We compared the sensory and motor behaviors of typically developing infants with those of infant siblings of children with autism spectrum disorders (ASD), who are considered high risk for the disorder, to explore potential sensory and motor markers for use in early diagnosis of ASD. We compared frequencies of sensory and motor behaviors during 10-min, videotaped, infant–mother play sessions and during 5 min of spoon-feeding between groups of 12-mo-old infants. Data from standardized measures of development, sensory processing, and behaviors commonly associated with ASD were also analyzed descriptively for the high-risk group. The results indicated that high-risk infants demonstrated fewer movement transitions ($t_{23} = -2.4, p = .03$) and less object manipulation ($t_{23} = -2.4, p = .03$) than low-risk infants. The sensory and motor differences found between typical and high-risk infants suggest that early screenings for ASD should include the examination of sensory and motor behaviors.


Autism spectrum disorders (ASD) are developmental disorders characterized by pervasive deficits in social interaction and communication and a tendency toward restricted and repetitive behaviors (American Psychiatric Association, 2000). ASD diagnoses have been steadily on the rise, and estimates from the Centers for Disease Control and Prevention (2012) indicate a prevalence of 1 in 88. Kogan and colleagues (2009) estimated a U.S. ASD prevalence among 3–17-yr-olds of as high as 1.1%. Although the cause remains unknown for most people with ASD, twin and family studies indicate a strong genetic link.

For children with ASD, early detection is essential for facilitating access to interventions that can shape neural connections during sensitive periods of development (Robins, Fein, Barton, & Green, 2001). Early intervention has been associated with improved developmental and functional outcomes such as language development, cognitive development, and success at school (McEachin, Smith, & Lovaas, 1993; Ospina et al., 2008). More specifically for young children with autism, a combination of play-based and behavioral interventions may be vital in promoting development and adaptive functioning and minimizing clinical features of the disorder (Dawson, 2008; Johnson & Myers, 2007).

Unfortunately, children with ASD are often not diagnosed until age 2–4 yr (Filipek et al., 1999; Ospina et al., 2008; Zwaigenbaum et al., 2007), although much progress in early detection has been made over the past 5–10 yr. The American Academy of Pediatrics Council on Children with Disabilities (2006) recommended that pediatricians incorporate autism screening as part of routine practice. However, Al-Qabandi, Gorter, and Rosenbaum (2011) reported that routine screening of all infants may be premature at this time because of a lack of effective screening tools and evidence-based, efficacious practices and because of the need for a cost–benefit analysis of conducting universal early screenings.
Nonetheless, early identification allows families access to supports and resources and has the potential to enhance our understanding of ASD by promoting the study of environmental, behavioral, and developmental factors that may influence the course of the disorder. Retrospective parent interviews (Young, Brewer, & Pattison, 2003) and studies of home movies of infants later diagnosed with autism (Baranek, 1999; Osterling & Dawson, 1994; Werner, Dawson, Osterling, & Dinno, 2000) suggest that abnormalities in development are evident in the first 2 yr of life. However, the higher incidence of ASD in infant siblings of children with autism provides a unique opportunity to look prospectively at the development of ASD from infancy and inform us of potential early signs that may be of diagnostic importance.

Siblings of children with autism have an estimated risk that is at least 50 times greater than that of the general population (Liu et al., 2001). Studies using infant siblings have reported a recurrence risk of 14% (Zwaigenbaum et al., 2005) to more than 20% (Ozonoff, Young, et al., 2008; Sullivan et al., 2007; Yirmiya & Charman, 2010). Several prospective, longitudinal studies of siblings have been completed or are under way to identify indicators of ASD in infants and toddlers through ongoing standardized developmental evaluations and structured observations of this at-risk population (Bryson et al., 2007; Iverson & Wozniak, 2007; Ozonoff, Macari, et al., 2008; Yirmiya & Charman, 2010; Yirmiya et al., 2006; Zwaigenbaum et al., 2005). Veness et al. (2012), for example, found social and communication differences between 12-mo-olds with and without ASD, including the early use of gestures. Prospective designs enable researchers to examine early neurodevelopmental signs, behaviors, and developmental patterns over time under standardized conditions, allowing greater comparability both within and between individuals over time. Ultimately, the information can be used in the development of screening and evaluation tools aimed at early detection.

