Motor Function and Social Participation in Kindergarten Children

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Abstract

This study focused on the associations between individual variations in children's motor abilities and individual differences in social participation and play behavior. Indoor and outdoor play behavior patterns of 88 kindergarten children were observed, and a battery of standard assessments of basic motor functions was administered. The findings indicate significant associations between children's motor abilities and social and nonsocial forms of play. Results are discussed in relation to existing conceptual models of the underlying causes for nonsocial behavior.

Keywords: motor skills; motor ability; social play; reticence; solitary behavior

Social play and peer interaction provide a framework for children to explore their physical and social environments. Conversely, lack of social interaction during childhood has been associated with a variety of social and emotional difficulties including behavior problems, peer rejection, depression, and low self-esteem (for reviews, see Cheah, Nelson & Rubin, 2001; Kupersmidt, Coie & Dodge, 1990; Rubin, Bukowski & Parker, 1998; Rubin, Burgess & Coplan, 2002). Noting the detrimental effect that lack of peer interaction may have on children's psychological and behavioral adjustment, much research has focused on possible etiologic and mediating factors relating to solitary behavior. These include, among others, interpersonal relationships, temperamental tendencies, cultural influences, social-cognitive deficiencies, and biological markers (e.g., Coplan, Rubin, Fox, Calkins & Stewart, 1994; Fox, Henderson, Rubin, Calkins & Schmidt, 2001; Henderson, Marshall, Fox & Rubin, 2004; Hinde, Tamplin & Barrett, 1993; Kagan, Reznick & Snidman, 1987; Kochanska & Radke-Yarrow, 1992; Rubin & Asendorpf, 1993; Spinard, Eisenberg, Harris, Hanish, Fabes & Kupanoff, 2004).

Interestingly, one rather obvious potential background factor in the development of social participation, that is, children's motor abilities, has been relatively neglected in the research literature. The present study explored whether individual variations in children's motor abilities are associated with individual differences in social and solitary play behavior. The logic behind this implied association relies on the fact that the processing and organization of external and internal sensory–motor input, and the coordination of motor output must be reflected in children's social interactive style.
Individual variations in posture and movement control, motor planning and execution, and visual–motor coordination provide children with different types of movement challenges that they must solve in order to exercise efficient social engagement (Fogel, 1992). For example, the ability to maintain standing postures significantly increases the amount of social interaction in 8- to 12-month-olds (Gustafson, 1984). Locomotor experience has been shown to facilitate the development of children’s social referencing skills (Campos, Kermoian, Witherington, Chen & Dong, 1997). And, upright locomotion has been shown to play a significant role in the affective organization of mother–infant interaction (Biringen, Emde, Campos & Appelbaum, 1995). However, if age-related motor capabilities are not achieved, a child's social behavior may be compromised. For instance, Smyth and Anderson (2000) reported that 6- to 10-year-olds with Developmental Coordination Disorder (DCD) spent more time alone and were onlookers more often during school playground activity compared with normally coordinated children. These authors suggest that children with impaired coordination can become isolated or solitary on the school playground.

Difficulties in processing and integrating motor actions can occur in children who have no diagnostically identifiable neuromotor impairment. Nevertheless, such difficulties may result in play dysfunction. During play, children are required to retain static postures that demand efficient balance control. Children also need to move freely in and out of postural positions in order to take part in peer play. Likewise, normal muscle tone is essential for executing and maintaining such motor actions and movements. Hypotonic children (i.e., children with low muscle tone) typically find it difficult to stay engaged in motor action for prolonged periods of time and therefore tend to avoid gross motor activities that involve continuous muscle endurance (Ayres, 1980a; Lane, 2002).

In addition, children’s play behavior is highly dependent on the ability to motor plan activities in an efficient way. The motor planning of a play task involves generating an idea of the motor task to be performed, sequencing the idea, and executing the sequence efficiently. If these complex neurobehavioral processes are successful, the child is able to produce an adaptive behavior and a goal-directed action that meets the environmental challenges of social activity. However, poor integration and processing of sensory–motor information may adversely affect play behavior and limit a child’s choice of play activities. It has been suggested that children characterized by poor motor planning abilities tend to have poor play skills and often fail to participate in activities or tasks performed in a group setting (e.g., Ayres, 1980a; Schaaf, Merrill & Kinsella, 1987). Clinical observations suggest that such children tend to move slowly and fearfully and may avoid gross motor activity (e.g., Parham & Fazio, 1997).

