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Prevalence of Sensory Integrative Disorders in Children with Attention Deficit Hyperactivity Disorder: A Descriptive Study

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Abstract. *This study describes the prevalence and range of sensory integrative (SI) disorders in children with Attention Deficit Hyperactivity Disorder (ADHD). Retrospective chart reviews were completed on 90 children diagnosed with ADHD/ADD who were referred for occupational therapy (OT), evaluation, and treatment in private OT clinics in the states of California, Pennsylvania, and Massachusetts. Subjects were included if they were evaluated using the Sensory Integration and Praxis Test (SIPT), clinical observations, and sensory history between January 1990 and February 1996; and if they had a diagnosis of ADHD/ADD.*

Results indicated three major SI deficits prevalent in children with ADHD/ADD. These include developmental dyspraxia (68.9%), tactile defensiveness (82.2%), and poor antigravity control (81.1%). These results imply that professionals who diagnose ADHD/ADD should be familiar with symptoms of SI dysfunction, and consider OT as a viable treatment for some children who have ADHD/ADD.

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Attention Deficit/Hyperactivity Disorder (ADHD) is the most common childhood psychiatric disorder and accounts for at least half of all referrals to child mental health clinics (Ingersoll, 1988). Estimates of its prevalence in school-aged children range from as low as 1% to as high as 12% (Frick & Lahey, 1991). However, the most recent estimate of prevalence by the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) is 3 to 5% in school-aged children (APA, 1994). The DSM-IV also describes ADHD as occurring much more frequently in male children as compared to female, with male-to-female ratios ranging from 4:1 to 9:1. Some researchers believe, however, that girls with ADHD may be underidentified since the problems of hyperactive girls are not as visible or as troublesome to adults as the problems of hyperactive boys (Berry, Shaywitz, & Shaywitz, 1985). Therefore, girls may be less likely to come to professional attention, and are thus probably not accurately reflected in the statistics on ADHD (Ingersoll, 1988).

Although ADHD is not considered a learning disability, between 15 and 20% of children and adolescents with learning disabilities will have ADHD (Gittelman, Halperin, Klein, & Rudel, 1984; Silver, 1981, all as cited in Silver, 1990). An even more notable statistic is that an estimated 50% or more of children with ADHD also have an accompanying learning disability (Stahl, 1995).

Stimulant medications are the most common form of treatment for this disorder (Ingersoll, 1988), with an estimated 3% of elementary children receiving them (Copeland & Wolraich, 1987; Dulcan, 1985; Hechtman & Weiss, 1986, all as cited in Hagerman & Murphy, 1992). Of those receiving medications, an estimated 80% of children and adolescents with ADHD can be helped significantly (Silver, 1990). However, there has been a great deal of controversy over the use of medications because of varying side effects (Ingersoll, 1988). Additionally, "medication is not a 'cure' for this disorder" but helps to inhibit hyperactive responses and impulsivity (Hagerman & Murphy, 1992). Other research on drug therapy with children with ADHD has shown that approximately 30% of the children are not helped. For those who do show improvement, drugs have only a temporary effect. Their influence on attention and arousal lasts only for the period of time that the drug is maintained in the nervous system

(Cermak, 1988b). Further studies have indicated that although medications enable many children to control ADHD related behaviors, they do not ensure improved learning (Stahl, 1995).

Current Descriptions of ADHD

"The essential feature of ADHD is a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development" (APA, 1994, p. 78). The DSM-IV (1994) classified subtypes of this disorder into the following three categories: (1) Attention Deficit/Hyperactivity Disorder, Combined Type; (2) Attention Deficit/Hyperactivity Disorder, Predominantly Inattentive Type; and (3) Attention Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type. The DSM-IV (1994) also clearly specifies that to be accurately diagnosed with one of these three subtypes, some symptoms have to be present before age 7, there must be impairment from the symptoms in two or more settings (i.e., school and home), and there must be clinically significant impairment in social, academic, or occupational functioning. Greenspan (1992) categorizes ADHD as a regulatory disorder characterized by difficulties in "regulating physiological, sensory, attentional, and motor or affective processes, and organizing a calm, alert, or affectively positive state" (p. 601).

Sensory Integration

Jean Ayres first coined the term *sensory integration* (SI) in the 1960s. She defined SI as the neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment (Ayres, 1991). Ayres' primary objective in developing this approach was to explain the underlying neurological cause of learning and behavioral problems in order to determine the optimal tool of treatment (Ayres, 1972b, 1975a, 1979, all as cited in Fisher & Murray, 1991). Sensory integrative treatment involves the use of enhanced, controlled sensory stimulation in the context of a meaningful, self-directed activity

in order to elicit an adaptive response. "The emphasis is on the integration of vestibular-proprioceptive and tactile sensory input, and not just on the motor response" (Fisher & Murray, 1991, p. 23).

Relationship of Attention Deficit and Sensory Integrative Disorders

A relationship exists between attention deficit and sensory integrative disorders. Information from Oetter (1986a,b), Cermak (1988a,b), and Burpee (1994) represents the bulk of occupational therapy literature that describes the relationship between sensory integrative and attention deficit disorders. Their findings have been developed through extensive literature reviews and clinical experiences, yet there has been limited research to support their observations. These authors describe several factors associated with attentional deficits and hyperactivity that suggest abnormal sensory integrative and sensorimotor development. These factors include: increased sensory sensitivity (Oetter, 1986a,b), also known and described as tactile defensiveness (Cermak, 1988a) and sensory hypersensitivity (Burpee, 1994); deficits in sensory registration (Oetter, 1986a,b), similarly described by Burpee (1994) as sensory hyposensitivity; decreased antigravity responses (Cermak, 1988a; Oetter, 1986a,b), further described by Burpee (1994) as motor incompetence; unusual patterns of arousal (Oetter, 1986a,b); dyspraxia and vestibular related disorders (Cermak, 1988a); and emotional and social challenges (Burpee, 1994).

