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Praxis Skills in Young Children With Down Syndrome, Other Developmental Disabilities, and Typically Developing Children

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Abstract

This study explored whether young children with Down syndrome show praxis deficits that impact activities of daily living, and whether these deficits are specific to Down syndrome. We compared the performance of young children with Down syndrome, a mental age-matched group of children with developmental disabilities of mixed or unknown etiologies, and a group of typically developing infants and toddlers on praxis tasks and overall adaptive behavior (Vineland Adaptive Behavior Scales). Children with Down syndrome showed poorer overall motor functioning than the developmental disabilities comparison group as measured by the Vineland Adaptive Behavior Scales, $F(2,47) = 5.24, p < .01$ (using one-way analysis of variance [ANOVA]). A one-way multivariate analysis of variance also showed that children with Down syndrome performed significantly worse overall than the developmental disabilities comparison group on a battery of praxis tasks, $F(7,18) = 2.95, p < .05$, and a series of object retrieval tasks, $F(7,18) = 2.95, p < .05$, suggesting a deficit in praxis that is specific to Down syndrome. Children with Down syndrome elicited significantly more help than both comparison groups during object retrieval trials, $F(2,48) = 4.94, p < .01$ (using one-way ANOVA). When chronological age was partialled out, a strong relationship was observed between praxis and adaptive functioning in Down syndrome, $r(8) = .69, p < .05$. These findings suggest that young children with Down syndrome may need targeted interventions that focus on both praxis skills and motivational orientation.

Individuals with Down syndrome generally show deficits in motor development (Palisano et al., 2001). Most infants and toddlers with Down syndrome show extreme delays relative to chronological age (CA)-matched typically developing infants, moving through stages of early motor development more slowly and exhibiting more within-group variability than typically developing infants (Chen & Woolley, 1978; Dunst, 1988). Abnormal movement patterns, hypotonia, and hyperflexibility are also common in this population (Harris & Shea, 1991). In addition, delays in the emergence and termination of reflexes are prevalent in early Down syndrome motor development (Block, 1991; Harris & Shea). These atypical features

seem to become more evident towards the end of the first year of life (Dunst; Henderson, 1985).

In older children with Down syndrome, motor problems persist. Jobling (1998) found that 10- to 16-year-old children with Down syndrome have specific motor impairments, including difficulty with precise movements of limbs (e.g., stepping over a stick while on a balance beam) and fingers (e.g., pivoting thumb and index finger) as well as gross motor tasks such as sit-ups and push-ups. Other studies have described poorer muscle strength, irregular jerky movements, and continued, though decreasing, hyperflexibility in this population (Morris, Vaughn, & Vaccaro, 1982; Parker & James, 1985). In other domains, however, such as running speed and agility and visual-motor control, Jobling (1998) reports that child performance in Down syndrome can be at CA levels.

Motor deficits in individuals with Down syndrome may be of particular importance for occupational performance in school, daily living, play, and performance in other areas of occupation (American Occupational Therapy Association, 2003). Understanding the specific nature of motor deficits in Down syndrome may make it possible for practitioners to anticipate and target problems with specific performance skills, and ultimately support engagement in meaningful occupations more effectively in this population. This notion of developing therapeutic approaches that are informed by syndrome-specific developmental profiles has been discussed recently in other related fields, including special education (Fidler, Hodapp, & Dykens, 2002; Fidler, Lawson, & Hodapp, 2003; Hodapp & Fidler, 1999).

One area of particular interest for improving occupational performance in Down syndrome is praxis. Praxis is the planning, execution, and sequencing of movements (Ayres, 1985). Early praxis skills, such as the planned reach for an object, develop in the first few years of life in typically developing children (von Hofsten, 1992; von Hofsten & Ronnqvist, 1988). A great deal of praxis is involved in activities of daily living, such as brushing one's teeth and feeding oneself. As these skills are crucial for later independence in adulthood, the early development of praxis may impact occupational performance throughout development in Down syndrome (Osaki, Rogers, & Hall, 2000).

What is known about praxis in Down syndrome has been primarily demonstrated in older individuals. Findings suggest that individuals with Down syndrome show slower prehension, or the action of reaching to grasp an object, and more variability in movement during prehension as well (Latash, 2000). Mon-Williams et al. (2001) found that individuals with Down syndrome are able to use specific advance positional information (e.g., information regarding exactly where an object is placed) in order to plan their movements more effectively and increase accuracy in prehension. But Mon-Williams et al. also found that individuals with Down syndrome did not make use of more general advanced positional information (e.g., what side of a table an object was placed) suggesting that individuals with Down syndrome need direct and specific advance information for praxis. Another finding suggests that individuals with Down syndrome have the ability to make various necessary movements, they have difficulty selecting a motor response and making the appropriate movement once selected (Hogg & Moss, 1983). Children with Down

syndrome may also have more difficulty with feedback components, but not feed-forward components of prehension when compared with mental age (MA)-matched and motor-matched children (Kearney & Gentile, 2002).

