Correlational Research to Examine the Relation Between Attachment and Sensory Modulation in Young Children

Deborah A. Whitcomb, Ricardo C. Carrasco, Ariela Neuman, Heidi Kloos

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- somatosensory disorders

This study investigated whether a relation exists between attachment and sensory modulation in young children. Participants were 68 children ages 3–6 yr recruited through the local community. Caregivers were asked to complete a standardized behavioral inventory of sensory modulation patterns, and parent–child interactions were observed in their home. The evaluator categorized these interactions on the basis of items related to attachment security and dependency. Results revealed modest correlations between attachment and sensory modulation: \( r_s (66) = .28, p = .02 \). The capacity to predict sensory modulation function by attachment characteristics and the capacity to predict attachment characteristics by sensory modulation function was significant but small (\( p < .05 \)). These findings supporting a relation between attachment and sensory modulation should be considered when assessing and planning treatment of children with problems in one or both of these areas.


Participation in childhood occupations, such as play and exploration, and in co-occupations, such as feeding and other activities of daily living, are requisite for the healthy development of children (Price & Stephenson, 2009; Turner, Cohn, & Koomar, 2012; Whitcomb, 2012). Participation in typical childhood occupations may be disrupted as a result of environmental factors such as deprivation, isolation, abuse, or exposure to violence. Such disruptions may be described as interrelational because they are rooted in the interaction between the individual and other systems (e.g., the caregiver, the environment, other significant people; Szalavitz & Perry, 2010). Participation also may be disrupted because of compromised function or limited capabilities of the child (Parham & Mailloux, 2005). These disruptions may be described as intrarelational, that is, having their root solely within the individual through the interaction of internal systems (e.g., sensory processing, motor function).

The attachment relationship is described, in the two broadest categories, as secure and insecure. Secure attachment relationships are evidenced by behaviors in the dyad that show reciprocal interactions, matching of affect, and exploration with reunification. Insecure attachment relationships, in contrast, are those that show inconsistency or ambivalence in responses in the dyad (Ainsworth, Blehar, Waters, & Wall, 1978). Ainsworth et al. (1978) found evidence of secure attachment in 66% of infants and toddlers.

Sensory integration theory, as first conceptualized and articulated by A. Jean Ayres (1972), describes how an organism senses, registers, interprets, and responds to information from the environment. The inability to integrate sensory information adaptively has been termed sensory processing disorder (SPD; Ahn, Miller, Milberger, & McIntosh, 2004). Sensory modulation, a subtype of sensory
processing, is defined as the ability to regulate and organize sensory input and to respond in an adaptive manner, neither under- nor overresponding (Reynolds, Lane, & Gennings, 2010). This process requires the registration and interpretation of the sensory information and a graded response to it (Parham & Mailloux, 2005).

Growing evidence has linked risk factors for attachment difficulties (e.g., environmental deprivation) with SPD (Cermak, 2001). Cermak and Daunhauer (1997) studied sensory processing in postinstitutionalized orphans from Romania. Their research examined the effects of environmental deprivation on the development of sensory processing. They reported evidence of problems in visual, auditory, tactile, and movement processing. Lin, Cermak, Coster, and Miller (2005) studied the relation between length of institutionalization and sensory integration in children from Eastern Europe adopted into homes in the United States. They found that sensory processing function is correlated with length of institutionalization—the longer the child spent in the orphanage, the more profound the deficits in sensory processing. Although their findings support the link between environmental deprivation and sensory processing problems, the impact of the child–caregiver relationship was not addressed.

In a recent study, Purvis, McKenzie, Cross, and Razuri (2013) reported a statistically significant correlation between sensory deficits and negative attachment behaviors in 18 adopted children ages 3–14 yr who had experienced complex trauma. Parental reports of sensory concerns related to tactile, auditory, coordination, and muscle tone correlated with negative attachment behavior (p < .05), whereas occupational therapy screenings revealed a correlation between vestibular function and negative attachment behaviors (p < .01). Although promising, these findings are based on measures of sensory deficits and attachment behaviors that lack established validity and reliability. In fact, Purvis et al. (2013) concluded that “obvious caveats . . . temper the current findings” (p. 171) and that more studies are needed to examine the relation between sensory processing deficits and insecure attachment.

Because research has been limited, the relation between attachment difficulties and SPD remains unclear. This lack of clarity may result in professionals working in isolation or at odds with one another in addressing a portion of the child’s presenting problems rather than the whole child and family. Evidence supporting or refuting a relation between problems associated with attachment and sensory processing may provide insight to clinicians and service providers whose goals are to prevent or remediate these problems.

