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LA THÈSE A ÉTÉ  
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Sensory Integration In Moderate  
And Mildly Retarded Adults

by Joseph Molino

Thesis presented to the School of  
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J. Molino, Ottawa, Canada, 1982

## ABSTRACT

The relationship between sensory integration and intellectual level of functioning was examined in the present study. The integration of information within (intra-modal) and across (inter-modal) the auditory, visual, and tactual sensory modalities was investigated for moderate and mildly retarded adults.

All subjects were required to demonstrate criterion performance on all intra-modal tasks, prior to the presentation of cross-modal tasks. Intra-modal tasks consisted of the presentation of a tactual-tactual matching task, a visual-visual matching task, and an auditory-auditory matching task. The order of presentation for the above intra-modal matching tasks was determined randomly for all subjects.

The results for the intra-modal tasks showed that moderately retarded subjects experienced considerably greater difficulty with the tactual-tactual matching task, than their mildly retarded counterparts. On all remaining intra-modal matching tasks, the moderately retarded groups performed as well as the mildly retarded groups.

For the inter-modal presentations, an incomplete counterbalancing design was used to vary the presentations of the three cross-modal tasks (auditory-visual; auditory-tactual; visual-tactual) such that each subject was randomly assigned to one of three training orders.

Inter-modal comparisons were thus obtained through a series of analyses. The results of these analyses suggest that the mildly

retarded subjects consistently performed superior to their moderately retarded counterparts, on all tasks. These results also show that the effects of intellectual level of functioning are not the same across the three tasks used, with the visual-tactual (V-T) task being the easiest initial task to master for both groups of subjects, while the auditory-tactual (A-T) was the most difficult for these groups.

An examination of the separate sensory modalities suggests that all subjects experienced severe difficulty with the processing of tactual information. This difficulty appeared considerably greater within the moderately retarded subjects, and appeared to stem from poor tactual discrimination or inputting rather than poor memory.

The examination of sensory integration in terms of cross-modal transfer effects also shows that the mildly retarded subjects consistently performed superior to their moderately retarded counterparts. These superior transfer of training effects would appear in part due to better developed verbal skills by the mildly retarded subjects. This was shown in the data, wherein the use of verbal labels greatly enhanced the transfer of information across tasks; i.e., information encoded verbally was recalled better, and resulted in superior transfer, than information encoded tactually or visually. These results were discussed in terms of theories by Brown (1974) and Jarman (1979), as well as the Developmental Lag Theory as outlined by Clarke and Clarke (1975).

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## CHAPTER I

### INTRODUCTION AND REVIEW OF THE LITERATURE

The present study was carried out to examine sensory integration abilities of moderate and mildly retarded adults. Sensory integration as defined by Ayres (1974) refers to the central process of the brain, wherein information received via one or more senses, is filtered, then organized and synthesized so that it becomes useful for the development and execution of the brain's function. This liason between the senses provides man with a unified perspective of the external world. The term intrasensory or within-modal integration is used to refer to the synthesis of information when stimuli are received in one modality. Thus, an individual might be presented with information in one sensory modality, and expected to relate this to other information presented in the same modality (e.g., matching a picture of a dog to the written word DOG). When information is received via different sensory modalities, the synthesis of this information is refered to as intersensory or cross-modal integration. In studying intersensory integration, the subject would receive information via one sensory modality (e.g., via touch - feeling a spoon); he/she would then be expected to relate this to information presented in one or more other modalities (e.g., the visual picture of a spoon, or the spoken word "SPOON").

Drader (1973) lists five techniques used to study sensory integration. These techniques include the method of equivalence, conditioning procedures, cross-modal learning and transfer, reaction time methods, and conditional learning. One's operational definition

of sensory integration, then would depend upon the type of test or technique used. Using a cross-modal learning and transfer approach, sensory integration might be defined by the ability of the participant to match information across sensory modalities, as described above. Of specific interest however, is the individual's ability to transfer information received from training, in establishing untrained liasons across modalities. This ability to transfer information received in one modality, to the solution of a problem requiring the use of another sensory modality, is termed cross-modal transfer. Cross-modal learning and transfer has been used as a measure of sensory integration in several studies (e.g., Birch and Lefford, 1963; Blank, Altman and Bridger, 1968; Blank and Bridger, 1966; O'Connor and Hermelin, 1961; Smith and Tunick, 1969). The degree or magnitude of this transfer has been found to be dependent upon the phylogenetic level, the type of task, and in humans to the developmental level of functioning (Smith and Tunick, 1969).

#### The Importance of Sensory Integration

Perceptually, several models can be examined in defining strategic approaches to the analysis of information. Sherrington's (1951) overview of the evolution of nervous system organization provides one such strategy for analysis. He suggests that although one would expect the course of evolution to have provided man with more varied sense organs, for sharper perception of the world, this has not happened. Instead, the nervous system has developed in such a way as to bring

the five major senses into closer touch with one another. Thus, instead of new senses, a better liason between the old senses, is what the developing nervous system has produced.

The above findings of comparative neurophysiology are not without support from comparative psychology. Birch and Lefford (1966) point out that as one ascends from fish to man in the vertebrate series, the unimodal sensory control of behavior comes to be superseded by multimodal or intersensory control mechanisms. Birch and Lefford (1966) cite the example of a study done by Abbot (1882) wherein a frog was incapable of modifying a visually determined response on the basis of information obtained through pain sensation. In Abbot's study, the frog continued to strike at a live fly imbedded on a post surrounded by spikes. Even though its tongue was being ripped to shreds with every outthrust of its tongue, the frog continued its pursuit of the fly. In this study, no integration of information appeared to be occurring between the visually determined response, and the tactual pain stimulus.

Birch and Lefford (1966) discuss their own extension of the above study by Abbot. They found that they could inhibit the frog's visually determined response to the fly, by coating the fly with a bitter substance (Quinine). It would appear therefore, that the frog is capable of integrating information presented gustatorily, but not tactually in inhibiting a visually determined response. In contrast, a normal adult human would appear capable of integrating information derived from all sense modalities.


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Theories of intellectual and cognitive development (Hebb, 1949; Hunt, 1961; Piaget, 1963) have also stressed the importance of sensory integration. Piaget (1963), for example, argues that cognitive development has its basis in the formation of new and higher order intersensory co-ordinations of sensory-motor processes. He defines intelligence in terms of an individual's ability to cope by continuous organization and re-organization of experience. Thus, the principle of adaptation is central to his theory of cognitive development. Adaptation refers to a process of adjustment. It consists of two simultaneous and complementary processes - assimilation and accommodation. By assimilation, Piaget refers to the process of incorporating new information by perceptually modifying its structure so that it fits into a preconceived notion which the individual possesses, of objects or the world. Accommodation, on the other hand, refers to the modification of these preconceived ideas to fit the new information. This dual process of assimilation - accommodation enables the child to form the basic units of cognitive development, which Piaget calls schema or schemata (pl.). The term schema is used to refer to a simple mental image or pattern of action. It is a form of mental organization of sensory information which a person uses to interpret and understand his environment. Thus, intersensory co-ordinations are fundamental to the individual's development of cognitive structures.

In addition to the above theoretical emphasis of sensory integration as it relates to cognitive development, Sabatino (1968) has stressed the importance of the integration of perceptual information

in learning. Sabatino (1968) suggests that information or stimulation begins as a sensory input. It is then coded neurally and transmitted as perceptual information. Sabatino sees the integration of this perceptual information (from more than one source), and the memory storage holding this information as fundamental to learning. Following the integration and categorization of the perceptual information, this information is relayed to higher cortical centers where language is formed into symbolic conceptual units. These concepts provide the basis for the formation of additional language symbols. In the model proposed by Sabatino, it is imperative that the higher cortical centers receive, associate, and mediate the symbolic units in a systematic manner. Failure to do this because of a breakdown in any one of the processes can result in inaccurate processing of the information received. Sabatino's model is of importance to the study of sensory integration because it suggests that a breakdown in the integration of sensory information would result in the transmission of inaccurate information to the higher centers, thus effecting the formation of constructive symbolic units. Thus, in Sabatino's model, as in the theories of intellectual development, intersensory integration appears to be at the basis of higher cognitive functioning.


In the study of normal child development, it would appear that changes in the relations among the sensory modalities, similar to those discussed above (Sherrington 1951), are characteristic features of child development (Zarophetes, 1965). That is, in infants and in very young children, stimulation applied to the skin surface



appears to be far more predominant in directing behavior, than information presented visually or auditorily. As the child matures developmentally, audition and vision become the most important sensory modalities for directing behavior (Birch and Lefford, 1966). By school age (six to seven years old), the child's experiences have equipped him with well developed skills in integrating information within and between the auditory and visual modalities (Muehl and Kremenak, 1966). Thus, once the hierarchical shift from the viscera to the teloreceptive modalities has become established, an increased intersensory liason appears to become developed. With these changes, the child comes to be dominated less by any single stimulus, and more by the inter-relations among stimuli reaching him through different sense modalities.

#### Sensory Integration and Mental Retardation

The intermodality association discussed above, appears to be a process of particular academic importance, and one known to be frequently affected in individuals with developmental and neurological or learning disorders (Belmont, Birch and Karp, 1965; Brown, 1974; Davidson, Pine, Wiles-Kettermann and Appelle, 1980; Jones and Robinson, 1973; O'Connor and Hermelin, 1978). Birch and Lefford (1963) suggest that a breakdown in intersensory integration, or a failure to establish such integration across sensory modalities, is fundamental to mental retardation. This disability, they argue, manifests itself as a deficit in the integration of information presented cross-modally (i.e., recognizing identical or analagous stimuli presented via different



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sensory modalities). Birch and Lefford (1963) however, looked at sensory integration in normal children; and from this sample, they generalized their results to developmentally retarded populations. They argue from their results that cross-modal transfer develops with age and experience in humans, and has little to do with intelligence or "mental age". Their study however, fails to explore this hypothesis, and one can only assume from their conclusions that mildly, moderately and severely retarded persons of the same chronological age would perform equally well on a sensory integration task. Birch and Lefford (1966) elaborate on the above hypothesis. In this latter study, they compare the performance of normal children with that of neurologically impaired ("brain-damaged") children. In this study, the "brain-damaged" groups are composed of children with "retarded speech development", several groups of unspecified mentally retarded children, a group of epileptic children, and a group of cerebral-palsied children. Unfortunately, so little information is given regarding the nature and severity of the "damage" in the brain damaged groups, that all comparisons between groups, and subsequent conclusions must remain suggestive rather than definitive. The results of these studies shed very little insight on the effects of developmental retardation across levels of functioning. That is, if sensory integration is developmentally linked in normal children, then this should be reflected as one goes across levels of retardation, linking sensory integration abilities to mental ages or IQ levels, rather than to chronological age.

Jones and Robinson (1973) attempted to compare the performances

of normal and mentally retarded children on sensory integration tasks. In the Jones and Robinson study, the retarded subjects differed significantly from their normal counterparts on intersensory (cross-modal) integration tasks. Their results are discussed in terms of the developmental model; that is, intersensory relations are more complex and later developed capacities in normal children, whereas intrasensory capacities are less complex and earlier developed. Thus, for the mentally retarded subjects, Jones and Robinson suggest that intersensory motor pathways have either not been laid down, or have suffered damage. Since the average mental age for the retarded children in Jones and Robinson's study was 5 years 5 months, the results would appear to be consistent with the normal developmental trend, which shows developmental shifts in the integration of information by age 6 to 7 years. Even the mental age matched group on normal children in the above study, experienced difficulty with cross-modal matching conditions when the stimulus presentation conditions were successive. It would appear from this study, that the mental age or developmental readiness of the individual is more pertinent than the question of "retardation" vs "normality" or "chronological age".

The above view regarding developmental readiness is supported by the Developmental Lag Theory, as proposed and outlined by Clarke and Clarke (1975) and by Zigler (1967; 1969). This theory suggests that the cognitive development of mentally retarded persons appears to be characterized by a slower progression through the same sequence of cognitive stages as the non-retarded or "normal" person. It is

argued also that the "retarded" development is further characterized by lower limits to full development. Clarke and Clarke (1975) suggest that the comparison of normal and subnormal development is analogous to that of normal and very superior. Thus, Zigler (1967) argues that many of the reported differences in the performances on normal and mentally retarded subjects, matched for M.A., can be attributed to such variables as motivation and experience, rather than to basic cognitive deficiencies.

Although developmental readiness appears to determine the individual's ability to integrate information within and between sensory modalities, several factors appear to influence this integration process in the developmentally retarded. Studies by Zeaman and House (1963) and Zeaman (1973) in comparing persons of various levels of retardation, have suggested that lower level retarded persons take longer to learn discrimination tasks. They suggest that these discrimination deficits in the retarded subjects occur as a function of attentional deficits. Zeaman and House (1963) emphasize that the difference between high and low level groups lies in how many trials they take before they start to show improvement (increases in correct responding). Thus, rather than show a slow and gradual acquisition of a discrimination, the lower level (severely retarded) group appears to show no increases in correct responding for several trials, and then suddenly shows large increases in correct responding. This latter increase is then at the same rate as normals. Thus, the learning process of the subnormal individual follows all the normal stages,

but considerably more slowly. Zeaman and House (1963) conclude that retarded persons take longer periods of time to learn, because their attention is not focused on the relevant cues; but that once they attend to a relevant cue, they can learn as fast as normal individuals. Lovaas, Koegel and Schreibman (1979) interpreted the above findings differently. Based on their own research with retarded and autistic children, they suggest that the reason retarded individuals take so long to attend to a relevant cue is that they are sampling (responding to) fewer cues at a time, as compared to normal subjects. Thus, they are reducing the probability of including a relevant cue in any sample, while learners of higher functioning levels have a higher probability of attending to relevant cues.

Zeaman and House (1979) in a revision of their earlier attention theory discussed above, modified their selective "one-look" characteristic to allow for "multiple-looking". Their revisions appear to support the Lovaas, Koegel and Schreibman (1979) interpretation, suggesting that higher functioning mentally retarded subjects demonstrate both a broader range of attention, sampling more dimensions per trial, and a more efficient capacity to direct this attention to the relevant cues, than their lower mental age (M.A.) group.

In addition to the attentional component discussed above, a second factor which appears to influence sensory integration in the mentally retarded, is verbal mediation. O'Connor and Hermelin (1963) review evidence that suggests that the retarded individual can carry out tasks very efficiently where verbal coding is present. This factor

of verbal coding or mediation is relevant to levels of retardation in that verbal skills become less and less developed as one examines progressively lower levels of retardation. Thus, just as vision and audition become more prominent developmentally (re: sensory integration) as the normal child approaches school age; similarly, the shift from visceral to auditory and visual integration appears to influence the intersensory skills as one progresses from lower to higher levels of intellectual functioning (i.e. levels of retardation).

Sensory Integration: Cross-Modal Learning  
and Subsequent Transfer of Training

Theorists such as Piaget (1963) and Werner (1957) have stressed the developmental importance of children's ability to establish an internalized model of the information available in the external world. By nature, the study of this internal representation of information, does not lend itself to objective measurement (Reese, 1970). Nevertheless, the paradigm of cross-modal learning followed by subsequent transfer appears to be one fruitful approach to this examination of representational skills in cognitive development (Rose, Blank and Bridger, 1972).

In the study of transfer, the subject is usually provided with some form of initial training in a task or problem for which he/she must make certain responses to a set of experimental stimuli. Following this training, the subject is required to perform a second

task, which may or may not resemble the first task in either or both the type of response demanded, and the stimuli used. Transfer therefore, would be measured by the differences in the rates of learning of the two tasks (Hermelin and O'Connor, 1964). A review of the literature suggests that the term "cross-modal transfer" has been used to describe at least three different experimental situations (O'Connor and Hermelin, 1971). These include: (a) cross-modal matching. In this procedure, the subject is asked to explore or attend to a sample stimulus through one sensory modality (e.g. auditory), and then subsequently to select a corresponding stimulus from among several choice stimuli presented in a different modality (e.g. vision). Studies by Sidman (Constantine and Sidman, 1975; Sidman, 1971; Sidman and Cresson, 1973; Sidman, Cresson, and Willson-Morris, 1974), Pace (1970), and Spradlin (Spradlin and Dixon, 1976; Gast, VanBiervliet, and Spradlin, 1979), have all utilized the above cross-modal matching procedure to study transfer effects across sensory modalities. (b) A second procedure often used to study transfer, is cross-modal discrimination. In the cross-modal discrimination procedure, two or more stimuli are presented and discriminated in one sensory modality, and immediately afterwards re-presented and discriminated in a second modality. Transfer in this latter procedure is measured in terms of the effects of one discrimination task upon the other. Tasks utilizing this transfer procedure can be found in studies by Hermelin and O'Connor (1961; 1964) and O'Connor and Hermelin (1961). A third procedure or experimental situation involves the transfer of a principle. In this situation,

a discrimination based on a dimension or cue in one sensory modality is transferred to a second modality using the same dimension or cue, but in relation to different discriminative stimuli. O'Connor and Helmeln (1971) for example, trained groups of blind, normal, sub-normal, and deaf children to discriminate between touch stimuli (pressure to the palm of the hand) lasting 6 seconds or 2 seconds. They trained the children to emit appropriate motor responses to the long and short stimulus durations. Following mastery of the matching task, all subjects were given transfer tasks wherein two signals of the above durations, but different from the original stimuli were used. The three transfer stimuli used were: (i) pressure to the palm delivered by a softer instrument, (ii) air-puffs to the palm, and (iii) either sounds or lights (for the blind and deaf subjects respectively). Thus, the above study attempted to examine the transfer of a dimensional discrimination or principle across sets of stimuli and sensory modalities.

It must be noted however, that the examination of sensory integration skills should not be made on the basis of cross-modal learning alone -i.e. without comparison with relevant within-modal learning (Bryant, 1968; Milner and Bryant, 1970). Studies by Bryant (1968) and Milner and Bryant (1970) suggest that apparent developmental changes (increases) in cross-modal performances can be attributed to improved within modal discriminations rather than altered inter-sensory relations. The study of sensory integration in the mentally retarded must therefore incorporate levels of retardation in order to more fully explore the developmental link. It must also incorporate

both intra and inter-modal comparisons for a more thorough investigation of the developmental changes within each level of integration.

Numerous studies have been carried out using within modal and cross-modal learning tasks to examine transfer and sensory integration abilities of normal, learning disabled, and mentally retarded subjects (e.g. Davidson, Pine, Wiles-Kettenmann, and Appelle, 1980; Jones and Robinson, 1973; O'Connor and Hermelin, 1971; 1974; Sidman, 1971; Zung, 1971). The results of these studies will be discussed in terms of (a) within vs cross-modal learning, (b) specific modality comparisons, and (c) the role of labelling and verbal mediation in the coding or integration of sensory information.