Amidst this evidence for motor deficits in Down syndrome, many questions remain unanswered. Can deficits in praxis be observed in very young children with Down syndrome? Are difficulties with praxis associated with performance in activities of daily living? If so, what do young children with Down syndrome do in order to compensate for their difficulties? And are these issues specific to Down syndrome, or are they related to disability status in general? The first two questions remain relatively unexplored, whereas evidence for the syndrome-specificity question to date is mixed. Some studies report gross or fine motor deficits, or both, specific to Down syndrome when compared to MA-matched children with developmental disabilities (Connolly & Michael, 1986; Henderson, Morris, & Ray, 1981), but this has not been found in all studies (LeBlanc, French, & Schultz, 1977).

To answer these questions, we explore motor functioning and praxis skills of young children with Down syndrome to a comparison group of CA- and MA-matched children with developmental disabilities, but not Down syndrome, and an MA-matched group of typically developing children. We explore whether deficits in praxis, if they exist, are specific to Down syndrome, or more generally associated with developmental disabilities, and whether they are related to activities of daily living in this population. We also explore how individuals with Down syndrome manage motor limitations by measuring the degree of help elicited by children with Down syndrome from the experimenter in the face of challenging tasks.

Methods

Participants

Participants were 16 toddlers with Down syndrome (male = 11; female = 5), 16 toddlers with developmental disabilities of mixed or nonspecific etiologies (male = 7, female = 9), and 19 typically developing infants and toddlers (male = 9, female = 10). No between groups differences were found on gender, $\chi^2(2, n = 51) = 2.38, ns$. The two developmental disabilities groups were equated on CA, $t(30) = .24, ns$, and all groups were equated on MA as measured by the Mullen Scales overall mental age equivalent, $\chi = 21$ months, $F(2, 47) = .01, ns$ (see Table 1 for developmental and demographic information). All children had normal vision and hearing or corrected to within the normal range had unimpaired hand use and were mobile. Children with Down syndrome had a genetic diagnosis of trisomy 21. Within the developmental disabilities comparison group, there were four children with other genetic abnormalities (velocardiofacial syndrome, Cochrane syndrome, partial deletion on chromosome 18, abnormalities on chromosome 15), and 13 children with developmental delays of unknown etiology.

There were no between disability-group differences in prematurity status, $\chi^2(1, n = 27) = 1.00, ns$, with one child with Down syndrome and three children in the mixed developmental disabilities comparison group born before 36 weeks' gestational age. Some of the children with disabilities had a history of other medical complications or illness. As is generally

found in the Down syndrome population, 60% of the children had a history of another medical condition (e.g., metabolic problems, heart problems, bronchitis). Almost 50% of the children in the developmental disabilities group had some accompanying medical condition (e.g., seizures). The typically developing children had no diagnoses and no delays in development, no illnesses, head injuries.

The two disability groups were equated on socioeconomic status (SES), though the families of typically developing children had a lower average SES, possibly because the parents were younger. No relationship was found between child MA and family SES in any of the groups (Down syndrome $r(14) = -.13$, *ns*; developmental disabilities $r(14) = -.37$, *ns*; typically developing $r(17) = -.16$, *ns*). No between group differences were observed on mother or father age in the disabilities groups, the majority of mothers and fathers in this study had completed some college coursework (Mothers: Down syndrome = 93%, developmental disabilities = 86%, typical = 89%; Fathers: Down syndrome = 100%, developmental disabilities = 100%, typical = 84%), Families of children in this study were predominantly Caucasian, and all child participants were currently living at home (see Table 1 for all developmental and demographic information).

Procedures

This study was part of a larger longitudinal study of the developing phenotype of autism, fragile X syndrome, and Down syndrome. Participants were recruited through university subject pools, JFK Partners University Affiliated Program, and parent support groups in the Denver Metropolitan Area (e.g., Mile High Down Syndrome Association, Fragile X Foundation). The entire study was carried out under internal review board approval. Consent forms were reviewed with each family and all questions were answered before consent was obtained and before any measures were gathered.

