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AN INVESTIGATION OF LATERAL HOLDING BIASES IN PRE-SCHOOL-AGE CHILDREN

By

Jason Bradley Almerigi

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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ABSTRACT

AN INVESTIGATION OF LATERAL HOLDING BIASES
IN PRE-SCHOOL-AGE CHILDREN

By

Jason Bradley Almerigi

Most adults hold infants asymmetrically and in the same direction, with the infant's head and upper body to the left of the holder's midline. Although many studies have explored the bias in adults, especially in mothers with their newborn infants, no adequate explanation of the bias has been supported. The current study approaches the question from a developmental standpoint, assessing the earliest manifestation of the bias to determine its origins and covariates, specifically sex and handedness. A community sample of ninety-seven pre-school children, who were tested in their homes, were asked to hold a realistic-looking infant doll on three occasions to assess degree of bias. Three main concerns were addressed. First, prior developmental studies assessed the bias in children from one of three different countries, Sweden, South Africa, and Brazil. The current study extended this work to children from the United States. Second, prior studies came to different conclusions about age of onset: one report first finding the bias in 2-year-olds, another in 4 year olds, and the last in 6-year-olds. The current study therefore sampled children between the ages of 3 and 5 to cover the possible period of transition. It also used improved methods to repeatedly assess the strength of the bias as reflected in the stability of the hold, its closeness and duration, and its flexibility when the child had to perform a concurrent manual task. Using realistic dolls, the results suggested that while the bias is not yet established in the group as a whole, girls but not

boys showed repeated, albeit non-significant, preferences to hold on the left. Girls also were significantly more likely to hold the dolls closer to their body and for longer periods of time. Finally, while handedness had no clear association to the bias in and of itself, when there was concurrent manual task, where the child was asked to "feed the baby," left-holders continued to hold on the left while middle- and right-holders switched to the left, presumably to free their dominant hand. In sum, findings provide a preliminary indication that the 3-to-5-year age range is an important transition period for the development of the bias and for the first appearance of sex differences in characteristics of infant holding.

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INTRODUCTION

The act of holding an infant serves many functions beyond simple transportation. It is in the arms of the caregiver that, among other things, the infant is whisked away from danger, carried to shelter, fed when hungry, and calmed when upset. The act of holding is the primary means by which the parent-infant bond (infant-parent and parent-infant attachment) is established (e.g., Bowlby, 1958; De Casper & Fifer, 1980; Feldman, 2003; Robson, 1967) and by which behaviors known to influence the infant's cognitive and socio-emotional development are facilitated. Examples include mutual gazing and face-to-face communication (e.g., Cohn & Tronick, 1988; Fogel, Messinger, Dickson, & Hsu, 1999), infant touching and caressing (e.g., Field, 2001), synchronous behaviors (e.g., Feldman, 2003), and mother-infant vocalizations (e.g., Papousek & Papousek, 1986, 1989).

Given its importance for infant development, an understanding of the factors underlying the act of holding represents an important goal for research. Other than research on nursing behavior (e.g., Lonstein & Stern, 1999; Nightingale, 1860; Stables & Hewitt, 1995) and an early investigation of holding styles by Rheingold and Keene (1965), infant-holding, with one exception, has not been well-studied.

A Left-Side Bias for Holding Infants

The exception is a small but vigorous body of work by researchers who study laterality. These researchers became interested in infant-holding on discovering that most adults hold infants asymmetrically and in the same direction, with the infant's head and upper body to the left of the holder's midline. The bias occurs whether the infant is held in one arm or both arms in the cradling position, so that the infant faces the holder. This left-side bias was reported as early as the mid-18th century (Harris, 2002) and can be seen in relics and artifacts dating back nearly 2000 years (Grüsser, 1983).

Features of the Bias

Near-Universality

While the bias is most often reported for mothers with their newborn infants, where about 80% hold to the left (e.g., Salk, 1960; Trevathan, 1982), it is not restricted to this group. It is seen in fathers (Bogren, 1984; Dagenbach, Harris, & Fitzgerald, 1988) and men and women in general (Harris & Fitzgerald, 1985) and in nulliparous college students of both sexes (Bundy, 1979; Saling & Tyson, 1981). It also is culturally ubiquitous, appearing in Western as well as Eastern countries, and in people from industrialized and non-industrialized cultures alike (Brüsser, 1981; Harris, Almerigi, & Kang, 2003; Harris, Jentoft, & Almerigi, 2002; Saling & Cooke, 1984). It even has been observed in non-human primates (Hatta & Koike, 1991; Manning & Chamberlain, 1990; Salk, 1960). Under what Manning and Chamberlain (1990) call "the most harmonious assumption that left-side holding is homologous in apes and humans," it would indicate that "a strong left-side cradling preference may have originated as early as the common ancestors of African apes and humans (about 6-8 million years ago)" (p. 1226).

Remarkably, elicitation of the bias does not require an actual infant to be held. It occurs when participants are asked to hold a doll that looks like an infant (e.g., Manning & Chamberlain, 1991; Saling & Bonert, 1983) or to hold a pillow or ball and to imagine that it is an infant (Weiland & Sperber, 1970; Sperber & Weiland, 1973). It is even found when adults are asked to imagine themselves holding an infant, without the aid of a physical object (Almerigi, Carbary, & Harris, 2002; Bogren, 1984; Harris, Almerigi, &

Kirsch, 2000; Nakamichi & Takeda, 1995). Furthermore, when mothers' imagined-holding is directly compared to the actual holding of their own infant, the two are in "full agreement" (Bogren, 1984, p. 15), meaning that the mothers imagined themselves holding their infants on the same side as they actually held their infants.