Increased sensory sensitivity (Oetter, 1986a,b) or sensory hypersensitivity (Burpee, 1994) describes the concept of hyper- or oversensitivity in all the sensory systems. However, this heightened sensitivity was first recognized within the tactile system. Ayres first coined the term *tactile defensiveness* in 1964, and described it as "feelings of discomfort and a desire to escape the situation when certain types of tactile stimuli are experienced" (p. 8).

The term *tactile defensiveness* was further elaborated by Ayres (1979) as a sensory integrative disorder that results in a syndrome or collection of behaviors that includes excess emotional reactions, hyperactivity, or other behavioral manifestations (as cited in Royeen,

1985). These behavioral manifestations can include excessive fighting, the inability to sit quietly at a school desk, the inability to enjoy "contact comfort" with a significant other (Royeen, 1985), and increased motor activity, which may be because anxiety surrounds tactile experiences that the child did not initiate (Ayres, 1964). Burpee (1994) added that clinically, sensory hypersensitivity can be manifested in a number of ways, none of which pave the way for attentive learning, and may in fact be misconstrued as a primary attentional deficit.

Deficits in sensory registration (Oetter, 1986a,b) have also been described by Bundy and Koomar (1991). Bundy and Koomar (1991) explain that sensory registration deficits are manifested by significant delays in responding to sensory information or in an apparent failure to notice sensory stimulation at all. "Disorders of sensory registration often are most noticeable when affected individuals experience an incident that most people would find to be painful or very noxious; yet they are either delayed in responding to the stimulus or fail to respond to it at all" (p. 278). Burpee (1994) further describes sensory registration deficits as including sensory hyposensitivity; a processing deficit in which individuals are relatively insensitive to input; i.e., individuals seem to require greater amounts and intensity of sensory input to respond, and they often have a high threshold to pain. These children, adolescents, and adults are also apt to show attentional problems, because they don't recognize that there is much to attend to within their environment (Burpee, 1994).

Decreased antigravity responses were described by Oetter (1986a, b). Burpee (1994) expanded the concept to motor incompetence that could be an additional factor linking attentional deficits with sensory integrative dysfunction. "Antigravity responses are some of the earliest developing as well as important sensory registration or orienting responses needed throughout life" (Ayres, 1979; as cited in Oetter, 1986a). A body that is automatically able to right itself and adjust to the environment is in a position to be alert, to attend to, and to interact with the environment. Oetter calls this phenomenon "postural attention." When there is a deficit in the ability to maintain postural attention secondary to poor antigravity and righting, rotation, and equilibrium responses, then a child's ability to receive consistent information about the body and its relationship to the

environment in terms of space, place, and time will be decreased (Oetter, 1986b).

Unusual patterns of arousal (Oetter, 1986a,b) and developmental dyspraxia (Cermak, 1988a) are also discussed within the occupational therapy literature as sensory integrative deficits relating to attentional deficits. Unusual patterns of arousal suggest behavioral patterns that can shift an individual into an overaroused state with resulting disorganized responses. Examples may include fluctuations in level of alertness and arousal, reflected in possible disorganized sleep patterns and fluctuations in the ability to attend during interactions with unfamiliar people, tasks, and environments that the individual perceives as overstimulating (Oetter, 1986a). In contrast, developmental dyspraxia is a disorder characterized by problems in motor planning and sequencing motor responses. Developmental dyspraxia can easily contribute to attentional deficits if an individual experiences difficulty planning the sequence of steps required to execute a motor task (Cermak, 1988a).

Vestibular related disorders, specifically shortened duration of postrotary nystagmus (PRN) and gravitational insecurity (GI) are other sensory integrative disorders that have been linked to resultant attentional deficits (Cermak, 1988a). Cermak describes a study by Ayres that found that about 50% of children with learning disabilities had a shortened duration of PRN (Ayres, 1978). These same children also demonstrated poor balance, difficulty maintaining antigravity postures, and low muscle tone (Ayres, 1978; as cited in Cermak, 1988a). Gravitational insecurity is the second type of vestibular related disorder that Cermak relates to ADHD. "Children with this disorder are fearful of changes in body position and losing head/body alignment" (Ayres, 1979; as cited in Cermak, 1988a). Gravitational insecurity may be considered overresponsiveness to vestibular input, whereas decreased PRN may be seen as underresponsiveness to vestibular input, both of which suggest that children with these disorders have difficulty modulating vestibular input. It is suggested that the behavioral response of these children to their inefficiencies are behaviors associated with and included in the descriptors of ADHD (Cermak, 1988a).

Empirical Research

Kimball (1986) hypothesized that sensory integrative testing could be used to determine children who would respond favorably or adversely to stimulant medications for hyperactivity. Her findings indicated there are at least two observable types of hyperactivity associated with ADHD that are specifically related to differences in vestibular processing: "one related to underaroused or overinhibited lower brain centers, and another related to deficient inhibition from higher brain centers" (p. 241). She concluded that children with an underaroused vestibular system (decreased PRN) tend to be good responders to stimulant medications. She offers the explanation that these are the children who have overinhibition of the lower brain centers and because of this, they become "hyperactive" in an attempt to compensate for this inhibition, "thus allowing the brain to function more optimally" (Kimball, 1986, p. 243). Stimulant medications that provide a "calming" effect for these children could do so because they no longer need to compensate by unconsciously trying to increase arousal. Conversely, if there is deficient inhibition from higher brain centers (children with increased PRN), then stimulant medications would serve to increase the amount of information they had to inhibit, thereby causing decreased attention (Kimball, 1986).

Another study investigated the possible correlation between tactile defensiveness and ADHD. Lightsey (1993) performed a comparison study on children with and without a diagnosis of ADHD using the Touch Inventory for Elementary School Aged Children (TIE) (Fortune & Royeen, 1990). He found that a high correlation ($p < .0059$) exists between tactile defensiveness and ADHD when children with and without a diagnosis of ADHD are compared on the TIE (p. 6).

