Influence of Sensory Integration Procedures on Language Development

(aphasia, apraxia, vestibular disorder)

A. Jean Ayres  Zoe Mailloux

The relationship between language development and sensory integration was explored through single case experimental studies of one female and three male aphasic children ranging in age from 4 years, 0 months to 5 years, 3 months. Other agencies had assessed all the children in the area of language development at least 6 months before the start of occupational therapy. Three of the four children had received either speech therapy, special education specific to aphasia, or both, before starting occupational therapy. Additional baseline data on language expression and comprehension, as well as on sensory integrative functioning, were gathered before beginning a year of occupational therapy that involved sensory integration procedures. Inspection of rate of language growth before and after starting occupational therapy showed a consistent increase in rate of growth in language comprehensive concomitant with occupational therapy compared to previous growth rate. The two children with depressed postrotary nystagmus demonstrated notable gains on expressive language measures.

In an early study (1) of the effect of sensory integration procedures on academic achievement among educationally handicapped children, students with primary problems in the auditory-language domain made greater academic gains than did a matched control group. While there was a significant difference between the groups in academic gain, inspection of the data indicated that not all children with language deficits were equally responsive. The study gave rise to the hypothesis that some aspect of language development depended upon the maturation and processing of somato-sensory and vestibular input and the generalized capacity to make adaptive responses.

Since the initial study, interest in

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the association between the body senses and language development has continued. Furthermore, other researchers have provided support for this hypothesis, de Quiros (2), for example, linked vestibular hyporeflexia to language and learning disorders. Stilwell, Crowe, and McCallum found a statistically significant frequency of shortened-duration postrotary nystagmus among children with communication disorders. They proposed that the “development of the language center is in some way dependent on previous, as well as ongoing, subcortical sensory integration.” (5, p 226) In a sample of 15 dysphasic children, Rider (4) found a significant number of abnormal postural responses. Her study further supports the notion that vestibular and somatosensory dysfunction may underlie some language disorders, particularly when viewed in light of Ottenbacher’s report (5) of strong relationships between some postural responses and duration of postrotary nystagmus, hence, and indirect relationship between the vestibular system and language development.

Educationally handicapped children with evidence of vestibular dysfunction have been shown to respond to sensory integration procedures with academic gains (6). If some children with language deficits also exhibit evidence of vestibular and concomitant somatosensory dysfunction, as the literature suggests, it would seem reasonable to expect them also to respond positively to sensory integration procedures.

**Purpose of the Study**

The purpose of this study was to identify change in patterns of language development associated with the institution of sensory integration methods of therapy among children with language disorders. Through an in-depth study of four young aphasic children, answers to the following questions were sought: Can a change in the rate of acquisition of language comprehension and verbal expression be observed when occupational therapy, using sensory integration procedures, is introduced into the intervention program of aphasic children? Will the change in growth rate be similar for both receptive and expressive language? Will some aphasic children respond better than others to the therapy? If so, can the parameters that differentiate the good and poor respondents be identified? These questions were addressed by single case experimental study of each child, focusing on the nature of sensory integrative status and the course of expressive and receptive language development throughout a year of individual occupational therapy, two 50-minute sessions per week, using sensory integration methods. The overall objective of the study was to generate, rather than to test, hypotheses.

**Method**

**Subjects.** The three boys (cases A, B, and C) in this study were diagnosed at other agencies as aphasic without other complications. The one girl in the study (case D) was also diagnosed aphasic, but was considered to be slow in development in all other areas as well. At the start of the study, ages ranged from 4 years 0 months for case A, to 5 years 3 months for case D. Each child’s age at the beginning of the study is shown in Figures 1 through 4.

The sensory integrative characteristics of these children were defined through the administration of the Southern California Sensory Integration Tests (SCSIT) (7), the Southern California Postrotary Nystagmus Test (SCPNT) (8), clinical observations of postural and ocular responses, and two praxis tests constructed by the authors for research purposes.