In conclusion, despite the intuitively expected association between sensory–motor capabilities and social behavior, mainstream experimental and developmental psychology have traditionally considered the question of how children plan and execute movement to be of relatively little interest to the field of social and emotional development (cf. Campos, Anderson, Barbu-Roth, Hubbard, Hertenstein & Witherington, 2000; Pellegrini & Smith, 1998; Smyth & Anderson, 2000). Therefore, the objective of the present study was to provide an analysis of the associations between individual differences in children’s motor abilities and individual differences in social and solitary behavior.

Children may play alone for different reasons. Researchers have identified at least three distinct forms of solitary behavior that appear to differ in terms of their behavioral manifestation and motivational underpinnings (e.g., Coplan et al., 1994; Coplan, Prakash, O’Neil & Armer, 2004; Rubin & Asendorpf, 1993).
Social reticence is characterized by a cluster of solitary behaviors consisting of prolonged onlooking at other children’s play without making attempts to join in, and of being unoccupied (Coplan et al., 1994). Children who engage in reticent behavior appear socially motivated but are wary, vigilant, and socially anxious (Rubin & Asendorpf, 1993). Reticent behaviors are readily detected as problematic by parents, teachers, and peers, and have been related to overt indicators of anxiety, poor performance on cooperative tasks, poor social skills, and deficiencies in the ability to regulate negative emotions (Coplan, Gavinski-Molina, Lagace-Seguin & Wichmann, 2001; Rubin, Coplan, Fox & Calkins, 1995). We hypothesize that part of the variance in children’s reticent behavior may be explained by deficiencies in their motor ability. Specifically, children with suboptimal motor performance may feel more anxious and disadvantaged in sequencing and performing the motor tasks associated with social interaction.

A second cluster of social withdrawal behaviors detected in children has been labeled solitary–passive play (Rubin, 1982). This behavioral pattern involves the quiet solitary exploration of objects and constructive play activities (e.g., drawing, building with blocks, dressing dolls). It has been hypothesized that these behaviors indicate low motivation to approach or avoid others (Asendorpf, 1990, 1991), and therefore reflect social disinterest. In general, solitary—passive play has not been associated with maladjustment (e.g., Coplan & Rubin, 1998; Coplan et al., 1994; Rubin, 1982). It is not entirely clear, however, that solitary–passive play is never associated with social or emotional difficulties. For example, Coplan et al. (2001) reported that observed solitary–passive play in kindergarteners was associated with temperamental shyness and indices of maladjustment for boys but not for girls. Henderson et al. (2004) also reported an association between a high frequency of solitary–passive play and maternal reports of temperamental shyness. Such findings may suggest that solitary–passive play is not always a matter of preference for solitude. However, because it has been suggested that solitary–passive behavior is more a function of low social interest, rather than inability for social interaction; and because solitary–passive play involves high frequencies of constructive and exploratory behavior, both requiring good posture control, motor planning, and coordination, no specific associations were expected between high frequency of solitary–passive play and motor abilities.

Another form of solitary play that has been described in the literature is solitary–functional play (Rubin, 1982). This form of solitary behavior involves simple motor activities and repetitive motor movements performed with or without objects (e.g., repeatedly banging two blocks together, jumping on and off a chair, swinging on a swing). It has been suggested that solitary–functional play is the first structural category of play to appear in infancy and that through functional play, children come to acquire basic motor skills inherent in their daily activities (Piaget, 1962; Smilansky, 1968). From a motor development perspective, solitary–functional behavior requires only low levels of motor planning and execution. In contrast to the expected high occurrence of solitary–functional behavior in infants and toddlers, high frequencies of solitary–functional play in kindergarten children may imply low levels of play development and an increased need for simple motor practice. We hypothesized that suboptimal motor development in kindergarten children may induce an increased need for simple sensory–motor exploration in the form of solitary–functional play.