The test battery was administered in a laboratory visit in a standardized fashion. All examiners were masters or doctoral level clinicians with several years of clinical experience working with young children with developmental disabilities. Mothers were interviewed for the Vineland Scales of Adaptive Behavior (Sparrow, Balla, & Cicchetti, 1984), generally during a home visit.

Measures

Experimenters administered a battery of developmental tests, in part consisting of:

- (1) Mullen Scales of Early Learning (MSEL; Mullen, 1995). The MSEL is a standardized developmental test for children 3 months to 60 months of age consisting of five subscales: gross motor, fine motor, visual reception, expressive language, and receptive language. The MSEL allows for separate standard verbal and nonverbal summary scores to be constructed and demonstrates strong concurrent validity with other well-known developmental tests of motor, language, and cognitive development (Mullen). The MSEL was administered to all subjects according to standard instructions by raters with advanced degrees, trained in assessing young children with autism and other

developmental disorders. Reinforcers for all subjects in all groups were used at times to reward cooperation and attention.

- (2) *Demographia Questionnaire* (Hollingshead, 1975). Parents were asked about information regarding parents' age, SES, education level, and ethnicity.
- (3) Vineland Scales of Adaptive Behavior, Interview Edition. The Vineland (Sparrow et al., 1984) is a standardized parent interview designed to assess adaptive behavior across four domains: social, communication, daily living, and motor skills.
- (4) *Praxis*. The praxis battery was developed by one of the coauthors (Rogers) with consultation from several expert occupational therapists (see Rogers, Stackhouse, Hepburn, & Wehner, in press). Items were designed to challenge praxis and execution abilities. Praxis tasks were videotaped and scored from tape by a clinical psychologist, an occupational therapist, a master's level speech-language clinician, and a graduate student. Scoring criteria for each item were established based on the number of errors involved in the child's performance. Each item was scored on a 4- or 5-point scale, with 0 reflecting no action at all, 1 reflecting some movement that was unrelated to the target movement, and higher scores reflecting increasingly smooth, well-coordinated, and accurate performance. Reliability was established and maintained at *kappas* of .85 or better for 20% of observations or more throughout the duration of the study. The battery consisted of seven tasks, described in Appendix A. For the praxis battery, data were not available for a large enough sample of typically developing children (mostly due to the length of the larger developmental battery), but were available for 11 of the children with Down syndrome and all 16 participants in the developmental disabilities comparison group. There were no CA or MA differences between children in the Down syndrome group who did complete praxis tasks and those who did not.
- (5) *Object retrieval*. The object retrieval task was designed to assess a child's problem-solving skills, involving cause and effect thinking, inhibition, and praxis. The object retrieval task was included in this study for two reasons: (a) to provide children with a less challenging task in terms of motor skills that involved only reach and grasp (only reach strategies were assessed, not grasping behavior), and (b) to assess the strategies used by children with Down syndrome when facing praxis limitations.

Children participated in 15 trials of an object retrieval task where a prize was placed under a plastic box with one opening, and the children were prompted to retrieve the prize through the opening. The child was then allowed to retrieve the reward without delay. Two box sizes (small and large) were used and the size of the box varied according to the trial. The open side of the box also varied (top, front, left, right) as did the side through which the child saw the reward. Trials were designed to move from the easiest (reward seen through the open side of the small box) to hardest (reward seen only through a closed side of the large box).

If the child became frustrated or stopped performing the task, experimenters were instructed to give help by either temporarily or permanently rotating the open side of the box toward the child to obtain a more line-of-sight view of the object. All experimenters were completely blind to the research questions being asked, and used their own judgment for when to administer help within any given trial. Reach scores assessed the accuracy of the child's reach (scored on an ordinal scale from 1 to 3, with higher scores indicated more efficient reach strategies). A complete description of the scoring criteria for reach scores is included in Appendix B. Help scores described the amount of help the child needed to obtain the reward (scored on a scale from 0 to 4.5, with higher scores indicating lower amounts of help). Reliability for reach scores was 89.13% overall, and reliability for help scores was 98.44%.

Statistical Analyses

For between-group analyses, independent samples *t* tests (two-tailed), one-way analysis of variation (ANOVA), and multivariate analysis of variation (MANOVA), and chi-square analyses were used. For within-group associations, Pearson correlations and partial correlations were used. The alpha level was set at .05. All analyses were performed using SPSS (version 11.0).