Reliability

As previously noted, the bias is repeatedly found across diverse samples of individuals, indicating its reliability at the population level. It is spatially reliable, in that it is found across diverse contexts and locations, and temporally reliable, in that it has been observed over hundreds of years.

The bias also is reliable at the individual level. Most people (> 85%) are consistent in the side to which they hold, whether the testing interval spans 20 minutes (Weatherill, Almerigi, Levendosky, Bogat, & Harris, 2002), an hour (Almerigi, Van Hooren, Bulman-Fleming, & Harris, 2002; Trevathan, 1982), a week (Bogren, 1984), 4 months (Harris, Almerigi, Carbary, & Fogel, 2001), or even 12 months (Dagenbach, et al., 1988). As just noted, people remain consistent even across different methods of holding (imagined and actual) (Bogren, 1984). Taken together, the left bias is remarkably consistent.

Proximity

Another noteworthy feature of the left-side hold is its proximity to the body. de Château (1991) compared mothers who held on the left with mothers who held on the right. The former held their infants closer, the latter farther away. Inasmuch as proximity relates to such aspects of the holder-infant relationship as attachment, maternal depression, and infant self-regulation (e.g., Feldman, 2003), side of hold may serve as an important index of the psychosocial welfare or interaction of the infant and/or holder (de Château, 1991; Weatherill et al., 2002).

Selectivity

The left-side bias does not seem to be merely an expression of a general bias for holding on the left. Adults show it for holding infants, pretend-infants (dolls, pillows), and imagined infants but not for inanimate objects such as books (Alley & Kolker, 1988; Scheman, Lockard, & Mehler, 1978), balls (Weiland & Sperber, 1970), or bags of groceries (Rheingold & Keene, 1965). Depending on the object, a bias is usually absent or to the right. For example, in a study of book-carrying style, Alley and Kolker (1988) found that a majority of adults held to the right. For another example, Almerigi et al. (2002) asked two groups of college students to imagine themselves holding an object and then an infant. For one group, the object was a simple shoebox; for the other it was a fragile vase. Both groups showed significant opposite-side biases for the infant and the object: to the left for the infant, to the *right* for the object. Even more compelling is that the same physical stimulus can elicit opposite-side biases depending on how the holder views it. In the study by Weiland and Sperber (1970), cited above, which instructed adults to hold a pillow close to their chest, the left-bias was found only when the adults were asked to imagine that the pillow was an infant. Otherwise, most adults held the pillow in the middle or to the right.

Sex Differences

Finally, although the left-side bias is found in both sexes, men's and women's biases differ in strength and reliability. In some studies, men's bias is as strong as women's (e.g., Harris et al., 2001), but just as often it is weaker (Dagenbach et al., 1988), absent (e.g., Lockard, Daly, & Gunderson, 1979), or even reversed, so that the bias is to the right (e.g., Brüsser, 1981; Manning, 1991). One investigator who found large sex differences in his sample even proposed calling left-side holding a female adaptation for the role as primary caretaker (Manning, 1991). Consistent with these differences, there is some evidence that women are more selective in their display of the bias. For example, in the shoebox-vase study mentioned previously (Almerigi et al., 2002), the women's holding-side patterns differentiated between the infant and the objects more clearly than the men's. That is, women, regardless of their side of hold for the infant, were more likely than men to switch to an opposite-side hold for the object.

The description of the left-side bias as a female adaptation fits with psychological and anthropological studies showing that women usually are more involved in infant care (e.g., Barry & Paxson, 1971). They also are more aroused by infants, more likely to pick them up and hold them, better at recognizing their cries, and better at soothing and quieting them (Fogel, 2001). In addition, women are more emotionally expressive and, as Maccoby (1990) concluded after reviewing the literature, more "relational" and "reciprocal" in their style of social interaction. This difference is perhaps reflected in what Rheingold and Keene (1965) found for infants under 1 year of age – that more mothers hold in the chest-to-chest, or facing-toward, position, whereas more fathers hold facing away. For women, holding an infant may be a more social-interactional act, even when the hold is primarily for transport.

Certainly, these sex differences may arise from social-cultural practices that teach us how to think and behave as males and females. They also may be partly biological, what Panksepp (1998) called a difference in "nurturance circuits," implying that they are adaptive and rooted in evolutionary selection. If so, and if the left-side hold itself is adaptive, it makes sense that it is stronger and more reliable in women.

Explanations of the Bias

In sum, the left-side bias is not an obscure, isolated phenomenon, occurring under unusual circumstances. It is ubiquitous and robust. What is especially intriguing about the bias, however, and what has contributed to its being studied for over four decades (since Salk, 1960), is that it is not easily explained. A variety of explanations have been proposed and tested. Five of them are summarized below.

Handedness

The most obvious explanation is that the bias is the direct product of handedness, that is, that most people hold on the side that keeps their dominant hand free for other activities, for example, for engaging the infant, for holding and manipulating feeding utensils, or for performing other duties. By this reasoning, right-handers would hold on the left, left-handers on the right. This explanation itself has a long history, and it appeals to common sense. According to one nineteenth-century investigator who reported that left-side holding was the mode, "an intelligent mother…will tell you that she must keep her right arm free for the other children, and for her various household duties" (Buchanan, 1862, pg. 162; cited in Harris, 2003). Likewise, in Bali, where left-side holding also is the mode (Harris, Jentoft, & Almerigi, 2002), the anthropologist Margaret Mead (1942) noted that for the Balinese mother, left-side holding would leave "her own right hand free" (p. 13). The handedness explanation, however, was abandoned after repeated demonstrations that right- and left-handers either had nearly identical left biases or that the bias in left-handers was only slightly weaker but not reversed (e.g., Ginsburg, Fling, Hope, Musgrove, & Andrews, 1979; Harris, Almerigi, & Kirsch, 2000; Salk, 1960; Weiland, 1964). It is also difficult to see how handedness can account for those studies where men show a weaker left bias than women, much less a reversed bias, considering that handedness patterns are very similar in men and women, the only difference being that left-handedness is slightly more common in men (~12% vs. 9%). The handedness explanation also cannot explain the selectivity of the bias. Inasmuch as holders require the use of their dominant hand whether holding infants or objects, a left bias should occur for both. It is unlikely that handedness can explain how the same individual can show a left-bias and right-bias for the same object, depending on the task (e.g., Weiland & Sperber, 1970).