In summary, we expected to find an interaction between motor ability and type of play behavior. Specifically, we expected that children with high motor ability would display a higher frequency of social play compared with children of low motor ability,
reflecting the efficient physical support that good motor abilities may provide for social interaction. Conversely, children with low motor ability were expected to display a higher frequency of social reticence and solitary–functional play compared with children with high motor ability. Unlike the expected associations between motor ability and social play, solitary–functional play, and reticent behavior, no specific associations were expected between solitary–passive play and motor abilities, as solitary–passive play involves constructive and exploratory behavior, both requiring good posture control, motor planning, and coordination.

In addition, it is possible that there are effects of context (indoor versus outdoor) and gender on children’s frequencies of social and solitary play behavior. For example, Spinard et al. (2004) suggested that solitary play exhibited during outdoor activities may be less appropriate and less voluntary than this type of behavior during quiet indoor activities. With respect to gender differences, there is a growing literature indicating that social withdrawal is a greater risk factor for boys than for girls (Caspi, Elder & Bem, 1988; Coplan et al., 2001; Dettling, Gunnar & Donzella, 1999; Rubin, Chen & Hymel, 1993; Stevenson-Hinde & Glover, 1996). In that respect, an interaction between motor ability and gender in predicting solitary behavior may be of interest. However, given the scant research data about gender differences and context influence on social and nonsocial behavior, and the lack of previous studies on the association between motor abilities and nonsocial behavior, hypotheses concerning possible context and gender differences were largely exploratory in nature.

**Method**

**Participants**

Participants were 88 children (53 girls, 35 boys), recruited from seven randomly selected mainstream public kindergarten classes situated in the greater Tel Aviv area, Israel. Their mean age was 5.83 years ($SD = 0.46$; Range = 5.04 to 6.36 years). Although approximately half the children in the selected kindergarten classes were 4-year-olds, age-related norms for several of the motor measures used in the study were available starting from five years of age. Therefore, an age of five years or higher was set as an inclusion criterion for the study. Parents of all eligible children in each of the selected classes were contacted, of whom 68 percent agreed to participate in the study. Excluded from the study were four children who, based on their parent reports, had auditory or visual impairments, or received treatment for sensory–motor problems. By virtue of attending mainstream public kindergartens, none of the children included in the study had a major developmental disorder such as Autism or Cerebral Palsy. Fifty-six percent of the participants were first-borns. Ninety-five percent of participants’ fathers and 98 percent of their mothers reported high school or higher levels of education. Eighty-eight percent of the parents were married and living together.

**Procedure and Measures**

**Assessment of Social Behavior.** Children’s indoor and outdoors behavior was coded using selected codes from Rubin’s (2001) Play Observation Scale. Data were collected through eight visits to each kindergarten over a period of three months. Observations were scheduled for the second semester of the school year to ensure that the children had a fair opportunity to adjust to their kindergarten settings, their classmates, and
their teachers. This provided a familiar context against which to assess children’s social behavior. During each visit, each child’s predominant free play behavior was recorded for a series of ten-second intervals, summing up to one minute of unstructured play indoors and one minute of unstructured play outdoors. Accordingly, a total of 16 minutes of play data were collected for each child, eight minutes indoors and eight minutes outdoors, yielding 96 ten-second coding intervals per child (48 intervals of indoor and 48 intervals of outdoor activity). To ensure good understanding of the context of the observed activity, each ten-second interval of coding was preceded by 30 seconds of free observation. A stopwatch was used to beep-signal the initiation and termination of the coding interval and behaviors were coded online into standard coding sheets.

During each visit, children were observed in a random order by one of three graduate students trained by the first author, who has been trained in use of the Play Observation Scale in K. H. Rubin’s laboratory, and achieved criterion levels of reliability. Inter-coder reliabilities were calculated on a randomly selected set of coding intervals totaling 20 percent of the sampled behavior. Percent agreement for the total variable matrix ranged between 93 and 96 percent; Cohen’s kappa ranged between .88 and .95.