#### (a) Within vs Cross-Modal Learning

In within-modal learning tasks, an individual attempts to match two stimuli presented to him in the same sensory modality, this differs from cross-modal learning, where the subject must match two stimuli, each of which is presented in a different sense modality. Proponents of the developmental view suggest that increases in cross-modal communications occur with age (e.g. Birch and Lefford, 1963; Davidson, Pine, Wiles-Kettenmann and Appelle, 1980; Rose, Blank and Bridger, 1972). These studies point out that the young normal child is largely dominated by the perception or sensation of single stimuli. The single stimuli domination undergoes a major change during the third, fourth and fifth years of life, when a great deal of inter-sensory organization begins to develop (Abravanel, 1968). The fastest rate of improvement appears to occur between the third and seventh year

(McGhie, 1969), reaching full development by 11 years (Birch and Lefford, 1963; 1966).

The above studies have been criticized, however, for failing to provide an adequate experimental control for intramodal changes also occurring with age (Bryant, 1968). A study by Milner and Bryant (1970), using children ages 5 to 7 years illustrates this problem. In their study, Milner and Bryant (1970) examined the developmental trend with respect to changes in intra and inter-modal matching. In this study, the authors found that the older children made fewer recognition errors (intra-modal matching) than the younger children. They also found that visual-visual matching was superior to that of all other matching conditions. Of particular importance, however, is their finding that the children showed no significant improvement with age in cross-modal as opposed to within modal matching. From these results, the authors conclude that developmental increases in the accuracy of cross-modal performance are attributable to improved intra-modal discriminations rather than to altered inter-sensory relations. There appears to be some confounding, however, in Milner and Bryant's (1970) study. That is, since all subjects performed the visual-visual matching as required, and since all cross-modal tasks involved the tactual matching (e.g. visual-tactual and tactual-visual matching), it would appear that the breakdown lay in the tactual discrimination rather than the cross-modal component of the task. This was supported by the poor performance of all subjects on the tactual-tactual within modal matching task in the study. The

above criticism would appear to be further supported by Jones and Robinson's (1973) data with their mentally retarded subject sample. Jones and Robinson's subjects performed equally poor on tactual-tactual matching as opposed to cross-modal tactual-visual matching. The approximate mental ages of the subjects was 5 years 10 months. Furthermore, the data for the normal subjects in the Jones and Robinson (1973) study provides no support for Milner and Bryant's (1970) hypothesis regarding intramodal discriminations controlling intermodal integration. The Age x Modality interaction for the normal subjects suggests that there may also have been developmental gains in intersensory integration (unrelated to intramodal discriminations). In both of the above studies, however, it remains unclear what the role of intra-modal learning is. To have fortified their position, the above authors should have trained intramodal discriminations, and then tested for cross-modal carry-over (if any). This would have allowed the authors to have attributed the experienced difficulty to inter or intra sensory relations rather than to particular task complexity.

In studying cross-modal integration in the mentally retarded, it would therefore appear imperative that one control for poor within-modal discrimination abilities. Such control allows the examiner to focus on the intersensory integration process without confounding as a result of poor modality discriminations. This control might best be achieved by training intra-modal discriminations and matching to criterion, prior to testing for cross-modal matching and transfer.

This procedure would differ from those procedures used in the above studies in that all intramodal tasks would be presented and mastered before cross-modal matching was attempted. This procedure would also differ from the controls used by Milner and Bryant (1970) in that all subjects would be trained to criterion on all intramodal tasks, and in this way, any inability to carry out cross-modal tasks could not be attributable to the complexity of the particular stimuli being used.

Bryant's (1968) criticism, therefore appears to remain valid; we cannot argue from errors in cross-modal learning directly to inter-sensory breakdown without comparisons with relevant within-modal learning tasks. This proposed progression would be consistent with the developmental model in that cross-modal communication appears to develop only after within-modal abilities are well developed. Based on these similarities between Bryant's (1968) model, and the developmental model, one would expect that the matching abilities of mentally retarded persons would follow the above trend, showing faster acquisition of within as opposed to cross-modal matchings, particularly in individuals of lower mental ages, who would be expected to experience particular difficulty with cross-modal learning tasks. This hypothesis has been confirmed in some studies (Birch and Belmont, 1964; Jones and Robinson, 1973; O'Connor and Hermelin, 1971; Smith and Tunick, 1969; Spradlin, Cotter and Baxley, 1973; Zung, 1971). In these studies, the mentally retarded participants were either unable to perform the cross-modal matching task, or if specifically

trained to perform a task, failed to transfer this information to related tasks (e.g. Dixon and Spradlin, 1976; Spradlin, Cotter and Baxley, 1973).

The above inability to perform cross-modal integration of information is not supported in other studies using similar subjects and tasks (e.g. Sidman, 1971; Sidman and Cresson, 1973; Conroy, 1978). Although not reported in the studies, the mental ages of the subjects may have been an important variable contributing to this difference in the reported results. A second variable appearing to influence the test results, is the specific sensory modality or modalities involved in the cross-modal and within-modal integration (matching) tasks. Differences in within and cross-modal integration might therefore stem from poor coding and retention of information by one or both of the sensory modalities. This latter variable is discussed below.

(b) Specific Modality Comparisons

(i) Tactual Information

Studies using normal and/or mentally retarded subjects suggest that in both groups, the integration and utilization of information presented tactually is much poorer than information presented non-tactually (Abravanel, 1973; Bryant and Raz, 1975; Davidson, Cambardella, Stenerson and Carney, 1974; Davidson, Pine, Wiles-Kettenmann and Appelle, 1980; Jones and Robinson, 1973; Pick, Pick and Thomas, 1966; Rose, Blank and Bridger, 1972; Zung, 1971). These studies disagree, however, on the reason for this inferior integration of tactual information. Three of the major interpretations regarding the nature or origin of this deficit are that it stems from (i) poor discrimination of

tactual information (Bryant and Raz, 1975; Smith and Tunick, 1969; Zung, 1971); (ii) poor tactual inputting (Jones and Robinson, 1973); and (iii) unstable tactual memory (Goodnow, 1971; Rose, Blank and Bridger, 1972; Davidson, Cambardella, Stenerson, and Carney, 1974).

Zung (1971) tested 20 institutionalized mentally retarded individuals (mean CA = 17 years 4 months; mean MA = 8 years 2 months) on a series of visual and tactual matching tasks. The subjects were required to find the form which was "the same as" or "exactly like" a standard. The standard and the four choice stimuli were presented simultaneously either visually or tactually, intra-modally and inter-modally. The results of this study indicate that the mentally retarded sample experienced exceptional difficulty with the tactual discrimination task used. In spite of this difficulty, though, all subjects were able to carry out the cross-modal matching tasks to criterion. These results provide little support for Hermelin and O'Connor's (1961) data, which suggested that mentally retarded subjects do not experience any greater difficulty in tactual-tactual matching as opposed to visual-visual or visual-tactual matching; and that the mentally retarded group was in fact significantly better than the normal group in matching through touch alone. Zung's (1971) results were later supported by Jones and Robinson (1973), who found that both their mentally retarded and non-retarded subject samples experienced considerably more difficulty with tactual as opposed to visual matching tasks.

Jones and Robinson (1973) interpreted this within-modal difficulty

as poor tactual inputting across all groups within their study. They argue however, that developmental increases in cross-modal matching involve more than increasingly finer discriminations in the tactual mode. They suggest that intersensory integration depends largely on neuroanatomical linkages between the various sensory areas, via the motor cortex; and that it is this cross-modal link, as well as the within-modal discriminations which increase developmentally. The processing and retention of tactual information, as well as the role of the tactual modality in intersensory integration has been examined further in other studies (e.g. Bryant and Raz, 1975; Davidson, Cambardella, Stenerson and Carney, 1974; Davidson, Pine, Wiles-Kettenmann and Appelle, 1980; Rose, Blank and Bridger, 1972).

Rose, Blank and Bridger (1972) tested three year old children on cross-modal and intra-modal matching of shape and textures. Three "time" conditions of presentation were used in the study. These included: (a) simultaneous presentation of shape and choice stimuli; (b) successive presentation, wherein the array of choice stimuli followed the sample stimulus immediately after the sample was removed; and (c) a 15 second time delay between presentations of the sample stimulus and the corresponding array of choice stimuli. Four modal conditions were also employed; two intra-modal conditions (visual-visual, and tactual-tactual matching), and two inter or cross-modal conditions (visual-tactual, and tactual-visual matching). Each subject received a series of 15 problems (either 15 form or 15 texture problems) in one of the four possible modality matching conditions. The 15

problems were divided such that five problems were assigned to each of the three delay or time conditions. The results of the study indicate that when no memory demands whatsoever are made (simultaneous matching), performance was equally good in all four modality conditions. The imposition of a delay, however, resulted in a marked deterioration of performance in all conditions involving a tactual component. The authors conclude from these results that poor cross-modal learning in children may be due primarily to difficulties in storing tactual information. The authors also argue that children's tactual perception is as good as their visual perception.

One of the major criticisms of the above study however, would be the encountering of a ceiling effect. The children in the study made no errors whatsoever in any of the simultaneous tactual-tactual and visual-tactual discriminations. It can be argued therefore, that these discriminations were far too easy to show any differences between the tactual and visual sense modalities. Rose, Blank and Bridger (1972) used three dimensional geometric shapes, and various grades of sand paper, felt and fur as stimuli. A more difficult discrimination task, perhaps one composed of nonsense designs might better detect differences between touch and vision. Jones and Robinson (1973) showed this with their successive condition.

Bryant and Raz (1975) attempted to explore the difference between visual and tactual perception of shape in young children (mean chronological age of 4 years). Using the same modality matching conditions as Rose, Blank and Bridger (1972), Bryant and Raz (1975).

employed nonsense shapes. In addition to the four modality matching conditions, a second variable introduced in the task was "type" of discrimination. Two types of discriminations were required by all subjects: (a) dissimilar, in which one of the two choice stimuli had straight edges, the other with curved edges; and (b) similar, in which both choice stimuli had either straight or curved edges. Five of the ten trial presentations for each modality matching condition, involved one type of discrimination, while the other five trial presentations employed the other type of discrimination. The results of the study suggest that with both types of discrimination, all children made more errors in the three conditions involving tactual information (tactual-tactual, visual-tactual and tactual-visual matching) than in the non-tactual, purely visual condition (visual-visual matching). The results, however, failed to show the predicted difference between similar and dissimilar discriminations. The authors conclude that young children do find it more difficult to discriminate many shapes by touch than by vision, and that this difficulty is one of discrimination at the sensory level, rather than a retention difficulty associated with poor tactual coding of information. One criticism of this study is that tactual discriminations were particularly hampered in that the subjects could only use one hand to manipulate a stimulus (e.g., the right hand might be used to feel the sample stimulus, while the left hand alternately felt the two choice stimuli in a tactual-tactual matching task). Based on hypotheses and findings by Hebb (1949) and Jones (1972), it can be argued that tactual perception,

and subsequent sensory integration is greatly hampered by restricting voluntary movement exploration. Jones (1972) has shown that such restriction of voluntary exploration affects not only tactual discriminations, but also visual recognition of shapes. This might account for the results reported by Bryant and Raz (1975).

Davidson, Cambardella, Stenerson and Carney (1974) allowed their subjects to manipulate the tactual stimuli with both hands. In all cases, the subject was required to hold the object down with the non-preferred hand while exploring the object with the dominant hand. Their subjects were children whose ages were 8 years and 11 years. Their stimuli were nonsense designs, and their modality matching conditions were identical to those described in the Bryant and Raz (1975) study (i.e., visual-visual, tactual-tactual, visual-tactual, and tactual-visual matching). The mode of presentation, however, was very different from that described by Bryant and Raz (1975). Davidson, Cambardella, Stenerson and Carney (1974) presented the sample stimulus for four seconds. The matching tasks were thus of a delayed-matching type. Furthermore, Davidson, Cambardella, Stenerson and Carney (1974) varied the number of choice stimuli available for comparison. For each modality group (across ages) five subjects matched a sample stimulus to a comparison array of one stimulus (i.e., a same/or different task); five children matched a sample stimulus to a comparison array of three stimuli; and five children matched a sample stimulus to an array of five choice stimuli. The results of this study suggest that under increasing memory demands

(i.e., delays), matching within and across visual and tactual modalities improves gradually with age. The results also show significantly larger decrements in performance, with increasing memory demands of tasks involving a tactual component. These results would appear to support those reported by Rose, Blank and Bridger (1972). Thus, Davidson; Cambardella, Stenerson and Carney (1974) conclude that the lack of a significant difference between intra and cross-modal tactual matching lends support to Rose, Blank and Bridger's (1972) previous arguments that matching deficits in children stem from poor retention of tactual information, rather than from poor discrimination as suggested by Bryant and Raz (1975), or from poor intersensory integration and tactual inputting suggested by Birch and Lefford (1963) and Jones and Robinson (1973).

#### (ii) Visual Information

Studies utilizing visual information in comparison with tactual information, in most cases report superior visual intra-modal matching performance, regardless of the ages of the children and handicapped adults used (Bryant and Raz, 1975; Davidson, Cambardella, Stenerson and Carney, 1974; Davidson, Pine, Wiles-Kettenmann, and Appelle, 1980; Rose, Blank and Bridger, 1972). This superior integration of purely visual information has been discussed in terms of several different hypotheses. Posner (1967) for example, has suggested that visual memory may have access to a central processing capacity, which does not appear to be available to kinesthetic memory.

Blank, Altman and Bridger (1968) and later Davidson, Cambardella,

Stenerson and Carney (1974) discussed the performance of their subjects on intra-modal visual tasks in terms of the over-learned properties of the visual modality. This overlearned characteristic has been argued on the premise that developmentally, the first symbolic functions develop on the basis of visual imagery (Piaget, 1965). The child or adult therefore, has had more practice in the representation and integration of visual information as compared to non-visual (e.g. ~~tactual~~) information. The greater number of errors reported across studies, in the visual-tactual matching conditions, relative to those errors in the visual-visual conditions (e.g., in Bryant and Raz, 1975; Davidson, Cambardella, Stenerson and Carney, 1974; Davidson, Pine, Wiles-Kettenmann and Appelle, 1980; Jones and Robinson, 1973; Rose, Blank and Bridger, 1972; Zung, 1971), however, appear to suggest that the image formed from the visual sample may be sketchy or incomplete to form a match, when this information must be coupled with that from a different sensory modality (tactual). Thus, the image or information extracted from a visual sample may only be sufficient for a match when the choice information is in the same or original modality.

Goodnow (1971) has proposed an alternate hypothesis to that of imagery discussed above. Goodnow (1971) suggests that the retention of the original visual information may be weakened by the need to switch one's attention from the visual stimulus properties, to the task of transforming this information from one sensory modality to another. This hypothesis, however, has never been verified or supported,

and would appear to require further research.

A similar explanation to that of Goodnow (1971) has been proposed by Blank, Altman and Bridger (1968) to explain the greater difficulty experienced in cross-modal matching tasks as opposed to purely visual tasks. Blank, Altman and Bridger (1968) suggest that the visual modality is prepotent so that its stimulus impact tends to suppress the influence of any information gained in other modalities.

(iii) Auditory Information

Whereas visual matching requires that an individual orders and relates graphic or visual patterns spatially, auditory matching usually requires that the subject order and relate sound patterns organized on a temporal basis (Muelh and Kremenack, 1966). In their study, Muelh and Kremenack (1966) found auditory-auditory matching considerably more difficult than either visual-visual matching or auditory-visual and visual-auditory cross-modal matching. The subjects' task in the study was to determine whether two sets of auditory stimuli were the same or different. The auditory sounds used corresponded to "dots" and "dashes". The authors discuss their results in terms of the subjects' ability or inability to supply verbal labels to material presented auditorily, visually and cross-modally. One explanation for the poor auditory-auditory matching performance may be that the unfamiliar auditory sounds may have produced "interference" within the auditory modality, resulting in the subjects' reduced capability to generate verbal labels. One criticism of the Muelh and Kremenack (1966) study is that the auditory-auditory task was

not a "matching" task, but rather a discrimination task, and in this way quite different from the remaining tasks. Perhaps this characteristic of the auditory-verbal modality, where "matching" by nature involves pairing a verbal label with an auditory stimulus, is the feature which should have received further attention in Muelh and Kremenack's (1966) study. Thus, to properly study auditory matching, the authors should have either presented auditory sounds and required the subjects to actively match other auditory sounds to these, or have required the subjects to match auditory sounds with spoken labels.

Intra-modal auditory matching has thus received very little attention in the sensory integration literature. Much of the emphasis has been placed on the auditory-visual matching, particularly as this relates to reading in normal and developmentally retarded children and adults (Constantine and Sidman, 1975; Kahn and Birch, 1968; Sidman, 1971; Sidman and Cresson, 1973). It is argued that reading can be broken down in terms of auditory-visual integration competence, and that a breakdown in this cross-modal matching ability results in marked reading disabilities (Birch and Belmont, 1964; Muelh and Kremenack, 1966). Considerable emphasis has also been placed on the role of the auditory modality in providing or training the subject to generate and use verbal labels in sensory integration tasks. This dimension of the auditory modality and its role in labelling and verbal mediation will be discussed further in the following section of this paper.

(c) The Role of Verbal Labelling and Verbal Mediation

O'Connor and Hermelin (1963) use the term "coding" to refer to the translation of information from one sensory modality to another. In their earlier work (Hermelin and O'Connor, 1961; O'Connor and Hermelin, 1961; O'Connor and Hermelin, 1963), they suggested that this verbal component served as the nucleus of cross-modal integration. That is, in that cross-modal transfer is believed to develop with age (Birch and Lefford, 1963), O'Connor and Hermelin (1963) suggested that verbal mediation, which develops concurrently, is the necessary component for coding to occur. O'Connor and Hermelin (1963) seem to have based much of their view on the earlier work of Luria (1961) in which verbal mediation was seen as facilitating coding. They also review evidence (Hermelin and O'Connor, 1961) suggesting that mentally retarded persons perform very well in cross-modal learning tasks, when verbal coding is built into the task; and that when such coding is absent, performance deteriorates significantly.

In their study, Hermelin and O'Connor (1961) compared normal and developmentally retarded children in visual and tactual cross-modal and within-modal matching of 10 Russian or Greek letters. In this study, subjects were presented with five test stimuli in succession. Following the presentation of the test stimuli, the subjects received recognition trials during which the five test stimuli, and five new stimuli were randomly presented. The task was to say whether or not each stimulus had been part of the original series. The results of this study showed that the normal subjects were superior to the

mentally retarded group in visual recognition, and in both cross-modal matching conditions. Nevertheless, the retarded subjects were significantly better in matching by touch alone. These results support their initial hypothesis that verbal labels (coding) facilitate cross-modal learning and transfer in the retarded. That is, Hermelin and O'Connor (1961) argue that once the opportunity to use verbal labels is removed (as in the above study), cross-modal matching performance deteriorates, becoming very poor compared to the performance of normal subjects matched for mental age (MA).