This study investigated the degree to which sensory modulation and attachment are related in children ages 3–6 yr. The research questions were as follows: (1) Is there a relation between attachment and sensory modulation in these children? (2) Is the health of the attachment relationship in these children predictive of their sensory modulation function? (3) Is sensory modulation function in these children predictive of the health of the attachment relationship? The predictive abilities of both attachment difficulties and sensory modulation disorder (SMD), which is a response to sensory input that is inappropriate for the magnitude of the input, are considered because attachment and sensory modulation are ontogenetically co-occurring; one cannot be said to precede the other developmentally.

Method

This study used a nonexperimental design and correlation and regression analyses to address the research questions. This study was approved by the institutional review board at Nova Southeastern University, Ft. Lauderdale, FL.

Participants

Children ages 3.0 yr to 6.0 yr who had lived with their primary caregiver for the past 12 consecutive months were eligible for inclusion in this study. Children who were receiving or who had received occupational therapy for SMD or psychotherapy for attachment difficulties were excluded from this study. Data were collected for 68 participants to ensure an adequate sample size based on an a priori power analysis assuming a 2:1 ratio of secure to insecure attachment as reported in the literature (Ainsworth et al., 1978).

Convenience sampling was used to recruit children through child care centers, schools, recreational facilities, and places of worship throughout the greater Cincinnati, OH, area. The sample consisted of 38 girls and 30 boys. The mean age was 51.1 mo (standard deviation = 9.63). All but 1 child were birth children of the primary caregiver. The primary caregivers were well educated; 88% held a bachelor’s or graduate degree. Eighty-five percent of the children were White, and 88% were non-Hispanic.

Assessments

Attachment Q-Set. Attachment was assessed using the Attachment Q-Set (Version 3; AQS; Waters, 1987). The AQS is an assessment that uses a card-sorting procedure to sort a total of 90 items descriptive of the interaction in the child–caregiver dyad. The card sort is based on an hour-long observation of the child with the primary caregiver. Therefore, the sort is based first on observed behaviors; second, on the verbal report of the caregiver or
child during the visit; and third, on the examiner’s judgment about whether an unobserved behavior was likely to be part of the dyad’s repertoire. When sorted by a professional familiar with attachment theory, the AQS has been found to be a reliable and valid tool for assessing attachment (Van Bakel & Riksen-Walraven, 2004; van Ijzendoorn, Vereijken, Bakermans-Kranenburg, & Riksen-Walraven, 2004). Teti and McGourty (1996) found the interrater reliability of the AQS security sort (AQS–S) score to be high ($r = .94$).

The methodology used for the observation and scoring of the AQS was consistent with the recommendations of its author (Waters, 1995, n.d.). After the card sorting, individual item scores were correlated with two expert sorts, the AQS–S and the dependency sort (AQS–D), to arrive at the attachment scores used in this study. The expert sorts provide a composite of the hypothetical “most secure” child as determined by experts in the area of attachment theory. In addition to the security sort, the dependency criterion sort was used because of the association in the literature between dependency in the preschool years and insecure attachment in earlier infancy (Sroufe, Fox, & Pancake, 1983; van Ijzendoorn, Goossens, Kroonenberg, & Tavecchio, 1985).

**Short Sensory Profile.** Sensory modulation was assessed through the use of the Short Sensory Profile (SSP; McIntosh, Miller, Shyu, & Dunn, 1999). The SSP was developed from the Sensory Profile (Dunn, 1999) to be used in research and as a screening tool. Caregivers are asked to report the frequency with which behaviors described in each item occur on a 5-point Likert-type scale. The 38 items are categorized into seven sections relating directly to sensory modulation: (1) Tactile Sensitivity, (2) Taste/Smell Sensitivity, (3) Movement Sensitivity, (4) Underresponsive/Seeks Sensation, (5) Auditory Filtering, (6) Low Energy/Weak, and (7) Visual/Auditory Sensitivity.

The reported internal reliability of the SSP, as determined by Cronbach’s $\alpha$, ranged between .70 and .90. Construct validity was established through a comparison of SSP scores and electrodermal responses during the Sensory Challenge Protocol (see Miller, Reisman, McIntosh, & Simon, 2001, for a full description of this protocol) in both typically developing children and children with SMD (McIntosh, Miller, Shyu, & Hagerman, 1999). In this comparison, significantly lower scores were found on all sections of the SSP for children with atypical electrodermal responses. To ensure internal validity, McIntosh et al. (1999) examined the intercorrelations between the section scores and the total SSP (SSP–Tot) scores. Correlations ranged from .25 to .76, indicating that the section scores contributed to the total score.