Motor disturbances have commonly been noted in children with autism (Baranek, 2002; Minshew, Sung, Jones, & Furman, 2004; Molloy, Dietrich, & Bhattacharya, 2003; Provost, Lopez, & Heimerl, 2007; Rinehart, Bradshaw, Bererton, & Tonge, 2001). Although researchers have begun to study early motor signs (Loh et al., 2007; Ozonoff, Young, et al., 2008; Teitelbaum, Teitelbaum, Nye, Fryman, & Maurer, 1998), few studies have examined scores from standardized motor assessments in conjunction with more functional fine and gross motor behaviors during typical infant activity such as feeding and play. Studies completed to date have produced inconsistent results. For example, Teitelbaum et al. (1998) reported that a sample of infants later diagnosed with autism showed many abnormal movement patterns, whereas more recent studies demonstrated no or few significant motor differences in infants later diagnosed with autism (Ozonoff, Young, et al., 2008; Provost et al., 2007). Loh et al. (2007) provided some evidence that arm waving in the context of standardized test administration was more often seen in children who were later diagnosed with ASD. Motor stereotypes and repetitive use of objects were found in a sample of high-risk infants at age 12 mo (Ozonoff, Young, et al., 2008). In a study of older boys with ASD (6–17 yr), Jansiewicz et al. (2006) found that children with ASD performed more poorly on many measures of motor control, including balance and coordination.

In examining potential early markers for identifying ASD in infants, Zwaigenbaum and colleagues (2005) noted that sensory orienting behaviors such as visual attention, orienting to name, visual fixation on certain objects, and visual tracking may be useful in distinguishing children with the disorder from typical children. Loh et al. (2007) found that high-risk infants who were later diagnosed with ASD used their hands to cover their ears (aversive response to sound) in the context of standardized test administration more often than children who did not have the disorder. Rogers, Hepburn, and Wehner (2003) found that parents reported sensory differences in their toddlers who were later diagnosed with ASD. Baron-Cohen, Ashwin, Ashwin, Tavassoli, and Chakrabarti (2009) conducted an interesting study examining the talents of children with autism, concluding that the excellent attention to detail and pattern recognition abilities of children with the disorder were often rooted in underlying sensory processing differences such as sensory hypersensitivities.

In a meta-analysis of 14 studies, Ben-Sasson et al. (2009) found evidence of significant differences in sensory modulation behaviors between typically developing children and children with ASD. In an examination of the sensory modulation patterns of sensory overresponsivity, sensory underresponsivity, sensory seeking, and total performance, differences were most pronounced from 6–9 yr of age, with a tendency toward sensory underresponsivity. More relevant to this study was the finding that children with ASD birth to age 3 yr were less often categorized as being sensory seeking than their typically developing counterparts. In summary, the research indicates that our understanding of the nature of early infant sensory processing and motor development is emerging with this population and suggests that these are promising areas for consideration in early screening of ASD.
Screening tools such as the Modified Checklist for Autism in Toddlers (Robins & Dumont-Mathieu, 2006) emphasize the examination of behaviors associated with emerging language, social interaction, and play that, if disrupted, are hallmark features of ASD. Because many of these types of behavior do not emerge developmentally until around 12–24 mo of age, however, relying on tools emphasizing social, language, and play behaviors is limiting at this young age (Baron-Cohen, Allen, & Gillberg, 1992). In contrast, sensory and motor behaviors are easily captured from birth, and if differences do exist in such behaviors, they may be able to be detected earlier than social, play, and language behaviors. Although sensory and motor behaviors are not core features of ASD, differences or abnormalities in sensory processing and motor skill development have commonly been found, as noted in the literature described earlier.

Feldman et al. (2012) emphasized the value of examining child behaviors in the natural context, leading them to develop the Parent Observation of Early Markers Scale (POEMS). POEMS includes a large range of possible early markers or signs of ASD that parents can observe within the context of their daily routines and interactions with their child. Feldman et al. found that differences between typically developing children and children diagnosed with ASD were more pronounced at 18–24 mo of age, although subtle differences were noted as early as 9 mo. The authors concluded that tools for ongoing surveillance of children by their parents in natural contexts are helpful additions to performance-based developmental measures for early detection of ASD.