One of the constructed tests was

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Scores on Southern California Sensory Integration Tests, on Southern California Postrotary Nystagmus Test, and on Clinical Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td>A</td>
</tr>
<tr>
<td>Age: (years-months)</td>
<td>4-0</td>
</tr>
<tr>
<td>Sex</td>
<td>male</td>
</tr>
<tr>
<td>Hand Preference</td>
<td>not established</td>
</tr>
<tr>
<td>Mean of SV, FG, PS, DC</td>
<td>+0.4 SD</td>
</tr>
<tr>
<td>Mean of SCPNT duration</td>
<td>unable to test</td>
</tr>
<tr>
<td>Manual Form Perception</td>
<td>+1.6 SD</td>
</tr>
<tr>
<td>Mean of FI, LTS</td>
<td>-1.1 SD</td>
</tr>
<tr>
<td>Mean of MAC-R, right and left hands</td>
<td>-0.9 SD</td>
</tr>
<tr>
<td>SCPNT duration</td>
<td>-0.1 SD</td>
</tr>
<tr>
<td>SCPNT quality</td>
<td>irregular</td>
</tr>
<tr>
<td>Eye pursuits</td>
<td>adequate</td>
</tr>
<tr>
<td>Equilibrium reactions</td>
<td>adequate</td>
</tr>
<tr>
<td>Total body flexion</td>
<td>poor</td>
</tr>
<tr>
<td>Prone extension</td>
<td>good</td>
</tr>
<tr>
<td>Motor sequencing</td>
<td>35</td>
</tr>
<tr>
<td>Praxis on verbal command</td>
<td>31</td>
</tr>
</tbody>
</table>

Space Visualization (SV), Figure-Ground (FG), Position in Space (PS), Design Copying (DC), Finger Identification (FI), Localization of Tactile Stimuli (LTS), Standing Balance: Eyes Open (SB:O), Standing Balance: Eyes Closed (SB:C), Motor Accuracy-Revised (MAC-R), Postrotary Nystagmus (SCPNT), Standard Deviation (SD).
designed to assess motor sequencing skill. Following demonstration by the examiner, the child was required to replicate 50 motor tasks of a one-to-five sequence using either unilateral or bilateral hand movements. For example, the examiner tapped a table first with the right fist, followed by the left fist, then with the palms of both hands. The child was expected to replicate the movements by using the opposite hands in a mirror image response. No verbal communication was involved in the actual test, but most items included auditory cues from clapping or tapping the table. The 50 items became successively more difficult. Two attempts to replicate each item were allowed. The test was discontinued after failure on each of two attempts of eight consecutive items. Test-retest reliability based on the performance of four clients with generalized sensory integrative dysfunction showed a mean total score agreement of 96 percent.

In the second constructed test, verbal commands (without demonstration) were given for assuming simple positions of the body and extremities. An example was: “Put your hand on your stomach.” The test, consisting of 50 items, was discontinued after failure on two attempts of eight consecutive items. Test-retest reliability based on the performance of four clients with generalized sensory integrative dysfunction showed a mean total score agreement of 96 percent.

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Figure 2
Scores on language comprehension tests, Carrow Elicited Language Inventory, and Weiss Articulation Test (Case B)

Case B (Age 4-7)

Event Legend:
A Started 6-week summer session at private school; emphasis on speech.
B Scored 2 years, 2 months on Peabody Picture Vocabulary Test administered by another agency.
C Began private, individual speech therapy, which continued to event H.
D Scored an average of 2 years, 8 months on Auditory Reception and Auditory Association of Illinois Test of Psycholinguistic Abilities administered by another agency.
E First of four baseline data collections.
F Occupational therapy started.
G Entered public school aphasia class, which he attended throughout study.
H Individual speech therapy discontinued.

The mean duration of five testings following rotation to the right was 6 seconds or -1.1 standard deviations (S.D.) below the mean for 5-year-old children, and following rotation to the left, it was 11.2 seconds or +0.2 S.D. Using the formula of Jongkees (9) and Norre (10) for computing directional preponderance in adults, case C showed 30 percent preponderance. This amount, considered significant by these authors, probably indicates a lateralized brain problem. The hyporeflexia was not in the direction most expected of a left-hemisphere problem, but according to Baloh and Honrubia (11), preponderance may be either toward or away from the lesion. A possible indication of a left-hemisphere problem might be found in comparing case C’s performance on Imitation of Postures test and two constructed tests of praxis with those of the other three children. Case C could imitate the examiner’s positions adequately but sequencing motor acts (a function usually attributed to the left cerebral hemisphere) was difficult for him, and he performed poorly in following verbal commands to assume certain positions. Inadequate modulation of vestibular input was inferred from his definite gravitational insecurity. After about 9 months of therapy, speech was still only partially intelligible and there was much jargon. A typical sentence was “Numbers I swing,” meaning he was going to swing a given number of times. His absences from 23 of the 100 scheduled treatments were intermittent.

