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INTERSENSORY INTEGRATION AND READING: A THEORY*

Oliver L. Hurley

Institute for Research on Exceptional Children

University of Illinois

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Intersensory Integration and Reading: A Theory

Clinical and experimental data suggest salient relationships between processes at the non-representational level of psycholinguistic functions and school achievement of children.

The question of the psycholinguistic processes necessary for a child to adequately learn to read has often been considered. The common answers have been in terms of "getting meaning", making the material meaningful, and so forth. Until recently, there has been little concern for the underlying psychological factors which contribute to the mechanics of the reading process. Recent research has led to a realization of the importance of such non-meaningful level processes as immediate memory, auditory closure, and orientation in space to the ability to learn to read. Nevertheless the reason why such processes should be important to learning and reading is unclear. There are suggestions that the importance of these processes may lie in their effect on intersensory integration and coordination. If this be so, then such intersensory integration should be related to unifying concepts.

This area of learning disabilities is in need of unifying concepts. This paper will present one such possibility. First, research relating to six key

concepts will be reviewed. Secondly, these six concepts will be synthesized into a theoretical model in which the notion of "intersensory integration" bridges the theoretical gap and serves as a unifying concept.

Review of the Literature

Since the theoretical framework is derived from a synthesis of several key concepts, the pertinent literature will be discussed under six headings corresponding to these concepts.

Concepts of Cognitive Growth

Piaget's theory (Flavell, 1963) relies heavily on the concept of schema. "A schema is a cognitive structure which has reference to a class of similar action sequences, these sequences of necessity being strong, bounded totalities in which the constituent behavioral elements are tightly interrelated." (pp. 52 - 53) Within a totality is a group of mutually dependent elements unable to function without each other. There are schemas of vision, hearing, touch, taste, and so on. These schemas are developed through the dynamic processes of assimilation and accomodation. Assimilation is the process of changing elements in the environment in such a way that they become integrated into the already existing structure of the organism. Accomodation occurs whenever a given experience results in the modification of the organism in such a way that further transactions with the environment are made more probable and possible. In a young

child, through these processes, new schemas are constantly being both created and integrated with other schemas. As the child grows older these initially separate schemata become integrated into new higher order schemas which in turn also go through a process of reciprocal assimilation.

> Observation shows that very early, perhaps from the very beginnings of orientation in looking, coordinations exist between vision and hearing... Subsequently the relationships between vision and sucking appear...then between vision and prehension, touch, kinesthetic impressions etc. These intersensorial coordinations, this organization of heterogeneous schemata will give the visual images increasingly rich meanings and make visual assimilation no longer an end in itself but an instrument at the service of vaster assimilations.
> (Piaget, 1952, p. 75)

An important point to remember here is that these intersensorial coordinations are necessary to the development of intelligence. A breakdown, then, in intersensory or intrasensory coordination of schemata will have an adverse effect on intellectual development. Normal development comprises the formation of organized, interlocking systems or networks of schemata. Assimilation and its resultant dynamic intercoordination of schemata are, for Piaget, a dominant component of intelligence.

Another important point is that assimilation, the coordinative process, becomes an instrument of cognition after having been a goal. To say it differently, it becomes automatic and more covert. It becomes less and less dependent upon physical actions, more and more abstract, and more internalized. Hence, schemata become more manipulable in the organization of cognitive material. The discussion of the sensory-motor period (Flavell, 1963, Chapter 3) is replete with references to

progressively more complex coordinations of schemata. In fact, this progression from primary to secondary to tertiary schemas and their coordination define this period of intellectual development which is a sine qua non for later developmental periods.

A third point is that visual imagery seems to play a dominant role in the process whereby assimilation becomes a tool at the service of cognition.

Cognitive growth, then, consists in part in the development of systems of representation as a means for dealing with information from the environment. The child proceeds from an action-pattern representation to a use of imagery and finally to the use of a symbol system. (Bruner, 1964)

Bruner (1964), in delineating these stages (action, iconic, and symbolic), emphasized that each stage subsumes the preceding one(s). He suggests that improved interaction between the senses accompanies the process. He points out that as long as the organism is dominated by image representations, it is not only tied to the immediate present, but will also experience great difficulty in developing symbolic representations. An individual who fails to develop adequately during the iconic stage will experience difficulties at the symbolic stage since the orderly and adequate development of the latter is predicated upon the orderly and adequate development of the former. The process of subsumption requires that deficits in earlier stages affect the development of later stages. Bruner cites supportive evidence which has demonstrated these stages in miniature with adults; viz., a minimal amount of motoric skill and practice seems to be

a necessary precondition for the development of an image to represent a certain sequence of acts.

There is, then, some theoretical and empirical basis for saying that integration of sensory inputs from differing modalities is an ontogenetic phenomenon. Further support is found in Hebb's neuropsychological theory of cell assemblies (1949) which relies heavily on successive integrations to produce higher order cerebral organization and thought processes. In fact, without integration of cell assemblies into phase sequences, phase sequences into phase cycles, and phase cycles into series and classes of phase cycles, the organism will sense no single experiences such as a "delicious steak" but isolated units of sensory stimulation such as the aroma of a steak (smell), its sizzling (auditory), or seeing it cooking (vision).

Birch and Lefford (1963) published a monograph which reported on the progressive childhood growth of patterns of intersensory integration and complementarity. This was a direct outcome of their basic research derived from a comparative psychological viewpoint. As Birch (1962) points out, and as has been discussed above, the evolution of behavior can be conceptualized as the process of development of intersensory patterning.