There are a limited number of research studies exploring the relationship between sensory integrative deficits and ADHD. Therefore, the purpose of this study was to describe the prevalence of various sensory integrative disorders in children with ADHD/ADD ages 4 years to 8 years, 11 months referred for OT evaluation and treatment. In this study, the following research question was addressed: What is the prevalence of various sensory integrative disorders as identified by a sensory integration evaluation, including the

Sensory Integration and Praxis Test (SIPT), clinical observations, and sensory history for children referred to OT who have a diagnosis of ADHD/ADD?

Method

Subjects

The sample consisted of 96 children between the ages 4 years and 8 years, 11 months who have a diagnosis of ADHD or ADD. Six subjects were discarded from the data because necessary information to complete the chart review was unavailable. Table 1 summarizes demographic information of the subject population.

The subjects were obtained from seven pediatric private practice settings across the United States that provide occupational therapy services, and that specifically use the SIPT as an assessment tool. Geographical locations in which the subjects were located include two private practices in Massachusetts, two in Pennsylvania, and four practices in California.

Subjects were included in the sample if they had been assessed using the Sensory Integration and Praxis Test (SIPT) between January 1990 and February 1996, and if they were diagnosed with ADHD/ADD by a physician, psychiatrist, or psychologist. Since both diagnostic categories had been used interchangeably within the literature, either a diagnosis of ADHD or ADD was accepted. Subjects were excluded from the sample if they had been administered the SIPT but were beyond the standardized age ranges of 4 years to 8 years, 11 months.

TABLE 1
Gender, Diagnosis, and Age of Sample (n=90)

Number Males	Number Females	Diagnosed ADHD	Diagnosed ADD	Mean Age (Months)	Standard Deviation Age (Months)
72	18	43	47	84.3	14.8

Instrumentation

The Sensory Integration and Praxis Test (SIPT)

The SIPT has been described as a sophisticated and psychometrically sound assessment tool designed to provide diagnostic and descriptive information related to sensory integrative and practice functions (Mailloux, 1990). The SIPT consists of a test battery of 17 subtests that assess practic abilities and various aspects of sensory processing including vestibular, proprioceptive, kinesthetic, tactile, and visual processing (Ayres, 1991). Norms for the SIPT were attained for children ages 4 years to 8 years, 11 months in a stratified national random sample of 1,927 children throughout the United States and Canada (Ayres, 1991). In addition to the 17 subtests of the SIPT, both a sensory history and clinical observations are necessary supplements for the assessment of sensory integrative dysfunction.

Clinical Observations and Sensory History

In addition to the SIPT, other sensory processing deficits that children with ADHD exhibit are assessed through clinical observations and a sensory history. The most standard clinical observations completed by therapists include general assessment of activity level, response to touch, visual control, coordination, praxis or motor planning, postural responses including antigravity control and balance reactions, and observation of residual reflexes. Clinical observations currently are not standardized, but based on a therapist's assessment of responses. Similarly, the sensory history is not currently standardized; however, it remains an important component of a SI evaluation. There are several forms for use as a sensory history, most of which are checklists depicting an individual's response to different types of sensory input including auditory, visual, olfactory, vestibular, tactile, and proprioceptive. In addition, an individual's social–emotional development is typically reviewed. The sensory processing deficits described within this study were generally assessed through both clinical observations and a sensory history. These sensory processing deficits include those described by Oetter (1986a,b), Cermak

(1988a), and Burpee (1994): tactile defensiveness, sensory defensiveness (SD)/hypersensitivity, sensory hyposensitivity, deficits in sensory registration, delay and/or disorder in the development of antigravity responses/motor incompetence, unusual patterns of arousal, developmental dyspraxia, shortened duration of postrotary nystagmus (PRN), gravitational insecurity (GI), and emotional and social challenges.

Procedure

A data sheet was designed that included demographic information, history, and SIPT testing results. The sensory processing deficits discussed by Oetter (1986a,b), Cermak (1988a), and Burpee (1994) were also listed on the data sheet. The sensory processing deficit of tactile or SD/hypersensitivity was subcategorized by sensory domains into tactile defensiveness, oral defensiveness, auditory defensiveness, visual hypersensitivity, and vestibular hypersensitivity in order to obtain more specific information. The sensory processing deficits of sensory hyposensitivity and deficits in sensory registration were combined into one category. This sensory processing deficit was also subcategorized into more specific information, including vestibular hyposensitivity, somatosensory (proprioception and tactile) hyposensitivity, and tactile discrimination deficits. In addition to recording shortened duration of PRN, prolonged duration of PRN was also recorded in order to gain more specific information about vestibular processing. Finally, if emotional and social deficits were reported and recorded in the chart, they were combined into one category titled social–emotional challenges.

Analysis

This study was descriptive, based on chart reviews of patient records in private OT settings from January 1990 to February 1996. Descriptive statistics were used for the purpose of data analysis. Percentages were used to examine number of males and females, and number of subjects diagnosed ADHD or ADD. The mean age and standard deviation were also calculated. The SIPT diagnostic groups were analyzed as a whole to determine the percent of subjects in each. The

frequency as well as the percent of subjects meeting criteria for the following sensory processing deficits was also determined: shortened duration of PRN, prolonged duration of PRN, developmental dyspraxia, poor antigravity control, deficits in arousal, and social–emotional challenges. The percent of subjects who had SD/hypersensitivity and sensory hyposensitivity/deficits in registration was calculated. Each subcategory as listed above was then analyzed separately. Finally, the number of sensory processing deficits demonstrated per subject was calculated. In addition, the frequency and percent of total subjects who experienced vestibular based deficits, tactile based deficits, and dyspraxia were calculated. The data were then used to either support or refute the information in the literature that described the sensory processing deficits that individuals with ADHD typically exhibit.