The most neurologically impaired of these children, case D, showed generalized sensory integrative dys- function, with vestibular and somatosensory processing deficits, hyperactivity, and distractibility. Tactile defensiveness was particularly severe around the mouth. She was considered left-handed by her family, whose members were all right-handed, but her right-hand time-adjusted raw score on the Motor Accuracy-Revised test was more accurate than that of her left hand. A typical sentence after 9 months of therapy was, “I wan don piwow,” for “I don’t want a pillow.” She was absent for 3 of the 96 treatments scheduled.

Assessing Language Skill. Examiners at other agencies had previously assessed the language comprehension of each child, using a variety of instruments. On referral to occupational therapy, further baseline data on receptive language development were obtained by three or four administrations of the Test for Auditory Comprehension of Language by Elizabeth Carrow (12). The test requires the child to pick one of three pictures in response to a word or phrase said by the examiner. In some instances the child’s score fell below the lowest age equivalent norms given. In these cases the age equivalence of the numerical score was extrapolated. This test was also given to each client at periodic intervals during the year of receiving occupational therapy to assess change in language comprehension capacity. Frequency of testing and age equivalents of scores obtained on all auditory comprehension testings are shown in Figures 1 through 4.

Both baseline data and measurement of change in expressive language were obtained on cases B and C with the Carrow Elicited Language Inventory (CEL-I) (13). In this test the child repeats increasingly complex sentences spoken by the examiner, and the number of errors is tallied. Poorly articulated words are considered correct as long as they are intelligible. If unintellig-
ble, they are scored as substitutions. In C's case, only the first ten items of the inventory were used. To assess expressive language in cases A and D, who could not respond to the CELLI, the authors constructed a simple expressive language test. Each child was asked the same series of questions at each testing, such as "What do you like to eat?" and "What color is this?" Performance scores were computed as the total number of different words attempted minus one-half the number of misarticulated words. Thus articulation as well as expressive vocabulary was represented in the language expression scores.

Of the four children, only case B was capable of taking a standard articulation test. To sample this aspect of language, he was given the Weiss Comprehensive Articulation Test (14) for establishing both the baseline and change of skill levels.

Treatment. Occupational therapy focused on active participation in activities providing controlled vestibular and somatosensory input and eliciting adaptive responses. The severity of the children's impairment and their inability to organize behavior initially interfered with their participation in therapy. Case A accepted only the simplest active and passive vestibular stimulation (mainly rotary) until about the 34th week, when he willingly began to undertake the most elementary motor planning tasks. B's therapy focused on vestibular stimulation with lesser emphasis on motor planning. He was eager and inner directed, but not often in an organized manner. Case C accepted only the most simple vestibular and proprioceptive stimulating activities for most of the first half year of therapy. His gravitational insecurity dictated the nature of his therapeutic tasks, and he had great difficulty staying with any but the most simple or passive activity for more than a few minutes.

Of the four clients, Case D had the most trouble organizing her behavior, and therapy of necessity initially focused on helping her to engage in any purposeful task that would hold her attention for a moment.

Results
The following data for each of the children are shown in Figures 1 through 4: 1. language comprehension age score assigned by agencies seeing the child before referral to occupational therapy; 2. language comprehension age score on the Test for Auditory Comprehension of Language procured at both baseline and periodic testing throughout the year of therapy; 3. baseline and periodic scores on an expressive language test; 4. an indication of the timing of events significant to language development. Case B's scores on the Weiss Articulation Test are also shown in Figure 2. The timing of the various events and testing was counted by weeks forward and back from the week of the first session of sensory integration therapy, identified in Figures 1 through 4 as week 1. To compare the four children on rate of change on receptive language from the time of initial testing at another agency to final testing for this study, the respective curves were fitted and superimposed on a single graph (Figure 5).