Posture

When college students are asked to explain their bias, many have referred not to handedness but to comfort, that is, that they preferentially hold on a certain side because it feels more "comfortable" or "natural" on that side (Harris, Kang, & Almerigi, 2003). When asked to hold on both sides and to compare their comfort levels directly, nearly all rate their preferred-side hold as more comfortable (Almerigi et al., 2002).

It is unclear what would make one side feel more comfortable or natural. One possibility is that the act of holding is less an act of hand skill than it is what Saling and Cooke (1984) called a "tonic postural configuration" (p. 335): how individuals normally arrange, or configure, the parts of their body, especially while in a state of repose. For the act of holding, some aspects of posture might be more important than others, depending on whether one is standing or sitting. For example, most people, when they stand in a relaxed position while *not* holding anything, shift their weight slightly to one side; that is, they extend one leg for support and slightly flex the other. Erber, Almerigi, Carbary, and Harris (2002) reasoned that people more comfortable with weight on one side might be more comfortable holding a baby on that side. If so, and if most people "balance" on the left, that might explain the left-bias for holding. It also might explain why the women in one study not only rated their preferred side as more comfortable, but why left-holders' overall comfort ratings were significantly higher than right-holders' (Almerigi et al., 2002).

Using an imagine-hold test with right-handed college students and a test of foot preference for balance to measure postural bias, Erber et al. (2002) found a modest relation between posture and holding-side bias. Fifty-five percent of the men and 68% of the women held on the left (only the women's score was significantly different from chance), with left-holders showing a weaker bias for balance than the right-holders. The correlation between scores, however, was significant only for women ($r = .252$, $p < .05$). The authors suggested that, inasmuch as women generally have more experience with infants, postural bias may play a greater role for people with more experience because with more experience comes a clearer sense of what is the more comfortable side.

Maternal Heartbeat

Salk (1960, 1961) proposed that the bias is a product of the left-side location of the mother's heart. He called the left-side hold "an instinctive response evolved from a need on the part of the infant to experience a continuation of the maternal heartbeat rhythm, a familiar sensation from intrauterine life" (Salk, 1960, p. 170). The left side therefore is preferred because the infant is nearer the precordial area where the heartbeat is stronger, soothing not only the infant but also the mother, who, "by virtue of having contact in this area," has the feelings of her own heartbeat reflected back (Salk, 1961, p. 745). Salk (1973, p. 27) went on to suggest that "the time immediately after birth is a critical period during which the stimulus of holding the infant releases a certain maternal response," a period he likened to the imprinting phenomenon found in such creatures as ducks and chickens as demonstrated by Lorenz (1964) and other ethologists.

The heartbeat explanation has been questioned on several grounds (e.g., Dagenbach et al., 1988; Turnbull & Lucas, 2000). Given its focus on pregnancy and the birth experience, it cannot explain why the bias appears not only in mothers but also in individuals with little or no experience with infants, including nulliparous women and male college students. Still, Salk must be credited with being the first to propose that the left-side hold is adaptive, or beneficial, not only for the infant but for the holder as well. Furthermore, consistent with the hypothesis, the left-side hold is at its peak for newborns and young infants (Rheingold & Keene, 1965). A more theoretically useful way to describe the role of the maternal heartbeat therefore may be as a "trigger" for a causal bio-regulator related to comforting and feeding (Fitzgerald, Harris, Barnes, et al., 1991).

Infant's Resting Head Position

So far, the focus has been on the attributes of the holder. Attributes of the infant also deserve consideration. One possible way for the infant to contribute to the bias is by its resting head position. While lying supine, most infants tend to turn their head to the right, even when the head is initially held at the midline for a brief time and then released (Harris & Fitzgerald, 1983; Turkewitz & Birch, 1971; Turkewitz, Gordon, & Birch, 1965). As such, it has been suggested that an infant in the rightward head position would predispose the holder to hold on the left. That would facilitate face-to-face contact with the holder as well as the initiation of breast-feeding, since the infant's head already would be turned toward the holder's face and body. Although this explanation has found some support (Ginsburg et al., 1979), the left bias persists independent of the infant's head position (Bundy, 1979; Dagenbach et al., 1988; Saling & Tyson, 1981). Indeed, in the study by Dagenbach and colleagues (1988), the greatest continuity in lateral preferences for holding occurred between the first and second months after birth, a time when infants themselves were often inconsistent in their head orientation (Cornwell, Barnes, Fitzgerald, & Harris, 1985).