Results

Table 2 identifies the mean, standard deviation, mode, and range of the number of sensory processing deficits demonstrated per subject. These deficits include individual sensory processing problems and/or social–emotional challenges. These data were obtained by combining the deficits a subject demonstrated on all measures including the SIPT, clinical observations, and sensory history.

To clarify these results, each deficit area will be described separately. Results of data analysis from SIPT formal testing procedures will be described first.

TABLE 2
Number of Sensory Processing Deficits Demonstrated per Subject

Mean	Standard Deviation	Mode	Range
6.3	1.9	7	1–10

Note: Table includes subjects demonstrating social–emotional challenges.

SIPT Formal Testing Procedures

Results of data analysis from SIPT formal testing procedures are described in Table 3. These results include the SIPT groups, as well as results from the PRN test and the praxis tests.

TABLE 3
Percent of Subjects in Specific SIPT Diagnostic Groups

SIPT Groups/Individual SIPT Tests	Number of Subjects	Percent of Total
SIPT Diagnostic Groups (based on a cluster of scores)		
Bilateral Integration & Sequencing	23	25.6
Dyspraxia (Visuo & Somato)	21	23.3
Dyspraxia on Verbal Command	9	10
General SI Dysfunction	10	11.1
Subjects Not Matching SIPT Group	32	35.6
Individual SIPT Tests (based on single test scores)		
Shortened Duration PRN	25	27.8
Prolonged Duration PRN	10	11.1
Dyspraxia	62	68.9

Note: Subjects could fall into more than one SIPT group or no group. Therefore, percentages will not sum to 100%.

As seen in Table 3, the largest number of subjects (25.6%) were identified as having deficits in Bilateral Integration and Sequencing. Thirty-two subjects were not identified as a specific SI pattern, therefore, individual test score patterns were evaluated, which is an accepted practice. Individual test scores from the SIPT indicated that developmental dyspraxia was found in slightly over two-thirds (68.9%) of the subjects. In addition, shortened duration of PRN was found in slightly over one-fourth (27.8%) of subjects.

Clinical Observations and Sensory History

Sensory processing deficits including SD/hypersensitivity, sensory hyposensitivity/deficits in registration, and deficits in arousal are identified during a sensory integration evaluation through the clinical observations and sensory history. Therefore, these sensory processing deficits are recognized as an integrated variable; i.e., evidence for them comes from various sources and the clinical judgment of the evaluator, not through standardized testing procedures. In addition, poor antigravity control is routinely identified through clinical observations. Therefore, within this study, poor antigravity control is also recognized as an integrated variable. Social–emotional challenges were identified through the sensory history and/or parent interview.

TABLE 4
Subjects Demonstrating SD/Hypersensitivity

Types of Defensiveness	Number of Subjects	Percent of Total
Tactile	74	82.2
Oral	6	6.7
Auditory	27	30.0
Visual	6	6.7
Vestibular	5	5.6
Gravitational Insecurity	13	14.4

Note: Subjects can demonstrate more than one type of SD/hypersensitivity.

Results of subjects demonstrating SD/hypersensitivity are described in Table 4. These data were obtained from a combination of both clinical observations and the sensory history. As shown in Table 4, 82.2% of subjects demonstrated tactile defensiveness. Auditory defensiveness was the second most frequent type of defensiveness and was evident in 30.0% of subjects.

Results of subjects demonstrating sensory hyposensitivity/deficits in registration are described in Table 5. These data were also obtained from a combination of clinical observations and the sensory history. As shown in Table 5, somatosensory hyposensitivity was evident in 44.4% of the subjects, followed by vestibular hyposensitivity at 32.2%. Tactile discrimination deficits were identified the least, but occurred in 20.0% of the subjects.

TABLE 5
Subjects Demonstrating Hyposensitivity/Deficits in Registration

Types of Hyposensitivity/Deficits in Registration	Number of Subjects	Percent of Total
Vestibular	29	32.2
Somatosensory	40	44.4
Tactile Discrimination	18	20.0

Note: Subjects can demonstrate more than one type of hyposensitivity.

Subsequent Analysis

Through analysis of Tables 4 and 5, it appeared that a large percentage of subjects demonstrated SD/hypersensitivity and/or sensory

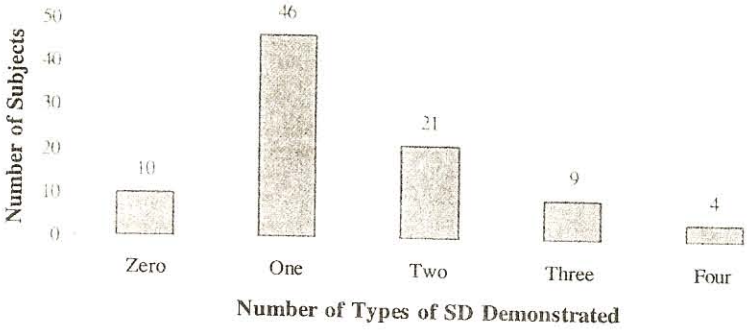

FIGURE 1. Number of Types of SD Found per Subject

hyposensitivity/deficits in registration. Further analysis showed that many subjects exhibited defensiveness in more than one sensory system. Figure 1 summarizes the number of types of defensiveness exhibited by individual subjects. The number of subjects not demonstrating SD/hypersensitivity is also included in Figure 1.

Likewise, 69% of subjects who demonstrated sensory hyposensitivity/deficits in registration (vestibular, somatosensory, and tactile discrimination) exhibited deficits in more than one sensory system. Figure 2 summarizes the number of types of hyposensitivity exhibited by individual subjects. The number of subjects demonstrating no sensory hyposensitivity/deficits in registration is also included in Figure 2.