**Procedure**

Children and their caregivers participated in one session of 1–1.25 hr that occurred at the children’s homes. Once the proper consents and assents were obtained, the caregiver completed the SSP and a demographic survey, and the primary author (Whitcomb) observed the engagement of the child and caregiver in their natural environment to score the AQS. The order of the observation and the administration of the SSP varied and was determined by a randomization table. Immediately after the home visit, the researcher scored the AQS on the basis of her recollection of the visit.

To confirm the reliability of the AQS as an objective instrument and the researcher as an objective observer, seven video recordings of the home visits (10.4%) were randomly selected, viewed, and scored by a second evaluator. The second evaluator was not an occupational therapist with training in sensory integration theory; thus, strong interrater reliability provided evidence that the initial evaluator was not biased by any evidence of sensory processing problems that she might have observed during the home visit.

Interrater reliability was calculated using Pearson product-moment correlations. The correlation between the two examiners was calculated as $r(628) = .65$, $p < .001$. The moderate correlation can be explained by the two different perspectives of the evaluators: The researcher was present and interacted with the dyad, traveling from the home and then scoring the AQS, whereas the second evaluator viewed a video recording as a passive observer and then immediately scored the AQS.

**Data Analysis**

Data were analyzed using SAS (Version 9.3; SAS Institute, Cary, NC) with the exception of AQS interrater reliability, which was calculated using Excel (Microsoft Corporation, Redmond, WA). Descriptive statistics are provided in Table 1. To answer our first research question, we conducted a Spearman rank order correlation to examine the relation between attachment and sensory modulation in children aged 3–6 yr. We hypothesized that a correlation would exist between SSP–Tot scores and scores obtained from the AQS.

To answer our second and third research questions, we performed simple and multiple regression analyses to examine whether child–caregiver attachment could predict sensory modulation function and, conversely, whether sensory modulation function could predict attachment in children aged 3–6 yr. We performed simple linear regression with SSP–Tot and each of the seven
sections of the SSP as the predictor variables and both AQS–S and AQS–D as outcome variables. In simple linear regression, the identification of a variable as independent or dependent produces the same coefficient of determination. Consequently, the simple linear regression provided results to answer both the second and third questions. We also performed multiple regressions to predict SSP–Tot scores from AQS–S and AQS–D scores, AQS–S scores from SSP section scores, and AQS–D scores from SSP section scores.

Results

Is There a Relation Between Attachment and Sensory Modulation?

The Spearman rank order correlation coefficient for AQS–S and SSP–Tot was significant: $r(66) = .28, p = .02$. Although statistically significant, the strength of the correlation between attachment and sensory modulation was modest. This finding supports our hypothesis that a relation exists between attachment as measured by the AQS and sensory modulation as measured by the SSP.

Can Attachment Predict Sensory Modulation Function?

The results of simple linear regression indicating the degree to which the SSP can predict the AQS–S and AQS–D are presented in Table 2. SSP–Tot, Tactile Sensitivity, and Visual/Auditory Sensitivity were predictive of AQS–D at a significant level.

A multiple regression using AQS–S and AQS–D scores to predict SSP–Tot scores also produced significant results, $R^2 = .10, F(2, 65) = 3.60, p = .03$. The $R^2$ value was .10, indicating that 10% of the variability of SSP–Tot scores could be explained by the variation in AQS–S and AQS–D scores. The significant predictor was AQS–D, $\tau(1) = 2.22, p = .03, \beta = 0.26$. There was a small, but significant, capacity to predict sensory modulation function by attachment security.

Can Sensory Modulation Function Predict Attachment?

A multiple regression using SSP section scores to predict AQS–D scores was significant, $R^2 = .20, F(7, 60) = -2.21, p = .05$. The $R^2$ value was .20, indicating that 20% of the variability of AQS–D scores can be explained by variation in SSP section scores. The only significant predictor was Tactile Sensitivity, $\tau(1) = -2.92, p = .005, \beta = .476$. A multiple regression using SSP section scores to predict AQS–S scores was not significant ($p = .41$). There was a small, but significant, capacity to predict attachment security by sensory modulation function using the AQS and the SSP.

Discussion

This exploratory study investigated whether there is empirical evidence of a relation between attachment and sensory modulation in young children. The literature has discussed similar sequelae, diagnoses, and functional limitations in children who show evidence of attachment difficulties and SMD in younger years (Koomar, 2009). This study is a step toward creating a clearer understanding of the connection between attachment and sensory modulation. This understanding is requisite for the responsible development of effective interventions for young children who are affected by either or both of these problems and supportive strategies for family interventions.