Birch and Lefford required their subjects to make a judgment of the identity or non-identity of simultaneously presented geometric forms from the Seguin Form Board. The sense modalities tested were those of vision, haptic (tactual, surface sensations through the hands and fingers), and

kinesthetic (sensory inputs obtained through passive arm movements). Their subjects, 73 boys and 72 girls, ranged in age from 5 to 11 years and had a median IQ of 115.

Results showed that errors in judgment decreased with chronological age. Errors of equivalence with non-identical forms and errors of nonequivalence with identical forms showed this negative correlation with age in all intersensory channels tested. The improvement in performance with age appeared to be adequately described by a typical logarithmic growth curve.

Birch and Belmont (1965) have demonstrated that auditory-visual integration efficiency improves with age with the most rapid development occurring between the ages of five and seven. This was based on a sample of 220 children with normal vision and hearing, ranging in age from 5-3 to 12-1.

Hunt (1961) has reviewed the same type of literature as discussed above, that relative to "learning set", and that pertaining to the programming of electronic computers to solve problems. He concludes that the quality and quantity of the organism's transactions with the environment determine, to some extent, the quality and style of that organism's later processing of information. Hunt says,

> Perception is a synthesis of elementary sensations, for perception may also be conceived as a system of relations with each relation itself being a whole. From such an assumption Piaget derives the notion that complex perceptual structures are the product of progressive construction arising from "adaptive differentiations and combinative assimilations." Perceptual constancies arise as central processes, derived from the aspects of objects that provide the most redundant patterns of input, become

> sufficiently autonomous to be evoked as a whole when the input concerned involves only small portions of the total pattern. (p. 254)

It is fairly obvious from this that assimilations become more and more abstract, the more they are expressed in the central process. This internalization can only occur if the organism has had the kinds of experiences which require certain types of assimilations to occur again and again, at different times, in different situations, with different stimuli. It is also clearly stated that throughout the life of the organism, he is called upon to make "differentiations and combinative assimilations." He must integrate incoming stimuli into a unit of experience. This would be accomplished only if there existed in his repertoire the assimilations required. (From computer programming, Hunt says, comes the obvious but often forgotten or ignored idea that you cannot program for what has not already been stored.) In the present context, the assimilations must be put into the central process before tasks requiring their use, in an automatic, matter-of-fact functional way, can be successfully handled by the organism. The evocation of the whole when stimuli are only a small portion of the whole would seem to be the mechanism (as with Hebb) whereby acts become automatic, habit-chains.

One more point is that these habit-chains are built from infancy. Early gaps in the assimilative process would force later deficiencies. The repetition of an act over and over again (function pleasure) is the mechanism by which the internalization of these information-processing strategies is accomplished. This "function pleasure" is accepted in infants

and toddlers but looked at askance in an older child of school age. This has the effect of preventing a previously-deprived child from reinforcing new assimilations. Also, the tasks usually given to the older child require the instantaneous elicitation of previous assimilations. If they have not been sufficiently "centralized", the child will experience some degree of difficulty.

Hunt, then, agrees with Piaget that assimilation becomes an instrument of cognition. He would go further, however, to say that since the types of assimilations--the tools of information processing--depend upon the quantity and quality of the child's encounters with the environment, the style of cognition also depends upon experience.

Delacato (1959, 1963) focuses his theory on the central processes. Delacato has developed a theory and accompanying remediation techniques based on the idea of "neurological organization." This neuropsychological theory holds that there are basic neurological developments which occur at different levels of the brain--medulla, pons, midbrain, and cortex.

> Neurological organization is that physiologically optimum condition which exists uniquely and most completely in man and is the result of a total and uninterrupted ontogenetic neural development. This development recapitulates the phylogenetic neural development of man...This orderly development in humans progresses vertically through the spinal cord and all other areas of the central nervous system up to the level of the cortex, as it does with all mammals. Man's final and unique developmental progression takes place at the level of the cortex and it is lateral (from left to right or from right to left to right).
> (1959, p. 19)

The basic idea of this theory is that if man doesn't progress

through this orderly progression, he will exhibit problems in mobility or communication. Delacato assumes that each person passes through all the stages of man's neurological evolutionary development. If the order is disrupted, the succeeding stages fail to develop properly. Consequently, the person fails to develop his maximum potential.

Environment and experience facilitate or disrupt this orderly progression. There are certain physical activities thought to be important to the neurological development at each level.

It is implicit in Delacato's theory that the functions of the lower cortical levels be of an automatic nature; instruments for further development rather than goals in themselves. The importance of intersensory patterning is implied in his theory, for the nature of his remedial practices involves this patterning and coordination.

Psycholinguistic Models

There has been a history of increasing interest in the development of diagnostic rather than classificatory instruments; tests for the diagnosis of molecular aspects of language functioning. One of the landmarks in this development was the publication of the Illinois Test of Psycholinguistic Abilities (ITPA). (McCarthy and Kirk, 1961)