In a similar study, O'Connor and Hermelin (1961), presented a group of mentally retarded subjects with simple line drawings of common objects. The subjects were required to recognize stimuli presented earlier. The results of the study suggest that when the subjects had to provide verbal labels for the pictures, recognition was facilitated as compared to recognition of earlier pictures or words alone. This study appeared to strengthen the authors' position that verbal labels enhance coding, and subsequently facilitate cross-modal integration and learning. Later, however, Hermelin and O'Connor (1964) rejected this hypothesis.

In this later study by Hermelin and O'Connor (1964), the subjects differed in their verbal abilities, but not in their ability to transfer information from vision to touch and visa versa. This latter study, however, was examining visual-tactual matching across levels of verbal abilities in subjects; whereas the earlier work (O'Connor and Hermelin, 1961; Hermelin and O'Connor, 1961) examined-

auditory-visual as well as visual-visual and auditory-spoken matching. Thus, because of the variation in the sensory tasks used, it would appear difficult to reject the hypothesis regarding the role of verbal labelling, based solely on the data from Hermelin and O'Connor's (1964) study. The (1964) study by Hermelin and O'Connor also fails to control for the effects of intra-modal learning.

O'Connor and Hermelin (1971) extended their earlier studies. In this study, they taught groups of blind, non-retarded, mentally retarded, and deaf children to discriminate between tactual stimuli (pressure to the palm of the hand) lasting either six seconds or two seconds. Following mastery of this discrimination, all subjects were presented with a transfer task either within-modally (i.e., a different tactual task - e.g., air puffs to the palm of the hand) or cross-modally (light or sound of the above durations). The results of the study concur with those of Hermelin and O'Connor (1964). That is, although most subjects could verbalize the solution to the initial task, they could not transfer this information to other modalities. Furthermore, the absence of speech appeared to cause no special problems, since the deaf performed as well as, and better than other groups on the transfer tasks. These results are also consistent with those of Bryant (1967) wherein verbal labelling appeared to affect initial learning, but not subsequent transfer. Bryant (1967) concluded that verbal labelling improves recall in subnormal children, but not recognition; whereas it seems to improve both recall and recognition in normal children.

The above results regarding the role of verbal coding are not supported in a study by Conroy (1978). In this study, Conroy examined the role of verbal and kinesthetic rehearsal on serial recall and modality transfer tasks. His subjects consisted of retarded children (CA= 122 months; IQ= 70.6) and adolescents (CA= 163 months; IQ= 68.8). In the study, an equal number of children and adolescents were randomly assigned to one of three treatment conditions: (a) verbal rehearsal, wherein subjects were prompted to verbally label the stimuli as they were presented; (b) kinesthetic rehearsal, where the subjects were prompted to trace with their finger the visual designs presented; (c) no rehearsal, this latter group being the control group. All subjects received each of three training tasks in a counterbalanced order. The training tasks consisted of (i) easily labelled pictures of common household objects; (ii) easily traced pictures of nonsense figures; and (iii) easily labelled and easily traced pictures of common geometric shapes. This latter task was used as the transfer test. Thus, seven visual stimuli were successively presented for brief inspection (2.5 seconds) on all trials, then laid down, face down. Following the seventh stimulus, the experimenter presented the sample or probe stimulus, and the subject was required to point to the card with "this picture on the front". The results of Conroy's (1978) study suggest that the re-coding of visually presented information in a second sensory modality system (i.e., cross-modal integration) strengthens visual recall. That is, both the recall of information, and the transfer of learned information

to a new task were superior for the groups recoding information as opposed to the control group which received only visual information. This study, however, fails to provide evidence or data regarding recoding and cross-modal transfer, since all tasks, including the "transfer" task were visual.

It would appear therefore, that verbal labelling affects initial learning, and improves recall on intra-modal matching tasks. There is some question however, as to the effects of verbal labelling on recognition and subsequent transfer, both intra-modally and inter-modally. Sidman and his colleagues (Sidman, 1971; Sidman and Cresson, 1973; Sidman, Cresson and Wilson-Morris, 1974) have examined this role of verbal labelling, on the establishment of cross-modal integration (auditory-visual equivalences), and cross-modal transfer, with moderately and severely retarded subjects.

In the cross-modal tasks used by Sidman (1971), he argues that the aim of matching is to establish a cross-modal equivalence such that each class member of one modality (e.g., a visual class member) becomes equivalent to, and thus leads to the selection of a corresponding class member from a second sensory modality (e.g., a corresponding auditory class member). It is this equivalence which Jones and Robinson (1973) refer to as "inter-sensory liason". In his study, Sidman (1971) has broken down a sighted reading task into auditory-visual equivalences (Figure 1 contains a schematic summary of Sidman's experiment). A 17 year

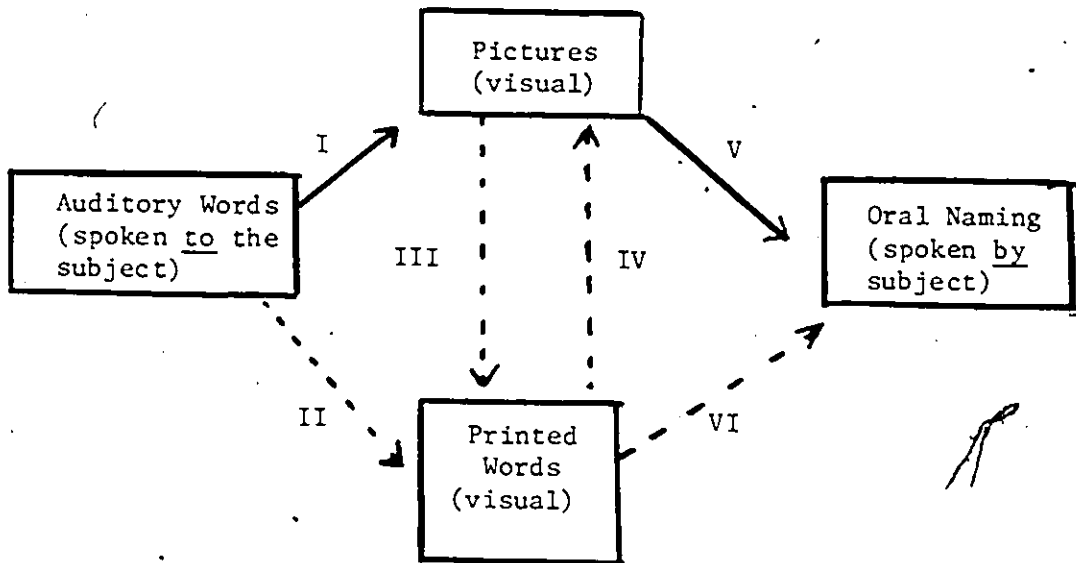


Fig. 1. Schematic summary of the experiment by Sidman (1971). The S began the experiment knowing I and V. After being taught equivalence II, S was able to do III, IV, and VI.

old, moderately retarded boy was used in this study. The boy came to the study able to match picture choices to spoken word samples. The boy was also capable of naming each picture sample provided. It would appear therefore, that the subject was able to provide verbal labels for all visual "picture" stimuli. Sidman (1971) examined whether teaching the boy to match printed word choices (visual) to spoken word samples (verbal labels) would transfer the training effects to other within-modal and cross-modal matching tasks (i.e., improving the ability to match picture choices to printed word samples). These results would appear to be consistent with those of O'Connor and Hermelin (1961), in that they suggest that the ability to match picture choices to printed word samples probably emerged since the printed word samples and the picture choices became equivalent to each other, because each, independently had become equivalent to the same spoken sample - verbal coding as a mediating link between classes of visual information. Sidman (1971) questions, however, whether this naming by the subject does in fact play a major role in simultaneous cross-modal matching, and whether the subject is capable of establishing the above link without actively verbalizing.

Sidman, Cresson and Wilson-Morris (1974) attempted to answer this question regarding the role of active naming by the subject. They chose to do this by restricting any sample naming by the subject during training. Two severely retarded subjects, ages 14 and 18 years

were used in the study. The subjects were taught to match picture choices to spoken word samples, and printed word choices to picture samples. Following the mastery of the above tasks, Sidman, Cresson and Willson-Morris (1974) tested the subjects' ability to match printed word choices to spoken word samples, and oral naming of printed word samples. The results of this study suggest that the subjects' naming skills did not appear to mediate the emergence of cross-modal matching (i.e. the ability to match printed word choices to samples spoken), since this reading skill emerged without active sample naming by either subject. Thus, it would appear that the response coding which mediated the link between sensory modalities in the above study, was independent of oral naming. The question still remains - what is the role of oral naming by the subject? Based on the above results, and those reported by O'Connor and Hermelin (1971), verbal coding appears to function independent of the subject's oral naming or verbalization. Although these two studies agree on this point, they appear to show conflicting results regarding the role of verbal labelling on cross-modal matching.

The results reported in the Sidman (1971; 1973; 1974) and Conroy (1978) studies provide repeated conflicting evidence to those of O'Connor and Hermelin (1971) and Bryant (1967) regarding the role of verbal labelling on subsequent transfer. One reason for this conflict may be that the modality matching tasks used in the O'Connor and Hermelin (1971) study were delayed matching task, and although the subjects could verbalize the solution, they were not transferring

this information to other modalities over a delayed interval. This is in fact similar to the performance of Conroy's (1978) control group, wherein delayed visual-visual matching was very poor, even though all subjects were familiar with the names of the common household objects, they did not appear to utilize this information. In the Conroy (1978) study, therefore, active verbal labelling by the subjects served to bridge the time delay by providing verbal links across bits of visual information, thus facilitating visual memory. This hypothesis was reinforced in a study by Constantine and Sidman (1975).

Constantine and Sidman (1975) found that although their subjects were able to perform simultaneous matching accurately (i.e., when the sample pictures remained available for comparison once the choice stimuli were presented), their performance on a delayed matching to sample task was very poor. During the delayed matching task, the sample pictures were removed four to 12 seconds before the choice stimuli were presented. Although the subjects (four severely retarded males, ages 17 to 22 years) could name each picture, it would appear that they were not applying their naming skills to the visually delayed matching task. In the second experiment conducted by Constantine and Sidman (1975), the subjects were instructed to name each picture sample during the matching task. This naming resulted in greater accuracy in the delayed matching of picture samples to picture choices. Thus, although active naming by the subject (i.e., generating verbal labels) does not appear to be essential for cross-

modal integration (Sidman, Cresson and Willson-Morris, 1974), it does appear to play a major role in the delayed matching, wherein naming and remembering names during a delay are necessary skills.

#### Specific Issues

In summary, the issues of particular interest in the present study relate to : (a) the relationship between intellectual level of functioning and sensory integration abilities of mentally retarded adults. That is, although cross-modal performance among mentally retarded adults has been investigated in several studies reviewed earlier in this chapter, the failure to include appropriate controls for intellectual functioning (level of retardation) or intra-sensory skills makes these results difficult to interpret. Comparisons to date have focused on normal vs retarded samples, retarded vs autistic groups, and normal vs autistic vs sensory impaired (deaf or blind subjects). One major disadvantage to this format is that the mentally retarded or subnormal groups vary so dramatically across studies, making comparisons and conclusions impossible. That is, mean mental ages of retarded subjects used across studies have varied from 5.2 years (Hermelin and O'Connor, 1961) to 8.6 years (Zung, 1961). But there has been little attempt to vary these mental ages systematically across levels of retardation within the same study. Such a variation should provide greater insight into the intersensory integration process across not only lowered mental ages, but also across levels of retardation (i.e. lowered mental age combined with adult level

transfer experience gained from transfer processes earlier in life).

(b) The second issue of interest arising from the studies reviewed, relates to the role of intra-sensory integration abilities in the sensory integration process. That is, the inclusion of both intra-sensory and inter-sensory integration tasks allows for the control of poor discrimination abilities at an intra-sensory level. This in turn allows the study to focus on the intersensory integration process without confounding as a result of poor modality discrimination. Furthermore, by training to criterion in the intra-modal tasks, the inability or difficulty experienced by the subjects in carrying out intersensory integration tasks, cannot be attributed to the complexity of the particular stimuli being used.

(c) A third issue of interest resulting from the earlier studies reviewed herein, relates to the modality matching tasks themselves - i.e., tactual vs auditory vs visual on an intra-modal level, and auditory-visual, auditory-tactual, and visual-tactual on an inter-modal level. There remain diverse opinions on the importance, and ease of mastery of information presented via the different sense modalities (e.g. the Montessori approach wherein it is believed that touch teach the other senses, to hypotheses by Posner, (1967) who suggests that visual memory is superior to tactual memory, and thus visual information is easier and more readily processed than tactual information). The present study attempts to compare the above sense modalities both within and across two levels of mental retardation. It also examines various intermodal pairings of the above three sense

modalities (i.e., auditory-visual ...etc) in terms of intersensory integration.

(d) The fourth issue to be examined in the present study was that of cross-modal transfer. The preceding literature review has examined cross-modal transfer in terms of the sense modalities involved (i.e., transfer of information received in ~~one~~ sense modality to the solution or processing of information received in a second modality). The issue of transfer - under what conditions it occurs, transfer effects across different groups of tasks...etc appears to remain unresolved, and confounded by additional variables (i.e. simultaneous vs delayed matching; variations in tasks, ranging from familiar objects as used by Blank, Altman and Bridger (1968), to nonsense designs and the Russian alphabet as stimuli (Hermelin and O'Connor, 1961). The studies reviewed seem to attach particular importance to verbal labels and the labelling process, in cross-modal transfer, although this issue itself also appears unresolved. The issue of verbal labels and their relation to sensory integration in the mentally retarded would appear particularly important in relation to intellectual level of functioning, in that verbal skills appear to be less developed as one goes from mild to moderate levels of intellectual development. This would suggest that verbal labelling or coding might be a skill less developed or frequently used among lower functioning mentally retarded persons.

Thus, the present research was carried out to investigate the above issues regarding tri-modal sensory integration in moderate

and mildly retarded adults. Specifically, the hypotheses arising from the above issues, and subsequently examined in the present study, can be summarized as follows:

Hypotheses:

1. Retardation Trends:

(a) There is a significant overall difference in total errors to criterion when comparing the performance of moderate and mildly retarded subjects on cross-modal matching. Both groups should be able to complete the tasks because of their levels of functioning (i.e., the tasks chosen are within the abilities of both moderate and mildly retarded adults); but the mildly retarded group should perform significantly better than the moderately retarded group because of greater proficiency with verbal labels, and because of their higher developmental functioning, which has been hypothesized to correlate highly with intersensory organization (McGhie, 1970).

(b) There is a significant difference in the overall rate of acquisition of sensory integration tasks (trials to criterion) between the moderately and mildly retarded groups. This difference should follow the direction of the results reported by Zeaman and House (1963; 1979) and by Lovaas, Koegel and Schreibman (1979) in that mildly retarded subjects should tend to focus on the relevant dimensions more readily, tending to show faster acquisition on initial trials.

2. Sensory Integration:

A. Intra and Inter-Sensory Examinations and Comparisons.

(a) There is no difference between the moderate and mildly

retarded groups in intra-modal performance. This would be consistent with the results of Birch and Lefford (1963) and Davidson, Pine, Wiles-Kettenmann and Appelle (1980) wherein young children and developmentally handicapped persons of low mental ages (less than five years) are largely dominated by the perception or sensation of single stimuli, and that intersensory organization does not become fully established until the age of 11 years (McGhie, 1970). Thus, because of the levels of retardation and the chronological ages of the subjects used in the present study, all subjects should be capable of completing all intra-modal tasks with little or no difficulty.

(b) There is a significant difference in the ability of all subjects to perform intra vs inter-modal integration tasks, with intra-modal tasks being completed with fewer errors. This would be consistent with results reported by Bryant (1968) and others (Jones and Robinson, 1973; Zung, 1971), which suggest that the matching abilities of the mentally retarded persons follow a developmental trend showing faster acquisition of intra as opposed to inter or cross-modal matchings, particularly in subjects of lower mental ages, who would be expected to experience particular difficulty with cross-modal (inter-modal) learning tasks.

#### B. Sensory Modalities.

(a) The difference in the overall rate of acquisition of tasks between moderate and mildly retarded subjects (hypothesis 1b) across both intra and inter-modal tasks, will depend on the specific

sensory modalities involved. That is, from the studies reviewed earlier, there would appear to be consistently poor performance by mentally retarded persons, in tasks involving tactual discrimination or memory (Jones and Robinson, 1973; Bryant and Raz, 1975; Zung, 1971). There also appears to be considerable information regarding the superior integration of visual and verbal information as opposed to tactual information (Bryant and Raz, 1975; Davidson, Cambardella, Stenerson and Carney, 1974).

### C. Cross-Modal Transfer

(a) There is no difference in the amount of overall transfer across modality integration tasks for the two levels of retardation. That is, there should be no difference in the number of errors on "final tasks", the third task in each condition, committed by moderately vs mildly retarded subjects. These results would be consistent with Hebb's (1948) view that adults will have already gained maximum benefit from transfer early in life, in that transfer seems to be a function of early development. That is, task complexity seems to be the major variable effecting transfer, and once this is overcome by performance to criterion and familiarity with all the relevant dimensions from preceeding tasks, transfer effects should be equal across levels of retardation on the final task.

(b) Transfer, measured in terms of total errors on a "subsequent" task, should be greatest (i.e., fewest errors) in tasks preceeded by modality integration tasks involving the auditory modality.

These results would be consistent with those reported by Sidman (1971) and Constantine and Sidman (1975) wherein verbal rehearsal or "pre-training" enhances transfer of information when a delay is imposed across tasks. These results would also reflect earlier results and hypotheses regarding the role of verbal labelling or coding (e.g., Luria, 1961; and O'Connor and Hermelin, 1963).

## CHAPTER II

### METHOD

Subjects. Sixty mentally retarded adults, thirty moderately retarded (Wechsler Adult Intelligence Scale I.Q. in the range from 40 to 50; mean I.Q. = 45.3; S.D. = 3.1; standard deviations from the norm = 3), and thirty mildly retarded (W.A.I.S. I.Q. in the range from 51 to 65; mean I.Q. = 60.9; S.D. = 3.4; standard deviation from the norm = 2), took part in the present study. All subjects were residents of the Rideau Regional Center at the time of the study. The length of institutionalization varied across subjects, from five to 15 years in length, with a mean length of stay of 9.9 years for the moderately retarded group and 8.5 years for the mildly retarded group (S.D.s = 3.6 and 3 respectively). The mean chronological ages of the subjects ranged from 18 years 2 months to 40 years 5 months, with all subjects being residents of adult wards. The mean chronological age of the moderately retarded subjects was 27 years 9 months (S.D. = 6.1), while the mean chronological age of the mildly retarded group was 27 years 10 months (S.D. = 9.2). Both groups were composed of equal numbers of male and female subjects; that is, both groups consisted of 23 male and seven female participants. The subjects were selected by screening the resident files. No individuals with recorded evidence of brain damage was considered for the present study. Furthermore, all subjects were free from any obvious sensory or motor deficits (e.g. Down's Syndrome individuals were excluded because of obvious speech limitations due to enlarged tongue) which might interfere with their

performance on the various tasks. No subject selected for the study was excluded for any reason; nor did any of the subjects drop out from the study once involved, although they were free to leave.