Attention and Selective Hemispheric Activation

The last explanation proposes that the bias is a product of selective neural activation accompanying the act of holding an infant. Drawing on evidence for lateral differences in hemispheric specialization for the perception and recognition of faces (e.g., De Renzi, Faglioni, & Spinnler, 1968; Kanwisher, McDermott, & Chun, 1997; Sergent, Ohta, & MacDonald, 1992) and emotion (e.g., Best, Wormer, & Queen, 1994; Borod, Andelman, Obler, et al., 1992), this explanation posits that the acts of perceiving the infant and responding emotionally to its facial expressions, vocalizations, and cries activate a greater network of neural systems in the holder's right hemisphere than the left hemisphere (e.g., Natale, Gur, & Gur, 1983), thereby driving the holder's attention to the opposite, left side of space (Reuter-Lorenz, Kinsbourne, & Moscovitch, 1990). The left-side hold thus is compatible with the direction of the holder's attention. The explanation further assumes that this same state of activation is adaptive by enhancing the holder's ability to interpret and monitor the infant's emotional state. So far, this hypothesis has found modest support from visual tests of attention (e.g., Harris, Almerigi, Carbary, &

Fogel, 2001; Vauclair & Donnot, 2003, unpublished data) and mixed support from auditory tests. The latter have compared left- and right-side holders' recognition of the emotional tone of dichotically-presented speech. Tests using emotionally-toned sentences found no differences (Sieratzki, Roy, & Woll, 2002; Turnbull, 2002; Turnbull & Bryson, 2001), but a test using emotionally-toned words gave more promising results, finding that only left-side holders showed a significant left-ear (right-hemisphere) advantage and were more accurate overall (Almerigi et al., 2002). Even in this case, however, only 9% of the variance was explained by hemispheric asymmetry for emotion perception.

The Complexity of the Bias

In summary, the holding-side bias is not easily explained by any single mechanism. The fundamental reason is probably that, like most psychological phenomena, it is multiply-determined, so that although any one factor may be necessary for its occurrence, no one factor is sufficient. This is to be expected if the bias is evolutionarily adaptive (e.g., Cosmedes & Tooby, 1994). That is, it makes sense that a biologically and psychologically important phenomenon is redundantly specified (cf. Fodor, 1983).

Aside from the complexity of the phenomenon, the difficulty of explanation also has to do, at least in part, with methodological limitations in how it has been assessed. In many studies, investigators have simply reported the existence and magnitude of the bias and have made only modest attempts to measure its association with any behavior or attribute of the holder or the infant. Moreover, where these efforts have been made, it often has been by oversimplifying the attribute through dichotomous classification. This is especially true for the handedness of the holder. Most studies have treated handedness as a dichotomous variable by classifying individuals into two groups, right-handers and left-handers, thus not taking variations in the degree, or strength, of handedness into account, as measured by a multi-item questionnaire or a performance-based measure of hand use. This practice is especially problematic with respect to left-handers because of their greater heterogeneity. As a group, they are less strongly lateralized than right-handers, but they also comprise at least two roughly equal-size subgroups varying in degree of handedness. On directional tests of attention, only strong left-handers have shown reverse biases from right-handers (Peters & Servos, 1989). Conceivably, then, a larger, if still limited role, for handedness might be found if, especially for left-handers, degree of handedness were taken into account.

In holding-side studies that have assessed the holder's handedness, many also have simply classified handedness by self-report (e.g., Bundy, 1979; Salk, 1960) or by assessing the hand used for writing (e.g., Bogren, 1984) instead of by using a multi-item questionnaire. Handedness classifications sometimes also have been reported without describing the decision rule used (e.g., Manning & Chamberlain, 1990). Finally, so far, no study has used performance-based measures that assess hand differences on tests of proficiency. With all these considerations in mind, the role of handedness in the holding-side bias should not be ruled out.

Development of the Bias

With the left bias repeatedly confirmed in adults, at least in women, the question arises as to its development. When does it first appear, how stable is it, what are the contributing mechanisms, and is the process the same or different in boys and girls? So far, only three studies have been reported. The first and most comprehensive was by de Château and Andersson (1976), who assessed 305 Swedish children (135 girls, 170 boys) in 8 age groups ranging from 2 to 16 years. The children were asked to enter an observation room where a doll had been placed on a bed, to pick up the doll and pretend it was a newborn baby, to sit in a chair while holding the doll, and finally to carry the doll to an adult observer seated across the room. For each child, the observer noted how the child held the doll while sitting and while carrying it. The three possible ratings were "left" (doll in arms with head turned to the left), "right" (doll in arms with heatumed to the right), and "in hands" (doll in hands, not in arms, regardless of head direction).

The two-year olds were reported to have difficulty understanding the directions. The four-year-olds had no difficulty but nonetheless failed to show a bias in either direction; instead, the majority (~70%) held and carried the doll in their hands ("in-hands") and away from their body. The first appearance of the bias was in six-year-old girls, with 79% holding on the left , 10% on the right, and only 11% in hands. In six-year-old boys, 51% held in-hands, only 32% held on the left, and 17% held on the right. For girls, a strong left bias persisted for all age groups; for boys, it appeared only by age 16, and then by a smaller margin. For both sexes, increases in left-side holds came largely as in-hand holds declined. Unfortunately, handedness was not assessed.

In the second study, Saling and Bonert (1983) asked 53 South African preschool children (mean age = 59 months) to hold a life-like doll "so that it can go to sleep" (p. 149). Sixty-six percent of the children spontaneously held the doll to their left while the remaining held to the right. That no children held in the middle or "in-hands" leaves open the question of whether these children spontaneously held only on the left or the right (either as a function of the experimental instructions or as a function of their own natural tendencies) or whether the authors simply removed these children from analyses. Further, the authors reported that the correlation between handedness and holding was not significant (r = .02), but they did not identify their handedness items or decision rules. In this study, boys were not tested.

In the last study, Souza-Godeli (1996) assessed holding-side bias in 520 Brazilian children between the ages of two and six. Each child was presented with a doll and was asked to hold it "as if it were a baby." Along with the holding task, the child's hand preference was assessed on 4 tasks (hammering, drawing, holding a spoon, and throwing a ball), and the child's foot preference was assessed on a single task (kicking a ball). The result was that 87% of the children "showed dexterity," presumably meaning that they were right-handed, and the group as a whole showed a left-bias for holding the doll. Side of hold was "unrelated" to either age or sex. Based on the results, Souza-Godeli (1996) called the holding bias an "innate behavior or at least a behavior emerging in the early stages of human ontogenesis" (p. 1422).