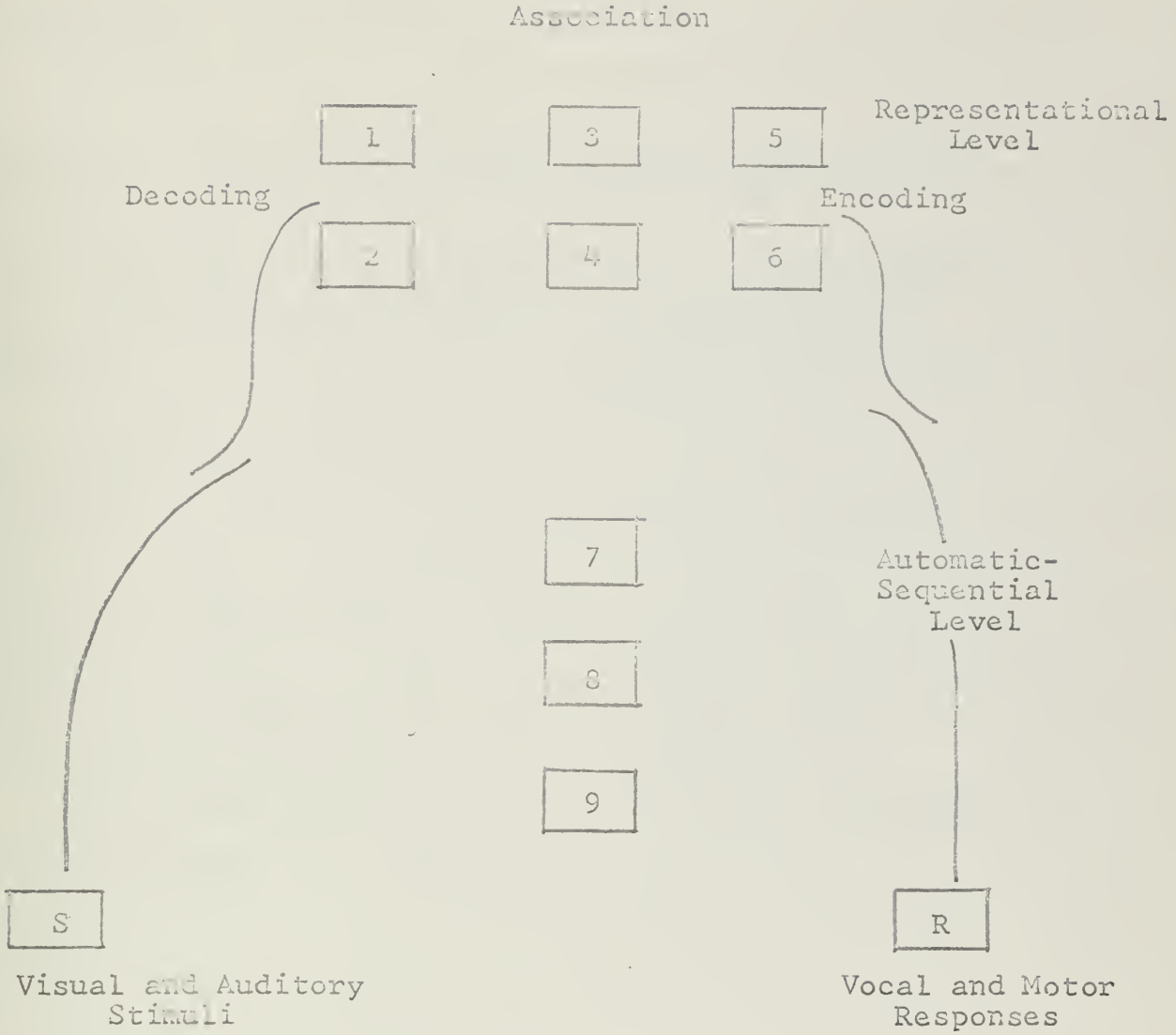
The ITPA was developed using the early psycholinguistic theory of Charles Osgood (1957) which postulated three levels of organization--projection, integration, and representation. The integrative level is of particular importance here. This level

was called the Automatic-Sequential level by McCarthy and Kirk. The tests developed for the ITPA at this level were the Auditory-Vocal Automatic Test, the Auditory-Vocal Sequential Test, and the Visual-Motor Sequential Test. There are no direct tests of the integrative process itself; i.e., the organization and integration of incoming and outgoing sensory units.

Wepman, Jones, Bock and Pelt (1960) presented a theoretical model of language which includes a level of organization called "Perceptual" which corresponds to Osgood's integrative level and McCarthy and Kirk's automatic-sequential level. This model was developed out of Wepman et al.'s clinical experiences with aphasics rather than from purely theoretical considerations as was Osgood's. Despite areas of difference, it is significant that these models, developed from differing frames of reference, both recognized the necessity for and the importance of a stage of integration in which discrete sensory units become coordinated into one unit of experience.

Bateman (1964), after extensive work with the ITPA, presents a new expanded model of psycholinguistic processes which clearly shows the kinds of tests lacking in the ITPA. She includes intersensory integration as one of the processes intermediate between receptive and expressive language. This is in addition to memory and closure processes which are already being sampled by the test.

The ITPA is the principal instrument of its kind and the one from which this research was germinated. The clinical model of the ITPA (Figure 1) presents three major dimensions--levels of organization, psycholinguistic processes, and channels of



Representational Level

1. Auditory Decoding
2. Visual Decoding
3. Auditory-Vocal Association
4. Visual-Motor Association
5. Vocal Encoding
6. Motor Encoding

Automatic-Sequential Level

7. Auditory-Vocal Automatic
8. Auditory-Vocal Sequential
9. Visual-Motor Sequential

Figure 1

The Clinical Model for
the Illinois Test of Psycholinguistic Abilities

(Kirk and Kirk,
1961, p.5)

communication. Two levels of organization are identified; viz., the representational level and the automatic-sequential level.

> The representational (or meaningful) level... mediates activities requiring the meaning or significance of linguistic symbols, and
>
> The automatic-sequential (or non-meaningful) level...mediates activities requiring the retention of linguistic symbol sequences and the execution of automatic habit chains. (McCarthy and Kirk, 1961, p. 3)

The three processes are decoding, encoding, and association. Decoding is the sum of habits required to gain meaning from sensory stimuli. Encoding is the sum total of habits necessary to express oneself verbally or motorically. Association is the totality of habits necessary to the manipulation of linguistic symbols internally, to relate one to the other.