Of specific interest to the present study were the sampled codes of social play (i.e., group play and conversation with peers), reticent behavior (i.e., unoccupied and onlooking behaviors), solitary–passive play (i.e., solitary–constructive and solitary–exploratory behaviors), and solitary–functional play. These raw scores were proportionalized by dividing by the total number of coding intervals.

Assessment of Motor Function. Three trained occupational therapy students, who were blind to the study’s hypotheses and goals, administered a battery of motor skills assessment at each child’s home. This home visit included standardized assessments of balance, kinesthesia, imitation of postures, muscle tone, and visual–motor integration. The selected motor tests were chosen so that collectively, they provided a comprehensive representation of children’s core motor abilities. That is, the combination of posture control (balance and muscle tone), motor planning and execution (kinesthesia and imitation of postures), and visual–motor integration. Each home visit lasted approximately 60 minutes.

Balance. The balance subscale of the Bruninks–Oseretsky Test of Motor Proficiency (Bruninks, 1978) is a widely used measure that consists of eight items: (1) standing on one foot on the floor with eyes open; (2) standing on a balance beam with eyes open; (3) standing with eyes closed; (4) walking forward on a line on the floor; (5) walking on a balance beam; (6) heel-to-toe walking on a line; (7) heel-to-toe walking on a balance beam; (8) stepping over a stick while walking on a balance beam. The test has established age-related norms and shows adequate internal consistency.

Kinesthesia. The kinesthetic sense arises from joints, tendons, and muscle receptors, and provides awareness of body position and movement. Kinesthesia was measured using the kinesthesia test (KIN; Ayres, 1980b). In this test, the experimenter moves the child’s hand from one predetermined point on a paper chart to another while the child’s hands remain out of his or her visual field. The child is then asked to repeat the motion on the kinesthesia chart, again without seeing his or her hands. The KIN test consists of ten test items, five for each hand. Hands are tested in an alternated sequence.
The KIN score is based on how accurately the child replicates the rehearsed motion, measured as the distance in millimeters of the child’s finger from the predetermined target points. The raw score is then converted to a standard age-related score.

**Imitation of postures.** Children’s ability to perceive and replicate different body positions was determined by the Imitation of Postures test (Ayres, 1980b). This test requires the child to assume a series of twelve positions or postures demonstrated by the examiner. The completion of each task requires motor planning of a familiar or unfamiliar motor act. Two points are given for postures that are imitated correctly within three seconds after the examiner has assumed the posture. One point is noted if the child imitates the posture correctly within four to ten seconds. No points are scored if the correct posture is assumed after ten seconds or if it does not meet the criteria for a score of one or two points. The raw score of the test is the total number of points noted for the 12 items. Raw scores are converted to standard age-related scores.

**Muscle tone (prone extension and supine flexion).** To obtain an index of the participants’ muscle tone and strength, the children were asked to assume and maintain prone extension and supine flexion positions. The prone extension assessment measures the child’s ability simultaneously to lift the head, flexed arms, upper trunk, and extended legs from a prone–lying position. For the supine flexion assessment, the children were asked to assume a position of simultaneous flexion against gravity of the knees, hips, trunk, and neck from a supine–lying position, where the top of the head had to approximate the knees. The number of seconds a child maintained in each of these positions was noted as the raw score. Children’s raw scores of the prone extension and supine flexion tests were highly correlated, \( r = .62; p < .0001 \). Therefore, the scores of the two measures were summed to create an aggregate index referred to as muscle tone.

**The developmental test of visual–motor integration (VMI).** The VMI (Beery, 1989) consists of 24 geometric forms to be copied in sequence from a test booklet. The geometric forms become progressively more complex, and the score continues to accumulate until all 24 forms have been successfully copied or until three consecutive forms are copied incorrectly. The VMI is designed for children ranging from 2 to 15 years of age and comes with age-specific norms.

