersensory tasks. Since 29 of the 64 subjects in Blank & Bridger's study were between five- and six-years old, the findings of the present study could be taken as discrepant with those of Blank & Bridger. In that case, the differences between the two studies could be attributed to more difficult task demands in the Blank & Bridger study. Another possibility might be a change in the role of transposition in auditory-visual processing at this age. Botuck, Turkewitz & Moreau suggested such a change in the role of transposition during development. They suggest that at earlier stages of development transposition may pose a problem in both intra- and intersensory matching but at later stages transposition appears to facilitate intersensory matching.

Although intrasensory information is generally encountered without transposition, e.g., hearing - auditory temporal information, seeing - visual spatial information (and, less frequently, visual-temporal), the aquisition of intersensory information equivalence, at least in the auditory and visual modalities, does require transposition, e.g. reading involves the establishment of equivalence between auditory temporal and visual spatial stimuli. It seems possible that in order to deal effectively with the changing demands involved in such tasks as learning to read, children begin to process intersensory information in a manner that is different from how they process intrasensory information or how they processed intersensory information at earlier stages of development. This difference may be the result of demands created by the need for continual intersensory transposition.

Both the seven- and 13-year-olds in the present study made more errors on visual temporal-visual temporal matching than on auditory temporal-auditory temporal matching. A similar finding was reported by Klapper & Birch (1971), who found that children between the ages of 5 and 9 made more errors matching visual temporal patterns than auditory ones, whereas 11 year olds showed no such difference. The somewhat similar findings in both studies suggest greater developmental improvements in the accuracy of visual temporal matching than auditory temporal and visual spatial matching.

The results of this study are in agreement with those of our prior study concerning 12 to 13-year-olds of average intellect. Although there were no discrepancies in the findings, the accuracy scores in this study were always higher. This may be the result of the improved presentation of the matching tasks as well as the decrease in the number of trials per task. (There were six trials in the present study compared to 10 trials in the previous study.) The present study took less time, (35-45 minutes in the earlier study vs. 20-35 minutes in the present study) which may have resulted in the subjects being more attentive to the tasks, hence, more accurate in their performance than the subjects in the previous study.

The data regarding the influence of direction on intersensory transfer indicated increased accuracy in performance when the standard pattern was visually presented. Both the seven- and the 13-year-olds made fewer errors on intersensory matching when the first pattern presented was visual rather than auditory, whether or not the standard pattern was visual-temporal or visual-spatial. This finding illuminates one possible source of confusion in interpreting the results of the studies on auditory-visual equivalence: influence of the direction of intersensory transfer. The results from this study indicate that presenting a visually pattern first facilitates matching, whereas presenting an auditory pattern first tends to increase errors in matching.

Comparison

In order to examine similarities and differences in the performance of the mentally retarded subjects and subjects of a comparable mental age, the mentally retarded subjects were compared with the intellectually average seven-year-olds. The results of the analyses detailed below without the correction for guessing appear in Appendix C. As may be seen from these tables the results are highly similar although the analyses with the correction yielded two statistically significant interactions which were only at the .07 and .06 level when the uncorrected data were used.

A 2x2x2 repeated measures analysis of variance with the factors of group, task, and transposition was used. There were many similarities between the two groups of subjects in equating auditory-visual information (see Table 10), and as a result there was no effect of group, i.e. the mentally retarded subjects and the seven-year-old children did not differ with regard to overall performance. However, there were statistically significant interactions between group and transposition, $F(1,46)=7.56$, $p<.009$; task and transposition, $F(1,46)=18.37$, $p<.0001$; and group, task and transposition, $F(46)=4.14$, $p<.05$. (see Figure 1) The mentally retarded subjects were significantly more accurate on tasks not requiring transposition, whether the tasks were intra- or intersensory. Although the mentally retarded subjects were more accurate on intrasensory than on intersensory tasks, it is worth noting that as a result of their poor performance on intersensory matching tasks involving transposition, their intersensory scores were depressed as compared to the 7 year olds). The seven-year-old subjects were more accurate on intrasensory

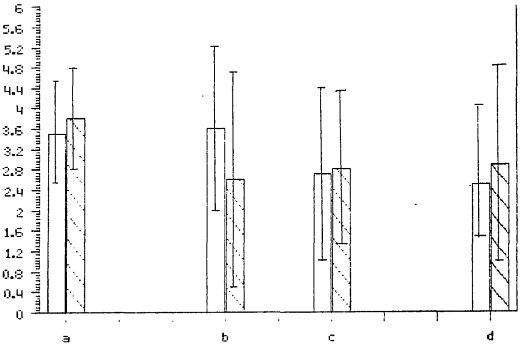
Table 10

Accuracy Scores on Matching Tasks by Mentally Retarded Subjects and 7 Year Old Subjects (n=48)