Results

Motor Skills

To gain a general picture of motor functioning in Down syndrome, the Vineland Scales of Adaptive Behavior interview was administered to parents. Children with Down syndrome had significantly worse overall Vineland motor age equivalent scores when compared to the developmental disabilities comparison group, but not the typically developing group, $F(2, 47) = 5.24, p < .01$ (see Table 3 for all dependent variable means and standard deviations). No gender differences were observed in the Down syndrome group, $r(14) = .30, ns$.

Children in the Down syndrome group also showed poorer scores than the developmental disabilities comparison group on both gross motor age equivalent scores, $F(2, 47) = 4.98, p < .01$, and fine motor age equivalent scores, $F(2, 47) = 3.67, p < .05$. No differences were found between the Down syndrome and the typically developing group on these dimensions. Similar effects were noted for standard scores; however, due to floor effects, age equivalents were utilized in this study.

In addition, Vineland Motor Skills domain scores were highly correlated with Mullen Scales Motor Skills domain scores for both fine motor skills, $r(51) = .47, p < .001$, and gross motor skills, $r(51) = .57, p < .0001$. Vineland and Mullen Gross and Fine Motor domain scores were also highly correlated with Overall Mental Age as measured by the Mullen scales, all *r*'s between .41 to .80, all *p*'s < .05.

Subsequent analyses were conducted in order to explore the extent to which children with Down syndrome reached various motor milestones on the Vineland Motor domain (see Table 2). Significantly more children in the developmental disabilities comparison group passed Vineland Motor item 10 "walks as a primary means of getting around," $\chi^2(1, n =$

36) = 6.56, $p < .01$; item 14, “walks up stairs, putting both feet on each step,” $\chi^2(1, n = 36) = 6.53, p < .01$; item 15, “walks down stairs, forward, putting both feet on each step,” $\chi^2(1, n = 36) = 6.53, p < .01$; and item 18, “jumps over small object,” $\chi^2(1, n = 36) = 7.31, p < .01$. The items that distinguished the Down syndrome group from the typically developing comparison group were, “walks as a primary means of getting around,” $\chi^2(1, n = 34) = 5.28, p < .05$; “walks up stairs,” $\chi^2(1, n = 34) = 6.17, p < .01$; and “rims smoothly,” $\chi^2(1, n = 36) = 5.71, p < .05$.

Praxis

In addition to showing poorer motor functioning overall, children with Down syndrome performed significantly worse on total praxis performance than the developmental disabilities comparison group, $t(24) = 4.92, p < .05$. A oneway MANOVA showed systematic differences between the two groups across all praxis tasks, $F(7, 18) = 2.95, p < .05$. Post hoc analyses showed that children with Down syndrome performed significantly worse than the developmental disabilities comparison group on the coins in the bank task, $t(25) = 2.53, p < .01$; the necklace in the cup task, $t(25) = 3.45, p < .002$; the pull toy, $t(25) = 2.42, p < .05$; and climbs out of the box, $t(25) = 2.45, p < .05$. No gender differences were observed in the Down syndrome group on overall praxis performance, $r(10) = .16, ns$.

Subsequent analyses were performed in order to determine the specific nature of the type of errors children with Down syndrome were more likely to make on each task. Children with Down syndrome showed marked difficulty on tasks involving prehension, or reaching and grasping items appropriately. For the coin in the bank task, 91.7% (11 of 12) of the children with Down syndrome scored a 2 or below. This suggests that children with Down syndrome were unable to coordinate the movement of holding several coins in their hand at once, and then transferring a coin from the palm of their hand to their fingers, and then to the bank. Instead, the majority of these children—66.7% or 8 of 12—simply picked up coins one by one with a thumb and finger pincer grasp and placed them in the bank individually.

For the necklace in the cup task, children with Down syndrome were more likely to show performances that were “clumsy and slow,” with 83.3% (10 of 12) of the children scoring 3 or below, whereas only 50% of the comparison children scored a 3 or below. In fact, 33.3% of children with Down syndrome (4 of 12) scored a 1 on this task, signifying that they made some efforts to place the necklace beads in the cup, but were largely unsuccessful.

Children with Down syndrome also had difficulty with full-body tasks. On the pull toy task, 72.7% (8 of 11) of children with Down syndrome could not coordinate walking multiple steps and watching the toy in a smooth fashion. Most children were able to move the toy through locomotion, but did not simultaneously move forward while watching the toy, or did not sustain this movement beyond a few steps. For the climbing out of the box task, 83.3% (or 10 of 12 children with Down syndrome) scored a 2 or below, signifying that they resorted to a more immature praxis scheme to get out of the box.