The study described in this article examined both sensory processing and motor behaviors that we thought, on the basis of prior research, would be useful for the early detection of autism in 12-mo-old infants at high risk for developing the disorder. Data collection for this study included observations and coding of sensory and motor behaviors within the context of the typical daily routines of play and feeding via videotape for both typically developing children and high-risk siblings. Standardized developmental measures and caregiver questionnaires were also administered for the high-risk ASD siblings. Details of these measures are provided in the Methods section. The specific aims of this study were to describe the sensory and motor development and behaviors of infant siblings of children with ASD at 12 mo of age and to compare sensory and motor behaviors of high-risk infants with those of low-risk, typically developing infants at 12 mo during both a semistructured infant–mother play session and spoon-feeding.

Method

Research Design

In this study we implemented a two-group exploratory design to describe and compare data regarding the sensory and motor behaviors of 13 infant siblings at high risk for ASD and 12 typically developing infants. The University of New Hampshire institutional review board for the protection of human subjects approved the study, and we obtained informed consent from the parents before data collection.

Participants

All infants in the study were between age 11 and 13 mo. Exclusion criteria included known genetic, neuromotor, or developmental problems or disorders as well as prematurity. High-risk infants were recruited through local service providers and clinics specializing in young children and through local organizations for children with special needs and their families. The high-risk group included 13 infants with a sibling who had a confirmed diagnosis of ASD determined by a qualified team of professionals that included a developmental neurologist or pediatrician. All older siblings were assessed using the Autism Diagnostic Observation Schedule (Lord, Rutter, DiLavore, & Risi, 2002) either before diagnosis or for confirmation as part of this study.

We recruited the 12 typically developing infants in the low-risk group through personal contacts and local day care and preschool centers. All typically developing infants had siblings without any developmental concerns. Although the typically developing infants were not formally tested as part of this study, they were screened by the first author (Mulligan) and a pediatrician, and only infants for whom the parents and pediatrician identified no developmental concerns were recruited to be in the low-risk group. We made a follow-up phone call to the parents when the low-risk children reached age 30 mo to verify that the parents continued to have no concerns regarding their child’s development.

Procedures

All infants participated with their caregivers in a 10-min play session and a 5-min feeding session. Each session was videotaped and subsequently coded for sensory and motor behaviors. The format of the play and feeding sessions and the defining and coding of sensory and motor behaviors were developed and refined by the primary author (Mulligan). Sensory and motor behaviors were selected on the basis of previous research examining potential early
markers and on a review of ASD screening tools. Each sensory and motor behavior was operationally defined and tested for interrater reliability. In total, we analyzed 16 behaviors for play and 14 behaviors for the feeding session (see the Appendix for a list of behaviors and definitions). We used time sampling, recording the presence or absence of each behavior in 30-s time intervals. To examine interrater reliability, we analyzed data coded from three trained raters using nine play and feeding sessions. Total occurrences for each of the 30 variables were tallied and analyzed using the intraclass correlation coefficient (ICC). The results yielded an ICC of .97 using average measures, demonstrating strong consistency across raters.

Infants in the high-risk group were administered developmental assessments at 11–13 mo of age by the first author (Mulligan), who was aware that the older sibling was diagnosed with ASD. Standardized performance-based measures included the Mullen Scales of Early Learning (Mullen, 1995) and the Autism Observation Scale for Infants (AOSI; Bryson, Zwaigenbaum, McDermott, Rombough, & Brian, 2008; Zwaigenbaum et al., 2005). The standardized interview format for the Vineland Adaptive Behavior Scale (VABS; Sparrow, Balla, & Cicchetti, 1984) was also administered. Test administration followed standardized protocols and occurred at a university setting with clinic space and testing rooms for children. In all cases, the mother was present throughout the testing. A parent (typically the mother) completed the Infant–Toddler Sensory Profile (Dunn, 2002) before the clinic visit.

The first author and a trained research assistant conducted the play and feeding videotaped sessions in participants’ home for both the high-risk and the low-risk groups. Play sessions occurred in the living room or play room where the child most often played and included 10 min of the infant playing with the mother on the floor using a standardized set of common, enticing toys. The toys included large soft blocks, a mirror, a play phone, rattles, balls of various sizes and textures, a doll with a spoon, a bottle and blanket, and a toy hammer–play structure. The toy hammer–play structure had balls that, when hammered into holes on the structure, moved through a maze and out another hole. The mother was directed to play with her infant and the toys in any way she liked and in ways that would reflect how the dyad would typically interact and play with toys. They were not required to use all the play materials or toys. Feeding occurred in the family’s kitchen using the child’s high chair. The mother was asked to support the child in any way she typically would, and the mother provided a food item that the child was accustomed to eating (cereal, applesauce, and yogurt were most common).