The VMI contains two supplemental standardized subtests. The first is the Visual–Spatial Perception Test assessing visual–spatial perception components without the requirement of motor action. On this test, the child is shown a target figure and is asked to select a matching figure from a set of two to seven alternatives. The test consists of 24 figures that become progressively more complex. A child’s score on this test continues to accumulate until all 24 figures have been matched or until three consecutive failures in matching occur. The second test is the Fine Motor Accuracy Test, in which the child is required to draw a clear, dark line while staying inside a set of defined lines. There are 24 configurations that require progressively refined motor accuracy and control.

Because the three subtests of the VMI were significantly correlated with \( r s \) ranging from .38 to .43, \( ps < .001 \), their z-scores were aggregated to form a visual–motor coordinaton index.

**Data Reduction of Motor Function Measures.** Table 1 presents the intercorrelations among the z-scores of the different motor function measures. Principal component
analysis indicated that all the motor function measures loaded on a single factor with Eigen value = 2.25, which explains 44.92 percent of the existing variance. Based on the results of the intercorrelations and the factor analysis, we created a global index of motor ability by aggregating the z-scores of all tested motor skills (i.e., balance, kinesthesia, imitation of postures, muscle tone, and visual–motor coordination). Based on their scores on the aggregated motor function index, children were assigned to one of three groups. One group consisted of 22 children (11 girls) representing the bottom quartile of the distribution on the combined motor aggregate. A second group consisted of 22 well-coordinated children (16 girls), featuring in the top quartile of the distribution. A third group consisted of 44 children (26 girls) whose scores on the combined motor aggregate were in the middle quartiles of the distribution.

**Results**

*Effects of Motor Ability, Gender, and Context on Frequencies of Social and Solitary Play*

A repeated-measures Analysis of Variance (ANOVA) was computed with Motor Ability (low, average, high) and Gender (Male, Female) as ‘between-group’ factors and Play Type (Solitary–Passive, Social Play, Social Reticence) as a ‘within-subject’ factor. Context (Indoor, Outdoor) served as a repeated ‘within-subject’ factor.

Table 2 presents the means and standard deviations of social play, solitary–passive play, and social reticence proportional frequencies by motor ability group and context. Significant main effects of play type and motor ability were qualified by a play-type-by-motor-ability interaction, $F(4,164) = 3.72, p < .01$. In addition, a play-type-by-context interaction was found, $F(2,164) = 19.94, p < .0001$. Main or interaction effects involving gender were nonsignificant.$^2$ To further assess the above interactions, separate follow-up ANOVAs for each play type were performed with motor ability (low, average, high) as a ‘between-groups’ factor and context (indoor, outdoor) as a repeated ‘within-subject’ factor.

**Social Play.** Children displayed higher frequency of social play outdoors ($M = .62, SD = .21$) than indoors ($M = .51, SD = .22$), $F(1,85) = 28.54, p < .001$. In addition, children with low motor abilities showed lower frequencies of social play ($M = .47, SD = .37$) than children with average and high motor abilities ($Ms = .57$ and $.66$, $p < .01$).

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Social Development, 15, 2, 2006
Social Reticence. Higher frequency of social reticence was displayed indoors (M = .16, SD = .15) than outdoors (M = .13, SD = .11), $F(1,85) = 4.64, p < .05$. Children with low motor ability showed a higher frequency of social reticence (M = .19, SD = .22) than children with average and high motor abilities (Ms = .12 and .13, SDs = .15 and .22, respectively), $F(1,85) = 3.11, p < .05$. The interaction between motor ability and context was again nonsignificant.

Solitary–Passive Play. Higher frequency of solitary–passive play was displayed indoors (M = .15, SD = .16) than outdoors (M = .06, SD = .08), $F(1,85) = 25.79, p < .001$. Children in the three motor ability groups did not differ in their frequency of solitary–passive play, and no interaction between motor ability and context was found.