Praxis Skills and Other Areas of Functioning

In order to explore whether overall motor functioning was associated with praxis skills, a partial correlation was performed between total praxis scores and overall Vineland Motor age-equivalent scores, partialling out (controlling for) chronological age. For the Down syndrome group, a strong association was observed between praxis scores and Vineland overall motor functioning, $r(8) = .69, p < .05$. A similar association was observed between Vineland gross motor functioning and praxis scores, $r(8) = .62, p < .05$. No significant association was observed between fine motor skills and praxis, though the directionality of the association was the same, $r(8) = .36, ns$. Similar associations between overall motor functioning and praxis, $r(12) = .52, p < .05$, and between gross motor adaptive functioning and praxis, $r(12) = .56, p < .05$, were found in the developmental disabilities comparison group.

More importantly, praxis performance in the Down syndrome group was highly correlated with overall performance on the Vineland Daily Living Skills domain, $r(8) = .78, r < .01$. A similar trend was observed in the developmental disabilities comparison group, $r(12) = .45, r < .10$. These findings suggest that praxis skills may play an important role in occupational performance in early development in children with disabilities.

Reach Strategies

It could be argued that the praxis tasks were challenging in terms of motor skills to the young children with Down syndrome in this study, and thus measured not only praxis, but other motor skills as well. To address this issue, we administered an object retrieval task, which was less challenging in terms of motor skills. Children with Down syndrome showed significantly poorer reach scores than both comparison groups across the 15 object retrieval trials, $F(2, 46) = 8.60, p < .001$. These findings suggest that children in the Down syndrome used less efficient strategies for retrieving the objects than the other two groups. Reach scores were significantly correlated with total praxis scores in the two disability groups, $r(26) = .62, p < .001$. No gender differences were observed on reach scores in the Down syndrome group, $t(12) = 1.08, ns$.

Further analyses showed that there were several non-optimal reach strategies that were found in higher rates in the Down syndrome group than the developmental disabilities comparison group. Children with Down syndrome were significantly more likely to attempt to reach through the top of the plastic box (where there was no opening) in order to obtain the toy than children in the two comparison groups, $F(2, 48) = 2.88, p < .05$. Children with Down syndrome were also significantly more likely than the comparison group children to look through the side opening of the box to locate the toy, straighten up, and then reach appropriately, even though the toy was visible through the clear plastic box at all angles, $F(2, 48) = 5.59, p < .001$.

Help Elicitation

What strategies did children with Down syndrome use when challenged by the object retrieval task? In addition to showing higher rates of non-optimal reach strategies on the object retrieval task, children with Down syndrome also elicited significantly more help than

children in both comparison groups across all trials, $F(2, 48) = 4.94, p < .01$. Individuals with Down syndrome received help on a significantly higher number of trials than both comparison groups, $F(2, 48) = 5.23, p < .01$. This was true for temporary help, $F(2, 48) = 5.33, p < .01$, where help was given to set a child back on track, and true for permanent help, $F(2, 48) = 5.91, p < .01$, where help facilitated ultimate task completion.

Average help scores varied a great deal from trial-to-trial in the Down syndrome group, but not in the two comparison groups. It does not appear that the children with Down syndrome necessarily elicited the most help on the most difficult object retrieval items, though the two trials with the most help elicited were both relatively difficult trials. A marginally significant relationship was found between help elicitation scores and overall Vineland motor functioning in the Down syndrome group, $r(16) = .47, p = .06$, but not in the developmental disabilities comparison group, $r(18) = .17, ns$.

Discussion

Though there have been recommendations in the literature for various types of occupational therapy approaches for children with Down syndrome (e.g., sensory integration, neurodevelopmental therapy, vestibular stimulation), for the most part these recommendations remain uninformed by research on the developing profile in Down syndrome (Uyanik, Bumin, & Kayihan, 2003). Over the past decade, developmental disabilities researchers have argued for the importance of describing the syndrome-specific profiles—or “behavioral phenotypes”—associated with specific genetic conditions to improve therapeutic efficacy (Dykens & Hodapp, 2001). However, many challenges remain in translating this information into clinical and therapeutic practice (Hodapp & Fidler, 1999).

One aspect of the Down syndrome behavioral phenotype that could potentially inform occupational therapy practice involves delays in motor development and praxis. Although it has been established that motor delays are common in this group, questions remain about how early deficits can be observed, specifically praxis deficits, and how they relate to performance in activities of daily living. In this study, the performance of toddlers with Down syndrome was compared with that of MA-matched children with developmental disabilities and typically developing children on a battery of praxis tasks.