**Instruments**

The VABS assesses adaptive functioning for individuals from birth to age 90 across four domains—Communication, Daily Living Skills, Socialization, and Motor Skills—and provides an overall Adaptive Behavior Composite score. The VABS was standardized on a national sample of 3,000 children matched to U.S. census data. Internal consistency examined by split-half reliability coefficients is acceptable, ranging from .84 to .88, and test–retest reliability reported in the manual is also acceptable, with $r$ values ranging from .78 to .92 for all areas for the birth to 3 yr age range (Sparrow et al., 1984).

The Infant–Toddler Sensory Profile (Dunn, 2002) is a caregiver questionnaire measuring the ability to process and modulate sensory information, developed with a normative sample of 589 children from birth to age 36 mo. The caregiver rates on a scale ranging from 1 to 5 the frequency with which his or her child exhibits certain behaviors indicative of sensory processing. Internal consistency estimates across sensory processing sections and quadrants (representing Low Registration, Sensory Seeking, Sensory Sensitivity, and Sensory Avoiding) varied with the children aged 7–36 mo and ranged from .42 to .85, with the strongest values representing the sensory processing patterns. Test–retest reliability values are acceptable on the basis of a study of a normative subsample ($n = 32$), with coefficients of .86 for sensory processing section scores and .74 for quadrant scores. Evidence regarding content, construct, and discriminant validity is also provided in the manual (Dunn, 2002).

The Mullen Scales of Early Learning is a standardized, norm-referenced, developmental measure for children from birth to age 68 mo. It was normed on 1,849 children based on U.S. census data and generates standard scores for five subscales—Gross Motor, Fine Motor, Visual Reception, Receptive Language, and Expressive Language—as well as an Early Learning Composite score. Split-half internal consistency coefficients are acceptable, with median values (from the normative data) ranging from .75 to .91. Test–retest reliability was obtained with 97 children over a 2-wk period and ranged from .71 to .96 (Mullen, 1995).

The AOSI was developed to assess behaviors specific to ASD in infants. The clinician administers several play-based activities to elicit possible behavioral markers for ASD, such as poor eye contact, lack of orienting to name, lack of social smiling, deficit in interest in others, and reactivity to sensory stimuli. The AOSI has demonstrated strong interrater reliability (.94 with children at 18 mo),
fair test–retest reliability (.61 using the total score for infants 12 mo of age). Predictive validity when administered at 12 mo has also been found to be strong (Bryson et al., 2008).

Data Collection and Analysis

Videotaped data from the play and feeding sessions were transferred to a DVD, and the sessions were viewed to record the targeted sensory and motor behaviors as being either present or absent every 30 s. Coding was conducted by the first author and three research assistants whom she trained in the use of the measure. Three demonstration tapes were used for training purposes, and research assistants achieved 90% agreement with Mulligan across all cells before coding independently. Training involved approximately 6 hr of review of the definitions, practice coding, and discussion with Mulligan to resolve disagreements. The research assistants were blind to group assignment and coded 70% of the digital recordings; Mulligan coded the remaining recordings.

The first author or a trained research assistant scored all standardized tests (i.e., AOSI, Mullen Scales) and parent questionnaires. Descriptive statistics were used to analyze data from the standardized developmental measures administered to the high-risk infants. One-sample t tests were used to compare the mean developmental scores of each of the 13 children in this group with each test’s normative data to determine whether the group differed significantly from the normative sample. To examine sensory and motor differences between the high-risk and low-risk groups, we coded mean frequencies for each behavior from the play and feeding sessions and then compared the groups using independent t tests, with the α level for determining statistical significance set at .05. All data were analyzed using PASW Statistics 18, Release Version 18.0 (SPSS, Inc., Chicago).