Equipment and Materials. The stimuli used in the present study consisted of eight novel shapes, and eight pseudo-words (i.e. non-words judged to sound like real words by a random sample of moderate and mildly retarded adults). The eight pseudo words chosen for the present study were selected as follows: (a) a brief 10 to 15 minute conversation was taped with 10 mildly retarded persons, each seen separately. All individuals were asked the same question, "I'd like you to tell me some of the things you did today, beginning from the time you got up." (b) From the above conversations, a list of 50 words used by the participants was constructed. The list consisted of the 50 most commonly used nouns (nouns used by two or more participants). Each word was then phonetically modified so as to sound similar to the real word (e.g., the word RUG became WUG). (c) This list of 50 pseudo-words was then presented to 10 moderately retarded persons with the statement: "I am going to read a list of words, and I want you to tell me if any of these sound like real words or real things you know". The participants were encouraged to select pseudo-words sounding like common nouns. (d) From the responses of the 10 moderately retarded participants, a list of eight commonly chosen pseudo-words was randomly selected. This latter selection was done by writing the names of the 17 words selected by all moderately retarded participants as sounding "real", on individual sheets of paper. The folded papers were then mixed in a container, and the eight pseudo-words to be used were thus selected.

The novel shapes were constructed by using small wooden cubes, each side measuring 2 centimeters (cm). Each novel shape consisted of eight cubes glued together. For all shapes, six cubes were joined vertically. The position of the remaining two cubes varied for each design, thus differentiating one shape from another. The eight shapes used in the present study are shown in Figure 2.

The novel wooden stimuli were presented visually and/or tactually on a raised wooden tray/box. The dimensions for the raised wooden tray/box are included in Figure 3. Blindfolds were used by all subjects for the tactual presentations (i.e., the tactual-tactual matching condition described below). All auditory stimuli (pseudo-words) were presented via a portable cassette tape recorder. The order of presentation of the auditory stimuli was randomly determined for each auditory condition. Thus, for the auditory-auditory (auditory equivalence) matching condition, the order of presentation for the auditory stimuli was determined by drawing individually folded pieces of paper with stimulus names on them - one pseudo word on each folded paper. The order of presentation for the remaining auditory conditions (auditory-visual, and auditory-tactual) were determined by repeating the above randomization procedure for each condition. The order of presentation of stimuli within each condition, however, was the same for all subjects.

Design. During Session 1 (day 1) the present study involved a mixed design, with two between and one within subject factor. Thus,

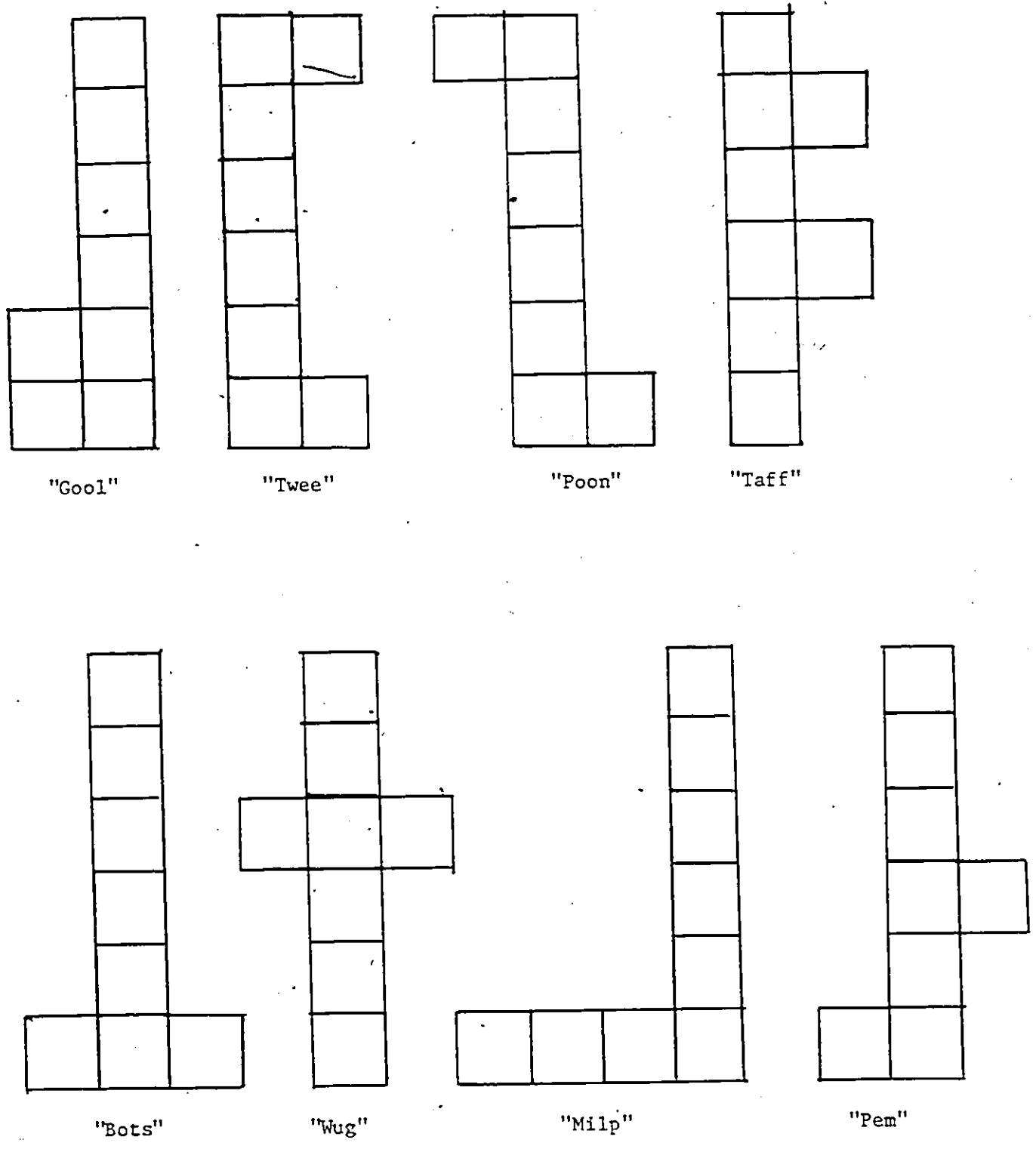


Fig. 2. Illustrated above are the eight novel forms used in the present experiment. Under each form is listed the pseudo-word paired with each form for all auditory tasks.

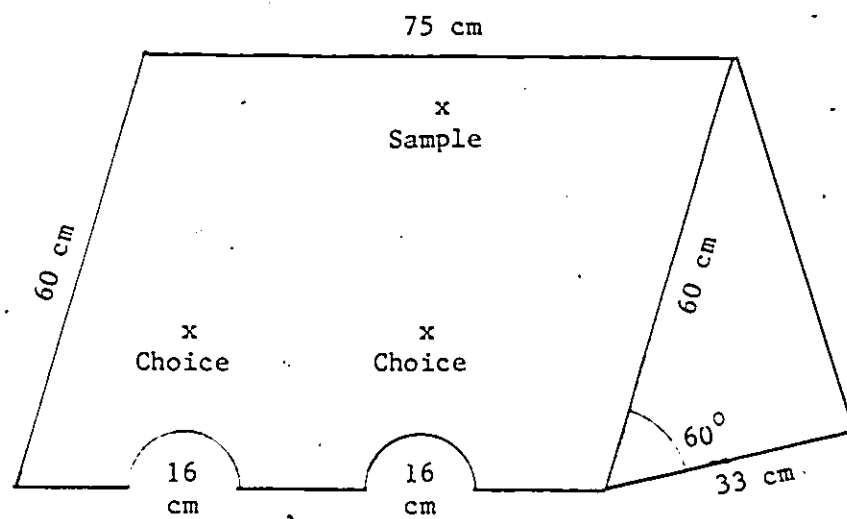


Fig.3. Display tray/box used in the present study. The sample stimulus was suspended from the upper central region of the display board, while the choice stimuli were either suspended above each arm hole, or positioned inside the box so as to be felt but not seen by the participant.

level of retardation (mild vs moderate range of intellectual development, represented by 2 and 3 standard deviations below the norm, and determined by scores on the Wechsler Adult Intelligence Scale), and order of presentation of the stimulus modality conditions, were used to study between subject variability; while stimulus modality (visual-visual matching, auditory-auditory matching, and tactual-tactual matching) determined the three levels of the within subject variability.

During Session 2 (the following day), a similar design was used, with two between (level of functioning and order of presentation) and one within (stimulus modality, consisting of auditory-visual matching, visual-tactual matching, and auditory-tactual matching) subject factor. Since one of the aims of the present study was to examine sensory integration in terms of transfer of training effects, the second between subject factor (order of presentation) was created by randomly assigning all subjects to one of the three orders of cross-modal presentations. This randomization was carried out by drawing folded slips of paper from a container; each slip of paper contained one of the three orders represented by  $C_1$ ,  $C_2$ , and  $C_3$  in Table 1. One slip of paper corresponding to an order of presentation was drawn for each subject, with a maximum of 20 subjects (10 moderately and 10 mildly retarded) assigned to any one condition. Only three orders of presentation were incorporated, and an incomplete counterbalancing design was used, since (a) all possible orders of presentation were not of interest to the present study, and (b) a sufficient subject

Table 1

Experimental Design. The Two Levels of the Between Subjects Variable are Represented by  $a_1$  and  $a_2$ . The Three Levels of Stimulus Modality are Represented by  $b_1$ ,  $b_2$  and  $b_3$ . The Three Levels of the Second Between Subjects Variable (Order of Presentation) are

Represented by  $c_1$ ,  $c_2$  and  $c_3$

	$b_1$	$b_2$	$b_3$
Mild $a_2$	A-V	A-T	V-T
	A-T	A-V	V-T
	V-T	A-V	A-T
Moderate $a_1$	A-V	A-T	V-T
	A-T	A-V	V-T
	V-T	A-V	A-T

sample was not available for complete counterbalancing. Nevertheless, to fulfill the requirements of an incomplete counterbalancing design as outlined by McGuigan (1968), each subject received each treatment or task once, and only once; and each treatment occurred an equal number of times (once) during each session.

Procedure. Experimental sessions were conducted in a vacant room in Stormont House - a ward area where the subjects resided. Appropriate verbal feedback ("Good! That's right") was given only on correct trials, with no tangible reinforcers being given during the testing procedures. A monetary incentive of \$1.00 was given to all subjects at the end of all testing. All subjects were informed at the beginning of the study that the money would be given, only if he/she participated in the entire experiment (two sessions over successive days). All subjects received six matching tasks. The six matching tasks were presented over the two session period. That is, the three intra-modal matching tasks were presented to mastery to a criterion of 16 consecutively correct responses, during Session 1. The three cross-modal matching tasks were presented during Session 2, one day later.

One of the primary interests of the present study was cross-modal integration, and the transfer of training effects involved therein. Thus, the within-modal matching tasks (i.e., visual-visual matching, auditory-auditory matching, and tactual-tactual matching) were completed first, to insure that all subjects could distinguish (a) the spoken stimuli from each other, (b) the visual stimuli from each other, and

(c) the tactual stimuli from each other. The aim of the above testing was to eliminate poor discrimination of stimuli. This permitted the examination of the stimulus-response relations which comprise the cross-modal matching tasks. The prior intra-modal testing would thus provide the controls outlined by Bryant (1968). The order of presentation of the within-modal matching tasks was randomly determined for all subjects. This was done by drawing (selecting) on of the six orders written on individually folded sheets of paper. Thus, five subjects received each of the six different orders (i.e., visual-visual matching followed by auditory-auditory matching followed by tactual-tactual matching...etc). In this way, the order of within modality matching was completely counterbalanced.

#### Session 1. Within-Modal Matching Tasks.

(a) Visual-Visual Matching. The subject was presented with a sample form in the upper central display region of the raised wooden tray. He/She was then required to visually examine and touch (but not tactually explore) the sample form. No fixed time limit was imposed regarding how long the subject was required to examine or to take before touching the sample. The combined requirement of visual examination and touch was used as an indicator of the subjects' attention to the sample stimulus. After the subject had touched the sample form to indicate that he/she had attended to it, two choice stimuli were presented. The choice stimuli were presented on the display tray, below the sample stimulus (which remained present throughout the trial), and with one choice stimulus to either side (both left and right sides)

of the sample. For all trials, only one of the choice stimuli corresponded to the sample stimulus. The location of the correct choice stimulus was randomized using folded slips of paper, as outlined earlier. Similarly, with the eight forms used, a different form was used as a sample stimulus for each trial within an eight trial block; the order of presentation of sample forms being determined randomly as outlined above. Thus, for each block of eight trials, each form was used as a sample stimulus, and the location of the correct choice form varied equally, appearing four times to the left side, and four times to the right side on the display tray. The choice pairs were also randomly determined by selecting the "correct" choice and randomly drawing one other choice from seven folded slips of paper representing the remaining seven forms. The only restriction imposed was that no choice form could be used on more than two consecutive trials. For all trials, the sample stimulus remained present for visual comparison while the choice stimuli were also present. The subject was required to respond by pointing to the correct choice. For all trials, the subject was permitted only one response. Each trial was followed by an inter-trial interval of approximately five seconds. The criterion for mastery or completion of the visual-visual testing, as well as all within-modal matching tasks, was 16 consecutively correct matchings (i.e., two correct matchings of each of the eight stimuli). Following the mastery of one within-modal matching task, the subject proceeded to the remaining within-modal matching tasks.

(b) Auditory-Auditory (Equivalence) Matching. During the auditory-auditory or auditory-equivalence matching task, the subject was presented with two auditory stimuli (via a portable cassette tape recorder) for each trial (e.g., the spoken pseudo-words "BOTS", "GOOL"). The inter-stimulus gap between the two words was one second; the gap between the pairs of words, since the word pairs were repeated twice, was three seconds. For some trials the word pairs were different from each other (e.g., "BOTS", "GOOL"); for other trials the pairs were identical (e.g., "BOTS", "BOTS"). The order of presentation of "same" and "different" pairs was randomly determined using folded slips of paper as outlined earlier. To assist the subject in attending to each spoken word, the experimenter always asked "Ready?" prior to each pseudo-word presentation. The subject was required to respond appropriately ("Ready") before the word pairs were presented and repeated. Following the second presentation, the subject was required to state whether the auditorily presented pseudo-word pairs were the same or different from each other. Appropriate verbal feedback was provided following each correct response ("Good..., that's right"); with no feedback being given for incorrect responses. Immediately following the experimenter's verbal feedback, the next trial began as outlined above, with an inter-trial interval of approximately five seconds between trials.

(c) Tactual-Tactual Matching. The subject was required to match a choice object from a two choice array, to a sample stimulus presented simultaneously. Thus, the subject, while blindfolded, was

presented with a novel form (sample) which he/she had to carefully feel with both hands. Following the subject's tactual exploration of the sample, he/she was required to feel the two choice stimuli, and respond by holding up the choice stimulus which corresponded to the sample. The subject was permitted to re-examine the sample stimulus throughout the trial. For this matching task, the choice stimuli were placed on the surface of the display tray, below and to either side of the sample stimulus (as with the visual-visual intra-modal matching task). On all trials, the subject's hands were guided by the examiner to the sample form, and to the choice forms. The subject was required to use both hands to feel the sample form, but only one hand to feel each choice form (the left hand on one choice form, and the right hand on the other choice form). As with the visual-visual matching task, the location of the correct choice was randomly determined across each block of eight trials. The correct choice was placed on the left side 50% of the time, and on the right side the remaining 50% of the trials. The randomization procedures used were identical to those described in the visual-visual matching task. The criterion for completion of the tactual-tactual matching task was 16 consecutively correct trials (i.e. two correct matchings of each of the eight sample stimuli). As with all tasks, an inter-trial interval of five seconds was used.

Session 2. (next day). Cross-Modal Matching Tasks.

Following the mastery (i.e., criterion performance) of all three within-modal matching tasks, subjects were tested for cross-modal

integration and subsequent transfer effects. All subjects were tested on three matching conditions; these conditions are described below. As mentioned, incomplete counterbalancing was used to determine the order of presentation of the three cross-modal matching tasks. Thus, 20 subjects (10 moderately retarded and 10 mildly retarded) each received the auditory-visual matching task first, followed by the auditory-tactual, and visual-tactual matching tasks. A second group of similar residents (10 moderately and 10 mildly retarded adults) received the auditory-tactual task first, followed by the auditory-visual and then the visual-tactual matching tasks. A third group of 20 mentally retarded adults (10 moderately and 10 mildly retarded subjects) received the visual-tactual matching task first, followed by the auditory-visual task, and finally the auditory-tactual matching task. In this way, each cross-modal matching task was presented in the first position once. The remaining orders were such that the effects of verbal labelling on subsequent tasks could most closely be examined. That is, conditions  $C_1$  and  $C_2$  (i.e. A-V followed by A-T followed by V-T; and A-T followed by A-V followed by V-T) involved a complete counterbalancing of the auditory-visual and auditory-tactual components, for examining transfer effects from training in each of these pairs on a subsequent common visual-tactual matching task. Similarly, conditions  $C_2$  and  $C_3$  (i.e., A-T followed by A-V followed by V-T; and V-T followed by A-V followed by A-T) involved a similar comparison of transfer effects from training on auditory-tactual and visual-tactual matching tasks, on a subsequent common auditory-visual matching task.

The testing procedures for all cross-modal matching tasks were similar to those used in the intra-modal matching tasks. That is, appropriate verbal feedback was given on all correct responses only; and a similar presentation and matching-to-sample format was also adopted.

(a) Auditory-Visual Matching. For the auditory-visual matching task, the subject was required to match visually presented choice stimuli to auditorily presented sample stimuli. Thus, an auditory stimulus (a pseudo-word) was presented via a portable cassette tape recorder, and repeated until the subject responded by selecting one of two choice stimuli. As with the auditory-auditory matching task, the inter-stimulus gap was one second. The subject was required to point to the choice stimulus corresponding to the auditory sample. As in session one, a two-choice stimulus array was used, with forms being suspended on the display tray; these were presented simultaneously with the auditory sample stimulus. As in all tasks, an inter-trial interval of approximately five seconds was used, with the subject being permitted only one response per trial. Furthermore, in spite of the "repeated" auditory stimulus within each trial, every trial consisted of the sample stimulus presentation, the subject's response to this repeated sample stimulus, and the subsequent verbal feedback (on correct responses) provided by the examiner.