Of the eight possible sensory-motor paths over which linguistic symbols are received and responded to, only the visual-motor and the auditory-vocal are used in the ITPA.

The individual subtests are listed in Figure 1. Fuller descriptions of these may be found elsewhere (McCarthy and Kirk, 1961). The three tests at the automatic-sequential level test either the results of an integrative process (auditory-vocal automatic) or immediate memory (the sequencing tests). Tests of associative ability are found only at the meaningful level. No similar tests of the coordinative process (stimulus-stimulus bonds) are found at the non-meaningful level.

Research with Children Using the ITPA

Kass (1962) sought to discover some psychological correlates of dyslexia. She tested 21 children with severe reading disabilities who were between 7-0 and 9-11 years of age and of normal intelligence. She administered the ITPA plus five supplementary tests at the integrational level. These were tests of visual closure, sound blending, mazes, memory for designs, and perceptual speed. Definite deficits were found in the auditory-vocal association subtest (ITPA), sound blending (Monroe), Mazes (WISC), memory for designs (Graham-Kendall), perceptual speed (PMA), and visual-motor sequential subtest (ITPA). Marginal deficits were found in the auditory-vocal automatic (ITPA) and visual-automatic (closure) subtests. In other words, these dyslexic youngsters were distinguished by their extremely poor performance on tests at the integrational level of psycholinguistic functioning; at the non-meaningful level of language. The children performed normally on tests at the representational level with the one exception noted above.

Bateman (1963) investigated the reading and psycholinguistic processes of 131 partially seeing children in grades one to four. She found a positive and significant correlation of reading achievement, measured by deviation of reading grade from grade placement, with the auditory-vocal sequential (r= .44), the auditory-vocal automatic (r= .43), and the visual-motor sequential (r= .35) subtests of the ITPA. These three subtests are at the non-meaningful level.

Sutton (1963) found that high achievers in reading tended

to score higher than low achievers on the visual-motor sequencing subtest of the ITPA. Her subjects were two groups of 12 educable mentally retarded children matched on MA, CA, and IQ. She administered six tests of visual memory and found significant differences on the two tests involving recognition of letters and writing of letters in non-meaningful material. There were no differences on the tests using designs while the ITPA subtest and the test involving copying of forms were intermediate.

ITPA scores of 18 children with articulation disorders were compared with those of a non-deviant control group by Foster (1963). Her problem group scored significantly lower on the following subtests: auditory-vocal automatic, auditory-vocal sequential, visual-motor sequential, visual decoding, visual-motor association, and vocal encoding. Since analytic methods used are questionable, attention is being drawn solely to the fact that the three tests of the integrational (automatic-sequential) level were among those which discriminated between the groups.

Ferrier (1963) also studied psycholinguistic factors as they related to functional articulation disorders. He administered the ITPA and six other tests to 40 children, aged 6-7 through 8-7, who were evaluated as having moderate to severe articulation defects. He found that children with functional defects of articulation scored significantly lower than children without these defects on the three ITPA subtests at the integrational level and on the auditory-vocal channel subtests at the representational level. Ferrier had predicted this result. He

reasoned that integrational level functions are responsible, in part at least, for the integrity of the function of the "higher" levels of operation; that in order to make use of any information, whether it is on the integrational or representational level, certain integrational level operations must occur.

Bateman and Wetherell (1965) surveyed current findings regarding psycholinguistic functioning of mentally retarded children using the ITPA. The overall summarizing conclusion was that, "There appears to be a 'typical' profile for groups of retarded children whose IQs are near or below 75. The outstanding feature is a deficit in the entire automatic-sequential level as compared to the relative strength at the representational level."

This research using the ITPA found that wherever there are patterns of deficits, the automatic-sequential level is involved. Bateman (1963) was one of the first to suggest that primary deficits at the automatic-sequential level may underlie other deficiencies; that reading is dependent on automatic-sequential functions as assessed by the ITPA. Eisenberg (1963) reports that audiologists and speech pathologists are recognizing more and more that non-verbal (visual-perceptual-motor) disabilities are frequently closely associated with language and auditory dysfunctions.

There are two studies which present evidence that the auditory-vocal channel at the integrational level may be the crucial one. Ragland (1964) compared adequate and inadequate readers in a mentally retarded sample. He found the inadequate

readers to be significantly inferior on a) the total ITPA, b) the total automatic-sequential level, and c) the auditory-vocal automatic subtest. Sheperd (1965) administered a battery of tests to similarly constituted groups of educable mentally handicapped children. His battery included tests of visual-motor and auditory-vocal skills at the integrational level. None of the visual-motor tests (the Graham-Kendall Memory for Designs, the Visual-motor Sequential of the ITPA, Kass' Visual Closure Test) discriminated between the groups. Of his four auditory-vocal tests, the Auditory-Vocal Sequential and Sound Blending tests discriminated the groups while the Auditory-Vocal Automatic and the Wepman Auditory Discrimination tests did not. Even though only one of the three ITPA subtests at the automatic-sequential level discriminated between the adequate and inadequate readers, the means of all three tests for both groups were below their mean mental ages. This substantiates Bateman and Wetherell's (1965) findings discussed above. It should be noted that Kass (1962) had found these same visual-motor tasks to discriminate between her dyslexic and normal children. This could be accounted for by the differences in subjects and the fact that all of the EMH youngsters scored low on these tests thus crowding the floor of the tests and, thereby, reducing their discriminative power.