Results

The study sample included 8 girls and 5 boys in the high-risk group (mean age 12.6 mo) and 7 girls and 5 boys in the low-risk group (mean age 12.1 mo). Most participants were White, and all were from New England. The groups did not significantly differ with respect to race, gender, and age. Follow-up at age 30 mo indicated that four of the high-risk infants met criteria for ASD, and another two children had received early intervention services for mild developmental concerns. None of the children received early intervention services before 12 mo of age, and none of the infants placed in the low-risk group exhibited developmental concerns.

The developmental profile of the high-risk group fell largely within the low end of the average range, although some relative strengths and weaknesses are noteworthy. A summary of these results is presented in Table 1. Fine motor performance and visual reception skills fell in the average to above-average range, whereas gross motor skills were within the low-average range. Test scores measuring social and communication skills were mixed, although most fell within the low-average to below-average range. The number of markers noted using the AOSI indicated that 31% of the children were at high risk for developing ASD. Sensory processing differences were also found; scores from the high-risk group reflected less sensory-seeking behavior than scores of children from the normative sample and a tendency for more difficulties in the area of auditory processing.

The results of the one-sample t tests revealed some significant differences between the scores of this group and the normative data for each of the tests. On the Mullen Scales of Early Learning, scores from the high-risk group were higher on Visual Reception (t[12] = 2.1, p = .059), approaching significance, and significantly higher on the Fine Motor Scale (t[12] = 3.2, p = .009). Performance of the high-risk group was, however, significantly poorer on the Expressive Language (t[12] = −3.6, p = .004) and Receptive Language (t[12] = −3.7, p = .004) scales. On the VABS, the Motor Scale showed significantly lower scores for the high-risk group than the normative sample (t[12] = −2.4, p = .03); there were no other significant differences.

Videotaped coding of sensory and motor behaviors during play and feeding revealed that compared with infants from the low-risk group, the high-risk group demonstrated significantly fewer movement transitions (t[23] = −2.4, p = .03) and less object manipulation (t[23] = −2.4, p = .03; see Table 2). Thus, children in the high-risk group tended to move around less during the play session, and they manipulated objects in their hands less frequently (see definitions in the Appendix). No significant differences were found between groups on the other sensory and motor behaviors coded during the play sessions, and no differences between groups were noted on the behaviors coded from the feeding sessions.

Discussion

The results suggest that contextual, play-based observations in conjunction with standardized developmental measures may have a vital role in the early detection of ASD. In this study, how the infants used their hands to manipulate toys in play and how much they moved...
around during play appeared to be important considerations. Although many of the high-risk infants scored within the normal range on the standardized motor measures, during more unstructured play, they used less sophisticated functional fine and gross motor movements than would be expected.

An examination of the variability and frequency of the sensory and motor behaviors that were observed and coded

Table 2. Mean Frequencies of Sensory and Motor Behaviors Coded From Play Sessions

<table>
<thead>
<tr>
<th>Coded Behavior</th>
<th>High-Risk Group, Mean (SD)</th>
<th>Low-Risk Group, Mean (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor stereotypy</td>
<td>0.2 (0.6)</td>
<td>0.2 (0.6)</td>
<td>.95</td>
</tr>
<tr>
<td>Object stereotypy</td>
<td>0.85 (1.1)</td>
<td>1.9 (0.5)</td>
<td>.19</td>
</tr>
<tr>
<td>Mouthing objects</td>
<td>5.7 (5.3)</td>
<td>3.7 (2.9)</td>
<td>.27</td>
</tr>
<tr>
<td>Movement transition</td>
<td>7.5 (5.5)</td>
<td>12.3 (4.7)</td>
<td>.03</td>
</tr>
<tr>
<td>Orient toward visual stimulus</td>
<td>19.8 (1.3)</td>
<td>17.7 (4.1)</td>
<td>.09</td>
</tr>
<tr>
<td>Orient toward auditory stimulus</td>
<td>15.5 (3.9)</td>
<td>14.9 (4.7)</td>
<td>.75</td>
</tr>
<tr>
<td>Orient toward tactile stimulus</td>
<td>9.7 (6.5)</td>
<td>6.3 (4.1)</td>
<td>.13</td>
</tr>
<tr>
<td>Aversive response to visual stimulus</td>
<td>0.23 (0.6)</td>
<td>0 (0)</td>
<td>.20</td>
</tr>
<tr>
<td>Aversive response to auditory stimulus</td>
<td>0.46 (1.1)</td>
<td>0.2 (0.9)</td>
<td>.61</td>
</tr>
<tr>
<td>Aversive response to tactile stimulus</td>
<td>0.61 (1.3)</td>
<td>0.2 (0.4)</td>
<td>.25</td>
</tr>
<tr>
<td>Object manipulation</td>
<td>9.7 (4.4)</td>
<td>13.4 (3.3)</td>
<td>.03</td>
</tr>
<tr>
<td>Motor imitation</td>
<td>3.3 (2.7)</td>
<td>2.5 (2.3)</td>
<td>.43</td>
</tr>
<tr>
<td>Construction play</td>
<td>0.15 (0.5)</td>
<td>0.3 (0.6)</td>
<td>.46</td>
</tr>
<tr>
<td>Sensorimotor play</td>
<td>13.4 (6.6)</td>
<td>12.1 (6.7)</td>
<td>.62</td>
</tr>
<tr>
<td>Functional play</td>
<td>10.8 (5.2)</td>
<td>11.2 (3.7)</td>
<td>.83</td>
</tr>
<tr>
<td>Associative play</td>
<td>9.0 (6.3)</td>
<td>10.3 (3.6)</td>
<td>.55</td>
</tr>
</tbody>
</table>