As evident in Figure 1, only 10 (11.1%) subjects demonstrated no SD/hypersensitivity. Conversely, 88.8% of the subjects demonstrated

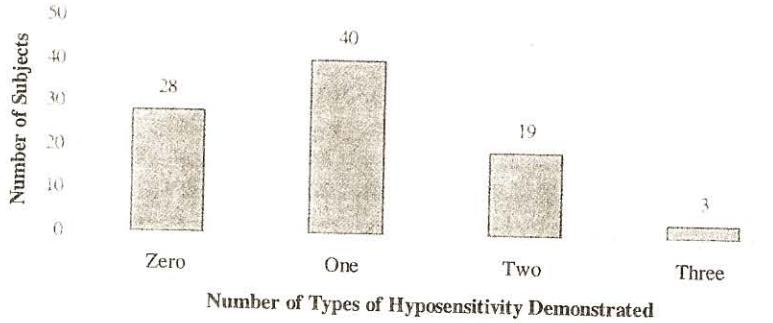

FIGURE 2. Number of Types of Hyposensitivity Found per Subject

some type of SD/hypersensitivity. Most frequently (51.1%), subjects demonstrated only one of the six types of SD/hypersensitivity noted above. As seen in Figure 2, slightly over two-thirds (68.9%) of the sample demonstrated some type of sensory hyposensitivity/deficits in registration. This indicates that many subjects may have had more than one deficit within a specific sensory system (i.e., both tactile defensiveness and somatosensory hyposensitivity).

Other Deficits

Subjects demonstrated other sensory processing deficits including poor antigravity control and deficits in arousal. These data were obtained through measures from clinical observations. Reports on social–emotional problems were obtained through the sensory history and/or parent interview. These deficits are summarized within Table 6.

As shown in Table 6, poor antigravity control and social–emotional problems were found in over 80% (81.1% and 89.9%, respectively) of the subjects. Deficits in arousal were found less frequently, but occurred in 23.3% of subjects.

TABLE 6
Other Sensory Processing Deficits Found Within the Sample

Type of Deficit	Number of Subjects	Percent of Total
Poor Antigravity Control	73	81.1
Deficits in Arousal	21	23.3
Social–Emotional Problems	80	89.9

Major Trends

When summarizing the results (see Figure 3), three SI deficits emerged as major trends within this study. Tactile defensiveness occurred in 82.2% of subjects, whereas 81.1% of subjects demonstrated poor antigravity control. Developmental dyspraxia occurred in 68.9% of subjects. In addition, social–emotional problems were reported in 88.9% of subjects.

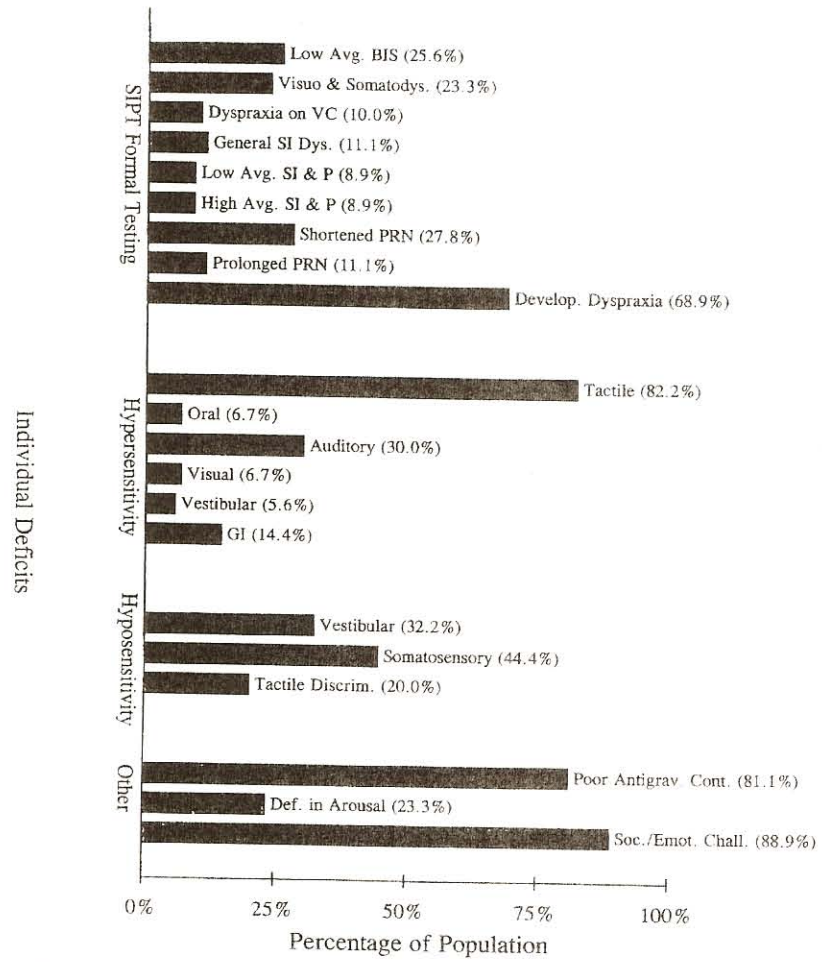

FIGURE 3. Individual Deficits vs. Percentage of Total Population

Additional follow-up analysis was done to explore the above trends. Since a large percentage of the population appeared to have vestibular based deficits, the total number of children demonstrating a vestibular based deficit was calculated. A vestibular based deficit was defined by combining the following categories: (1) Bilateral Integration and Sequencing; (2) shortened duration of PRN; (3) prolonged duration of PRN; (4) vestibular hypersensitivity; (5) vestibular

hyposensitivity; (6) gravitational insecurity; and (7) poor antigravity control. Results indicated 84 subjects (93.3%) demonstrated a vestibular based deficit. Likewise, since a large percentage of the population appeared to have tactile based deficits, the total number of children demonstrating a tactile based deficit was calculated. A tactile based deficit was defined by combining the following categories: (1) dyspraxia (visuo and somato); (2) tactile defensiveness; (3) tactile discrimination; and (4) somatosensory hyposensitivity. Results indicated 87 subjects (96.7%) demonstrated a tactile based deficit.