Change in Language Comprehension Growth Rate. Figures 1 through 5 show that the rate of growth in language comprehension increased in all four cases when occupational therapy was started. The rate of change was remarkably similar among all for the first 22 weeks of therapy. The fact that instruments other than the Carrow

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Figure 3
Scores on language comprehension tests and Carrow Elicited Language Inventory (Case C)

Event Legend:
A Scored an average of 3 years, 2.5 months on Reynell Developmental Language Scale and Peabody Picture Vocabulary Test administered by another agency.
B First of four baseline data gathered.
C Started occupational therapy.
D Started individual speech therapy 3 hours per week.
E Entered public school aphasia class; which he attended throughout the study. Discontinued individual speech therapy.
F Started developmental therapy 3 hours per week.
were used by the referral agencies raises the question of comparability between different language comprehension tests. As an additional factor, the children each had received varying amounts of speech therapy and special language instruction, thus making it difficult to sort out the effects of the different therapies. Nevertheless, strong patterns emerged that suggest a positive relationship between involvement in occupational therapy and growth in language development.

Case A was enrolled in a public school aphasia class 35 weeks before starting occupational therapy. During that time he gained an estimated 5 months in language comprehension. His scores then showed a gain of nearly 2 years in the next 22 weeks, followed by an unexplained decline, then a slight recovery placing him about 1 year and 3 months above the baseline data. The contribution of the first attempt at individual speech therapy to this language comprehension growth cannot be determined because A was discharged for noncooperation, but it is not likely that those 15 weeks of speech therapy were the major influence on language growth.

Case B received either private school instruction with emphasis on speech, or private individual speech therapy, or both, for 47 weeks before starting occupational therapy. During that time his scores showed a growth of 1 year. During the year that occupational therapy was added to a speech therapy or special instruction program, he gained more than 2 years in scores, even though the private speech therapy was discontinued at the 13th week of occupational therapy. Thus his 3-year language comprehension growth during 1 year of occupational therapy reflects both influences, which may account for the slightly more rapid rise of his curve than that of the other children (Figure 5).

Case D, the most severely impaired child, received 30 weeks of individual, private speech therapy, three sessions per week, before starting occupational therapy. She had also been enrolled in the public school aphasia program for 10 weeks. During the 25 weeks between initial language testing and starting occupational therapy. her language comprehension scores showed a decline, possibly reflecting chance factors in testing as well as poor response to speech therapy and special instruction. During the year of occupational therapy those scores showed a 2½-year gain.

It is reasonable to conclude that occupational therapy, using sensory integration procedures, facilitated language comprehension growth in at least three of the four children. Various constellations of sensory integrative dysfunction could not be definitely associated with different rates of growth because the rates are too similar, but it is noted that the two children with the most severe and extensive somatosensory processing disorder made excellent gains, whereas case A, with a minimal integrative problem, gained less.

None of the expressive language tests used in this study yielded an age-equivalent score. For these tests, changes in raw and percentile scores were used to roughly compare the growth curves of the four children. Case A showed relatively little change in expressive language as measured for this study, although
Clinical impression was that he changed more than the formal test performance indicated. C showed a slightly greater gain, but B and D made excellent gains and definitely greater ones than did A and C. B's baseline scores on the CELF hovered around the first percentile, but his scores reached a high of the 62nd percentile within the year of occupational therapy. His articulation also improved from a score of 75 to 96 percent intelligibility on the Weiss Articulation Test.

**Discussion**

Sensory integration procedures are expected to have a generalized effect on brain function resulting not only in the increased ability to use cognitive potential, but also the ability to organize meaningful interaction with the social-emotional environment and the physical world. Gains in all of these areas were seen in each child and all may have contributed to the increased rate of growth in language comprehension test scores as well. Taking the language comprehension test requires a certain level of ability to organize behavior, a problem for all four clients. The child must sit and be attentive, must respond to an examiner, then finally, associate auditory and visual stimuli. Speaking requires an even higher level of ability to organize behavior.

Although occupational therapy cannot be credited with all the changes in growth rate, it may have contributed to the child's generalized ability to organize behavior in a way that speech therapy and instruction did not. Neurobiological and clinical research, as well as comparison of the four children in this study, direct attention to the role of the vestibular system in both auditory processing and speech production. All four clients sought and received considerable vestibular stimulation within the context of purposeful activity. The two children who originally tested as depressed postrotary nystagmus showed greater gains in expressive language than did the other two. This finding suggests a definite relationship between expressive language development and vestibular processing.