(b) Auditory-Tactual Matching. The subject was required to match tactually presented choice stimuli to auditorily presented sample stimuli. As in the above auditory-visual matching condition,

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the subject was presented with a tape recording of a pseudo-word (e.g. "Wug"), while seated at a table and facing the raised wooden tray/box housing the choice stimuli. During all trials, the subject's hands were inside the designated slots at the base of the raised wooden tray/box, with one hand in each slot. Following the assumption of this position, two wooden choice stimuli were introduced - one under each hand, while the verbal stimulus was simultaneously presented. The word was repeated twice, or until the subject responded by holding up the tactually presented choice object (novel form). At no time was a subject permitted to look inside the slots to visually examine the choice objects. The subject was required to feel the forms while listening to the auditorily presented sample stimulus. All subjects were instructed to respond by holding up the choice form corresponding to the sample stimulus. The verbally presented pseudo-words, and the position of the "correct choice stimulus" were determined randomly, similar to the within-modal matching tasks, with each word being presented once for each block of eight trials, and no word being presented over two successive trials. As for all matching tasks, the criterion for completion was 16 consecutively correct trials (i.e., two consecutively correct matchings for each of the eight auditory-tactual pairings).

(c) Visual-Tactual Matching. During the visual-tactual matching task, the subject was presented with a novel wooden form suspended from the upper-central display region of the apparatus (raised wooden tray/box). The subject was asked to visually examine this sample stimulus, and to briskly touch it (but not explore it

tactually) as a sign that he/she was attending to it. Upon touching the sample stimulus lightly, the subject was required to insert his/her hands into the slots at the base of the wooden tray/box, and to feel the two choice stimuli therein. The subject was required to feel the two choice stimuli, one in each hand; and indicate his/her response (selection) by holding up the choice stimulus (inside the box) corresponding to the sample suspended on the front of the apparatus. The two choice stimuli were thus presented simultaneously with the visual sample stimulus. Furthermore, the two choice stimuli were placed inside the apparatus, and therefore not visible to the subject. The above procedure allowed the subject to tactually explore the choice stimuli while simultaneously being able to visually examine the sample stimulus.

For all trials, the subject was permitted only one response. An inter-trial interval of approximately five seconds was used for all conditions. Each trial consisted of a sample stimulus presentation, the subject's response to that sample stimulus, and the subsequent verbal feedback provided by the examiner (on correct trials only, with no feedback being provided following incorrect responses). On correct trials, the subsequent trial proceeded following the usual five second inter-trial interval.

## CHAPTER III

### RESULTS

Overall Group Comparisons. A Groups (2) x Tasks (2) analysis of variance (ANOVA) was performed on the overall total errors to criterion. The mean number of errors to criterion for all tasks (intra-modal and inter-modal) performed by the moderate and mildly retarded groups were 10.5 and 4.7 respectively. The Group effects,  $F(1, 58) = 126.1, p < .01$ , indicate that as the level of intellectual functioning of the subjects within these groups decreased from mild to moderate (from two standard deviations below the norm to three standard deviations below the norm), the mean number of errors increased. The summary for this ANOVA is shown in Table 2. Within this same analysis, a significant Tasks effect was obtained,  $F(1, 58) = 1033.5, p < .01$ . An inspection of the means (errors to criterion) for intra-modal and inter-modal tasks (0.4 and 14.8 respectively), suggests that inter or cross-modal matching tasks proved considerably more difficult than intra-modal matching tasks. The Groups x Tasks interaction also proved to be a significant source of variance within the above analysis,  $F(1, 58) = 135.9, p < .01$ . Figure 4 shows the mean number of errors as a function of the intellectual level of functioning (Groups) for intra and inter-modal matching tasks. This Groups x Tasks interaction qualifies the main effects due to the Groups

Table 2  
 Summary of the Analysis of Variance For Total Errors  
 On Intra and Inter-Modal Tasks

<u>Source of Variance</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Groups	13388.1	59		
A (Level of Functioning)	9170.0	1	9170.0	126.1*
S:A (error)	4218.1	58	72.7	
Within Groups	66645.5	60		
B (Intra vs Inter)	56116.9	1	56116.9	1033.5*
AxB	7379.0	1	7379.0	135.9*
BS(A (error))	3149.6	58	54.3	
Total	80033.6	119		

Note: \* p < .01

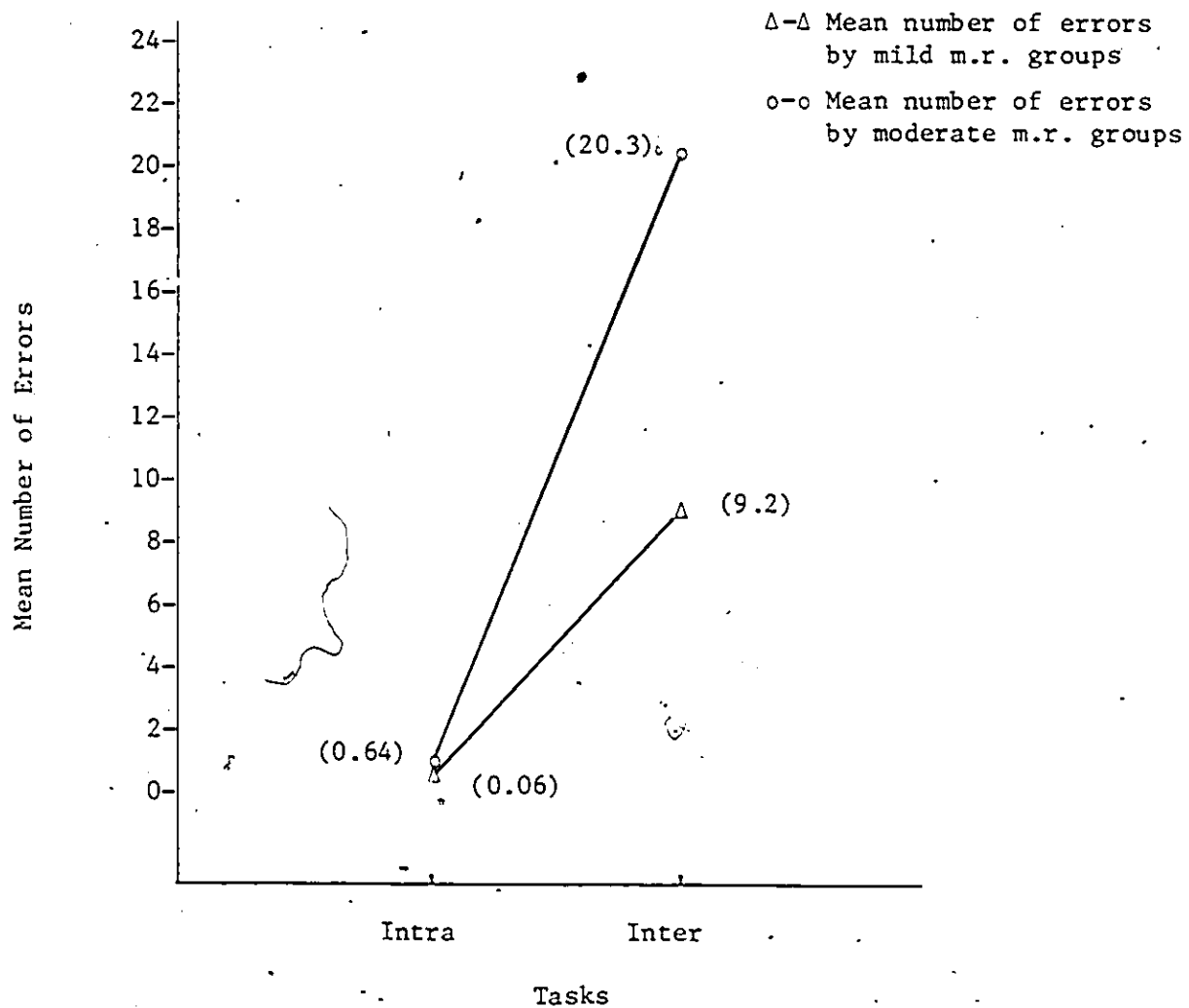


Fig. 4. Mean number of errors for intra and inter modal matching tasks as a function of moderate and mild levels of intellectual functioning.

and Tasks sources of variance. This interaction suggests that the effect of intellectual level of functioning upon a subject's performance, is not the same within intra and inter-modal matching tasks. An inspection of Figure 4 suggests that the moderate and mildly retarded groups performed similarly on the intra-modal tasks, but that on the inter-modal tasks, the moderately retarded group performed significantly poorer.

Intra-Modal Matching Comparisons. A Groups (2) x Tasks (3) analysis of variance was carried out on the total errors to criterion<sup>1</sup> for all intra-modal matching tasks across moderate and mild levels of intellectual functioning (Groups). The summary for this ANOVA is shown in Table 3. The mean number of errors to criterion for the moderate and mildly retarded groups within the intra-modal matching tasks were .64 and .06 respectively. Consistent with the above overall group comparisons, the Groups effects for intra-modal comparisons,  $F(1, 58) = 14.2, p < .01$ , suggest that as the level of intellectual functioning decreases from mild to moderate across groups, the mean number of errors to criterion increases significantly.

A comparison of the means (errors to criterion) for the three intra-modal matching tasks (visual-visual = .02; auditory-

<sup>1</sup> A transformation ( $\sqrt{X + 1}$ ) of the raw data for intra-modal tasks was carried out due to skewed distributions resulting from the predominance of 0 error score. The F ratios from a Groups (2) x Tasks (3) ANOVA carried out on the transformed data were essentially the same as those for raw scores; hence, all further analyses were carried out on raw scores only.

Table 3

Summary of the Analysis of Variance For Total Errors  
For Intra-Modal Tasks

<u>Source of Variance</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Groups	78.9	59		
A (Level of Functioning)	15.6	1	15.6	14.2*
S:A (error)	63.3	58	1.1	
Within Groups	146.0	120		
B (A-A; V-V; T-T)	24.7	2	12.4	12.7*
AxB	15.5	2	7.7	7.9*
BS:A (error)	105.8	116	0.9	
Total	224.9	179		

Note: \*  $p < .01$

auditory = .16; and tactual-tactual = .87) for all subjects, was carried out, suggesting that the source of variance representing the difference between these means yielded a significant Tasks effect,  $F(2, 116) = 12.7, p < .01$ . This difference due to Tasks, and the significant main effect due to the Groups (moderate vs mild retardation) source of variance, are qualified by the significant Groups x Tasks interaction,  $F(2, 116) = 7.9, p < .01$ . This interaction suggests that the effects of intellectual functioning are not the same across the three intra-modal tasks. An inspection of the means suggests that this interaction resulted from the great difficulty experienced with the tactual-tactual problems, particularly by the moderately retarded group.

A comparison of the mean errors for the visual-visual, auditory-auditory, and tactual-tactual intra-modal tasks across moderate and mild levels of retardation was carried out using the Duncan's Multiple Range Test. All comparisons of the highest mean for total errors (1.6 for the tactual-tactual matching task by moderately retarded subjects) with other means were found to yield significant differences ( $p < .01$ ). None of the remaining comparisons of means yielded significant differences ( $p > .05$ ). These results would indicate that the tactual-tactual matching task for the moderately retarded participants was the most difficult as measured by total errors to criterion; none of the remaining tasks differed in terms of difficulty as measured by total errors to criterion.

Inter-Modal Matching Comparisons. A Groups (2) x Order (3)

analysis of variance was performed for the total errors<sup>2</sup> to criterion for all inter-modal matching tasks. There was a significant main effect for Groups,  $F(1, 36) = 10.3, p < .01$ . The means (mean number of errors) for the moderate and mildly retarded groups were 20.3 and 9.2 respectively. Within the above ANOVA, a significant Order effect was also obtained,  $F(2, 36) = 3.4, p < .05$ . An inspection of the means (errors to criterion) for Order conditions (12.8, 15.9, and 15.5 for  $C_1, C_2,$  and  $C_3$  respectively), suggests that the three orders varied in difficulty, with condition  $C_1$  resulting in the fewest number of errors.

The remaining comparisons that might be done by including a Tasks factor in the above analysis of variance are inappropriate because of the incomplete counterbalancing of tasks within Orders of Presentation for inter-modal tasks. Since a limited number of suitable participants were available for the study, an incomplete counterbalancing design was incorporated to examine only those cross-modal orders of interest to the present study. However, in order to make a variety of other comparisons, Levene's Test for Homogeneity of Variance was carried out to insure that the sample variance of subjects within the three orders selected, did not differ markedly from equality. Table 4 contains a summary of the Levene Test.

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<sup>2</sup> A separate Groups (2) x Order (3) ANOVA was also carried out on the trials to last error for all inter-modal matching tasks. These results were found to correlate very highly with those for errors. Hence, the results for errors will be presented throughout this study.

Table 4  
 Summary of the Levene Test for Homogeneity of Variance

<u>Source of Variance</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Groups	150.4	2	75.2	.8
Within Groups	5450.4	57	95.6	
Total	5600.8	59		

Note:  $\rho > .2$ , therefore F is not significant

It was possible to compare the relative difficulty of the three inter-modal tasks for each intellectually impaired group by an analysis of Problem 1 performance, which was not influenced by Order effects. Thus, a Groups (2) x Tasks (3) analysis of variance was carried out to compare the three cross-modal tasks (A-V, A-T, and V-T) when each was presented as Task or Problem 1, across the moderate and mild levels of functioning. The mean number of errors for the moderate and mildly retarded groups was 37.2 and 17.7 respectively. The significant Groups effect,  $F(1, 54) = 147.5, p < .01$ , shows that the source of variance representing the difference between the group means was significant. These results are consistent with all similar comparisons of moderate and mildly retarded groups within the present study. The summary for the above ANOVA is shown in Table 5. Within this ANOVA, a significant Tasks effect,  $F(2, 54) = 221.4, p < .01$ , was also obtained. The significant main effects for Tasks, suggests that the three cross-modal matching tasks used (A-V, A-T, and V-T), differed significantly from each other in terms of difficulty measured by total errors. A visual inspection of the means for these tasks would suggest that the auditory-tactile matching task was the most difficult of the three tasks. A Groups x Tasks interaction within the above analysis was also found to be significant,  $F(2, 54) = 16.4, p < .01$ . Figure 5 shows the mean number of errors for the cross-modal tasks across moderate and mild levels of retardation. This Groups x Tasks interaction qualifies the main effects due to each of these variables. An inspection of the means (errors

Table 5

Summary of the Analysis of Variance for Total Errors  
for the Auditory-Visual, Auditory-Tactual  
and Visual-Tactual Tasks when presented  
as the First Inter-Modal Task

<u>Source of Variance</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Groups	24183.1	5		
A (Level of Functioning)	5723.2	1	5723.2	147.5*
B (Tasks: A-V; A-T; V-T)	17186.6	2	8593.3	221.4*
AXB	1273.3	2	636.7	16.4*
Within Groups (error)	2095.6	54	38.8	
Total	26278.7	59		

\*Note:  $p < .01$

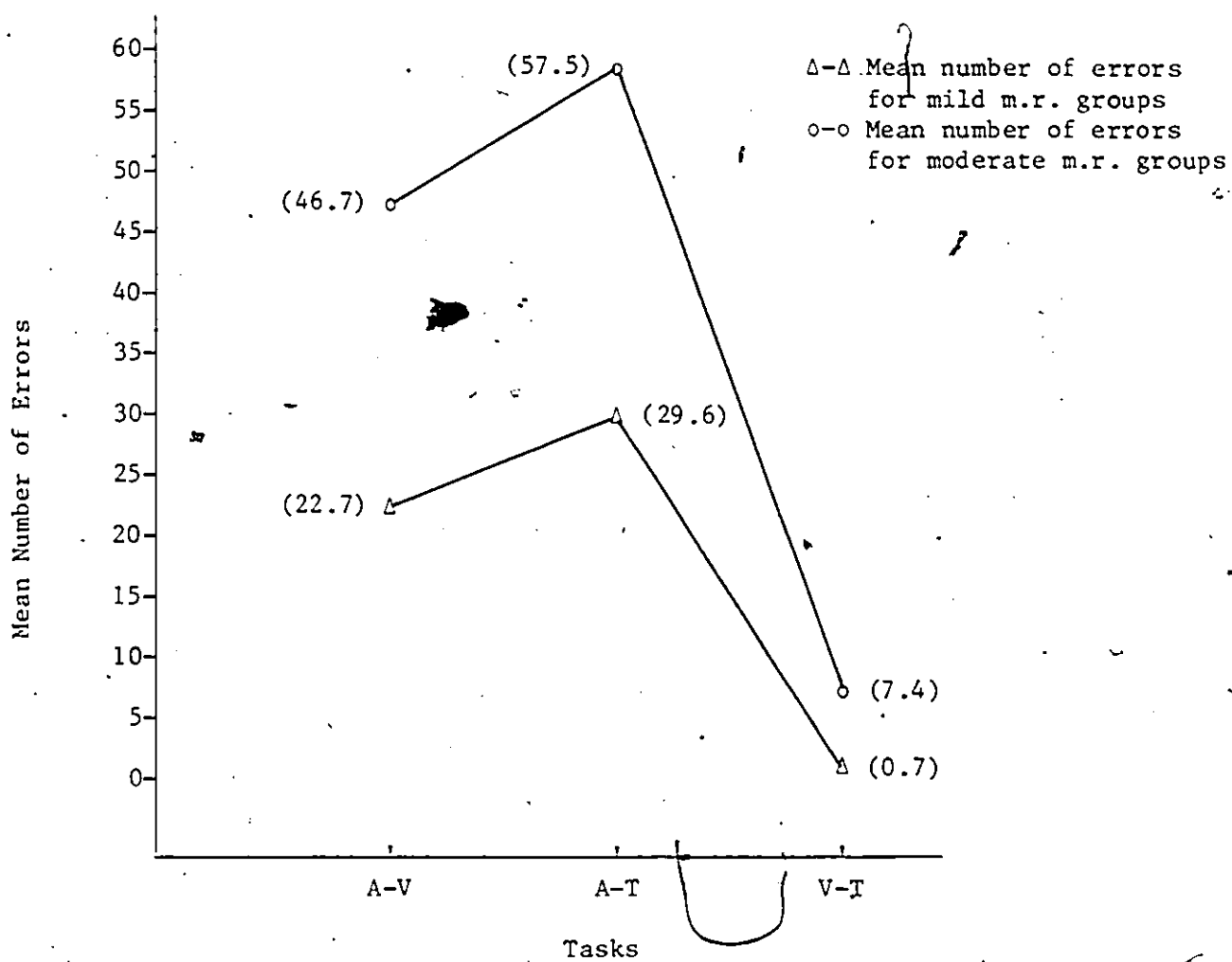


Fig. 5. Mean number of errors for cross-modal matching tasks as a function of moderate and mild levels of mental retardation.

to criterion) for the three cross-modal matching tasks across the mild and moderate levels of functioning suggest that the effects of intellectual level of functioning are not the same across the three tasks (A-V, A-T, and V-T). This inspection would suggest that the particular ease of the V-T matching task for both groups was primarily responsible for this interaction.