Relation Between Attachment and Sensory Modulation

In this study, we found a significant correlation between AQS–S scores and SSP–Tot scores. This finding demonstrated
a relation between attachment and sensory modulation in the study population. A child who had lower scores on the AQS–S was more likely to have lower scores on the SSP–Tot. This finding suggests that young children who are insecurely attached to their primary caregiver may also struggle with correctly interpreting and responding to sensory stimulation from the environment. It also suggests that children who initially have atypical responses to sensory information may have difficulty forming a healthy attachment to their primary caregivers.

This finding supports the results of Purvis et al. (2013), who found a correlation between some sensory problems and negative behaviors in a sample of 18 children. Our larger sample from the general population provides findings that are more generalizable than those of Purvis et al., whose study was limited to children with sequelae from exposure to complex trauma. Our study also provides evidence of an association across a continuum of function rather than an analysis of dysfunction alone.

DeSantis, Harkins, Tronick, Kaplan, and Beeghly (2011) argued for an integrative model for describing an infant’s interactions with and responses to the environment and the caregiver. Their view called for a deeper consideration of whether the processes examined here (1) are separate and distinct constructs; (2) are the same but are described differently according to the perspective of the person describing them; or (3) involve some behavioral, biological, or system overlap. This study was not designed to provide definitive answers to these questions, but the findings shed some light on the possible answers. First, the significant correlation between attachment and sensory modulation as measured by the AQS and the SSP indicates that it is not a result of error; however, the strength of the correlation is modest. Therefore, the association is present, but the strength of that association supports the view of distinct constructs of attachment and sensory modulation.

Second, to aid clinical reasoning in treatment planning, it is important for occupational therapy practitioners to understand the similarities and distinctions in terminology used by various fields of study when describing symptoms of attachment difficulties and SMD. We have often found in practice that terms used by psychotherapists to identify a problem in attachment are similar, and sometimes identical, to terms used by occupational therapy practitioners to describe SMD. For example, hypervigilance is used to describe attachment difficulties, and overarousal is used to describe SMD (Miller, Anzalone, Lane, Cermak, & Osten, 2007; World Health Organization, 1992). These terms are often defined similarly by the various professionals who deal with each of these problems. However, there is a large distinction between the two in occupational therapy that is important to consider in treatment planning.

Hypervigilance indicates an extreme state of alertness attributed to the person’s desire for protection, whereas overarousal in sensory integration theory does not connote a heightened sense of a need for protection. Therefore, the approach taken by a practitioner when working with a child who has a heightened state of alertness deriving from the child’s sense of safety and self-preservation is different from the approach taken by the practitioner when the child has an underresponsive vestibular system. In the first case, the practitioner and child might create an intimate, contained space that is free from outside perturbations. In the second case, a great deal of active movement and “crashing” might be prescribed.

Third, it behooves occupational therapy practitioners to be detailed about collecting family and social history that includes more than developmental milestones. The family structure, living environments, and primary caregivers throughout the lifespan are examples of overlapping information that would help create the most efficacious treatment environment and activity possible.

**Predictive Ability**

The findings indicate that function in either co-occurring process—sensory modulation or attachment—can be explained or predicted by the other. These findings suggest that at least two possible patterns can support or undermine the healthy development of a child. The interaction of the two patterns can either exacerbate or remediate a maladaptive pattern or exploit or challenge an adaptive one.

One pattern is reflected in the child’s response to the caregiver’s initiative. For example, if children respond in a manner designed to protect themselves from sensory sensitivities (e.g., crying, arching away from the stimulus), caregivers may become less confident and more tentative with them, thus creating less consistent and less frequent contact. This situation may then lead to an insecure attachment relationship. Conversely, children with a typical response to sensory input will respond in a manner that will encourage the attenuation and reciprocity that is requisite to a healthy and secure attachment.

The second pattern focuses on caregivers and their responsiveness to infants. If caregivers are distant, inconsistent, or unresponsive, then children are likely to develop insecure attachments. Insecure attachment, because of the absence of a secure base, may limit children’s exploration of the environment and prevent the stimulation...
necessary to develop a well-modulated sensory system. Conversely, caregivers who are available and attentive will engage in the co-occupation of intersubjectivity and will become a secure base from which children can explore the world and have a sensory-rich experience leading to typical sensory modulation.