Solitary–Functional Play. Because solitary–functional play occurred in less than 3 percent of coding intervals, and because many children did not display this behavior at all, this variable was recoded to create two groups of children (see Coplan et al., 2001). One group consisted of children who did not demonstrate any solitary–functional behaviors (n = 40), the other group consisted of children who demonstrated any number of solitary–functional behaviors (n = 48). To assess the effect of context (indoor versus outdoor) on the occurrence of solitary–functional behavior (‘none’ versus ‘any’), a Chi-square analysis was performed. The results show that when solitary–functional play occurred, it occurred more outdoors (46 percent) than indoors (31 percent), $\chi^2 = 9.75, p < .01$. More importantly, additional Chi-square analyses revealed that during outdoor free play, 68 percent of the children with low motor ability displayed solitary–functional behavior, whereas only 23 percent of children with high motor ability showed this behavior, $\chi^2 = 9.17, p < .01$ (see Table 3 for cross-tabulations of indoor and outdoor solitary–functional behavior by motor ability). During indoors free play, children with low motor ability again displayed higher occurrence of solitary–functional behavior (46 percent) compared with children with high motor ability (18 percent). This difference however did not reach statistical significance, $\chi^2 = 3.90, p = .14$.  

Table 2. Means and Standard Deviations (in parentheses) of Social Play, Solitary–Passive Play, and Social Reticence Proportional Frequencies by Motor Ability Group and Context

<table>
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<th></th>
<th>High Motor</th>
<th>Mid Motor</th>
<th>Low Motor</th>
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<tr>
<td></td>
<td>Outdoor</td>
<td>Indoor</td>
<td>Outdoor</td>
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<tr>
<td>Social Play</td>
<td>.74 (.17)</td>
<td>.57 (.18)</td>
<td>.62 (.20)</td>
</tr>
<tr>
<td>Social Reticence</td>
<td>.10 (.11)</td>
<td>.15 (.13)</td>
<td>.12 (.10)</td>
</tr>
<tr>
<td>Solitary Passive</td>
<td>.03 (.06)</td>
<td>.11 (.11)</td>
<td>.08 (.10)</td>
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SDs = .26 and .37, respectively, $F(1,85) = 5.15, p < .01$. The interaction between motor ability and context was nonsignificant.
Consistency of Play Behavior Across Context

Pearson correlations between indoor and outdoor frequencies of social play, solitary–passive play, social reticence, and solitary–functional play revealed significant consistency of these play behaviors across context, $r_s = .63, .34, .47, \text{ and } .34$, respectively, $p_s < .001$.

Discussion

Taken together, the findings from the present study indicate significant associations between social engagement and motor adeptness. Specifically, in accord with predictions, children with low motor abilities displayed a lower frequency of social play and a higher frequency of social reticence compared with children of average or high motor abilities. In addition, children with low motor abilities displayed a higher frequency of solitary–functional play compared with children with high motor abilities. Finally, as expected, motor abilities were not significantly associated with solitary–passive play, suggesting that motor function may not be a major factor in the development of this pattern of solitary play behavior.

High frequency of solitary–functional play typically characterizes infants and young toddlers (Piaget, 1962; Smilansky, 1968). Functional play provides young children with the opportunity to manipulate objects in a sensory–motor fashion that informs them about the physical qualities of objects (Cheah et al., 2001; Hutt, 1970). In addition, repetitive sensory–motor behavior normally provides sensory–motor feedback that is important to the planning of goal-directed movement (Bundy, Lane & Murray, 2002). Developmental deficiencies in motor function may therefore result in difficulties obtaining good information about objects as well as poor feedback on body motion. From a motor function perspective, children displaying a high frequency of solitary–functional play may use repetitive movements to increase their diminished sensory–motor feedback and to practice simple motor actions.

Poor motor ability also makes the physical activity associated with social engagement more demanding, and may reduce a child’s capacity to deal with the social environment (Smyth & Anderson, 2000). The association between high frequency of social reticence and poor motor abilities fits well with the documented links between poor balance control and anxiety on the one hand (Balaban & Thayer, 2001; Balaban, 2002; Sklare, Konrad, Maser & Jacob, 2001), and social reticence and anxiety symp-
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toms on the other (e.g., Rubin & Asendorpf, 1993; Rubin, Chen, McDougall, Bowker, & McKinnon, 1995). It may be the case that the observed anxious behavior typically tied with social reticence partly reflects low motor abilities. The child with poor motor abilities may be motivated towards social interaction, but at the same time may feel anxious about the motor challenges posed by social engagement. Such children may find themselves onlooking at other children’s play without the ability to motor plan and execute the required actions for joining in. Alternatively, they may avoid the motor challenges of goal-oriented social behavior and wander about unoccupied. Thinking about approach–withdrawal motivational conflicts (e.g., Asendorpf, 1990) from the viewpoint of motor development may provide a new and viable approach to the assessment and understanding of the factors that drive reticent behavior.