As expected, children with Down syndrome showed significantly worse motor functioning scores than children in the developmental disabilities group on the Vineland Adaptive Behavior Scales. This established that deficits in motor functioning that are specific to Down syndrome, and not a function of disability in general. In addition, children with Down syndrome also performed more poorly on a battery of praxis tasks, including reaching into a jar to grasp a Nerf ball, and stringing beads. Thus, a profile of early praxis deficits was observed specifically in the Down syndrome group, but not in the mixed developmental disabilities comparison group.

Partial correlations demonstrated a strong association between overall motor functioning and praxis in both disability groups even when age was partialled out. Similar associations were

found between praxis skills and the daily living skills domain of the Vineland, suggesting that praxis deficits in Down syndrome may also be associated with activities of daily living, and not only overall motor functioning.

However, one could argue that the praxis tasks were motor challenging for young children with Down syndrome, and the between-group findings described above could be interpreted in terms of overall motor deficits. Yet the children with Down syndrome also performed more poorly than the comparison groups on the executive function/object retrieval task, a task that was less motor challenging. Though grasping could be considered a challenge for children of this age, this study focused exclusively on reaching behavior, which has been shown to develop in the first year of life in typically developing populations (von Hofsten, 1992).

Children with Down syndrome had less efficient reach strategies, and were more likely to show unsuccessful reaches and extraneous position changes that did not provide them with additional information to improve their reach. Often, children with Down syndrome had to obtain a direct visual map of the reach, as though they could not have their hand move in a different route than their angle of visual gaze. These findings may suggest that young children with Down syndrome have praxis difficulties independent of overall motor problems, and also that they may not be using perceptual information in order to plan their reaching strategy as effectively as children with other types of developmental disabilities.

This study also examined the compensatory strategies employed by children with Down syndrome on the object retrieval task. Previous reports have described that children with Down syndrome may use “less challenging, suboptimal strategies” for completing difficult motor tasks (Latash, Kang, & Patterson, 2002). Similar motivational issues were observed in this study, as children with Down syndrome in our sample elicited significantly more help on the object retrieval task than children in both comparison groups. Help elicitation in the Down syndrome group was also marginally related to adaptive functioning on the Vineland, suggesting that the more help a child elicits, the poorer their performance on activities of daily living. This finding may relate to a larger body of research on task persistence and higher levels of off-task behavior during task completion in Down syndrome (Landry & Chapieski, 1990; Pitcairn & Wishan, 1994; Ruskin, Kasari, Mundy, & Sigman, 1994; Vlachou & Ferrell, 2000). An alternative interpretation of these findings may relate to the ability of children to elicit scaffolding from parents and others more effectively than comparison group children (Rogoff, 1990).

The interaction between early motor deficits and a tendency to elicit help from others has implications for occupational therapy intervention planning. On one hand, individuals with Down syndrome may be using their ability to relate to others in ways that help them complete tasks more successfully. This may bode well for individuals who might otherwise not be able to perform certain daily living skills tasks. On the other hand, most new tasks are difficult for children at various points of development, and part of the growth process involves taking on new challenges. If individuals with Down syndrome are eliciting help this early in development, they may be missing out on important challenging early experiences that may promote their growth. Thus, previous findings substantiating motor

deficits in older children with Down syndrome may reflect deficits in both physiological integrity and lack of experience.

To address the larger issue of motivation in Down syndrome, intervention plans could include approaches such as errorless learning techniques and targeting other areas of strength (i.e., visual-spatial processing and social functioning) in order to prevent task abandonment in Down syndrome (Fidler, in press). Errorless techniques remove the experience of failure from learning trials, and give children with difficulty learning a chance to experience success over time in areas of particular challenge. Existing studies that use errorless learning techniques have yielded mixed results (Duffy & Wishart, 1994), but it is possible that errorless approaches used in ways that target specific areas of functioning within an occupational therapy framework may prove more successful.

Several limitations to this study must be noted. One of our measures of motor functioning, the Vineland Adaptive Behavior Scales, is a parent report measure. Thus, this measure may provide a different picture of motor functioning than was obtained with the praxis and object retrieval tasks, which are administered to the child directly. In addition, these findings are based on relatively small sample sizes and warrant replication.

Another important issue that arose related to the choice of comparison groups. There is an ongoing debate in the study of research on behavioral phenotypes with regard to appropriate comparison groups. The approach used here is to try to represent the population of individuals with mental retardation as whole in the comparison group. Dykens et al. (2000) note that, “comparisons with groups with mixed etiologies directly test whether a behavioral feature is characteristic of people with mental retardation in general or instead to the specific etiological group under study” (p. 247). Thus, a mixed group of children—such as the one used in this study—would draw from children with nonspecific (familial or environmental) mental retardation, children with other genetic syndromes, children with pre-, peri-, and postnatal defects, and children with no identifiable etiology for their mental retardation, without overrepresentation of any one group.