These observations lead to the hypothesis that vestibular sensory input and responses during therapy that tend to organize the input will promote auditory processing in those centers associated with the vestibular system. In cases in which depressed postrotary nystagmus indicates deficits in vestibular system functioning, sensory integration therapy may facilitate vestibular system functioning as well as any speech and language mechanisms dependent on that system. The fact that change in expressive language could be associated with the occupational therapy in some cases but not others suggests that some language development problems may reflect disorder in neural systems that are not particularly dependent upon currently known vestibular or other somatosensory processing mechanisms.

Neurobiological research on lower animals and their evolution indicates several means by which vestibular and auditory input can interact and influence sensory processing in lower animals. There is a long phyletic history of structural and functional association between the acoustic and vestibular systems, both in the initial formation of the systems and in the early organization of their mechanisms in the medulla and pons (15). Cell “Group Y” of the vestibular nuclear complex in the brain stem receives fibers from the saccular nerve. While the projections from this cell group are not exactly known, Gacek (16) reports that preliminary evidence indicates a possible projection back to the dorsal cochlear nucleus.

Sarnat and Netsky (13) suggest that the inferior colliculus, which is primarily an acoustic processing center, may serve as one correlation center for auditory, tactile, and possibly, vibratory impulses. Phylology links the saccule with vibration that can be interpreted as sound (15). One study on guinea pigs (17) found single semicircular canal stimulation excited 33 percent of units recorded in the inferior colliculus and its brachium. Fifteen percent of the units were inhibited by the stimulation. The authors found these results in agreement with similar data on cats and primates.

A great deal of acoustic and semicircular canal sensory input converges in the medial geniculate body of many animals, including pri-
mates. Troiani, Petrosini, and Pallastrini (17) found that, in the guinea pig, 94 percent of the recorded medial geniculate body units responded to canal stimulation, and of those responsive units, 87 percent also responded to acoustic stimuli. Only a few units responded to acoustic stimuli only. Fredrickson and Schwarz (18) suggest that the medial geniculate body, usually considered primarily an auditory processing center, may also be a vestibular center. Fibers terminating within the thalamic-vestibular-cortical relay nucleus pass through the medial geniculate body which also receives vestibular input from other routes. The noncortical areas of vestibular and acoustic sensory convergence may serve an important function in the auditory processing necessary for acquiring language comprehension.

Auditory processing, enhanced by vestibular input, may have improved in all four study cases and, consequently, assisted in language comprehension in each case. That such enhancement may not account for expressive language growth is suggested by discrepancies in speech development among the four clients. Some of the expressive language gains might be explained by the concept of the brain operating on the basis of functional systems, with many different areas or complex mechanisms of the brain contributing to the system that enables the development and production of speech. The hypothesis that one of those contributing mechanisms involves a type of vestibular sensory input is consistent with the findings of this study. Cases B and D, who had depressed duration nystagmus, showed appreciable expressive language gains whereas cases A and C, without depressed nystagmus following rotation in both directions showed little language gains that could confidently be attributed only to the sensory integration procedures. Case A’s lack of progress in speech indicates that other neurolinguistic mechanisms may be involved and may seriously interfere with speech acquisition, resulting in failure to respond to therapy designed to affect somatosensory and vestibular mechanisms. Of the four clients, case A demonstrated the least evidence of vestibular or somatosensory deficit.

**Concluding Hypotheses**

This study generates the following hypotheses:

1. **Occupational therapy, employing sensory integration procedures, will facilitate language comprehension of young aphasic children who have minimal-to-severe sensory processing disorders.** The less the somatic and vestibular involvement, the less gain may be expected.

2. **Occupational therapy, employing sensory integration procedures, will facilitate language expression in young aphasic children with moderate to severe somatosensory processing disorders and attenuated postrotary nystagmus.** Up to a certain point, the child with a more severe neurological impairment may be a better candidate initially for occupational therapy than for special instruction and even classical speech therapy.

Only through further research can these hypotheses be tested and findings from these cases be generalized.

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