Intersensory Integration Studies

Birch and Belmont (1964) studied auditory-visual integration in 50 normal and 150 retarded readers ranging in age from

9-4 to 10-4 drawn from the total population of school children in Aberdeen, Scotland. The task was an auditory-visual pattern matching task. The child first heard a pattern of sounds (taps) composed of ½ second or one second intervals. He was then required to choose one out of three visual dot patterns presented to him. The test is composed of three sample and ten test items. The retarded readers made significantly more errors than the normal readers. Within each group there was a tendency for the children with the lower test scores to have lower reading scores. In addition, when only those with IQs of 100 and above were considered, the significant difference between the groups was maintained. These findings were interpreted to mean that the breakdown in the ability to integrate the input from these two sensory modalities greatly increases the probability of a child becoming a poor reader. Deficits in either sense or in immediate auditory memory were ruled out. These findings tended to be supported in the already discussed study of Birch and Belmont (1965) using the same task with 220 American youngsters having a mean IQ of 120.3 (Otis Quick-Scoring Tests of Mental Ability). Since this was a developmental study, reading ability was not a criterion for selection. However, a rho correlation between reading and auditory-visual integration was significant at the first and second grade levels.

Katz and Deutsch (1963a, b) also related reading to the ability to shift from auditory to visual stimuli. Seven techniques were utilized--Bimodal Reaction Time, Continuous Performance Test, Modality Preference Test, Discrimination Tasks,

and Memory Span Tests are relevant here. Subjects were 168 Negro, male pupils from the first, third, and fifth grade classes from two Harlem schools. There were 28 adequate and 28 inadequate readers at each grade level. All Lorge-Thorndike IQs were 70 or above. There were no severe emotional, visual or auditory problems evident. Not all Ss received all techniques. The children were randomly selected from the 168 to receive one or two measures. They found that poor readers showed significantly greater difficulty in shifting from one modality to another. The Bimodal Reaction Time apparatus required the children (48) to lift a finger from a button every time they heard a sound or saw a light. Two sounds and two colors were the stimuli. Each was preceded by every other one an equal number of times. Interaction of reading level and reaction time was not significant nor was the task found to be significantly related to IQ scores. The second technique, the Continuous Performance Test, required the youngsters to press a button when they a) saw the color red, b) heard the word "red", and c) heard or saw "red". The main effects of age, reading level and modality were all statistically significant. That is, the older children did better, the better readers were more efficient, all children did better on the auditory form than on the visual. No interactions were significant. When the Ss had to respond to both types of stimulus (either heard or saw the word "red") a) older children made significantly more correct responses; b) the visual stimuli were most difficult for all subjects; c) poor readers showed a significantly greater discrepancy between

auditory and visual vigilance than did adequate readers. There is a suggestion here that "vigilance performance on two channel tasks may not be predictable from single channel ones. Apparently, having to attend to auditory and visual stimuli at the same time may require different skills than attending to either modality in isolation." (1963, a, p.26) Other pertinent results were: a) that modality preference was unrelated to reading ability; b) that significant differences on the discrimination tasks were not due to the level of familiarity of the material; and c) that good readers exhibited longer memory spans for both auditory and visual stimuli separately and combined. In summary, Katz and Deutsch found significant differences between adequate and inadequate readers on all measures of intersensory equivalence which verified the results of an earlier study. (Raab, Deutsch, and Freedman, 1960).

Remedial Teaching Techniques

Most remedial teaching techniques stress the use of a multisensory integrative approach. For the most part, these techniques have been developed from clinical experience with little or no regard for experimental verification. Their development over a period of years and the final almost universal recognition of the necessity of intersensory coordination bespeaks the importance of such coordination. Fortunately, later investigations, such as those discussed in previous sections, tend to substantiate the correctness of the clinical judgments.

Fernald (1943) advocated a kinesthetic-tracing method. She sought the utilization and integration of three sense

channels--the visual, the auditory, and the tactual-kinesthetic. She stressed the latter when she wrote, "The various visual and auditory perceptual and association deficiencies would disappear if the visual and auditory experiences were supplemented by tactual and kinesthetic experiences." (p. 166) In other words, she considered intersensory patterning an important factor in remediating learning disabilities.

Monroe (1932) differs from Fernald in her emphasis on word elements and phonic, auditory elements. She used stylus tracing to facilitate visual and auditory coordination. Her methods of remediation would appear to lead to the development of improved automatic sensory equivalences. She says, "Many of the reading-defect cases had no observable deficiencies in sensory organs and yet failed to discriminate certain characteristics of sensations such as the sounds of vowels or the spatial position of patterns. It is probable that, in cases of no sensory defect, the difficulty in discrimination lies in the central co-ordinating mechanism. By forcing the child to make different motor responses to the different sensory characteristics, and thereby reinforcing the visual and auditory stimuli with discriminable kinesthetic cues, we may ultimately develop more precise discrimination of the visual and auditory characteristics." (p. 112)

Hegge, Kirk, and Kirk (1937) also use an approach in which the visual and auditory sense channels are supplemented by and coordinated with the tactual and kinesthetic channels. Their aim is a final synthesis of sense and stimuli differentiated data

into a unit-whole. This synthesis, to be functionally effective, must be accomplished automatically. This automatic integration of diverse sensory cues into a unit of experience is what is thought to be tested by the automatic-sequential level of the ITPA.

Spalding and Spalding (1962) advocate a spelling method of teaching reading which begins with the writing of phonograms. These phonograms are combined to form words. By having the child write down sounds used in spoken English, they are using the well-known TVAK principle to form habit-chains in the child. "....He reserves his phonic knowledge for the printed words that are now to him, and he eventually comes to use it almost unconsciously, instantly, habitually...." (p. 21) The Spaldings, too, recognize the importance of the integrational level of psycholinguistic functioning as do McGinnis (1963), Bloomfield and Barnhart (1961), and Frostig (1964).