Even amidst these issues, the findings of this study suggest that children with Down syndrome show a specific profile of praxis deficits in early development. These findings should contribute to the larger base of information on the early developmental trajectory of motor skills in this population, and can potentially inform intervention planning by occupational therapists and other practitioners. By understanding the early developmental trajectory of a particular set of outcomes in genetic disorders, researchers and practitioners may be able to employ interventions that are time-sensitive, and that prevent or offset future delays.

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Appendix A: Praxis Tasks (from Rogers et al., in press)

Nerfballin containen: The child is presented with a Nerf ball inside a small plastic fishbowl, and is encouraged to retrieve the Nerf ball. A 4 is scored if the child compresses the ball with his or her fingers and withdraws the ball. A 3 is scored if the child manually removes the ball by tugging on it, and uses compression only as a handle. A 2 is scored if the child stabilizes the fishbowl with one hand and gives a tug with the other but is unsuccessful in removing the ball. A 1 is scored if the child shakes, bangs, or tugs, but does not remove the ball. A 0 is scored if no effort is made to retrieve the ball.

Pull toy on a string: The child is standing on the floor, and is presented with a pull toy on a string, and the child is given the string. A 3 is scored if the child coordinates walking multiple steps and watching the toy in a smooth fashion, whether by walking backwards while pulling or by walking forwards or sideways while watching toy. A 2 is scored if the child moves the toy through locomotion, but does not simultaneously move forward while watching toy, or does not sustain walking beyond a few steps. A1 is scored if the child pulls the string with his or her arm and sees the toy move, but does not locomote the body forward. A 0 is scored if no effort is made to pull the toy.

Necklace in a cup: The child is seated at a table and is given a tall cup and a beaded necklace with no instructions. If the child does not spontaneously place the necklace in the cup, the examiner asks the child to do so. A 5 is scored if each hand is doing a different movement and the performance is fast, smooth, and accurate. A 4 is scored if the hands are carrying out the same movements but the performance is fast, smooth, and accurate. A 3 is scored if the hands are doing different movements, but the performance is clumsy or slow or both. A 2 is scored if the hands are carrying out the same movements but the performance is clumsy or slow or both, or if the child shows one-handed slow or clumsy success, or both. A 1 is scored when the child makes some efforts to get beads in the cup but is largely unsuccessful. A 0 is scored if no effort is made to put the beads in the cup.

String beads on a rope: The child is given rope and three beads, experimenter indicates that the rope will go through the hole in the beads, and child is encouraged to string all three beads. A 5 is scored if each hand is doing a different movement and the performance is fast, smooth, and accurate, with no or minimal bead spill, or if there was perfect one-handed performance. A 4 is scored if the hands are carrying out the same movements but the performance is fast, smooth, and accurate. A 3 is scored if the hands are doing different movements, but the performance is clumsy or slow or both. A 2 is scored if the hands are carrying out the same movements, but the performance is clumsy or slow or both. A1 is scored if the child makes some effort to get beads in the cup but is largely unsuccessful. A 0 is scored if no effort is made to put beads in the cup.

Rod in hole: The child is given a fat 12' stick and a lidded box with a hole on top, and child is encouraged to put the rod in the hole. A 4 is scored if the child manipulates (not just

stabilizes) both box and rod (help radially—thumb down) in integrated bilateral fashion, or if they are able to place the rod one-handed quickly into the hole without assistance from the other hand. A 3 is scored if one hand stabilizes the box on the table, while the other hand inserts the rod with a radial grasp. A 2 is scored if there is no stabilization of the box, and the child inserts the rod with an ulnar (thumb up) grasp (or attempts to). A1 is scored if there is no stabilization of the box, and the child inserts the rod with a radial grasp (or attempts to). A 0 is scored if no effort is made to put the rod in the box.

Quarters in bank: The child is presented with a bank with a coin slot and the child is handed coins to place in the box. A 5 is scored if two or more coins are transferred from palm to finger to bank. A 4 is scored if the coins are accurately placed in the bank while holding more than one in hand, involving the palm to transfer two or more coins. A 3 is scored if one coin is transferred from palm to bank. A 2 is scored if the child picks up the coin from the table or other hand with their thumb and fingers in pincer type grasp and places coin in the bank. A1 is scored if the coin is raked up from the table with the whole hand, and it may or may not be dropped into the bank. A 0 is scored if no effort is made to put the coins in the bank.