To determine differences between means, a Duncan's Multiple Range Test was carried out on the means for all initial tasks (A-V, A-T, and V-T) for moderate and mild levels of functioning. These means for the A-V, A-T and V-T tasks when each of these was presented first were: 46.7, 57.5, 7.4, 22.7, 29.9 and 0.7 respectively for moderate and mild levels of retardation. All comparisons of the highest mean for total errors (57.5 for A-T moderate) with other means were found to yield significant differences ( $p < .05$ ). Similarly, all comparisons of tasks within and across the moderate and mildly retarded groups were also found to differ significantly ( $p < .05$ ). These results would suggest that the visual-tactual task was the easiest initial task for both the moderate and mildly retarded groups; while the auditory-tactual task was the most difficult for both groups.

Sensory Integration and Cross-Modal Transfer. Since one of the purposes of the present study was to examine sensory integration in terms of cross-modal transfer effects for the above orders, across levels of intellectual functioning, separate analyses of variance were carried out for each of the three cross-modal matching tasks. To facilitate some of these analyses, levels of the Order of Presentation

variable were collapsed from three levels (i.e., the task being presented first, second, or third), to two levels (i.e., the task being presented first, as opposed to the task being preceded by other tasks). In all cases wherein the above levels were collapsed, analyses of variance for unequal cell distributions were carried out.

(a) Visual-Tactual Analyses. A Groups (2) x Order of Presentation (2) analysis of variance was carried out for the total errors to criterion for the visual-tactual matching task. The mean number of errors to criterion for the mildly and moderately retarded groups were 0.4 and 3.9 respectively. From Table 6 it may be seen that the source of variance representing the difference between the group means yielded a significant F,  $F(1, 56) = 27.7, p < .01$ . Within this same analysis, the means (mean number of errors) for the Order of Presentation conditions were 4.1 and 1.2, for the visual-tactual matching task when this task was presented first (V-T-1), and for the visual-tactual matching task when this task was preceded by other tasks, respectively. An examination of the variance representing the difference between these means, showed the Order of Presentation effects to be significant,  $F(1, 56) = 12.1, p < .01$ . Figure 6 shows the mean number of errors as a function of mild and moderate levels of functioning when the visual-tactual matching task was presented first (V-T-1) and when it was preceded by other tasks (V-T-P). Within the above analysis, a significant Groups x Order of Presentation interaction was found,  $F(1, 56) = 8.9,$

Table 6  
 Summary of the Analysis of Variance for Total Errors  
 for the Visual-Actual Matching Condition  
 (Unequal Cell Distribution)

<u>Source of Variance</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Groups	32.1	3		
A (Level of Functioning)	18.3	1	18.3	27.7*
B (Order of Presentation)	7.9	1	7.9	12.1*
AXB	5.9	1	5.9	8.9*
Within Groups (error)	37.1	56	0.7	
Total	69.2	59		

Note: \*  $p < .01$

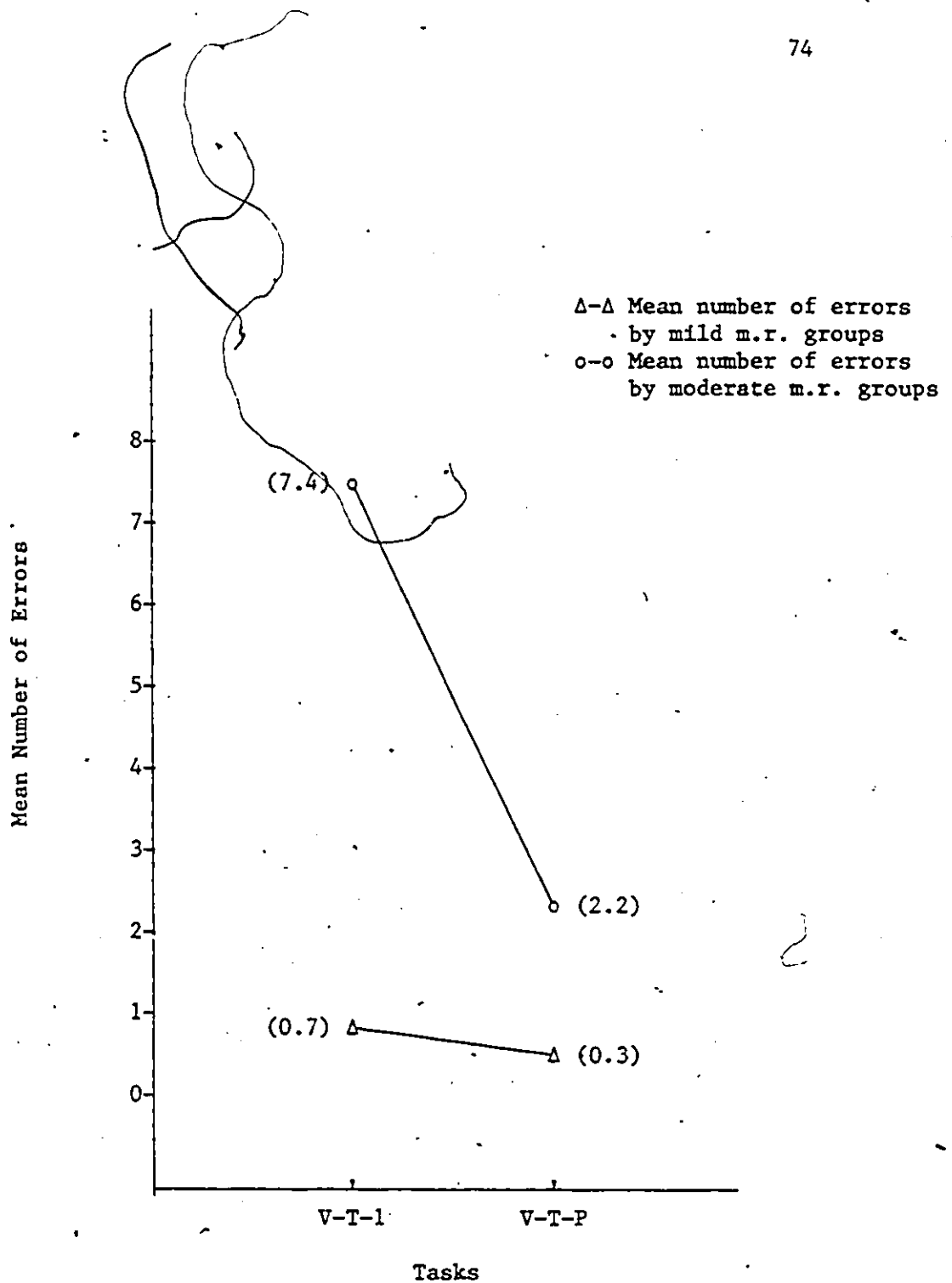


Fig. 6. Mean number of errors for the V-T task when presented first (V-T-1) vs when preceded by other tasks (V-T-P), as a function of moderate and mild levels of retardation.

$\rho < .01$ . This interaction qualifies the main effects for the level of functioning (Groups) and Order of Presentation sources of variance. An inspection of Figure 6 suggests that the interaction resulted from the particular ease of the second task (V-T-P).

As a result of the above Groups x Order of Presentation interaction, a series of t-tests were carried out to clarify the interaction. The mean number of errors within the mild level of functioning for V-T-1 was 0.7; when the visual-tactual matching task was preceded by other tasks (V-T-P), the mean number of errors for the mildly retarded group was 0.3. A comparison of these means indicates that they do not differ significantly ( $\rho > .05$ ). The mean errors for conditions V-T-1 and V-T-P within the moderate level of functioning were 7.4 and 2.2 respectively. A comparison of these means using a t-test, showed them to differ significantly,  $t = 3.3$ ,  $df = 28$ ,  $\rho < .01$ . Similarly, all comparisons of V-T-1 and V-T-P across intellectual levels of functioning were significant,  $\rho < .05$ .

The visual-tactual matching task was preceded by two different training or presentation procedures. In condition  $C_1$  (see Table 3), the visual-tactual matching task was preceded by training in auditory-visual matching (A-V) followed by training in auditory-tactual (A-T) matching. This order was reversed for condition  $C_2$ ; wherein the visual-tactual (V-T) task was preceded by training in A-T followed by training in A-V matching. Thus, a Groups (2) x Order of Presentation (2) x Tasks (2) analysis of

variance was carried out on total errors for A-V and A-T matching tasks within Order conditions  $C_1$  and  $C_2$ , for moderate and mildly retarded groups. Of particular interest within this analysis was the transfer of training effects for the Order of Presentation conditions  $C_1$  vs  $C_2$  (i.e., A-V followed by A-T vs A-T followed by A-V) on the common subsequent V-T matching task. From Table 7 it may be seen that the main effects for Groups, for Order of Presentation, and for Tasks were all found to be significant; that is,  $F(1, 36) = 126.2, p < .01$ ;  $F(1, 36) = 10.5, p < .01$ ; and  $F(1, 36) = 1618.3, p < .01$ , respectively for Groups, Order of Presentation, and Tasks sources of variance. The Tasks x Order interaction for the above analysis was also found to be significant,  $F(1, 36) = 27.8, p < .01$ . This Tasks x Order interaction qualifies the main effects for the Tasks and Order sources of variance, suggesting that the effects of a task are not the same across the two Orders of Presentation. The above results would suggest that transfer of training effects are not the same for Order conditions  $C_1$  and  $C_2$ , when the tasks are identical but their Order of Presentation varies. An inspection of the means (52.1 and 4.9 for first and second tasks presented to moderately retarded subjects; 26.2 and 0.7 for similar tasks given to mildly retarded subjects) suggests that the interaction resulted from the particular ease of the second task (transfer of training).

Since the A-V and A-T training orders were found to differ

Table 7

Summary of the Analysis of Variance for Total Errors for  
Auditory-Visual and Auditory-Tactual Matching Tasks  
Within Conditions C<sub>1</sub> and C<sub>2</sub>

Source of Variance	SS	df	MS	F
Between Groups	6211.8	39		
A (Level of Functioning)	4530.1	1	4530.1	126.2*
C (Order of Presentation)	378.5	1	378.5	10.5*
AxC	12.7	1	12.7	.4
S:AC (error)	1290.5	36	35.9	
Within Groups	29822.0	40		
B (Tasks)	26426.5	1	26426.5	1618.3*
AxB	2376.2	1	2376.2	145.5*
BxC	404.9	1	404.9	27.8*
AxBxC	26.5	1	26.5	1.6
BxS:AC (error)	587.9	36	16.3	
Total	36033.8	79		

\*Note: p < .01

significantly across conditions  $C_1$  and  $C_2$ , a t-test was carried out comparing the means for the V-T task in conditions  $C_1$  and  $C_2$  of the moderately retarded group. This test was carried out to provide information regarding transfer of training effects of different A-V, A-T pretraining on subsequent V-T tasks. The mean number of errors for the V-T tasks in conditions  $C_1$  and  $C_2$  of the moderately retarded group were 1.2 and 3.1 respectively. A comparison of these means yielded a t which was not significant at the required probability level,  $t = 2$ ,  $df = 18$ ,  $p > .05$ . A visual examination of the mean errors for V-T tasks in conditions  $C_1$  and  $C_2$  of the mildly retarded group (0.3 and 0.3 respectively), shows these means to be identical, and thus indicate no difference in the amount of transfer of training for conditions  $C_1$  and  $C_2$  of the mildly retarded group.

(b) Auditory-Tactual Analysis. A Groups (2) x Order (2) analysis of variance for unequal cell distributions was carried out for the auditory-tactual (A-T) inter-modal matching task. The mean number of errors to criterion for the mildly and moderately retarded groups was 10.6 and 23.9 respectively. From Table 8 it may be seen that the source of variance representing the difference between these means yielded a significant F; that is,  $F(1, 56) = 137.6$ ,  $p < .01$ . The Order effects within the above analysis were also found to be significant,  $F(1, 56) = 741.1$ ,  $p < .01$ . The mean number of errors to criterion for A-T when this task was preceded by other tasks (A-T-P) was 4.1; when A-T was presented first (A-T-1), the mean

Table 8  
 Summary of the Analysis of Variance for Unequal Cells, Using  
 Total Errors From the Auditory-Factual  
 Matching Condition

Source of Variance	SS	df	MS	F
Between Groups	1964.1	3		
A (Level of Functioning)	289.0	1	289.0	137.6*
B (Order of Presentation)	1556.3	1	1556.3	741.1*
AxB	118.8	1	118.8	56.6*
Within Groups (error)	115.5	56	2.1	
Total	2079.6	59		

Note: \*  $p < .01$

number of errors was 43.5. A significant Groups x Order interaction was also reported in the above ANOVA,  $F(1, 56) = 37.1, p < .01$ .

Figure 7 shows the mean number of errors as a function of the mild and moderate levels of intellectual functioning, for A-T-1 and A-T-P.

A series of t-tests were conducted to clarify the source of the above interaction. The mean number of errors to criterion within the mild group for A-T-1 was 29.6. The mean (mean number of errors) for A-T-P within the mild group was 1.1. A comparison of the latter two means, using a t-test, showed them to differ significantly,  $t = 12.6, df = 28, p < .01$ . Similarly, comparisons were carried out for A-T-1 and A-T-P within the moderate group. The mean number of errors reported for A-T-1 and A-T-P within the moderate level of functioning were 57.5 and 7.2 respectively. A comparison of these means using a t-test showed them to differ significantly,  $t = 18.7, df = 28, p < .01$ . All remaining comparisons of A-T-1 and A-T-P across Groups (levels of functioning) showed the means to differ significantly ( $p < .01$ ).

(c) Auditory-Visual Analyses. A Groups (2) x Order (2) analysis of variance was carried out to examine Order of Presentation effects across moderate and mildly retarded groups, for the auditory-visual (V-T) matching tasks. The mean number of errors for the mildly and moderately retarded groups were 16.7 and 33.0 respectively. From Table 9 it can be seen that the Groups effects were found to be significant,  $F(1, 56) = 17.7, p < .01$ . Within this analysis, the mean number of errors for A-V-1 and A-V-P were 34.7 and 19.9 respectively.

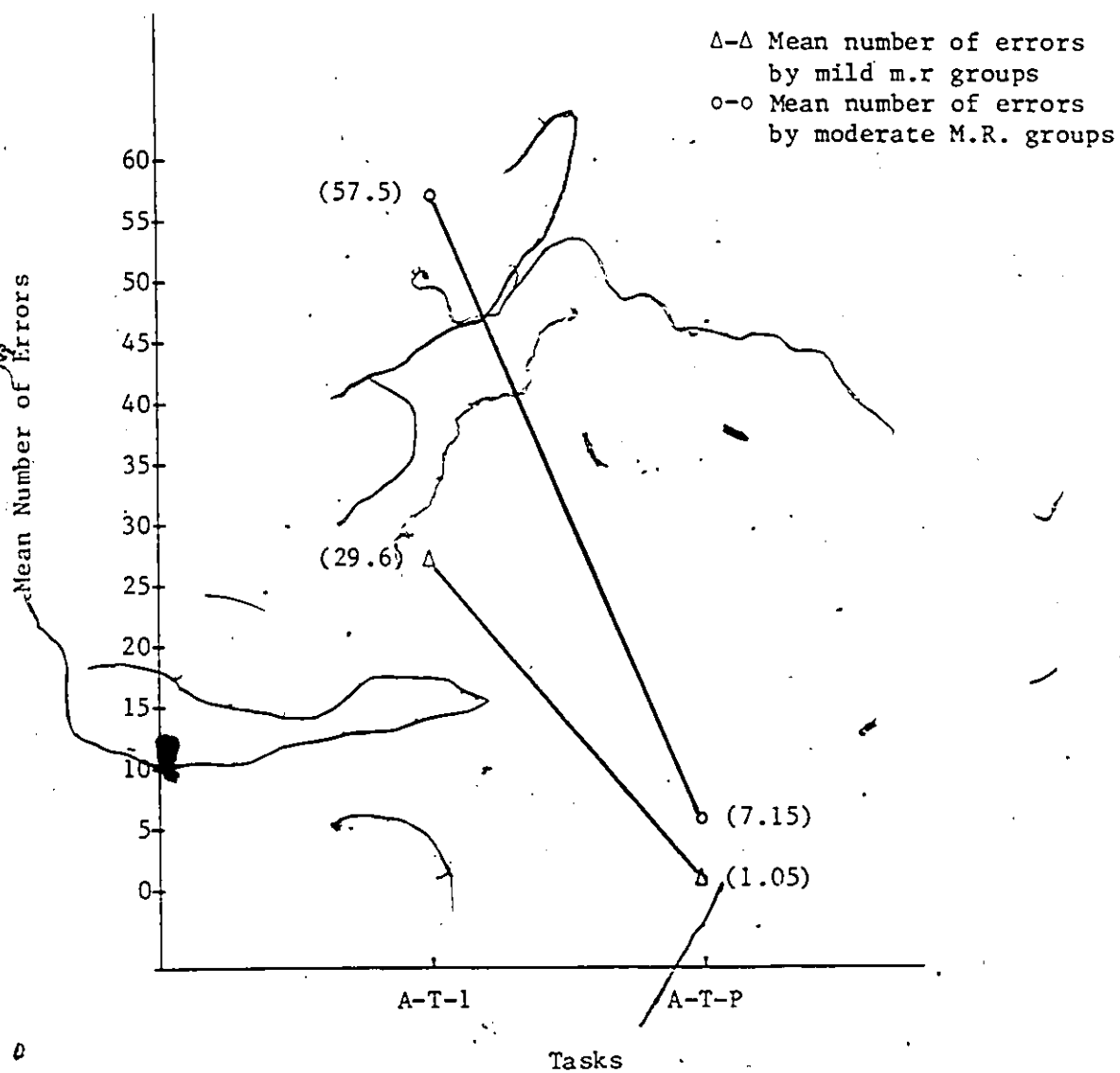


Fig. 7. Mean number of errors for A-T matching task when presented first (A-T-1) as opposed to when it was preceded by other tasks (A-T-P), for moderate and mild levels of retardation.

Table 9  
 Summary of the Analysis of Variance for Unequal Cells,  
 Using Total Errors From the Auditory-Visual  
 Matching Condition

Source of Variance	SS	df	MS	F
Between Groups	583.9	3		
A (Level of Functioning)	332.2	1	332.2	17.7*
B (Order of Presentation)	218.3	1	218.3	11.6*
AXB	33.4	1	33.4	1.8
Within Groups (error)	1050.5	56	18.8	
Total	1634.4	59		

Note: \*  $p < .01$

The source of variance representing the difference between these means yielded a significant Order effect,  $F(1, 56) = 11.6, p < .01$ . Figure 8 provides a graphic display of the mean number of errors across the moderate and mild Groups for A-V-1 and A-V-P. The Groups x Order interaction for the above conditions was found to be not significant,  $F(1, 56) = 1.8, p > .05$ . As a result of this lack of significant interaction, no further tests for simple effects were conducted with the above groups.