Matching	7 Year Olds(n=24)				Mentally Retarded (n=24)			
Task	M	SD	S´s With Score Zero	S´s With Score Six	M	SD	S´s With Score Zero	S´s With Score Six
AT-AT	3.6	1.41	0	1	3.9	1.75	2	5
VS-VS	5.2	1.02	0	13	5.0	1.23	0	11
VT-VT	1.8	1.80	9	0	2.4	1.91	5	2
VT-VS	2.6	1.64	3	0	3.0	1.85	4	2
VS-VT	2.8	2.16	4	2	2.9	2.07	5	1
AT-VT	2.3	2.01	6	2	2.9	2.07	5	3
VT-AT	2.6	1.67	3	0	2.9	1.91	4	3
AT-VS	3.0	1.83	3	1	2.5	2.02	7	1
VS-AT	4.1	1.80	2	6	2.8	2.30	7	2

Figure 1

Differences on intra- and intersensory tasks involving and not involving transposition between mentally retarded and 7-year-ild subjects.



a = Intra-
No Trans

b = Inter-
Trans

c = Intra-
Trans

d = Inter-
No Trans

= seven-year olds

= mentally retarded

tasks when they did not involve transposition, but were more accurate on intersensory tasks when the tasks involved transposition.

Intra- and intersensory performance was also examined without the visual temporal tasks using a 2x2 repeated measures analysis of variance with the factors: group and modality - within and cross. As was the case in the analyses described above, no main effect of group was evidenced. There was a main effect of modality, $F(1,46)=28.80$, $p<.0001$, with both groups making more errors on intersensory matching than on intrasensory matching. However, there was a statistically significant interaction between group and modality, $F(1,46)=3.96$, $p<.05$. While both groups of subjects were more accurate on intrasensory matching, the mentally retarded subjects made many more intersensory errors than did the seven year olds.

To determine whether the differences in accuracy between the two groups of subjects were statistically significant, T-tests were performed between the scores of both groups of subjects on intra and intersensory tasks involving and not involving transposition, as well as as on each of the nine tasks (see Figure 1). The only statistically significant difference in accuracy between the two groups was on the visual spatial - auditory temporal task, $t(46)=2.15$, $p<.02$. There were no differences between the two groups on intersensory tasks not involving transposition, intrasensory tasks not involving transposition and intrasensory tasks involving transpositon. Thus, the only area where the mentally retarded subjects' performance differed from the intellectually average seven year olds' was intersensory transposition.

These results, together with the results from previous studies (Botuck & Turkewitz, 1984; Botuck, Turkewitz & Moreau, 19869 suggest different patterns of processing intersensory information for mentally retarded individuals than for individuals of average intellect. This is evidenced by the depressed performance (more errors) of the mentally retarded children, adolescents and young adults when matching auditory-visual patterns, particularly those requiring transposition. In contrast, the seven-year-olds,who were equivalent to the mentally retarded subjects with regard to mental age, demonstrated equal proficiency with intrasensory nontransposition tasks and with intersensory transposition tasks; and were more accurate on intersensory transposition tasks than on intrasensory nontransposition tasks.

The fact that both the intellectually average seven-year-olds and the mentally retarded pre-adolescents and adolescents have the same or similar scores on intrasensory tasks and on intersensory nontransposition tasks is additional evidence in support of the view first expressed by Birch & Belmont (1964, 1965a) that the difficulty in equating intersensory information found in brain damaged individuals is due to an integrative deficit, and not an intrasensory deficit (Bryant, 1968; Freides, 1974). Even though both the mentally retarded subjects and the seven-year-old subjects scored lower on intrasensory tasks than the 13- and the 17-year-olds, the subsequent drop in intersensory accuracy by the mentally retarded subjects cannot be explained by deficiencies in either the auditory or visual modalities. This supports Botuck, Turkewitz, & Moreau (1986) in positing that poor performance on auditory-visual matching tasks cannot be accounted for soley by intrasensory deficits in either or both of the sense systems.

Finally, the present data give additional support to the position that mentally retarded individuals process auditory-visual information by a different process than do their nondisabled peers. The results of this study challenge the approach to mental retardation which views those diagnosed mentally retarded as individuals whose development is fixed at a level which is comparable to a child of average intellect.