Getting out of cardboard box: The child's mother places them in a cardboard box that reaches to midhigh level for the child, and is encouraged to get out of the box. A 3 is scored if the child swings one leg out, transfers weight to that leg, and swings out the other leg without falling or crumpling the side of the box. A 2 is scored if the child tries to get one leg out of the box but cannot complete the maneuver, and the child resorts to holding the side of the box and falling out. A1 is scored if the child gets out of the box by falling, squishing the side, or pushing the box over, but does not attempt to free one leg. A 0 is scored if the child does not get out of the box on his or her own.

Appendix B: Scoring for Object Retrieval Task

Reach Scores

1 point = Child tries to reach through the top of the box. The child may then search and find the opening but the initial reach is through the top.

1.5 points = Child leans to look through the opening of the box, and reaches through the opening while looking through the opening.

2 points = Child leans to look through the opening of the box, straightens, reaches through the opening while looking through the top of the box.

3 points = No look at all, child reaches through opening, while looking through the top of the box.

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Table 1Demographic and Developmental Variables ($N = 51$)

	Down syndrome	Developmental disabilities	Typical	$F(2,48)$ or $\chi^2(2, N = 51)$
Child CA M in months (SD)	33.81 (8.04)	31.12 (7.65)	18.00 (3.54)	29.55 *
Child Gender Male:female	11:5	7:9	9:10	2.38
Overall Child MSEL MA	21.31 (6.35)	21.53 (4.64)	21.50 (4.32)	.01
Child Ethnicity	87.5% Caucasian 6.3% Latino 6.3% Biracial	81.3% Caucasian 12.5% Latino 6.3% Biracial 5.6% Black	84.2% Caucasian 5.3% Latino 10.5% Biracial	.97
Father Age in Years M (SD)	39.46 (5.56)	35.93 (14.69)	32.28 (4.91)	.81
Mother Age in Years M (SD)	37.76 (4.54)	36.92 (6.63)	30.78 (5.41)	2.30 *
SES	57.49 (5.69)	54.36 (8.53)	47.62 (15.42)	3.12

* $p < .01$

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Table 2

Percentage of Children With Down Syndrome and Comparison Groups Passing Vineland Motor Items 9-24

	Down syndrome	Developmental disabilities	Typical
Rolls ball/sitting	100.00	100.00	94.70
Primarily walks	62.50	100.00	89.50
Climbs in/out bed	93.80	100.00	73.70
Climbs low play equipment	87.50	100.00	89.50
Pencil on surface	81.30	92.90	78.90
Walks up stairs	50.00	92.90	84.20
Walks down stairs	50.00	92.90	63.20
Runs smoothly	31.30	50.00	68.40
Opens doors with doorknobs	31.30	64.30	42.10
Jumps over small objects	6.30	50.00	26.30
Screws lids	31.30	57.10	47.40
Pedals tricycle	.00	14.30	10.50
Hops on one foot	6.30	21.40	5.30
Builds 3D structures	25.00	21.40	15.80
Opens/closes scissors	18.80	62.50	.00
Walks up stairs alternating feet	6.30	28.60	.00

Table 3

Vineland, Praxis, and Object Retrieval Mean Scores and Standard Deviations

	DS	DD	Typical	F or t
Vineland Overall Motor Age Equivalent <i>M (SD)</i>	17.63 (4.93) ^a	23.19 (4.31) ^b	19.72 (5.15) ^{a,b}	5.42 ^{**}
Vineland Gross Motor Age Equivalent <i>M (SD)</i>	17.88 (4.98) ^a	24.50 (7.24) ^{a,b}	20.72 (5.53) ^b	4.95 ^{**}
Vineland Fine Motor <i>M (SD)</i>	17.75 (5.41) ^a	22.13 (4.59) ^{a,b}	18.56 (4.64) ^b	3.67 [*]
Overall Praxis <i>M (SD)</i>	13.12 (5.68)	18.05 (4.68)	N/A	2.42 [*]
Total Reach Score <i>M (SD)</i>	32.53 (6.56) ^a	39.81 (2.66) ^b	37.05 (4.72) ^b	8.60 ^{**}
Total Help Score <i>M (SD)</i>	63.63 (6.61) ^a	67.31 (0.44) ^b	67.19 (0.48) ^b	4.90 [*]

*
p < .05

**
p < .01

^a connote homogenous subgroups according to Sheffe post hoc tests

^b connote homogenous subgroups according to Sheffe post hoc tests