Note. SD = standard deviation.  
*p < .05.
during the play sessions provides some insight into which behaviors may be useful for future consideration related to screening for ASD. For example, behaviors that were coded as being absent or not observed in almost all intervals would not be helpful, such as movement stereotypy; aversive responses to visual, auditory, and tactile sensory input in both feeding and play sessions; construction play; and motor imitation during feeding. Behaviors that were seen a moderate amount of time that appear more promising as possible early markers in young infants include object stereotypy; mouthing of objects; motor imitation during play; and spontaneous sensorimotor, functional, and associative forms of play.

It was somewhat surprising to find no differences between groups in the frequency of functional, sensorimotor, and associative forms of play. It may be that differences in types of play and other behaviors may not be clear until after age 12 mo. Christensen et al. (2010), for example, in a study of infant siblings of children with ASD at age 14 mo, found that high-risk infants engaged less often in functional play than did age-matched, typically developing counterparts.

During the feeding session, the finding of no significant differences in sensory or motor behaviors between groups may be explained in part by the nature of the context. First, the opportunity for movement was limited in the high chair to largely oral–motor and upper-extremity movement. Second, the task of feeding is familiar and routine and lends itself to little variation in how it is performed. It may be that such a familiar task, with little variation in how it was carried out among the dyads, resulted in similar sensory and motor behavioral responses from the infants.

The developmental profile of the high-risk group in this study was consistent with that found in other studies of young siblings, which have found relative strengths in visual–perceptual skills, motor performance falling within the low end of the average range or borderline, and difficulties in receptive and expressive language (Landa & Garrett-Mayer, 2006). We also found sensory processing differences in the high-risk infant siblings, detected through the use of the Infant–Toddler Sensory Profile (Dunn, 2002). In particular, the high-risk infants tended to be less sensory seeking, a finding consistent with that of Ben-Sasson et al. (2009). It may be that early on, these infants have less capacity or motivation for exploration within their natural environments. It may also be an adaptive response learned by the infants to avoid exposure to sensory stimulation that they may experience as distressing.

Prospective study designs have been helpful for supporting research in the design of valid screening and evaluation instruments for young children before age 2 yr. Zwaigenbaum et al. (2007) reported that valid instruments are becoming increasingly available, and clinicians trained in their use are showing evidence for reliable and stable early diagnosis (as early as age 2). Although consensus on the need for universal screening has not yet been reached, early identification of ASD provides families with important information and resources. With very early entry into effective intervention services, the possibility for significant reductions in symptoms associated with ASD, or even the possibility for prevention, is promising.

Limitations and Future Research

A number of limitations must be considered in the interpretation of this study’s findings. First, the sample size was small, which increases the risk for Type I error, and because only predominantly White families from New England were represented, generalizability is limited. Second, the high-risk group, as expected, was quite heterogeneous in that 4 children ultimately were diagnosed with ASD, 2 children received early intervention for speech and language concerns but were not diagnosed with the disorder, and 7 were not identified as having any neurodevelopmental disorder or delays in development. In addition, a few of the children who were diagnosed with an ASD may have represented a broader ASD phenotype with subtle characteristics of the disorder, but not to the extent that a diagnosis was made. Therefore, as more data are collected, analyses using data from only those children who eventually have confirmed ASD diagnoses would provide a clearer picture of early markers.