Appendix A
ANOVA MR with Correction for Guessing
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	590.352	1	590.352	72.22**
Ment	37.423	2	18.711	2.29
CA	1.216	2	0.608	0.07
CAxMent	11.084	4	2.771	0.34
Error	122.609	15	8.174	----
Trans	8.467	1	8.467	10.93**
TransxMent	1.602	2	0.801	1.03
TransxCA	2.953	2	1.477	1.91
TxMentxCA	3.450	4	0.862	1.11
Error	11.620	15	0.775	----
Task	12.101	1	12.101	8.21**
TaskxMent	8.076	2	4.038	2.74
TaskxCA	0.128	2	0.640	0.04
TxMentxCA	8.496	4	2.124	1.44
Error	22.115	15	1.474	----
TransxTask	0.346	1	0.346	0.40
TxSxMent	1.395	2	0.697	0.80
TxSxCA	0.284	2	0.142	0.16
TxSxMentxCA	7.595	4	1.899	2.19
Error	22.115	15	0.867	----

Modality (M)

Source	SS	DF	MS	F
Subjects	404.265	1	404.265	113.54**
Ment	16.912	2	8.456	2.38
CA	4.302	2	2.154	0.61
MentxCA	13.090	4	3.560	0.92
Error	53.406	15	3.560	----
Modality	47.918	1	47.918	23.38**
MXMent	0.937	2	0.468	0.72
MXCA	0.986	2	0.492	0.24
MxMentxCA	14.017	4	3.504	1.71
Error	30.739	15	2.050	----

Direction (D)

Source	SS	DF	MS	F
Subjects	216.704	1	216.704	31.05**
Ment	34.766	2	17.383	2.49
CA	0.640	2	0.320	0.05
CAxMent	13.171	5	3.293	0.47
Error	104.692	15	6.979	----
Direction	0.004	1	0.004	0.01
DxMent	2.445	2	1.224	2.52
DxCA	0.528	2	0.264	0.54
DxMentxCA	2.912	4	0.728	1.50
Error	7.275	15	0.485	----fp

ANOVA MR without Correction for Guessing
Transposition (T) - Task (S)

Subjects	876.995	1	876.995	308.04**
Ment	13.435	2	6.718	2.36
CA	10.600	2	5.299	1.90
CAxMent	3.536	4	0.884	0.31
Error	42.702	15	2.846	----
Trans	3.045	1	3.045	9.57**
TransxMent	3.102	2	1.550	4.87*
TransxCA	6.997	2	3.498	11.00**
TxMentxCA	4.570	4	1.142	3.59*
Error	4.772	15	0.318	----
Task	2.582	1	2.582	3.34
TaskxMent	3.242	2	1.620	2.10
TaskxCA	3.219	2	1.609	2.08
TxMentxCA	7.296	4	1.824	2.36
Error	11.115	15	0.772	----
TransxTask	2.860	1	2.860	5.69*
TxSxMent	0.367	2	0.183	0.36
TxSxCA	0.617	2	0.309	0.61
TxSxMentxCA	4.265	4	1.066	2.12
Error	7.542	15	0.867	----
Modality (M)				
Subjects	561.794	1	561.794	339.88**
Ment	9.268	2	4.634	2.80
CA	10.228	2	5.114	3.61
MentxCA	5.164	4	1.291	0.78
Error	24.792	15	1.653	----
Modality	15.490	1	15.490	21.66**
MXMent	3.520	2	1.760	2.46
MXCA	8.195	2	4.097	5.73**
MxMentxCA	8.401	4	2.100	2.94
Error	10.725	15	0.715	----
Direction (D)				
Subjects	392.182	1	392.182	159.69**
Ment	14.786	2	7.393	3.01
CA	12.629	2	6.315	2.57
CAxMent	7.570	4	1.892	0.77
Error	36.837	15	2.546	----
Direction	0.011	1	0.011	0.02
DxMent	1.793	2	0.897	1.96
DxCA	1.280	2	0.640	1.40
DxMentxCA	0.804	4	0.201	0.44
Error	6.871	15	0.458	----

Appendix B1
ANOVA 7 & 13 year olds
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	3553.520	1	3553.520	1610.94**
CA	104.037	1	104.037	47.16**
Error	101.470	46	2.206	----
Trans	2.521	1	2.521	4.38*
TransxCA	0.836	1	0.836	1.45
Error	26.505	46	0.576	----
Task	0.000	1	0.000	0.00
TaskxCA	0.391	1	0.391	0.67
Error	26.886	46	0.584	----
TransxTask	21.333	1	21.333	35.34**
TxSxCA	0.009	1	0.009	0.02
Error	27.768	46	0.604	----
Modality (M)				
Subjects	2170.753	1	2170.753	1389.79**
CA	56.273	1	56.273	36.03**
Error	71.849	46	1.562	----
Modality	2.503	1	2.503	4.09*
MxCA	5.753	1	5.753	9.41**
Error	28.120	46	0.611	----
Direction (D)				
Subjects	1576.260	1	1576.260	653.22**
CA	102.094	1	102.094	44.14**
Error	114.146	46	2.481	----
Direction	11.344	1	11.344	16.49**
DxCA	0.010	1	0.010	0.02
Error	31.646	46	0.688	----