This last study presents more problems than the others. First, data were not reported for each age group or sex. Instead, the author simply reported a non-significant Chi-square statistic for age by hold side and noted the absence of any age differences, even though she reported in the discussion that, similar to what de Château and Andersson (1976) found, the two-year-olds had difficulty following the instructions. The statement that the results were "unrelated" to sex, likewise, is difficult to interpret in the absence of separate statistics for boys and girls and the different age groups, especially considering de Château and Andersson's (1976) finding of an interaction between sex and age. Finally, for the handedness measure, the Chi-square statistic that was reported indicated that the author dichotomously classified the sample into right-handers and left-handers. Scores for individual laterality items and score ranges also were not reported, and no mention was made of the single footedness measure.

Questions for the Current Study

Prior studies show a holding-side bias in children, but they leave many questions about the development of the bias unanswered. The current study sought answers to some of these questions, four sets of questions, in particular.

Age of Onset

The first set of questions has to do with age of onset. In combination, the evidence suggests that the left-side bias first appears somewhere between three and six years of age, but why was it substantially earlier in the Brazilian and South African children than the Swedish children, and why were there age differences in the Swedish children but not the Brazilian children? The answers to both questions may have less to do with nationality and more to do with the greater complexity of the method used. In the current study, therefore, an age range was chosen that covered the period of first reported appearance of the bias, and the method used was designed to be understandable to this age group.

Role of Handedness

The second set of questions pertains to the role of handedness. For a study of the role of handedness in young children as distinct from a study of its role in adults, two different kinds of questions must be distinguished.

Relation between establishment of handedness and establishment of side hold as a style of holding. In studies with adults, the only possible comparison, understandably, has been between individuals with already established handedness. Unlike young children, nearly all adults show a lateral hold, that is, to one side or other, instead of an "in hands" hold, with the infant (or doll) held in the middle, or midline, of the holder's body (e.g., de Château & Andersson, 1976). Weatherill and colleagues (2002) found that of over 500 holds observed in mothers with their one-year-old children, fewer than 10% were in the middle, and most of these were observed while the mother was sitting rather than standing.

Inasmuch as holding an infant is a motor act, a reliable holding-side bias, irrespective of direction, presumably would not be possible until the child has developed a reliable lateral bias for hand and hand-and-arm acts of the kind that conventionally comprise measures of handedness. For the current study, then, the first question is whether a necessary condition for holding the doll to one side, in contrast to holding "in hands" at the body midline, is the establishment of a lateral bias on the handedness measure. If it is a necessary condition, the next question is whether the direction of handedness is related to the direction of hold.

Flexibility of holding-side bias when one hand is required for a skilled act. For adults, as already noted, the similarity of holding-side patterns for right- and left-handers suggests that the choice to keep the dominant hand free for other tasks is not a major contributor to side of hold. But circumstances also were noted where it presumably would play a role, prominently, when the infant must be fed with a utensil requiring motor control for which the dominant hand is more suited. The role would be different for right-handers and left-handers. For right-handers, the large majority of whom hold on the left, the right hand would already be free; it is the minority who hold on the right who would have to shift to the left for feeding. For left-handers, a majority of whom also hold on the left, a proportionately larger number therefore would have to change sides to free the dominant hand. Only right-holders therefore would have their dominant hand free. This means that a minority of right-handers and a majority of left-handers would have to be flexible in their choice of holding side, depending on the circumstances. For children, the same questions about flexibility can be posed. For example, for right-handed children (based on their predominant hand use on a variety of tasks), if the majority hold the doll on the left, it seems reasonable to suppose that they will continue to hold on the left if asked to feed the doll. It seems less reasonable to suppose that those who hold on the right will change to the left. That may require a measure of flexibility still beyond young children's capabilities.

Role of Footedness and Posture

The third set of questions pertain to footedness and posture. The score for the single measure of footedness – kicking a ball – used in Souza-Godeli's (1996) study may not have been reported separately because it was treated as a test of skill like the tests for handedness and thus was incorporated into the author's overall estimate of laterality. As such, it may have added little to the mix for the purpose of testing the relation of laterality to side of hold. For the current study, as in the adult study by Erber et al. (2002), some of the footedness items were used for this same purpose, but other items were used for a different purpose – to assess the role of posture. These items were those designed to assess foot and leg preference for stability and balance. As in the adult study, for the doll-holding task, the children were tested in a standing position in order to assess the relation between directional bias for stability and balance and the adoption of a lateral-style hold as well as the direction of the hold. In addition, for one of the stability-balance measures, a test of proficiency was added.

Role of Sex of Child

The last set of questions pertain to sex differences. What role does sex play in the development of the bias, and why were sex differences pronounced in the Swedish children but absent in the Brazilian children? The latter question cannot be answered without more information about the results of the Brazilian study. But in light of evidence reviewed earlier of the breadth of social-emotional-perceptual functions served by infant-holding along with the evidence of sex-related differences in adults in interests and skills important for infant care, it is reasonable to predict that similar differences will be found in children.

There is, in fact, abundant evidence of sex differences in young children having a possible relevance for the doll-holding task. Generally speaking, these are studies showing differences in the general orientation of boys and girls toward other people. For example, in a review of these differences, Haviland and Malatesta (1981) noted that whereas "girls and women establish and maintain eye contact more than boys and men" (pg. 189), boys and men gaze-avert more frequently, a difference found as early as 6 months. Further, in the first few days of life, girls orient to faces and voices more frequently on average than do boys (Haviland & Malatesta, 1981) and, by at least 6 months of age, girls have better memory for faces and are more skilled than boys in discriminating between similar faces (e.g., Fagan, 1972). These latter differences, however, are more consistent in older children (Hall, 1984; Haviland & Malatesta, 1981; Maccoby & Jacklin, 1974; McGuinness & Pribram, 1980).