Finally, since a large percentage of the population demonstrated developmental dyspraxia, the total number of children demonstrating dyspraxia was calculated. Dyspraxia was defined by combining the following categories: (1) developmental dyspraxia; (2) dyspraxia (visuo and somato); and (3) dyspraxia on verbal command. The SIPT diagnostic groups high-average SI and praxis and low-average SI and praxis were not included since these groups typically describe normal children or those with mild deficits (Ayres, 1991). Results indicated 68 subjects (75.6%) demonstrated dyspraxia. Table 7 summarizes the results of this follow-up analysis for each global category (vestibular, tactile, dyspraxia).

TABLE 7
Subjects Demonstrating Vestibular or Tactile Based Deficits and/or Dyspraxia

Global Category	Number of Subjects	Percent of Total
Vestibular	84	93.3
Tactile	87	96.6
Dyspraxia	68	75.6

Discussion

Formal Testing Results

SIPT diagnostic groups and individual SIPT tests were first explored to determine patterns of sensory integrative dysfunction in children with ADHD/ADD. Fifty-eight (64.4%) of the subjects with ADHD/

ADD matched a specific SIPT diagnostic group. The additional 32 subjects (35.6%) did not match a specific group. Of those matching a specific SIPT diagnostic group, 1/4 of subjects (25.6%) had deficits in bilateral integration and sequencing. An additional 12.5% of the subjects not matching a specific SIPT diagnostic group were most similar to the bilateral integration and sequencing group. According to Ayres (1991), children with bilateral integration and sequencing deficits demonstrate their lowest scores on several tests identified with bilateral integration and sequencing, and have approximately typical scores on the remaining SIPT.

A description by Ayres (1991) of the children in the bilateral integration and sequencing group states, "the children fitting this group should not be considered to be profoundly dysfunctional but, rather, as showing a small degree of specific dysfunction" (p. 188). Although the sensory integrative deficits of children with ADHD/ADD may not be severe, the behavioral ramifications related to the underlying sensory integrative deficits can severely impact learning.

Dyspraxia (visuo and somato) was the second most common group comprising 21 subjects (23.3%). An additional 31.3% of the subjects did not specifically fall into this SIPT group, but demonstrated more similar patterns to this group than any other. Ayres (1991) describes children within the dyspraxia (visuo and somato) group as scoring below average on measures of tactile localization, visual praxis, and somatopraxis. This group of children also tend to demonstrate low scores on measures of bilateral integration and sequencing, and have the lowest mean score on the postrotary nystagmus test.

Individual SIPT Scores

The second focus of exploration within this study examined some specific individual SIPT scores, i.e., the PRN test and the praxis tests. It was evident that more subjects demonstrated a shortened duration of PRN (27.8%) than a prolonged duration of PRN (11.1%). This finding is consistent with the literature by Ayres (1979) who describes shortened duration of PRN as a vestibular related and sensory integrative disorder that affects learning. This finding also supports the

literature from Cermak (1988a) who describes shortened duration of PRN as one of the sensory integrative deficits related to ADHD.

In addition to 27.8% of the subjects demonstrating a shortened duration of PRN, 32.2% of subjects demonstrated vestibular hyposensitivity, or a deficit in registering vestibular input. Clinically, these findings suggest that a vestibular processing disorder in which subjects were hyporesponsive to vestibular stimulation was indicated in over 50% of the children. Kimball's description of children with an underaroused vestibular system supports this finding and suggests that a large percentage of children with ADHD may, indeed, appear "hyperactive" in an attempt to compensate for the overinhibition of the lower brain centers (Kimball, 1986, p. 243).

Developmental dyspraxia was another deficit area that emerged and was operationally defined as poor praxis or motor planning (Ayres, 1979). Poor praxis or motor planning was usually reported in the chart as part of the therapist's clinical observations or clinical summary of the child. In an attempt to assess the extent of dyspraxia in children with ADHD/ADD, the children with low scores on praxis tests were identified. Praxis tests of the SIPT that were used in identifying these children included bilateral motor coordination, sequencing praxis, postural praxis, and oral praxis. If a subject demonstrated below average scores on these tests, or if a description of dyspraxia was evident in the therapist's clinical observations or clinical summary, then the child was included in the number of children who demonstrated dyspraxia.

As previously described, developmental dyspraxia was one of the SI deficits that appeared as a major trend among the subjects. Dyspraxia was evident in 62 subjects, or 68.9% of the sample. This finding supports the contention of Cermak (1988a) who describes developmental dyspraxia as a type of sensory integrative disorder found in children with ADHD/ADD.

The third group of results examined were the various sensory processing deficits. These deficits composed an integrated variable that included SD/hypersensitivity, sensory hyposensitivity/deficits in registration, deficits in arousal and poor antigravity control. Each of these factors will be discussed separately.

SD/Hypersensitivity

SD/hypersensitivity was another SI deficit that emerged as a major trend within this study. Separating SD/hypersensitivity into specific sensory systems resulted in a more accurate description of the deficits found in children with ADHD/ADD. The information on SD/hypersensitivity was often reported through the sensory history and through the therapist's clinical observations, which included clinical impressions and a clinical summary.

Tactile defensiveness (82.2%), auditory defensiveness (30.0%), and gravitational insecurity (14.4%) were the three categories of defensiveness that occurred most commonly throughout this study. The high incidence of tactile defensiveness supports the assumption of its relationship to ADHD by Oetter (1986a,b), Cermak (1988a), and Burpee (1994). This finding is also consistent with the study of Lightsey (1993) who found that a high correlation exists between tactile defensiveness and ADHD.