These two patterns occur simultaneously or overlap; they are not mutually exclusive experiences that lead to a particular outcome. Figure 1 illustrates both capabilities, sensory modulation and attachment, in an isolated system without the influences of other systems or the environment. It depicts an area of optimum functioning in which patterns of adaptive behaviors create efficiency and balance for the system, thus preparing that system for growth and development. Because this equilibrium is not a static point, as we traditionally think of homeostasis, but consists of patterns of behavior that maintain balance, we have named this area the homeodynamic corridor. In this area, each system (the child and caregiver) functions optimally. The areas outside of that corridor represent responses that are maladaptive.

In this study, the focus has been on the inter- and intrarelational aspects of the child. This treatment is a simplified version of a much more complex system that involves the interplay of the child, the caregiver, the dyad as a distinct entity, and the environment. Just as this study demonstrated the effect that attachment security and sensory modulation have on one another, any capability or effectivity of the system under scrutiny, or any affordance provided by the environment, may have an effect on the overall function of the system. Figure 2 represents the child–caregiver dyad in the context of its environment. The illustration shows that when there is an alignment of both the child’s sensory modulation and the caregiver’s attentiveness, the opportunity for optimum performance is available, represented by the dark center square. The figure depicts only one capability of each member of the dyad; as one considers additional combinations (e.g., the caregiver’s sensory processing), the picture becomes more complex and demonstrates that there are multifarious influences on the dyad’s performance.

Our findings, along with the conceptual model illustrated in Figure 2, may compel occupational therapy practitioners to consider inter- and intrarelational contributions to the problems for which their clients are receiving services. These findings may create a heuristic model that will allow practitioners to think about each member of the dyad and his or her relative position to good performance. Practitioners, understanding the importance of the effect of the dyad and the caregiver on the child, may consider all three when developing intervention strategies to improve the performance and participation of the child.

This research study provides support for the conceptualization of a model that considers more than the child’s capabilities in isolation but the interplay among

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**Figure 1.** Sensory modulation and attachment as isolated systems.

**Figure 2.** Interaction among child, caregiver, dyad, and environment.
and within the members of the dyad and the environment. For example, an occupational therapy practitioner may choose to incorporate the caregiver into therapy sessions as much as the caregiver is able. In this way, opportunities during the session may be created to facilitate attunement, joined attention, and joined intention between the child and caregiver. The child can use the caregiver, rather than the therapist, as a reference point for coregulation. The caregiver can experience the burgeoning connection with the child and develop a greater sense of competence in caregiving. Involving the caregiver in therapy will help build and strengthen the important relationship between the child and caregiver, which, in turn, will improve the child’s ability to participate.

Limitations

The caregivers who responded to our recruitment efforts were very attentive to their children and demonstrated initiative and interest in reaching out to understand their children better. Moreover, the sample included only 1 child for whom there was explicit evidence of multiple caregivers at an early age. Because of the sample’s homogeneity, the range of AQS scores was smaller than anticipated. If the sample had been more diverse, the range of scores may have been broader, resulting in stronger evidence of a correlation. The data range may also have been broader if the researcher had more frequent or longer encounters with the caregiver and child, thus observing a more extensive repertoire of behaviors.

The assessment tools available at the time of this study were potentially limiting factors. The AQS is not standardized or norm referenced. It does not provide classifications of children based on scoring, only a comparison between the child being tested and an “ideally” attached child, which was evaluated by an expert panel. The interrater reliability of the AQS provides an argument for its use and against any concerns that its use was a limiting factor in this study. The SSP is standardized and norm referenced, but it is a caregiver inventory. A caregiver inventory, rather than a performance-based assessment, may result in responses influenced by emotional reactions to recent experiences or the nature of the relationship. In this study, no mechanism was used to control for caregiver bias.

Implications for Occupational Therapy Practice

The findings of this study indicate that a relation exists between attachment and sensory modulation and that these two processes are influenced one by the other. These findings and the conceptual model in Figure 2 have the following implications for occupational therapy practice:

- Intervention that affects change in a child’s sensory modulation may create change in the child’s attachment relationship, and, conversely, change in the attachment relationship may affect sensory modulation.
- Occupational therapy practitioners may find it useful to consider both inter- and intrarelational factors as they serve children and families.
- The child’s primary attachment figure may be a valuable tool in the treatment process.

Conclusion

These findings provide new insights into how both sensory modulation and attachment can be viewed in the child’s early development and how both may be addressed in treatment. These findings also resulted in the support of a conceptual model that shows the dynamism between the two processes and, consequently, in the child–caregiver dyad. Further research is indicated to provide support of these findings and to examine implications for intervention and prevention. ▲

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