Girls and boys also differ in the nature of their social interactions. Several lines of research have found that infant girls are more responsive, and even more sensitive, to social cues than are boys (Gunnar & Donahue, 1980; Gunnar & Stone, 1984). Gunner and Donahue (1980) found that mothers were equally likely to initiate social interactions with their sons as with their daughters, but daughters were more responsive than sons to their mother's verbal requests. While the origins of these differences lie beyond the scope of the current study, it is interesting to note that these differences have been observed across several diverse cultures (Whiting and Edwards, 1988).

Of perhaps special relevance for the study of lateral biases in doll-holding in children are studies of alloparenting, or "pretend parenting" during play. Although this form of play can occur in both sexes, girls are far more likely to be observed in such play (Lever, 1978; Meyer-Bahlburg, Sandberg, Dolezal, & Yager, 1994; Pitcher & Schultz, 1983). That alloparenting has been observed in non-human primates, especially in young females who have not yet had their first offspring (Nicolson, 1987; Pryce, 1993), evolutionary explanations for the origins of the sex differences in social interactions in the context of infant care become more likely.

In light of this evidence, the current study asked whether and to what extent boys might differ from girls not only in the strength of the side bias but in its flexibility in a concurrent task requiring use of one hand for infant care. It also asked whether any such differences are related to age and to the direction and degree of handedness and posture.

Given the sex role differences between boys and girls, it also sought to assess any differences in the proximity and duration of the hold.

Advantages that the Study of Young Children Offer for Understanding the Origins of the Holding-Side Bias

In contrast to studies of adults, studies of young children – those in the 3- to 6-year period – offer three main advantages for helping to understand the origins of the holding-side bias. First, whereas handedness is already established in adults, in 3- to 6-year-olds it is still undergoing development at least in degree if not necessarily in direction (cf. McManus et al., 1988). As a result, even though adults show variations in strength of handedness, the variations will be greater in young children, since some will be further along in the process than others. In fact, for degree of handedness as measured by the number of different tasks for which the same hand leads, some longitudinal studies find changes until ages eight or even nine (Bruml, 1972). Assuming that the underlying neural bias is relatively constant, it may be that improvements in motor control allow for better expression of the bias and that it takes time for children to discover and consolidate their preferences across tasks, especially for new, complex tasks like writing and tool-use (see Harris & Almerigi, 2001).

Second, individual differences in the development of general motor control necessary for lateralized hand use therefore would be expected to contribute to young children's overall greater variability. There also is evidence that variability or instability will be even greater in young children with a left-handed pattern. For example, where direction of handedness was based on hand-use for writing, a cross-sectional study of 5-, 7-, and 10-year-olds showed that left-handers in every age group were less stable than right-handers on a variety of other preference as well as proficiency measures (Bruml, 1972). Similarly, in a longitudinal study at 5, 8, and 11 years, hand preference at 5 predicted preference at 11 for only 74% of left-handers versus 97% of right-handers (Fennell, Satz, & Morris, 1983).

Finally, as already noted, whereas on tests of holding side, adults normally comprise two unequal-size groups – left-holders and right-holders – prior studies of children, especially young children, show greater variability, with left- and right-side groups more similar in size and with the appearance of a third group – "in hands" – less often seen in adults. In sum, in young children, all of the bio-behavioral-action systems that may be contributing to the holding-side bias are *still developing, at different rates, in different children*. As such, from a purely statistical standpoint, the greater variability of the systems allows for more latitude and more opportunity to examine the inter-relationships. This is one of the major guiding assumptions for the current study.

Hypotheses and Predictions

Hypotheses

Inasmuch as infant holding is a motor behavior, the development of motor systems must precede the behavioral manifestation of an infant hold. Likewise, the development of lateralized motor biases must precede lateralized biases in holding. Both conditions are necessary (but not necessarily sufficient) for the bias to occur. Further, given the biological and psychological differences between boys and girls in behaviors related to infant care (reflecting other contributing, possibly necessary, conditions), boys' and girls' holding-behavior patterns will reflect these differences. Six directional predictions were made to test these hypotheses.

Prediction 1

Like adults, children as a group will show a left-side bias for holding a doll, but it will be smaller in magnitude due to the presumably still incomplete development of the underlying motor systems.

Prediction 2

Degree, or strength of handedness, as a proxy for motor development, as measured by the extent of same-hand use across hand-use tasks, will predict lateralized holding, regardless of side.

Prediction 3

As with adults, direction of handedness will be related to but not completely predict direction of hold.

Prediction 4

Degree, or strength, of handedness, again as a proxy for motor development, will predict flexibility in hold side on a task that requires holding an infant while performing a skilled motor task.

Prediction 5

Postural bias, as measured by strength and direction of footedness, will augment the predictive power of handedness for side-of-hold bias.

Prediction 6

Compared to boys, girls will show a stronger lateral holding-bias, a stronger left bias, a closer and longer hold, and greater flexibility in arm choice for holding when presented with a concurrent hand-use task.