The fact that auditory defensiveness occurred in over one-fourth of subjects also warrants attention. Auditory defensiveness may contribute to difficulty attending or focusing for the child with ADHD/ADD, since certain noises may cause the child to overreact or be distracted as opposed to remaining focused on the task at hand.

The third most common type of SD/hypersensitivity found among the subjects was gravitational insecurity (GI). This finding is consistent with the work of Cermak (1988a) who describes GI as a sensory integrative disorder related to ADHD.

Sensory Hyposensitivity/Deficits in Registration

Sensory hyposensitivity/deficits in registration were another component of the integrated variable. As was done for SD/hypersensitivity, separating the different types of sensory hyposensitivity into specific sensory systems allowed for a more accurate description of the deficits a child with ADHD/ADD may exhibit. Sixty-nine percent of the sample demonstrated some type of sensory hyposensitivity/deficits in registration. This trend supports the contention of Oetter (1986a, b), Cermak (1988a), and Burpee (1994) who describe how hyposensitivity can interfere with an individual's ability to attend.

Within this study, somatosensory hyposensitivity was apparent in 44.4% of subjects. Somatosensory hyposensitivity indicates a deficit in registering both tactile and proprioceptive stimulation (Burpee, 1994). In the chart, this deficit was usually described in the therapist's clinical observations by comments including "decreased registration of a painful stimulus" or "seeks out rough-and-tumble play."

It may seem contradictory that such a large percentage of subjects demonstrated tactile defensiveness, while at the same time somatosensory hyposensitivity was identified in a moderate number of subjects. Greenspan (1992) offers an explanation for this phenomenon by describing how a therapist should explore a child's reaction to firm pressure if, for example, a child appears overly sensitive or reactive to tactile stimuli. "For some children, firm pressure, as part of rough-and-tumble type play, can help the child to normalize sensory input and foster better capacities to focus and concentrate" (Greenspan, 1992, p. 611). In addition, Lane and Royeen (1991) suggest that "sensory defensiveness and sensory dormancy are adjacent and related phenomena under the rubric of a sensory modulation disorder. Such a theoretical model allows for an 'atypical' individual to shift from defensiveness to dormancy (or vice versa) without ever being in the midrange or within normal limits" (p. 122).

Poor Antigravity Control

Poor antigravity control was the third SI deficit emerging as a trend that appears in children with ADHD/ADD. Poor antigravity control was reported in 81.1% of subjects. This finding also lends support to the work of Oetter (1986a,b) and Burpee (1994), who describe how poor antigravity control often occurs in children with ADHD, and how this does not allow an individual to assume a posture that enables good attending.

Clinically, this finding and its implications need to be described to parents and educators, so there is increased understanding of why a child with ADHD/ADD may not be able to maintain an upright posture at the table or their desk. Since poor antigravity postural control appears to be a result of a sensorimotor processing problem, then perhaps what may be described by others as "laziness" with

motor activities needs further explanation. A label of "lazy" may only add to the frustration and social–emotional problems that many children with ADHD/ADD tend to exhibit.

Deficits in Arousal

Deficits in arousal, as described by Oetter (1986a,b), were supported in this study and reported in 23.3% of subjects. These deficits were usually identified in the chart through a description of the child poorly modulating sensory input so that the child became disorganized or overaroused. It is likely that if it were more clearly defined, that deficits in arousal would be reported more consistently.

Social–Emotional Challenges

An additional trend that appeared throughout this study was the high incidence of reported social–emotional challenges that occurred throughout the population (89.9%). This variable was identified through parent report within the sensory history, and included factors such as poor frustration tolerance, difficulty making friends, rigid personality, and feelings of anxiousness, anxiety, or depression. Since social–emotional challenges were not a standardized measure throughout this study, it is important to analyze this trend with caution. It is recognized that social–emotional challenges occur from a complex interaction of physiological, psychological, and family–environmental factors. Future research that measures the severity of social–emotional challenges within the ADHD/ADD population across varying age spans would be beneficial. It would also be beneficial for future research to measure the possible neurological components that could lead to social–emotional challenges. For example, it seems likely within this study that the varying sensory processing deficits that the subjects exhibited (i.e., tactile defensiveness, dyspraxia, etc.) could have contributed to the high incidence of social–emotional challenges.

Conclusion

Since this study was only descriptive in nature, there are limitations that affect the degree of generalization. For example, the relationship between age and severity of symptoms was unable to be measured. This information would be helpful for diagnostic purposes. It would also be beneficial for future research to further examine the possible neurological symptoms underlying ADHD/ADD. This would help therapists prioritize treatment strategies based on areas of need.

It is also important to remember that the subjects in this study were children referred to OT who also had a diagnosis of ADHD/ADD, and the subjects were given a sensory integrative evaluation at a clinic with known expertise in SI. These factors may also influence the degree of generalization of this study. This study does not presume that all children diagnosed as ADHD/ADD have sensory integrative dysfunction, but rather raises awareness that sensory integrative dysfunction may be one of a variety of causes or correlates of ADHD/ADD. Attention deficit hyperactivity disorder is a behavioral diagnosis and as such, it must be recognized that there may be a number of causes of the behaviors; one of which may be sensory integrative dysfunction. If sensory integrative dysfunction is a contributing factor in the diagnosis of ADHD/ADD, then treatment of this dysfunction may substantially impact extremes of behaviors.

Appendix: Definition of Terms

For the purpose of this study, the following definitions apply:

Attention Deficit Disorder (ADD): This term is used to describe Attention Deficit Disorder without Hyperactivity. The DSM-III definition for ADD states, "the child displays, for his or her mental and chronological age, signs of developmentally inappropriate attention, impulsivity, and hyperactivity" (APA, 1982, p. 42, cited in Silver, 1990).

Attention Deficit Hyperactivity Disorder (ADHD): "The essential feature of ADHD is a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than is

typically observed in individuals at a comparable level of development" (APA, 1994, p. 78).