Frostig (1964) believes that most children who have learning problems have some type of visual perceptual handicap. The Marianne Frostig Developmental Test of Visual Perception focuses on five perceptual abilities: a) perception of position in space; b) perception of spatial relationships; c) perceptual constancy; d) visual-motor coordination; and e) figure-ground perception. These five also serve as the focus of her remedial and developmental program. Even though she doesn't speak of intersensory patterning, many of her remedial and training procedures are geared to this end; e.g., all pencil and paper tasks are preceded by three-dimensional concrete tasks which by their nature involve the assimilation process. The point being made

is that even though Frostig conceptually speaks of visual perception while relegating the sense of touch to a minimal and insignificant role, she implicitly recognizes the need of intersensory patterning in her training procedures.

Kephart (1960) is speaking of intersensory patterning of an automatic nature in his discussion of motor bases for achievement. Such patterning is referred to when he says that the child must match the control of his eyes to cues of directionality from the kinesthetic; that he must learn to reverse the translation at the midline without interrupting the continuous external movement; that the efficiency of the higher thought processes can be no better than the basic motor abilities upon which they are based.

Delacato (1959, 1963), like Kephart, uses motor activities to achieve remediation. Since he sees all learning disabilities as stemming from a lack of neurological organization, he uses physical activities as the means of reorganizing the central nervous system. It seems to this writer that Delacato is referring to the reorganization and integration of perceptual data, albeit in neurological terms; that by his "patterning" procedures with severely handicapped children he is forcing the institution of schemas, accomodations, and assimilations previously non-existent.

These methods all stress a structured, sequential approach in which later learnings are built on earlier learnings. They all aim, at least implicitly, at the integration of vision and audition with the addition of the tactual-kinesthetic when the problem is severe.

Everything that has been said has relevance for the minimally brain-damaged child. Both Kephart and Delacato work with demonstrably brain-damaged youngsters in their clinics with some reported success. In a paper on psychoneurological learning disorders, Myklebust (1963) says, "To prevent over-learning in the most intact area and to achieve the highest degree of recovery of function in the area of greatest deficit, the most suitable approach is to combine stimulation of the deficit area with another more intact area or channel." Wepman (1963) speaks of the arrest or delay of the developmental process of the central integrative process. Strauss and Kephart (1955) discuss perceptual dysfunctions and disorganizations in brain-damaged youngsters as they relate to the central integrative process. Many of the techniques of Strauss and Lehtinen (1947, Chapter XI) involve intersensory coordination and patterning or facilitate it; e.g., use of color cues to overcome directional confusion, puzzles, and motoric manipulation of materials. All lists of characteristics of brain-damaged youngsters include problems of perception, hyperactivity, and motor performance to some degree. According to the theories of cognitive growth discussed previously these can all be interpreted in terms of some degree of impairment in intersensory patterning.

Hermelin and O'Connor (1960, 1961) found that elicitation of cross-modality responses enhanced the learning of familiar tasks by imbeciles (1960) but interfered with the learning of tasks using unfamiliar materials (1961). The latter was

explained by the fact that the stimuli were not easily named (Greek and Russian letters) thus preventing the translation from one type of sensory image into another. The former were also explained as a release from set, from the compelling force of direct stimuli which they tended to imitate rather than respond to. In addition, stereognosis was found to be unimpaired in some imbeciles. Stereognostic-stereognostic matching was significantly superior to visual-visual, stereognostic-visual, or visual-stereognostic matching. This revealed a lack of vision system dominance.

Visualization in Integrative Tasks

Pillsbury (1895) reported on a series of experiments at Cornell University. The experiments investigated cutaneous sensibility. They sought a) to prove a quantitative relationship between average localization error and two point limen, and b) to determine the part played in localization by the visual image. The data for the latter were obtained through introspection. The subjects were members of the laboratory staff--Titchener, Knox, Washburn, Read, and Watanabe. All except one reported being unable to control visualization. In explaining why the greatest numbers of point localization errors was longitudinal on higher parts of the arm and horizontal near the wrist, Pillsbury discusses the direction of prominent skin markings. He says:

> The most obvious explanation is to be given in terms of the effect of visualization. The "local signs" of the skin seem to be translated by association into terms of the visual image, and the localization made by means of a second association with the local signs. The experiment seems to be a search for a sensation of the same local sign as

> the original sensation. In this search, the observer is first, and, in a general way, assisted by the association formed with the visual image, and through this with the appropriate motor sensation. As the exploring point touches the skin the local signs call up the associated visual image in terms of which, principally, the direction of the error is noted and the necessary corrections made. When a local sign and its associated visual image coincide with the local sign and visual image originally given, and for which the observer is seeking, the localization is considered as complete. In most cases, however, the local sign is to a great extent lost sight of, and the comparison takes place almost wholly in terms of the visual image alone....the great aid rendered by the visual image was noticed and frequently remarked upon by the reagents. They declared that they saw the point touched upon a mental image and used this image as a chart in their localization. (p. 50)

Parrish (1897), replicated these experiments with the difference that the subjects did not touch themselves and move around until they found the "point" but rather held the point in the air above the arm. His findings were the same as Pillsbury's. His subjects were unable to separate the tactual and the visual.

Cutsforth (1933), in his extensive study of the relationship between visual and tactual perceptions, makes the following conclusions relative to visualization.

1. The tactual perception of size and form is exclusively a visual configuration.
2. No truly tactual patterns were found in the tactual perceptions of form.
3. The perceptions of tactual form were carried in visual imagery. Tactual qualities provide texture, body and subjective reference but form, extent, position and organization are visual.