METHOD

Participants

Participants were 97 pre-school-age children who were recruited as part of a larger study by Michigan State University Outreach and Engagement[1] of the effectiveness of the Genesee County "Ready, Set, Grow! Passport initiative, a community-based early childhood intervention program designed to enhance the well-being of young children.[2] The sample for the current study consisted of 47 boys and 50 girls ranging in age from 43 months to 64 months (mean = 52.6).[3] As shown in Table 1, age and ethnicity were nearly equally distributed between the sexes. Forty-eight children (49.5%) were African-American, forty-one (42.3%) were Caucasian, seven (7.2%) were multi-racial, and one (1.0%) was Hispanic. These percentages correspond well to the racial distribution of the overall program, with Caucasian children slightly underrepresented (6.3%) and African-American children slightly overrepresented (7.3%). The other race/ethnicities differed by less than one percent. For the overall community, the differences were slightly larger but in the same direction (see Barnes, 2003, for more information).

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[1] The data collection for the evaluation was conducted by Jessica Barnes (and several undergraduate students) under the guidance of Hiram Fitzgerald, Director of Outreach and Engagement, Michigan State University.

[2] This program is an ongoing, population-based program that attempts to enroll all families in Genesee County, Michigan, with children under the age of 5 years (Barnes, Determan, & Fitzgerald, 2003). At the time of testing, nearly 9,000 children and their caregivers were enrolled. For member families, the Passport program provides a broad spectrum of information on healthy child development through the use of fact sheets and timetables for prenatal care, well-baby check ups, and immunizations. The Passport program also provides access information to social services related to child development and incentives (coupons) for the use of such services and activities that promote positive social, emotional, cognitive, and physical development.

[3] Eight children who were tested for the evaluation were excluded from the current study because of prior brain injury (n=2), clinical psychiatric disorder (n=3), language difficulty (n=2), or refusal to complete the tasks (n=1).

Table 1. Participant Demographic Information

	Boys	Girls	Total
N	47	50	97
Age (months)			
Mean (SD)	52.7 (4.7)	52.5 (5.5)	52.6 (5.1)
Range	44 - 64	43 - 62	43 - 64
Ethnicity (%)			
Caucasian	19.6	22.6	42.3
African American	25.8	23.7	49.4
Hispanic	1.0	0.0	1.0
Multi-racial	2.1	5.2	7.2
Asian, Native American, Other	0.0	0.0	0.0

Recruitment and Consent

The children and caregivers were recruited via a mail flyer sent by the "Ready, Set, Grow!" Passport program to all the individuals enrolled in the program. Contact information for positive respondents was provided by the Passport program to university research assistants who then telephoned the respondent to briefly explain the purpose of the evaluation and to schedule an interview at the respondent's home.

Individuals who agreed to be interviewed were informed that participation was voluntary, that they or their child could withdraw at any time without suffering any negative consequences, and that all information gathered was confidential. Prior to any data collection, the research assistant read two consent forms to the caregiver: one for the evaluation of the Passport program (Appendix A), another for the data collected for the current study (Appendix B). Caregivers who agreed to participate then signed the consent forms. All caregivers gave consent.

Data Collection and Design

Children and caregivers were separately interviewed in their own home by two research assistants. One assistant interviewed the caregiver while the other interviewed the child. Both interviews were conducted simultaneously and in separate rooms. The caregiver interview usually took place at a kitchen table while the child interview usually took place on the living room floor or another space large enough for the performance-based tasks. All information from questionnaires and tasks was recorded by the research assistants on a prepared answer form. In the case of questionnaires, the research assistant briefly described the questionnaire and read each question and corresponding response scale aloud.

The caregiver interview consisted of questions about family demographics and history and the use of Passport information and services. The caregiver's knowledge of child development, parent confidence and efficacy, and caregiver/child activities also were assessed (Barnes, 2003). Finally, information about the child was assessed by reading each of the items from the Child Behavior Checklist for Ages 1½ - 5 (Achenbach & Rescorla, 2001).

The child interview mainly consisted of simple behavioral tasks that assessed the child's behavior regulation, emotion regulation, social problem solving, and ability to produce and perceive facial emotions (Barnes, 2003). In addition, there were 23 tasks assessing the child's infant-holding bias, handedness, footedness, and motor coordination. Appendix C provides a complete listing of the caregiver and child tasks in the order they were administered. Below is a fuller description of the tasks used in the current study.

Infant-Holding Tasks

Two realistic-looking infant dolls (approximate age representation: 6 months) were used to assess side-of-hold. Both dolls were purchased from a local toy store and were identical in material ("natural touch" soft plastic "skin"), size (approximately 40 cm long x 15 cm wide), weight (.726 kilograms)[4], and apparel (plain white diaper). Each doll was sex-neutral but differed slightly in facial features, hair texture, and skin color to represent babies of two different races (Black and White). The use of dolls of different races was not integral to the study; the intent rather was to slightly alter the task in order to make the two holding-trials more discrete.

For the first hold trial, the interviewer placed the dolls side-by-side and directly in front of the child. The child was then told to pretend that the dolls were real babies and to point to the "baby" that he/she wanted to pick up. Once the child made a choice, the interviewer removed the other doll from the child's sight by putting it into a plastic toy bin and then put the chosen doll directly in front of the child. The interviewer then said, "Pretend the doll is a real baby, pick up and hold the baby and give it love." Once the child picked up and held the doll, the interviewer recorded the side to which the child held it (to the left, to the right, in the middle, or alternating between left and right sides), the proximity of the hold (doll touching body, doll near but not touching body, or doll out and away from body), and the duration of the hold, or hold time. Appendix D shows the coding form used by the interviewer. Hold duration, recorded by stopwatch, was the time between initially picking up the doll and ending the hold (e.g., putting the doll down or playing with it in a way that did not involve an arm hold).

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[4] The choice of a doll that was smaller and lighter than a normals 6-month-old infant was made so that a young child who wanted to could comfortably and naturally hold it for a sustained period of time.

The procedure for the second hold trial was the same as for the first, except that instead of asking the child to choose a doll to hold, the interviewer placed the non-chosen doll from the first trial in front of the child prior to repeating the instructions on pretending that the doll was a real baby and to pick it up and "give it love."