Neurophysiologic studies also suggest possible links between motor abilities and social behavior. It is widely recognized that there are extensive reciprocal connections between the pre-frontal cortex (PFC) and the amygdala, and that these two brain structures form a circuitry that is highly involved in various aspects of social behavior (for reviews, see Amaral, Price, Pitkanen & Carmichael, 1992; Davidson, 2002; Fox, 1991; Kagan, 1994). The PFC/amygdala circuitry is also tightly connected to motor planning and execution areas in the brain. For example, there is evidence suggesting functional associations between the PFC, amygdala, and nucleus accumbens (NAc), the latter being described as the brain’s motor-limbic interface (e.g., Goto & O’Donnell, 2002). These associations seem to play an important role in integrating emotional and contextual cues with frontal motor planning, to determine response selection in social or otherwise challenging contexts (e.g., Burns, Annett, Kelley, Everitt & Robbins, 1996; Grace, 2000; Jackson & Moghaddam, 2001). Such transactions between these brain structures may be compromised in some clinical conditions.

One example of a clinical condition that involves both motor and social deficiencies is the spectrum of autistic disorders. The clinical profile of these disorders contains, among other difficulties, disturbances in reciprocal social interaction (APA, 1994), and clinically significant motor impairments (e.g., Ghaziuddin, Butler, Tsai & Ghaziuddin, 1994; Manjiviona & Prior, 1995; Rinehart, Bradshaw, Brereton & Tonge, 2001). It should be noted however, that motor difficulties in autism are typically considered secondary to abnormal communication and interpersonal relationships. In contrast, in DCD, motor difficulties and clumsiness are the defining features. Compared with normally coordinated children, children with DCD are reported to display high frequencies of onlooking and unoccupied behavior in the playground (e.g., Smyth & Anderson, 2000, 2001), higher levels of anxiety (Skinner & Piek, 2001), and poor psychosocial adjustment (Dewey, Kaplan, Crawford & Wilson, 2002). Such differences in clinical focus may suggest that the comorbidity between social and motor deficiencies does not necessarily involve a similar etiology. The findings from the present study further suggest that even in a normative population, a mild and non-clinical deficiency in motor function may be associated with a significant reduction in social engagement.

The association between motor abilities and reticent behavior and solitary–functional play may also imply the possible application of motor-oriented interventions for socially withdrawn children. Teachers, parents, and clinicians may wish to consider a standard motor evaluation for children displaying excessive frequencies of these solitary behaviors. Based on the results of such assessment, sensory–motor intervention (e.g., occupational therapy, physiotherapy) may be applied along with conventional psychotherapy. For example, a preliminary study in our laboratory revealed
that twelve sessions of sensory–motor therapy can significantly reduce anxiety symptoms in highly anxious children with balance deficiencies (Karmon-Weisman, 2003). It is important to note, however, that the design of the present study does not allow the inference of causality in the interplay between motor function and social participation. Some motor abilities may be regarded as prerequisites for the participation in certain social activities. Alternatively, however, social play provides children with the opportunity to practice and perfect motor skills. Increased social participation may therefore account for the increased motor proficiency in highly sociable children. In addition, social behaviors are also influenced by other skills such as language, self-regulation, problem-solving ability, and interpersonal cooperation. Normally developing children who are poor in motor skills may find alternative strategies, such as verbal communication, to achieve social engagement. A more accurate description of these elements in relation to motor ability awaits further research attention.