The inconsistency in scores across the measures of social and communication skills is also a weakness of the study and may be attributed in part to the specific characteristics of the tests used and the differences in the measures’ sensitivity for detecting differences in children at age 12 mo. For example, the expectation of word utterances at 12 mo of age is very low for even typically developing infants. Therefore, this type of test item is not as discriminating as it would be for children at age 18 mo. The study design would also have been strengthened if all data had been coded by researchers blind to group assignment; although we attempted to blind researchers, occasionally they were able to hear siblings on the videos in the background, and because of limited resources, only about 70% videotapes were coded blindly. Therefore, researcher bias may have affected the coding, although the operational definitions of the behaviors and strong interrater reliability data addressed the risk of researcher bias to some degree.

Ongoing research is needed to further develop and validate screening and assessment measures for early
diagnosis. Larger studies that systematically collect data longitudinally from at-risk infants from more diverse populations at multiple time points, such as at 6, 12, 18, and 24 mo of age, would provide a more in-depth understanding of potential markers and increase generalizability. In addition, an analysis of data from only those children who eventually develop ASD would provide more clarity with respect to potential markers for early screening and diagnostics.

Implications for Occupational Therapy Practice

The results of this study have the following implications for clinical occupational therapy practice:

- Occupational therapists and other team members who are involved in the initial diagnosis of children with ASD should be aware of reliable and valid evaluation and screening tools, receive training in their use, and apply them in the diagnostic process.
- Occupational therapists are and should continue to be involved as valuable contributors in the evaluation process for determining ASD diagnoses, in light of their expertise in the areas of occupational performance, sensory processing, play behaviors, and motor development of infants and toddlers.
- Contextual observations of mother–infant play should be considered for inclusion in the diagnostic process. Not only do they have the potential to elicit sensory and motor behaviors that may be important for diagnostic purposes, but they can enhance our understanding of how such behaviors may influence a young child’s ability to play, learn, and perform daily activities. ▲

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Note. Appendix begins on next page.
Appendix.
Operational Definitions for Coding Sensory and Motor Behaviors

Behaviors During Play

**Motor stereotypy**—Repetitive body movement. Child may engage in wiggling, flapping, or flicking of the fingers or hands; alternate flexion and extension of the fingers; alternate pronation and supination of the forearm; or head rolling, head banging, body rocking, or body swaying back and forth.

**Object stereotypy**—Repetitive movement with an object. Child makes the same movement with an object more than 10 times in a 30-s interval.

**Mouthing objects**—Child puts a toy or object partially or completely in mouth for any length of time, or an object touches child’s lips.

**Movement transition**—Child transitions from one position to another or physically moves from a location. Examples of movement transitions include moving in or out of sitting or to and from kneeling; side lying, supine, or prone lying positions; crawling; scooting; pivoting in sitting; or walking. Repositioning self in sitting—for example, from side sitting to cross-legged or a long sit—does not qualify as a movement transition if child remains in the same spot.

**Orients toward visual**—Child responds positively to visual stimuli, such as mirror, mom’s face, moving objects, or bright colors, by turning head toward, moving body toward, reaching for, or looking toward the stimulus.

**Orients toward auditory**—Child responds positively to auditory stimuli, such as squeaky ball, ringing phone, rattle, banging of the mirror, mom’s voice, or other environmental sounds, by turning head toward, moving body toward, reaching for, or looking toward the stimulus.

**Orients toward tactile**—Child responds positively to tactile stimuli, such as parent’s touch, baby blanket, bumpy ball, or fuzzy blocks, by turning head toward, moving body toward; repeatedly touching, rubbing, or patting; or mouthing the stimulus.

**Aversive response to visual**—Child reacts negatively to visual stimuli, such as mirror, moving objects, or bright colors, by closing eyes, screaming, crying, or turning head or moving away from the stimulus.

**Aversive response to auditory**—Child reacts negatively to auditory stimuli, such as squeaky ball, ringing phone, rattles, or banging, by covering ears, screaming, pushing toys away, crying, or turning head or moving away from the stimulus.