Appendix B2
ANOVA 13-year-olds
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	2436.807	1	2436.807	1466.38**
Error	38.221	23	1.662	----
Trans	3.130	1	3.130	4.32*
Error	16.648	23	0.724	----
Task	0.196	1	0.196	0.34
Error	13.165	23	0.572	----
TransxTask	11.116	1	11.116	17.64**
Error	14.495	23	0.630	----
Modality (M)				
Subjects	1463.020	1	1463.020	1458.62**
Error	9.729	23	0.423	----
Modality	0.333	1	0.333	0.91
Error	8.417	23	0.366	----
Direction (D)				
Subjects	1240.333	1	1240.333	1156.53**
Error	24.667	23	1.072	----
Direction	5.333	1	5.333	7.83**
Error	15.667	23	0.691	----

Appendix B3
ANOVA 7-year-olds with Correction for Guessing
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	902.418	1	902.418	163.22**
Error	127.165	23	5.529	----
Trans	0.612	1	0.612	0.75
Error	18.804	23	0.818	----
Task	0.196	1	0.196	0.18
Error	24.804	23	1.078	----
TransxTask	22.362	1	22.362	17.75**
Error	28.971	23	1.260	----
Modality (M)				
Subjects	764.005	1	764.005	282.87**
Error	62.120	23	2.701	----
Modality	7.921	1	7.921	9.25**
Error	19.703	23	0.695	----
Direction (D)				
Subjects	438.021	1	438.021	112.59**
Error	89.479	23	3.890	----
Direction	6.020	1	6.020	8.67**
Error	15.979	23	0.695	----

Appendix B3
ANOVA 7-year-olds without Correction for Guessing
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	1220.751	1	1220.751	443.92**
Error	63.249	23	2.749	----
Trans	0.227	1	0.227	0.53
Error	9.856	23	0.428	----
Task	0.196	1	0.196	0.33
Error	13.721	23	0.597	----
TransxTask	10.227	1	10.227	17.72**
Error	13.273	23	0.577	----

Modality (M)

Subjects	825.021	1	825.215	389.41**
Error	48.729	23	2.119	----
Modality	3.000	1	3.000	6.42*
Error	10.750	23	0.467	----

Direction (D)

Subjects	595.021	1	595.021	289.77**
Error	89.479	23	3.890	----Direction
2.520 1	2.520	8.62**		
Error	6.730	23	0.293	----

Appendix C1
ANOVA 7-year-olds and MR with Correction for Guessing
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	1781.406	1	1781.406	267.82**
Group	0.765	1	0.765	0.01
Error	305.968	46	6.651	----
Trans	2.049	1	2.049	2.40
TxGroup	6.441	1	6.441	7.56**
Error	39.211	46	0.852	----
Task	4.636	1	4.636	3.55
SxGroup	2.333	1	2.333	1.78
Error	60.149	46	1.306	----
TransxTask	20.563	1	20.563	18.37**
TxSxGroup	4.636	1	4.636	4.14*
Error	51.503	46	51.503	----
Modality (M)				
Subjects	1357.510	1	1357.510	419.24**
Group	5.052	1	5.042	1.56
Error	148.948	46	3.238	----
Modality	40.042	1	40.042	28.80**
MxGroup	5.510	1	5.510	3.96*
Error	63.947	46	1.390	----
Direction (D)				
Subjects	802.148	1	802.148	153.04**
Group	1.628	1	1.628	0.31
Error	241.099	46	5.241	----
Direction	4.815	1	4.815	7.66**
DxGroup	1.628	1	1.628	2.59
Error	28.932	46	0.629	----

Appendix C2
ANOVA 7-year-olds and MR without Correction for Guessing
Transposition (T) - Task (S)

Source	SS	DF	MS	F
Subjects	2446.259	1	2446.259	895.13**
Group	0.002	1	0.002	0.00
Error	125.711	46	2.732	----
Trans	0.729	1	0.729	1.62
TxGroup	2.445	1	2.445	5.00*
Error	22.485	46	0.489	----
Task	1.389	1	1.289	1.65
SxGroup	0.306	1	0.306	0.36
Error	38.693	46	0.841	----
TransxTask	9.780	1	9.780	18.18**
TxSxGroup	1.947	1	1.947	3.620
Error	24.745	46	0.538	----
Modality (M)				
Subjects	1580.315	1	1580.315	783.28**
Group	0.753	1	0.753	0.37
Error	92.807	46	2.018	----
Modality	16.252	1	16.252	21.91**
MxGroup	2.503	1	2.503	3.37
Error	34.120	46	0.742	----
Direction (D)				
Subjects	1165.523	1	1165.523	479.88**
Group	0.128	1	1.128	0.05
Error	111.724	46	2.429	----
Direction	1.628	1	1.628	4.59*
DxGroup	0.940	1	0.940	2.65
Error	16.307	46	0.355	----

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