The above auditory-visual task was immediately preceded by the A-T matching task on some occasions (in condition  $C_2$ ), and by the V-T matching task on other occasions (in condition  $C_3$ ). Thus, a Duncan's Multiple Range test was carried out to examine and compare the mean errors for the auditory-visual tasks in conditions  $C_2$  and  $C_3$  across moderate and mild levels of functioning. The mean number of errors to criterion for the auditory-visual matching tasks (A-V) when it was preceded by the auditory-tactual (A-T) matching task, was 4.6 and 0.8 respectively for the moderate and mildly retarded groups. A comparison of these means using a Duncan's Multiple Range test showed them not to differ significantly at the required probability level ( $p > .05$ ). When the A-V matching task was preceded by the visual-tactual (V-T) matching task, the mean number of errors to criterion for the moderate and mildly retarded groups was 47.7 and 26.6 respectively. A comparison of these latter means for the A-V tasks, using a Duncan's Multiple Range test, showed them to differ significantly ( $p < .05$ ). Similarly, all remaining comparisons of A-V tasks within

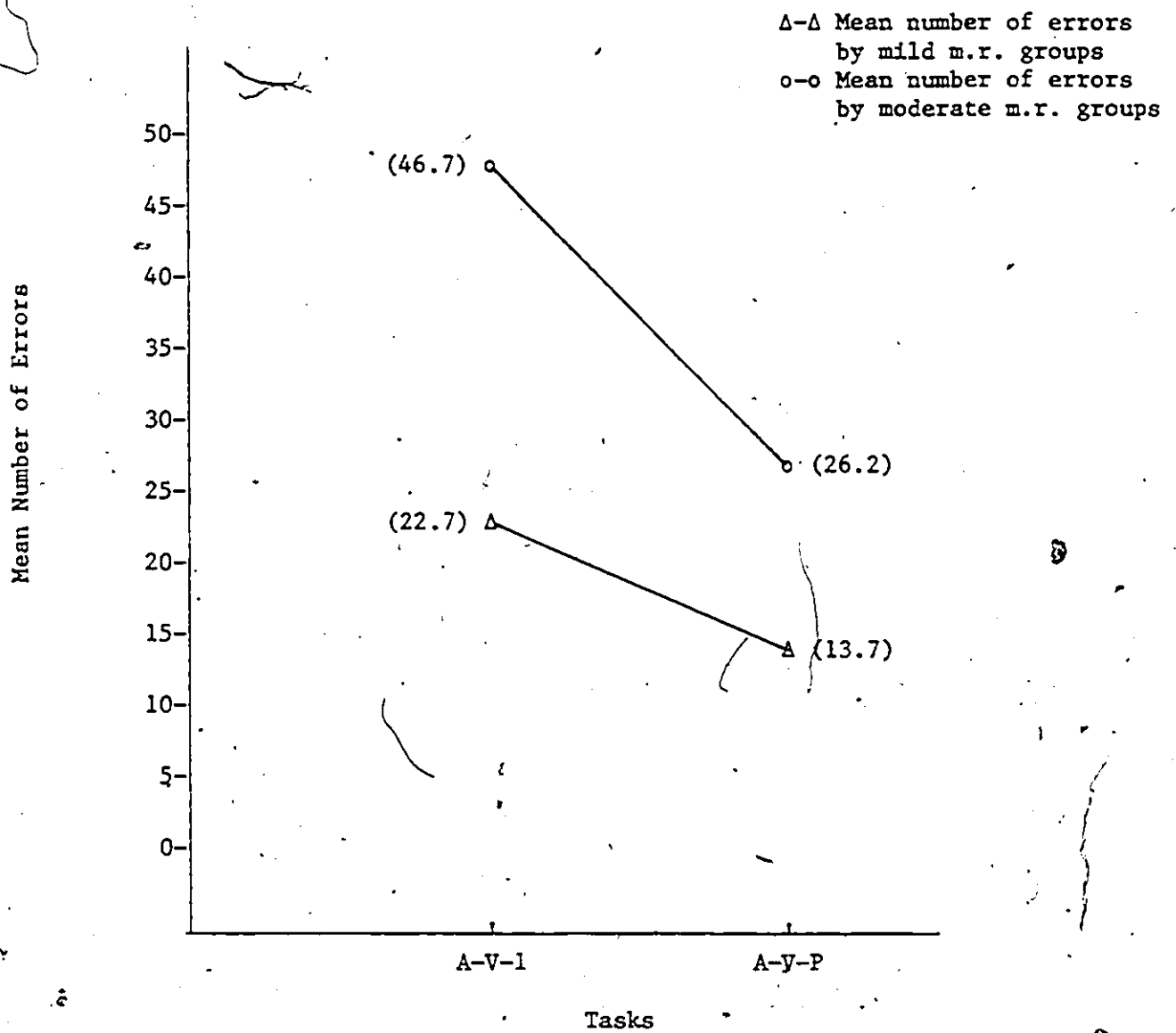


Fig. 8. Mean number of errors for the A-V matching condition when this was the first task presented (A-V-1) as opposed to when it was preceded by other tasks (A-V-P), for moderate and mild levels of retardation.

and across the moderate and mild levels of functioning were also found to be significant ( $p < .05$ ). The means representing the errors across the moderate and mild levels of functioning, for the different Orders of Presentation (i.e., A-V preceded by A-T; A-V preceded by V-T), are shown in Figure 9.

The above results would suggest that the A-T matching task produced superior transfer of training effects on the subsequent A-V task, as compared to the V-T matching task. Furthermore, these results would appear to be consistent across both the moderate and mild levels of functioning.

(d) Overall Transfer. To compare overall transfer effects across levels of functioning for the three Orders of Presentation used in the present study ( $C_1$ ,  $C_2$ , and  $C_3$ ), a final Groups (2) x Order of Presentation (3) analysis of variance was carried out. The mean number of errors for the final tasks in conditions  $C_1$ ,  $C_2$ , and  $C_3$  across all levels of functioning were: 0.8, 1.7, and 5.4 respectively. From Table 10 it may be seen that a comparison of these means suggests that the source of variance representing the difference between these means yielded a significant  $F$ ,  $F(2, 54) = 15.9$ ,  $p < .01$ . Furthermore, as in all previous analyses, the source of variance representing the difference between Group means, was significant,  $F(1, 54) = 29.3$ ,  $p < .01$ . The significant Groups x Order of Presentation interaction within this analysis,  $F(2, 54) = 8.3$ ,  $p < .05$ , however, qualifies all main effects. Thus,  $t$ -tests were carried out to compare individual Group means within each of the moderate and

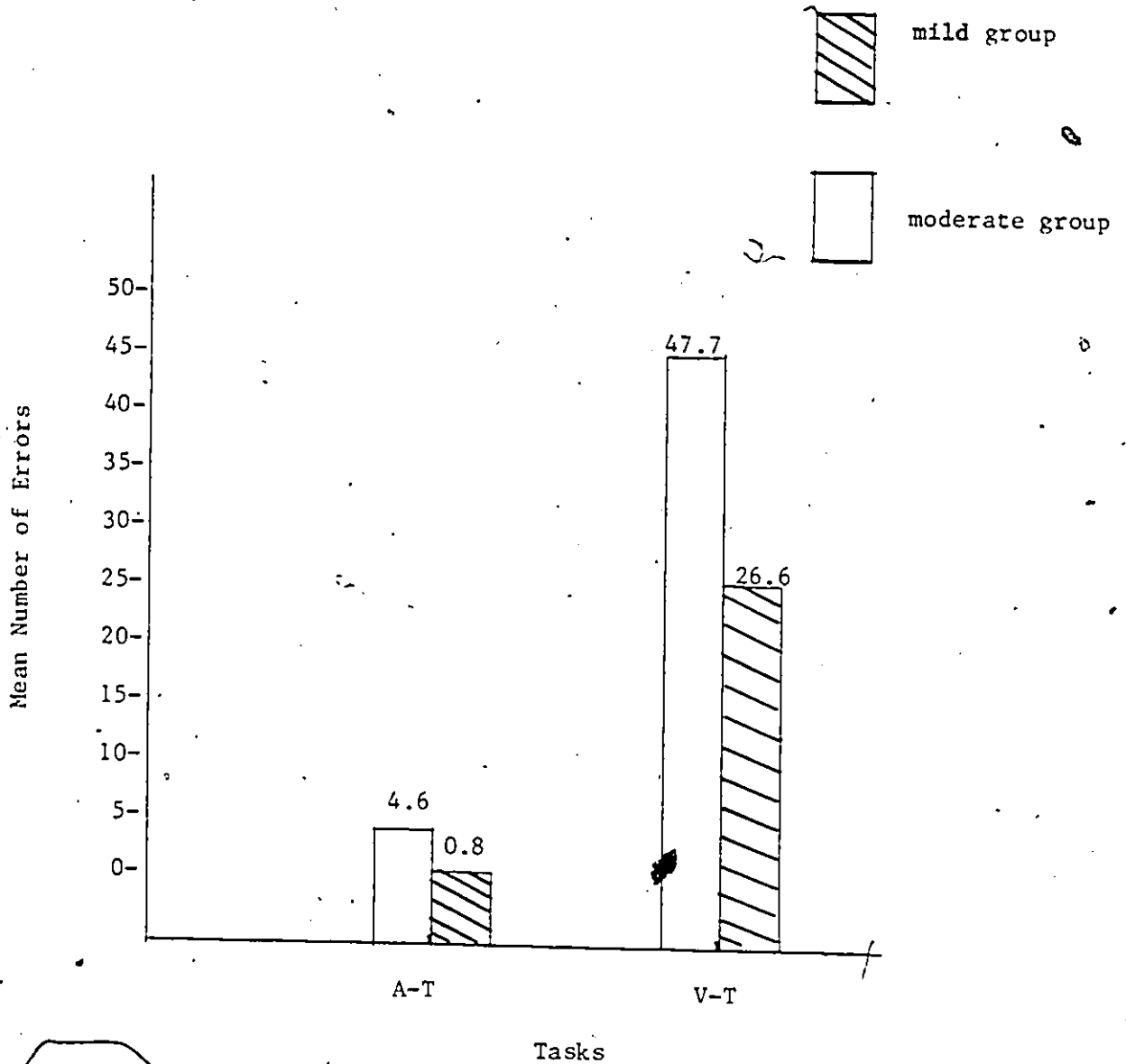


Fig. 9. Mean number of errors for the A-V matching task when this was preceded by the A-T matching task as opposed to when it was preceded by the V-T matching task, for moderate and mild levels of retardation.

Table 10

Summary of the Analysis of Variance for Total Errors From  
Final Tasks Across Levels of Functioning

<u>Source of Variance</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>F</u>
Between Groups	575.6	5		
A (Level of Functioning)	216.6	1	216.6	29.3*
B (Order for Final Tasks)	235.9	2	117.8	15.9*
AxB	123.1	2	61.5	8.3*
Within Groups (error)	398.8	54	7.4	
Total	974.4	59		

Note: \*  $p < .01$

mild levels of functioning.

The mean number of errors for the final tasks within the moderate level of functioning were: 1.2, 3.1, and 9.2 for conditions  $C_1$ ,  $C_2$ , and  $C_3$  respectively. A comparison of the mean number of errors for the final tasks in conditions  $C_1$  and  $C_3$  (3.1 and 9.2) yielded a significant difference,  $t = 3.2$ ,  $df = 18$ ,  $p < .05$ . All remaining comparisons were not significant at the required level of probability ( $p > .05$ ). Similarly, all comparisons of the final tasks within the mild range of functioning were found to yield  $t$  scores which were not significant at the required probability level ( $p > .05$ ). These latter results would suggest that all Orders of Presentation within the mild range, yielded similar amounts of transfer to final tasks, whereas in the moderate range, the  $C_3$  condition resulted in the least overall transfer to the final task; conditions  $C_1$  and  $C_2$  producing similar transfer of training effects.

## CHAPTER IV

### DISCUSSION

The major purposes of the present study were: (a) to examine the relationship between intellectual level of functioning, and sensory integration abilities of moderate and mildly retarded adults; (b) to clarify the role of intra-modal integration in the overall sensory integration process; (c) to compare modality discrimination and matching abilities within and across selected levels of intellectual functioning, and specific to the three sensory modalities used - i.e., information presented visually, auditorily<sup>3</sup>, and tactually; (d) to expand on the role of verbal labelling in the cross-modal transfer of sensory information.

#### (a) Level of Functioning and Sensory Integration

The present study is unique in that it provides a comparison of sensory integration skills across levels of intellectual functioning. Prior studies have chosen to focus on comparisons of normal and sensory or developmentally impaired groups. The groups of developmentally handicapped subjects of these prior studies have usually consisted of subjects combined across several levels of functioning (retardation).

The results of the present study suggest that intellectual level of functioning greatly affects the ability of the adult subject

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<sup>3</sup> The auditory task in the current study was more heavily weighted verbally than in other studies (e.g., Hermelin and O'Connor, 1971; Jarman, 1979), wherein the auditory stimuli used were sounds or tones. In the present study, the auditory task could be viewed largely as a verbal condition.

to perform both intra-modal and inter-modal matching tasks. That is, mildly retarded subjects recorded significantly fewer errors overall across intra and inter-modal tasks, than their moderately retarded counterparts. Nevertheless, in spite of requiring more trials to attain criterion performance, all subjects in the moderately retarded groups (as well as mildly retarded subjects) mastered all tasks received. These latter results would appear to support the Developmental Lag Theory as outlined by Clarke and Clarke (1975) and by Zigler (1969).

The Developmental Lag Theory suggests that cognitive development in the mentally retarded person, is characterized by a slower progression through the same sequences of cognitive stages as the normal or higher functioning individual, but by fewer units to maximum development. Thus, one would expect that the performance of the moderately and mildly retarded subjects should vary markedly only with respect to this "slower progression" or more trials and errors to criterion. The above results also appear to support the findings of Zeaman and House (1963; 1979) wherein the difference between the higher and lower functioning subject samples, was seen in the number of trials required before improvement in performance (number of correct responses) began. Zeaman and House (1963) attribute their findings to an attentional deficit which appears to become more pronounced across lowered levels of intellectual and cognitive development. They suggest that retarded persons are not focusing on the relevant stimulus dimensions. Well, Lorch and Anderson (1980)

have chosen to view this attentional issue in terms of distractability. They suggest from their findings that this distractability is related to cognitive development. Thus, it would appear that the Developmental Lag Theory, and the Attentional Theories are in many ways compatible, in that each suggests that in the development of the retarded person, as in normal development, the individual must learn to attend to the relevant stimulus dimensions.

Due to the varying sensory nature of the stimulus dimensions in the present study (auditory stimuli, visual stimuli, and tactual stimuli), it was imperative that the subjects were able to select and attend to the relevant stimulus dimensions across the different sensory modalities. However, since the reported difference between the moderate and mildly retarded groups in the present study appeared most specific to the tactual modality, it would appear that attention to the relevant stimulus dimensions was most impaired during the tactual matching tasks. These results would support Jarman's (1979) hypothesis that sensory integration may be viewed as "modality specific" in early developmental years - i.e., each sensory modality having separate qualities and capabilities, with cognitive development being a process of increasing intersensory organization. Jarman (1979) suggests that this integration of information changes to a "non-modal" processing at a later point (approximately 7 years of age), as part of a cognitive - developmental shift.

A breakdown of the variance (total errors to criterion for moderately and mildly retarded groups) in terms of intra and inter-

modal comparisons, as well as a further breakdown in terms of separate sensory modalities involved, appear to provide some explanation for the large differences in the performances of the moderate and mildly retarded adult subject samples.

(b) The Role of Intra-Modal Matching in Sensory Integration

All subjects within the present study were required to master all intra-modal matching tasks to a criterion of 16 consecutively correct responses. This was done both to examine intra-modal integration of sensory information, but also to examine inter-modal performance once all subjects had been equated on intra-modal tasks. It was hypothesized in Chapter I that because of the nature of the present tasks, and the levels of functioning and chronological ages of the subjects, no difference should be reported in the performance of the moderate and mildly retarded subjects on the intra-modal tasks. The results, however do not support this null hypothesis. Upon closer examination of the results, it would appear that the difference in the performances of the moderate and mildly retarded subjects within intra-modal tasks, is due to the extreme difficulty experienced by the moderately retarded subjects on the tactual-tactual matching task. These results reflect similar results reported by Jones and Robinson (1973), by Bryant and Raz (1975), and by Zung (1971).

Milner and Bryant (1970) had suggested that the developmental increases in the accuracy of subjects' cross-modal performance must

be attributable to intra-modal discriminations rather than to altered inter-sensory relations alone. The results of the present study, however, do not support the hypothesis by Milner and Bryant (1970). The present results suggest that even after all subjects are equated in terms of their performance on intra-modal matching tasks, moderate and mildly retarded subjects continued to differ very significantly in their performance on cross-modal matching tasks. These results would suggest that cross-modal relations remain to be learned in addition to, if not independent of intra-modal relations. This latter hypothesis would appear to receive considerable support from the results of the study by Jones and Robinson (1973).

In the Jones and Robinson (1973) study, the Age x Modality interaction suggests that the developmental gains in intersensory integration were made by the subjects, unrelated to intra-modal discriminations. This would thus suggest that intra-modal and inter-modal integration of information appears to involve separate processes. That is, intra-modal learning appears to involve the mastery and utilization of concepts such as "the same as" and "different from"; it involves equivalence judgements, and thus basic discrimination skills on a single modality or sensory level. Inter-modal integration involves the above processes, but also the ability by the individual to equate or associate information across modalities - i.e., information not involving identical units or elements of information. The establishment of these processes appears to relate to cognitive development (Abravanel, 1968; Davidson, Pine, Wiles-Kettenmann and

Appelle, 1980). One explanation therefore, for the apparent discrepancies between the Milner and Bryant (1970) study, and the present study, would be that the subjects in the Milner and Bryant (1970) study ranged in ages from 5 years to 7 years; whereas the subjects in the present study were all adults with estimated mental ages of 8 to 12 years. Thus, it might be suggested that for the 5 to 7 year age group, most developmental changes occur in the intra-modal relations. In the 8 to 12 year group, however, most intra-modal relations are established, and inter-modal relations remain most outstanding.