4. Visual imagery furnishes continuity between otherwise discrete tactual features of complex tactual perceptions, such as varying intensities and qualities at different places on the skin. Visual imagery furnishes continuity between tactual figure and conscious ground. The ground of tactual perception is visual.

These conclusions were based on introspective data as were those of Pillsbury and Parrish. Cutsforth used ten trained observers (staff members and graduate students) and 120 naive subjects (students from elementary laboratory classes).

Bartley (1953) postulated that if tactile and kinesthetic data were processed in terms of the visual mechanism, then the behavior resulting from such information should obey the laws of vision. The results of a series of studies seemed to indicate that a visual mechanism was involved. A later study (Bartley, Clifford, and Calvin, 1955) was designed to test these results using both blind and normally seeing children matched on sex, age, and IQ. Ninety pairs of forms were presented to each child--45 in a frontal position and 45 in a medial position. The forms were wooden squares $3\frac{1}{2}$, 4, and $4\frac{1}{2}$ inches square placed at either 5, 10, or 13 inches from the blindfolded subject.

In the first experiment, comparisons were made of forms presented at the same distance and in the same position. The first square presented was always the medium one. The second was one of the three. The expectation that both groups would make the same number of errors was supported since there was no

opportunity for the factors of kinesthesis or visual imagery to be manifest.

In the second part, the standard four-inch square was always presented at 10 inches with the second at any one of the three distances. Working distance was not found to appreciably affect the blind subjects' perception of size. With the normal subjects the expectation was that in the frontal plane, visual imagery would dominate thereby causing more diminution errors than enhancement errors at the farther distance. On the other hand, in the median plane it was expected that kinesthesis would dominate, thereby causing more enhancement errors than diminution errors at the farther distance. Even though no significant differences were found in the frontal plane, graphing revealed the hypothesized tendency. In the median plane, three of four significant differences were as hypothesized. Graphing supported the hypotheses also. Thus, the authors present further evidence that, where allowed to do so, visualization will dominate the integration of tactual input.

Other studies tend to show the importance of visual imagery in spatial and directional orientation. Hatwell (1959) and Worchel (1951) both found the blind do as well as the sighted in the tactile recognition of forms but in reproduction tasks (using plasticene) the seeing and accidentally-blinded were superior to the born-blind.

Conceptual Schema

Reading development depends on the coordination, most

obviously, of the sense channels of vision and audition. The breakdown in this coordination at a non-meaningful psycholinguistic level has already been demonstrated to be significantly related to reading achievement. (pp. 15-17) Is it not logical, then to question whether there are other intersensory coordination problems such as visual-haptic, visual-kinesthetic, and haptic-kinesthetic which may also underlie reading failure? Such coordinations are developmentally important to the intellectual growth of the young child. (p. 2) They are thought to be also relevant to the mechanics of reading and primary reading problems. Further, integration of such sensory inputs must operate at an automatic, nonconscious level in order to be functional. It is postulated that this automatic coordination must operate before the child can make appropriate progress in reading. Since a minimal level of sensory integration is necessary for a successfully adequate development of the iconic stage and the subsumption of it by the symbolic stage of cognitive growth, it seems that learning to read also depends to some extent on this psycholinguistically lower level visual-haptic-kinesthetic integrative process.

Primary reading problems are characterized by primitive rotations and reversals, an inability to see the word as an entity, uncertain memory for shapes of letters, poor comprehension and slow reading speed. (Kolson and Kaluger, 1963, p. 31) These problems are conceptually associated with problems in mentally manipulating space and spatial properties as well as with poor visual memory.

Reading is a skill requiring integration of visual information with information relating to spatial direction and distribution. The reader must immediately and automatically distinguish between letters and words which present the same gestalt but differ only in direction or orientation such as b and d, p and q, Z and N, saw and was, wordy and rowdy, etc. Unlike a spoon which remains a spoon whether it is vertical, horizontal, upside down, or upside up, changes in the orientation of alphabetic symbols produce changes in meaning. Changes in the spatial arrangement of these symbols in words also produce changes in meaning. "Their positional sequence and not their mere presence is then of utmost importance." (Money, 1962, p.18) The reader, then, must make automatic judgments of laterality, direction, and spatial properties not only of the symbols themselves but also of their relation to one another. This "directionality" is gained developmentally through tactual and kinesthetic sense data with reference to one's own body and the consciousness of one's own body. It involves "the relationship of the visual image to the body image in ahead and behind, toward and away-from, left and right, and facing upward or downward." (Money, 1962, p.20) "Intersensorial coordinations", then, have occurred to the required degree. Tactile and kinesthetic schemata have been assimilated by the visual. Therefore, to rephrase an earlier sentence, reading is a skill requiring integration of visual information with information garnered from haptic and kinesthetic sensations. This is what the remedial approaches discussed attempt to facilitate.

Since there is ample evidence that tactual and kinesthetic sensory input is interpreted in terms of a visual image, which then is coordinated with visual external stimuli or another mental image, the mechanism of visualization seems to be the means by which visual-haptic-kinesthetic integration is achieved. Both immediate memory and spatial ability can be shown to be necessary to the visualization process. The effect of the deficits found in immediate visual memory and spatial-closure ability at the automatic and sequential level of the ITPA would, therefore, seem to be on intersensorial interaction via poor visualization. In other words, it could be that a lack of intersensory integration is the primary deficit which is contributed to by poor visual memory and poor spatial ability by their effect on the formation of a mental image by which integration is achieved.

This hypothesis is presented schematically in Figure 1. As the child experiences a stimulus, he stores bits of data (immediate, sequencing memory), relates these in space to one another (spatial ability), and gradually builds a mental image of the stimulus which can be compared with a previously constructed mental image (integration). As indicated by the arrows, this is conceived of as a dynamic process with continual interplay of the elements or factors of maturation and intelligence, immediate sequential memory, and spatial ability until the final completed image is constructed.