Auditory defensiveness: An oversensitivity to certain sounds that may involve irritable or fearful responses to noises like vacuum cleaners, motors, fire alarms, etc. (Wilbarger & Wilbarger, 1991).

Delay and/or disorder in the development of antigravity responses/motor incompetence: The inability to maintain antigravity positions of prone extension and supine flexion for an age appropriate amount of time.

Dyspraxia: Poor praxis or motor planning (Ayres, 1979) demonstrated as difficulty in planning and carrying out skilled, nonhabitual motor acts in the correct sequence (Cermak, 1991). For the purpose of this study, developmental dyspraxia was determined by individual SIPT scores and clinical observations.

Emotional and social challenges: Emotional and social challenges are defined as feelings of anxiety, frustration, or poor self-esteem, as well as difficulties with peer or social interaction. This variable was not specifically defined or measured in this study. The incidence was determined by parent report as recorded in the chart and obtained by interview or history.

Gravitational insecurity (GI): "Abnormal anxiety and distress caused by inadequate modulation or inhibition of sensations that arise when the gravity receptors of the vestibular system are stimulated by head position and movement" (Ayres, 1979, p. 182).

Oral defensiveness: A dislike or avoidance of certain textures or types of foods (Wilbarger & Wilbarger, 1991).

Prolonged duration of PRN: Greater than or equal to one standard deviation above the norm on the postrotary nystagmus test (Ayres, 1979).

Sensory defensiveness/hypersensitivity: Sensory defensiveness (SD) is a tendency to react negatively or with alarm to sensory input that is generally considered harmless or nonirritating (Wilbarger & Wilbarger, 1991; as cited in Kinnealey & Miller, 1993). Type of SD/hypersensitivity described in this study include: tactile, oral, auditory, visual, vestibular, and gravitational insecurity or defensiveness. See definitions for each term.

Sensory hyposensitivity/deficits in registration: Significant delays in responding to sensory information or an apparent failure to notice sensory stimulation at all (Bundy & Koomar, 1991). Types

of sensory hyposensitivity/deficits in registration described in this study include: vestibular hyposensitivity, somatosensory hyposensitivity, and tactile discrimination deficits. See definitions for each of these terms.

Sensory integration (SI): "The neurological process that organizes sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment" (Ayres, 1989, cited in Fisher & Murray, 1991).

Shortened duration of PRN: Postrotary nystagmus (PRN) is the series of rapid back-and-forth movements that occurs following rotation. The duration of PRN is one of the better simple measurements of the efficiency or integrity of the vestibular system (Ayres, 1979). For the purpose of this study, shortened duration of PRN is defined as greater than or equal to one standard deviation below the norm on the postrotary nystagmus test (Ayres, 1979).

SIPT diagnostic groups: Categories of children based on cluster analysis on a national sample. There are six SIPT diagnostic groups including: Deficits in Bilateral Integration and Sequencing, Visuo- and Somatodyspraxia, Dyspraxia on Verbal Command, Generalized Sensory Integrative Dysfunction, Low-Average Sensory Integration and Praxis, and High Average Sensory Integration and Praxis (Ayres & Marr, 1991). See definitions of these diagnostic groups.

Bilateral integration and sequencing: A deficit area associated with inadequate processing of vestibular and proprioceptive inputs; demonstrated as an inability to use two sides of the body together in a coordinated manner (Ayres, 1972, 1976, 1979; all cited in Fisher, 1991).

Dyspraxia on verbal command: Difficulty with the components of auditory or language processing and motor planning bilateral and projected movements from a verbal command (Fisher & Murray, 1991).

Generalized sensory integrative dysfunction: The diagnostic group that tends to score far below average on all the SIPT, characterized by consistently low level of performance (Ayres & Marr, 1991).

High-average sensory integration and praxis: The diagnostic group of children who tend to fall in the average to high-average range on most of the tests of the SIPT (Ayres & Marr, 1991).

Low-average sensory integration and praxis: The diagnostic group of children who tend to fall in the low-average range on most of the tests of the SIPT (Ayres & Marr, 1991).

Somatodyspraxia: A specific type of developmental dyspraxia hypothesized to result from impaired tactile and proprioceptive processing (Ayres, 1991). Further described as a disorder of encoding a new motor response strategy; i.e., difficulty learning new tasks (Ayres, 1989, cited in Cermak, 1991).

Visuodyspraxia: Defined clinically as difficulty with form and space perception, visuomotor coordination, and visual construction (Fisher & Murray, 1991).

Somatosensory hyposensitivity: A deficit in registering tactile (touch) and proprioceptive (position sense) input suggesting underresponsiveness to these types of stimulation (Burpee, 1994).

Tactile defensiveness: "Feelings of discomfort and a desire to escape the situation when certain types of tactile stimuli are experienced" (Ayres, 1964, p. 8).

Tactile discrimination deficits: A disorder of tactile perception involving an inability to optimally perceive and organize incoming discriminative touch information for use (Lane & Royeen, 1991). Hyporeactivity is the basis for tactile discrimination deficits (Kinnealey & Miller, 1993), and may contribute to impaired awareness of self or body scheme (Ayres, 1972, 1979, both cited in Lane & Royeen, 1991).

Unusual patterns of arousal: Behavioral patterns that suggest a shift into an overaroused state with resulting disorganized responses (Oetter, 1986a). Within this study, deficits in arousal were measured based on comments from the sensory history and through clinical observations.

Vestibular hypersensitivity: Overreactivity within the vestibular system which may be demonstrated by either gravitational insecurity or

intolerance to movement (Ayres, 1976, as cited in Kinnealey & Miller, 1993).

Vestibular hyposensitivity: A vestibular modulation disorder suggesting underresponsiveness to vestibular input (Cermak, 1988a).

Visual defensiveness: An oversensitivity to light and/or visual distractability (Wilbarger & Wilbarger, 1991).

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