This above hypothesis would be very consistent with the cognitive - developmental shift period proposed by White (1965). In this latter shift period (from ages 5 to 7 years), information processing shifts from being modality specific (i.e., intersensory organization consisting of separate qualities and capabilities for each sensory modality) to being non-modal specific (i.e., all modalities processing information with similar capabilities, and with language serving to integrate them). This "shift" concept is also supported by the work of Jarman (1979) described earlier. The performance of the moderate and mildly retarded subjects in the present study reflect this latter shift; that is, intra-modal or modality specific relations appear well established, and resulted in significantly fewer errors and trials to criterion, than the matching tasks requiring the establishment of inter-modal relations. These results would also be consistent with the normal developmental trend described by Abravanel (1968) and McChie (1970), which suggest that a

great deal of intersensory organization begins to develop between the ages of 3 to 7 years, and reaches full maturity only by 11 years of age ( Birch and Lefford, 1967).

(c) Sensory Modalities - A Comparison and Analysis

Tasks requiring the processing of information within and across three sensory modalities were used in the present study. These modalities were the auditory, visual and tactual, sensory modalities. From the results of the present study, it would appear that the source of variance representing the different sensory modalities, produced a significant effect on the dependent measures used (i.e., total errors and trials to criterion). That is, consistent with earlier studies by Jones and Robinson (1973), Byrant and Raz (1975), and Davidson, Cambardella, Stenerson and Carney (1974), tasks involving tactual matching were considerably more difficult than auditory or visual matching tasks - particularly for the moderately retarded subjects. Most moderately retarded subjects had to be verbally prompted; however their explorations seemed to be meaningless during the initial trials. That is, the motions of exploration were present, but appeared to be largely random motions. Furthermore, for most moderately retarded subjects, in spite of earlier tactual-tactual training (matching), the subjects seemed to require several trials before they began to utilize this tactual information on the inter or cross-modal matching trials. These results would appear to reflect a "learning - to - learn" phase, not unlike

that proposed by Zeaman and House (1963), or Lovaas, Koegel and Schreibman (1979). It was suggested above, however, that the present results reflect a sensory specific lag rather than a "general" attentional deficit proposed by Zeaman and House (1963), or a dimension selection deficit discussed by Lovaas, Koegel and Schreibman (1979). That is, the results of the intra-modal matching tasks within the present study, appear to reflect poor sensory (tactual) development, and thus a resulting impairment or lag in the subjects' attention to relevant tactual stimulus dimensions. This latter attentional-specific model is suggested in place of the Zeaman and House (1963) general attentional deficit, since all subjects completed all non-tactual intra-modal tasks with very few errors.

An examination of the performance of the moderately retarded subjects, shows that on the intra-modal matching tasks, their tactual-tactual matching performance differed significantly from their performance on the visual-visual or auditory-equivalence matching tasks, in terms of total errors to criterion. The above observations regarding the tactual exploration by the moderately retarded subjects, along with the fact that all trials involved simultaneous matching, and thus little or no memory component, lends strong support to the hypothesis that poor performances by subjects on the intra-modal, tactual matching task, stems from either poor discrimination of tactual information and/or poor tactual inputting, rather than unstable tactual memory as suggested by Davidson, Cambardella, Stenerson, and Carney (1974). These results would thus support earlier studies

by Bryant and Raz (1975), Smith and Tunick (1969), and by Zung (1971). These studies interpret their findings regarding the tactual matching tasks, as stemming from poor tactual discrimination. Jones and Robinson (1973) offer a similar explanation, choosing however to refer to the poor tactual performance as stemming from poor tactual inputting. The fact that the mildly retarded subjects experienced no particular difficulty with the tactual-tactual matching task as compared with other intra-modal matching tasks, suggests that the tactual discrimination skills may be related to the level of cognitive development of the individual.

The above results would support the earlier work of Baumeister (1967) who suggested that as mental deficiency becomes more severe, one can expect a progressive deterioration of many normal motor skills. Thus, the tactual inputting theory of Jones and Robinson (1973) would appear particularly relevant, in light of the apparent deterioration of motor skills, proposed by Baumeister (1967) and supported by the results of the present study. Thus, motor skills development appears to be of particular importance to sensory - integration, particularly with respect to the processing of tactual information. Jones (1972) has suggested that sensory integration depends on neuroanatomical links between the different sensory areas via the motor cortex. Furthermore, Baumeister, Hawkins and Holland (1966) have suggested that in spite of a progressive deterioration of many normal motor skills across lower levels of mental retardation, for many of these skills, practice improves performance dramatically.

This trend is reflected in tactual components of tasks used in the present study, and the tactual discrimination skills of the subjects, particularly the moderately retarded subjects participating in the study. The performance of the moderately retarded subjects on the tactual (motor) tasks was initially very poor, but improved with practice. Although the other tasks followed this same trend, the tactual tasks involving manual exploration and subsequent discriminations, appeared to provide significantly greater difficulty, as reflected in both the trials and errors to criterion, but also by the overt problem solving behavior of these subjects. That is, the moderately retarded subjects were not able to utilize this tactual information as readily as their mildly retarded counterparts, experiencing some apparent confusion with it. However, similar to the Baumeister, Hawkins and Holland (1966) results, the subjects in the present study demonstrated the same ability to acquire this motor skill (tactual exploration and discrimination) with practice.

(d) Sensory Modalities and Cross-Modal Matching

An examination of the results for both the moderate and mildly retarded subjects on inter or cross-modal matching tasks involving a tactual component, show a trend similar to that described above. That is, on the visual-tactual matching task, the mildly retarded subjects appeared to experience no particular difficulty with this matching; regardless of whether the visual-tactual task was presented first, or was preceded by other matching tasks. In

both conditions, visual-tactual matching was very easy for the mildly retarded subjects. For the moderately retarded subjects, however, a significant difference in the number of errors to criterion was reported, when the visual-tactual matching task was presented first, as opposed to when it was preceded by other matching tasks. Thus, the moderately retarded subjects continued to experience difficulty with the utilization of tactual information during the visual-tactual cross-modal matching as they did for the tactual-tactual intra-modal matching; with this difficulty being particularly great when the visual-tactual matching task was presented first. These results would appear to be consistent with the above intra-modal matching test results in suggesting a particularly lengthy learning-to-learn phase for the moderately retarded subjects in the discrimination of tactual information (as compared to the performance of the mildly retarded subjects on the same task). As with the tactual-tactual intra-modal matching task, the visual-tactual cross-modal matching task placed very little memory demands on the individual, since all trials involved the simultaneous presentation of sample and choice stimuli.

Of particular interest during the visual-tactual matching task, was the behavior of the moderately retarded subjects. The moderately retarded subjects tended to close their eyes following the visual examination of the sample stimulus, and during the tactual exploration of the choice stimuli. It would appear from this behavior that the subjects were experiencing considerable visual

interference during the matching; to the point where they were unable to perform both visual and tactual examinations simultaneously. This hypothesis was further reinforced by the initial behavior of most moderately retarded subjects who made several attempts during the first eight trials to visually see the hidden choice (tactual) stimuli. In spite of tactually exploring the choice stimuli, the moderately retarded subjects appeared frustrated on these initial trials, at being able to see the sample stimulus, but apparently being unable to process or use the tactual information from the choice stimuli. This behavior and hypothesis would be consistent with Jones and Robinson's (1973) interpretation of their subjects' poor performance on their tactual matching tasks. Jones and Robinson (1973) attribute the poor performance of both the retarded and the non-retarded subject samples within their study, to poor tactual inputting. It would appear from the present study that this poor tactual inputting may have been as a result of visual interference, since most moderately retarded subjects utilized an eye-closing strategy to successfully perform the visual-tactual matching task. That is, it can be argued from this data, that the visual interference was inhibiting sensory input at the tactual level, and that once this interference was removed (by closing one's eyes), the subject became able to focus on the mental images of the sample stimulus, and the tactual information from the choice stimuli, and in this way proceed with the required discriminations and subsequent cross-modal associations. This latter explanation is reported by

Rose, Blank and Bridger (1975) and by O'Connor and Hermelin (1978).

Rose, Blank and Bridger (1975) discuss the retention of visual information in terms of "visual images". They suggest that the subject forms images of the visually presented stimuli. This hypothesis would appear consistent with the behavior displayed by the moderately retarded subjects in the present study - i.e., closing their eyes following the visual examination of the sample stimulus, and attempting to focus on this "image" that Rose, Blank and Bridger (1975) discuss, while exploring the tactualy presented choice stimuli.

Rose, Blank and Bridger (1975) go on to discuss their results which suggest that this "visual image" may be incomplete in some way, and therefore only sufficient when matching within the original modality is required (e.g., visual-visual matching). Therefore, when the stimulus is re-presented in a different modality (e.g. from a visual sample to tactual choices), the image would be incomplete and insufficient for a match, thus providing some of the frustrated behavior exhibited (e.g. attempting to look in the apparatus' slots to see the tactual stimuli) during the tactual cross-modal matching.

O'Connor and Hermelin (1978) suggest that : (a) sensory codes determine the manner in which data is structured; and (b) the processing modality might not be the same as the stimulus modality. Thus, in the present study, it can be argued that although the stimulus modality was touch, the subjects attempted to re-code this information via mental (visual) images representing the tactual information, thus facilitating the processing of the information through the recoded

and better established modality.

(e) Transfer Effects Across Sensory Modalities

It would appear from the present study, that not only is tactual inputting particularly poor within the moderately retarded participants, but that the storage of tactual information appears to be susceptible to very rapid decay. This can be seen from the poor performance of the moderately retarded subjects on the visual-tactual matching task, when this was the first cross-modal matching task provided, and was thus presented within 24 hours of the tactual-tactual intra-modal matching task. This hypothesis is further reinforced by the data from the Orders of Presentation  $C_1$  and  $C_2$  for both the moderate and mildly retarded groups. These results would support the hypothesis suggesting that the storage of tactual information is subject to rapid decay, since transfer was greatest in the visual-tactual matching task most closely preceded by a tactual matching task. These results would also lend support to the hypotheses proposed by Davidson, Cambardella, Stenerson and Carney (1974), by Posner (1967), and by Rose, Blank and Bridger (1975), which suggest that tactual retention of information is often very poor, especially when compared to the retention of visual or auditory information. Thus, it would appear that tactual information presents several difficulties for the moderately retarded person, both in terms of inputting and in terms of memory or storage for later utilization or integration. The performance of the mildly retarded subjects on the tactual-tactual and visual-visual matching tasks also lends further support to the hypothesis that tactual development is related to cognitive development.

The above results regarding subjects' performances on the auditory-tactual matching tasks also reflect the transfer of information across matching tasks. That is, both moderate and mildly retarded subjects appeared to be utilizing information received in the "preceding" tasks, to carry out auditory-tactual (A-T-P) matching, with very few errors to criterion. These results would be consistent with those reported by Sidman and Cresson (1973), wherein learned equivalences of spoken (dictated) words to pictures and to printed words transferred to the purely visual equivalences of printed words to pictures.

The effects of the third cross-modal matching task, the auditory-visual matching task, were also examined across all conditions for moderate and mildly retarded groups. An examination of this data reveals that the subjects in both groups (mild and moderately retarded) experienced considerably greater difficulty with the auditory-visual matching task when this task was preceded by the visual-tactual matching task as opposed to the auditory-tactual matching task. That is, the presentation of the auditory-tactual matching task resulted in significantly greater transfer effects to the subsequent auditory-visual matching task, than the presentation of the visual-tactual task on this same auditory-visual task. These results would support earlier findings of Conroy (1978), Ettinger (1968) and O'Connor and Hermelin (1963), where it was reported that the use of verbal labels greatly enhanced the transfer of information across tasks. Presumably, these labels serve as internally generated cues for the reconstruction of visual and tactual information (Brown, 1974; Conroy, 1978). It would appear from these results of the present study,

that information encoded verbally (in verbal or echoic memory) is recalled better, and thus results in superior transfer, than information which is encoded tactually or visually. These results would further support the hypotheses proposed by Davidson, Cambardella, Stenerson and Carney (1974), and by Posner (1967) which suggest that tactual retention of information is often extremely poor in comparison to the retention of visual or auditory information. The present results would also support earlier findings by Conrad (1972) which suggest that visually presented information must be encoded auditorily in short term memory before it can be used by the individual. Thus, in the present study, the auditory-tactual matching task led to superior transfer on the subsequent auditory-visual matching task, since the subjects were able to make use of common verbal labels or codes learned in the preceding (auditory-tactual) matching task. In the visual-tactual matching task, however, the subjects were required to re-code the visually presented information auditorily during the matching task; and they were required to make use of this recoded information on the subsequent auditory-visual matching task.

It was hypothesized earlier, that no difference would be found in the overall transfer effects across tasks for the moderate and mildly retarded groups, as measured by total errors to criterion on the final tasks. This hypothesis of "no difference" was not supported.

by the present results. It was found that the mildly retarded subjects consistently made better use of previous training in transferring learned equivalences to the final tasks. Consistent with Hebb's (1948) hypothesis of maximum benefit of transfer being a function of early development, all subjects did display excellent transfer of training effects; with correct responding on the initial eight trials for each of the final tasks ranging from 70% to 100%. Task complexity, the major variable described by Hebb (1948) to effect transfer, appeared to be at the basis of the above difference in the performance of the moderate and mildly retarded subjects. That is, the above difference between the groups appeared to be most directly attributable to the poor performance of the moderately retarded subjects on the final auditory-tactual matching task, wherein the mean number of errors to criterion was 9.2, significantly higher than all other mean errors for final tasks. It would appear therefore, that in spite of the verbal labels available, the addition of the tactual information resulted in a "confusion" effect, as compared with the visual information which seemed to compliment and enhance the effectiveness of the verbal information (labels).

The above cross-modal confusion was experienced largely by the moderately retarded group, as compared to the mildly retarded subjects who appeared to better utilize verbal labels. These results would support Jarman's (1979) hypothesis suggesting that language becomes more predominant in integrating a single type of information-processing common to all modalities.

### Suggestions For Future Research

In light of the findings of the present study, future research in the study of sensory integration and the mentally retarded, should focus on the effects of verbal label training (i.e., training in the generation and utilization of verbal labels), and movement training. Since a sensory lag specific to the tactual modality was felt to create an imbalance across modalities, this appeared to create an apparent breakdown in the sensory integration process, as described by Jones and Robinson (1973). Thus, attempting to bring the sensory modalities in balance via the above pre-training, should enhance the exchange and transfer of information across modalities. Perhaps an initial comparison using familiar objects or stimuli would provide a starting point to be followed by training in the utilization of verbal cues or labels, and extensive motor-training of the variety utilized by Ayres (1972). It would appear that these latter forms of training should enhance sensory integration and thus cognitive development.

Furthermore, comparisons of cognitive-developmental deficits and sensory deficits in the study of sensory integration, appear to provide avenues for further understanding of the "re-coding" process outlined by O'Connor and Hermelin (1978), and discussed herein. Thus, future research should incorporate sensory-impaired comparison groups (e.g., blind or hearing impaired subjects), in addition to different levels of developmentally handicapped subjects.

## SUMMARY

The present study was carried out to examine sensory-integration skills of moderate and mildly retarded adults. Thirty moderate and thirty mildly retarded subjects participated in the study. All subjects received both intra-modal and inter-modal matching tasks, in an effort to compare the difficulty of each of these types of tasks, as well as to clarify the relationship between intra and inter-modal integration abilities; particularly with respect to the role of intra-modal integration in the overall sensory integration process. For intra-modal matching, three tasks were used, each specific to one sensory modality. The three matching tasks used were: visual-visual matching, auditory-auditory matching, and tactual-tactual matching. The presentation of these tasks was randomly determined, with equal numbers of subjects within each condition.

For inter-modal matching conditions, three orders of presentation were used to examine transfer of training effects across the moderate and mild ranges of mental retardation. The role of verbal labelling and tactual discrimination were of particular interest herein. Thus, the three cross-modal matching tasks selected were: auditory-visual matching (A-V), auditory-tactual matching (A-T), and visual-tactual matching (V-T). The three presentation orders of interest, subsequently selected were:

(i) A-V followed by A-T, followed by V-T; (ii) A-T, followed by A-V, followed by V-T; and (iii) V-T, followed by A-V, followed by A-T.

The results of the study clearly indicated consistently superior performance (as measured by both trials and errors to criterion, with analyses performed on raw data as well as on the transformed data:  $\sqrt{X+1}$ ) on both intra and inter-modal matching tasks, by mildly retarded subjects, as compared to their moderately retarded counterparts. These results were discussed in terms of a Developmental Lag Theory, as well as Jarman's (1979) and White's (1965) models of modality specific vs non-modal processing, as this relates to a cognitive-developmental shift. That is, it is argued along the lines of the Developmental Lag Theory, that cognitive development in the moderately retarded person is characterized by a slower progression through the same sequences of cognitive stages as the mildly retarded, or higher functioning individual, but with lower units to maximum development.

The superior performance of the mildly retarded subjects over the moderately retarded subjects, for intra-modal tasks was restricted to the tactual-tactual matching task. With respect to the role of intra-modal integration, the results of the present study suggest that the inter-modal relations remain to be learned in addition to, if not independent of intra-modal relations. These results do not appear to support an earlier hypothesis by Milner

and Bryant (1970) suggesting that developmental increases in the accuracy of a subject's cross-modal performance must be attributed to intra-modal discriminations rather than altered inter-modal relations alone.

The results of the present study were also discussed in terms of the ability of the above subject samples to process information presented via the three different sensory modalities (auditory, visual and tactual). Consistent with earlier studies discussed in Chapter 1 of this text, tasks involving tactual matching were more difficult than auditory or visual matching tasks - particularly for the moderately retarded subjects. These tactual matching results appear to be related to poor tactual inputting. The moderately retarded subjects seemed to require several trials before learning how to classify or interpret the tactual information; and it was argued that much of this initial difficulty occurred at a sensory level. That is, the performance and behavior of the moderately retarded subjects during initial tactual matching tasks, seemed to reflect poor sensory (tactual) development, and thus a resulting impairment or lag in the subject's attention to relevant tactual stimulus dimensions.

In addition to the poor tactual inputting, it was felt that the storage of tactual information appeared to be susceptible to very rapid decay. Consequently, transfer of training appears poorest in tasks preceded by tactual matching tasks. Transfer

effects appear to be greatest in those tasks preceded by verbal labelling tasks (tasks providing auditory or verbal labels). These results were discussed in terms of coding, and the re-organization or translation of information presented in other modalities, into verbal codes.

Suggestions and recommendations for future research were outlined. Emphasis for this research was placed on verbal label training, and movement training; particularly as this relates to the applied work of Ayres (1972) and Kephart (1960). Suggestions were also made with respect to further explorations and comparisons of cognitive-developmental deficits, and sensory deficits (e.g. incorporating mentally retarded subjects, hearing impaired subjects, and blind subjects) as these effect sensory integration. ~

Recommendations for the applications of these findings for training the mentally retarded were outlined also. It was felt to be imperative that movement, motor and tactile training programs be established, and used in conjunction with other kinds of educational and training programs.

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