The present findings also revealed interesting simple main effects of context on play behavior. Considerable consistency of play behavior was found across context, indicating that children are likely to maintain their relative ranking within the peer group in terms of indoor and outdoor frequencies of social and solitary behavior. However, children also displayed higher frequencies of social play and solitary–functional play outdoors than indoors, and higher frequencies of social reticence and solitary–passive play indoors than outdoors. These findings suggest that different physical settings may elicit different types of play behavior (Barbour, 1999).

Spinard et al. (2004) speculated that solitary play exhibited during outdoor activities may be less appropriate than this type of behavior during quiet indoor activities. Our data indicate that indeed solitary–passive play and reticent behavior were more frequent during indoor than outdoor activity. However, in contrast to Spinard, Eisenberg, Harris, Hanish, Fabes, and Kupanoff’s (2004) suggestion, solitary–functional play was significantly more frequent outdoors than indoors. It could be that solitary–functional play, when enacted outdoors, is in fact perceived as appropriate and functional. For example, we coded the rather normative actions of solitary swinging or bouncing a ball outdoors as solitary–functional play.

Another aspect of the associations between motor abilities and social and solitary behavior is gender differences. Similar to previous studies (e.g., Coplan & Rubin, 1998; Coplan et al., 1994, 2001; Rubin, 1982) the present study found no gender differences in the occurrence of social play, solitary–passive play, reticent behavior, and solitary–functional play. In addition, we found no gender differences in the tested motor abilities. Furthermore, in the present study, no significant gender differences were observed in the pattern of associations between motor ability and social or solitary behavior. We therefore conclude that, based on the present data, gender may not be a significant contributor to the association between motor ability and social behavior. However, the present findings should be interpreted with caution, because sample size may have limited the power for detecting gender differences. Fabes, Martin, and Hanish (2003) showed that boys’ play is more active, forceful, and stereotyped compared to girls’ play, and that this pattern is even more exaggerated in group settings. Therefore, boys with low motor abilities may find it more difficult than girls with low motor abilities do to participate in active group play. Further research is needed in order to clarify this issue.

In summary, the results of the present study provide preliminary evidence for an association between individual differences in children’s motor ability and variations in their social and solitary behavior. Specifically, stable individual differences in motor
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Capabilities may be viewed as a temperamental factor contributing to the maintenance of individual variations in social behavior. An important issue for future research would be to assess the neural substrates of the associations between brain areas linked with nonsocial and inhibited temperament (e.g., Fox et al., 2001; Fox, Schmidt, Calkins, Rubin & Coplan, 1996; Kagan et al., 1988) and activity in specific motor control areas. In addition, it would be of interest to assess the relative and combined contributions of motor abilities and other important factors that also explain individual differences in children's social and solitary behavior. Specifically, motor capabilities should be considered along with more traditionally cited factors such as temperament (e.g., Burgess, Marshall, Rubin & Fox, 2003; Fox & Calkins, 1993; Fox & Henderson, 1999; Fox et al., 2001; Henderson et al., 2004; Kagan, 1989), parental behavior (e.g., Ladd & Golter, 1988; Ladd & Hart, 1992; Rubin, 1995), parent–child relationships (e.g., Booth, Rose-Krasnor, McKinnon & Rubin, 1994; Rose-Krasnor, Rubin, Booth & Coplan, 1996), cultural beliefs and norms (e.g., Chen, Hastings, Rubin, Chen, Cen & Stewart, 1998; Chen, Rubin & Li, 1995; Rubin, 1998), and status within the peer group (e.g., Harrist, Zaia, Bates, Dodge & Pettit, 1997; Rubin et al., 1993).

References


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**Notes**

1. Solitary–functional play is typically aggregated with solitary–dramatic play to form a category labeled solitary–active behavior. In the present study however, we observed practically no incidence of dramatizing while playing alone in the company of peers. Therefore, we treated solitary–functional play as a separate category.

2. Although we entered Gender into the analysis as a between-subjects factor, it is important to note that the sample size may have prevented a fully adequate assessment of the effect of this variable. We reran the above-described analysis with Gender entered as a covariate. The results were practically the same as those reported in the text.