**Aversive response to tactile**—Child reacts negatively to tactile stimuli, such as baby doll, blanket, or bumpy ball, by withdrawing hands after touching object, pushing object away, or moving object away from the object. Child cries or sounds distressed following a tactile stimulus.

**Object manipulation**—Child transfers object from one hand to the other; repositions object in the hand, perhaps using the floor or body part to help reposition object in the hand; or manipulates object in the hand, which does not include simple picking up, grasping, holding, throwing, and shaking.

**Motor imitation**—Child imitates hand motions (pushing, rubbing, tapping, banging hammer, squeezing, turning, pointing, shaking rattle), facial movements (blowing, kissing, sticking out tongue), or other body movements that he or she has seen the caregiver perform; includes movements performed after verbal prompting if the movement was also demonstrated. The imitated behavior must occur within the same time segment as the stimulus movement.

### Types of Play

**All forms of play may be seen in the same segment.**

**Construction play**—Child builds or attempts to build with soft blocks.

**Sensorimotor play**—Child examines sensory features of play objects by feeling, looking at, touching, listening to, or exploring the objects but does not need to display any functional use of the objects.

**Functional play**—Child uses objects functionally for their intended purposes, such as covers baby doll with blanket, puts bottle to baby doll’s mouth, hammers ball into hole, rolls ball, talks or babbles on phone, brings phone to ear, presses phone buttons, or builds with blocks.

**Associative play**—Child demonstrates at least one instance of social play or engagement with the parent during the segment. Examples include turn taking, performing 3-point eye gaze between parent and object (parent–object–parent or object–parent–object), imitating, giving, showing, following a verbal direction, and responding appropriately to gestural communication.

### Behaviors During Feeding

**Motor stereotypy**—Repetitive body movement. Child may engage in wiggling, flapping, or flicking of the fingers or hands; alternate flexion and extension of the fingers; alternate pronation and supination of the forearm; or head rolling, head banging, body rocking, or body swaying back and forth.

**Object stereotypy**—Repetitive movement with an object. Child makes the same movement with an object, such as banging the spoon or spinning the bowl, more than 10 times.

**Individually scoops**—Child uses spoon to scoop food on his or her own.

**Spoon to mouth**—Child brings food to mouth using spoon and places food in mouth.

**Hand to mouth without spoon**—Child brings hand to mouth in the context of feeding, such as putting food item in mouth, pushing food into mouth, stopping food loss, wiping food, or sucking fingers.

**Plays with food**—Child uses food nonfunctionally (not trying to eat it) by, for example, pushing food around tray, throwing food, or mashing food between fingers.

**Orients toward visual**—Child responds positively to visual stimuli, such as mom’s face or moving objects, by moving head or body toward or reaching for stimulus; child visually tracks spoon as it is brought to mouth.

**Orients toward auditory**—Child responds positively to auditory stimuli, such as mom’s voice or other environmental sounds, by turning head toward, moving body toward, reaching for, or looking toward the stimulus.

**Orients toward tactile**—Child responds positively to tactile stimuli, such as parent’s touch or contact with food, by turning head toward, moving body toward, or repeatedly touching the stimulus; child plays with food or licks food off lips or hands.

**Aversive response to visual**—Child reacts negatively to visual stimuli, such as caregiver’s face or moving spoon or bowl, by closing eyes, screaming, crying, or turning head or moving away from the stimulus.

**Aversive response to auditory**—Child reacts negatively to auditory stimuli, such as mom’s voice or other environmental sounds, by covering ears, screaming, pushing stimulus away, crying, or turning head or moving away from the stimulus.

**Aversive response to tactile**—Child reacts negatively to tactile stimuli, such as holding spoon or feeling food on hands, by withdrawing hands; shaking hands to remove food; pushing food, bowl, or spoon away; or moving body away from the stimulus.

**Sits upright**—Child sits upright in high chair without slouching or needing repositioning by the parent.

**Motor imitation**—Child imitates hand motions (pushing, rubbing, tapping, pointing, scooping) or facial movements (blowing, kissing, sticking out tongue) that he or she has seen the caregiver perform; includes movements performed after verbal prompting as long as the movement was also demonstrated in the same segment.