In terms of reading, this model would be interpreted as follows. The child sees combinations of symbols which he must

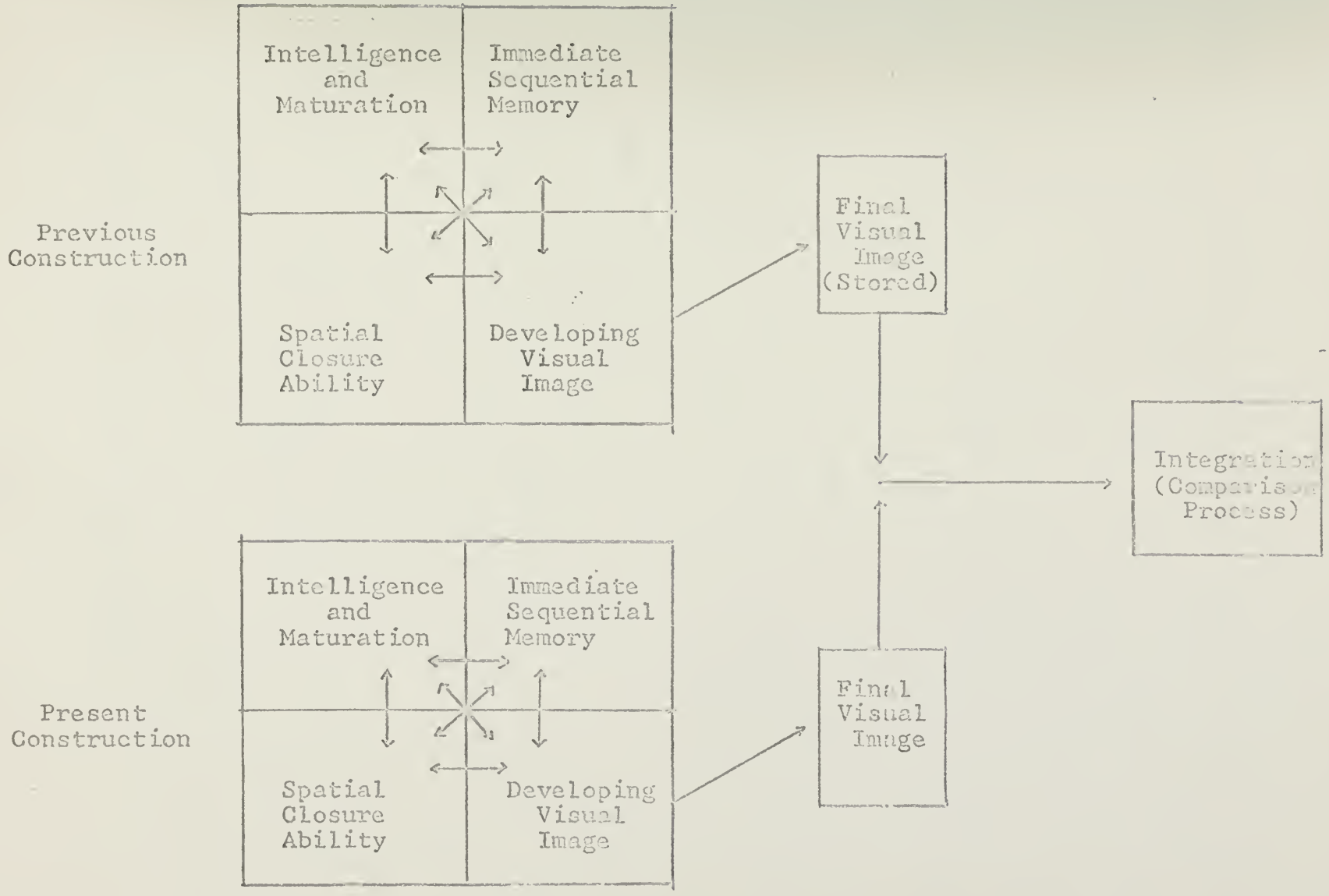


Figure 1.

A Diagram of Intersensory Integration

temporarily store in sequence, relate spatially to one another, and finally relate to previously built images. Any breakdown in memory or spatial manipulation may occasion either a previous faulty image or a present one which results in incorrect comparisons and judgments. This, in turn, results in poor reading. It can readily be seen that poor reading speed, poor comprehension, and the other characteristic problems would result if this integrative process were not accomplished automatically and non-consciously; i.e., if too much attention were paid to the details of the process itself.

Using this conceptual model, one would conclude that measures of intersensory integration should consistently discriminate reading-problem from non-reading-problem children. If a child required to make comparative judgments makes incorrect judgments to a significant degree, one can infer that the integrational process is deficient. Whether this is due to lack of proper experience, neurological disorganization, or minimal brain damage, the observed behavior remains the same and must be treated by the teacher. (Capobianco, 1964; Kirk, 1963) One cannot infer from Figure 2 that either intelligence, immediate sequential memory, or spatial ability is defective since the possibility remains that these three could be intact but the integrational ability itself is not. However, any defect in the former three necessitate a deficit in the latter by reason of their impact on the visualization process.

Summary

This paper has presented the idea that the importance of the automatic-sequential level of the ITPA and the integrational level in psycholinguistic theory lies in the realm of intersensorial coordinations; that the deficits often found at this level are related to learning and reading via their effects on intersensory integration.

There is a need for a conceptual link between the findings of second level deficits and faulty learning. This is an attempt to supply such a link. If it has any value, it should be testable through experimental and correlational research.

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