Following the second hold, the interviewer placed a small bowl and spoon directly in front of the child and asked the child to pretend that "the bowl has cereal in it for the babies." The child was then asked to stir the cereal with the spoon. After this, the interviewer placed both dolls side-by-side in front of the child but in reversed position from the first trial and again asked the child to point to the "baby" that he/she wanted to pick up and feed. After making the choice and following the procedure of the first trial, the non-chosen doll was placed out of sight and the chosen doll was placed directly in front of the child. Again, the child was asked to pick up, hold, and feed the "baby." For this third trial, hold side, hold proximity, and hand used to feed the baby were recorded. Hold duration was not recorded.

Handedness and Footedness

Handedness and footedness were assessed with performance-based tasks, as shown in Tables 2 and 3. For handedness, 14 tasks were administered (including some repetitions for reliability); for footedness, 9 tasks were administered (again with some repetitions). Tasks of the kind used have been shown to be reliable for assessment of handedness and footedness in pre-school-age children (see Harris & Almerigi, 2001).

As shown in Table 2, the handedness tasks varied in the quality of movement (fine versus gross) and degree of skill required.

Table 2. Handedness Tasks with Motor Characteristics

Item	Task / Instructions	Fine vs. Gross Motor	Relative Degree of Skill
1.	Hang a small monkey onto a string of monkeys	Fine	Less
2.	Hang another small monkey onto the string of monkeys	Fine	Less
3.	Throw the ball to me	Gross	More
4.	Throw the ball to me, again	Gross	More
5.	Draw shapes	Fine	More
6.	Point to a Lego	Gross	Less
7.	Place one Lego on top of another	Fine	More
8.	Push a care quickly from here to there	Gross	Less
9.	Push a car slowly from here to there	Gross	Less
10.	Push a car quickly from here to there, again	Gross	Less
11.	Push a car slowly from here to there, again	Gross	Less
12.	Use a spoon to stir a bowl of imagined cereal	Fine	More
13.	Use a spoon to feed a doll	Fine	More
14.	Draw a picture	Fine	More

As shown in Table 3, the footedness tasks also varied according to whether they constituted tests of target-oriented actions or balance. The first five items (kick, stomp, point with foot) are target-oriented; the last four (standing on one foot, hopping on one foot) assess balance. For the balance items, both the foot used and the length of time performing the task were recorded.

For all handedness and footedness items, the interviewer used the same response format to record whether the child used the left hand or foot, right hand or foot, both hands or feet, or alternated hands or feet. Appendix E shows a sample response form for the handedness tasks. For the four balance items on the footedness test, both the foot used and the length of time performing the task were recorded.

Table 3. Footedness Tasks with Motor Characteristics

Item	Task / Instructions	Motor Action
1.	Kick a ball to me	Target Oriented
2.	Kick a ball to me, again	Target Oriented
3.	Kick the Lego tower over with your foot	Target Oriented
4.	Stomp on the bag with one foot	Target Oriented
5.	Point to the red Lego with your foot	Target Oriented
6.	Stand on one foot for as long as you can	Balance
7.	Stand on the other foot as long as you can	Balance
8.	Hop on one foot for as long as you can	Balance
9.	Hop on the other foot for as long as you can	Balance

Missing Data

Because the data for the current study were collected during an interview with the child, there were very few missing data points, and where data were missing, it was usually because the interviewer neglected to record the child's response or action. In most such cases, only 1 or 2% of the data were missing for each variable. The variable with the greatest amount of missing data was length of time hopping on the non-preferred foot (17%). Over 50 percent of the children had no missing data (there were no sex differences in this regard). Furthermore, no child had more than 20% missing data, and only six (6%) were missing more than 10% of their data.

In the current study, missing data were replaced with values calculated using the EM algorithm (Little & Rubin, 1987). Missing data for each variable were computed separately for each sex and by using behaviorally similar and maximally correlated (all r's < .10) predictor variables. In addition, outlier estimates were downweighted using a normal distribution, and the convergence criterion for the estimates was 0.001. No estimates took more than 20 iterations.

RESULTS

For each dependent and independent variable, descriptive statistics will be presented first, followed by subgroup comparisons. Results will be presented in the following order: hold location, hold proximity, hold duration, handedness, and footedness (posture). The hold side, proximity, and duration results will be described separately for each of the three trials.

Hold Location

To recapitulate, the presence and degree of side bias were assessed with three doll-holding trials. Prior to the first two trials, the child was shown two dolls that differed only in color (black vs. white) and was asked to point to the doll that he or she wanted to hold. Then, on Trial 1, the child was asked to hold the chosen doll (Preferred Doll) and, on Trial 2, to hold the other doll (Non-Preferred Doll). Prior to Trial 3, the child once again was shown both dolls and was asked to point to the doll that he/she wanted to hold. On Trial 3, the child then was asked to hold that doll while pretending to feed it with a spoon (Preferred Doll/Feeding).

There were three possible hold locations: on the left, middle, or right. As these data are categorical, the analyses primarily consisted of non-parametric analyses (e.g., Chi-square) and group-based analysis of mean differences (e.g., Student's T-test, Analysis of Variance).

Trial 1: Preferred Doll

Table 4 shows frequencies for hold location for Trial 1, the preferred doll. Sixty-nine percent of the children held the doll in a lateral position, with middle holding significantly less often observed ($t(96) = 4.04, p < .001$). This was equally true for boys (70% side-hold; $t(46) = 3.00, p < .01$) and girls (68% side-hold; $t(49) = 2.70, p < .01$).

Table 4. Trial 1: Preferred Doll – Hold Location Frequencies for Boys and Girls

	Left	Middle	Right
Boys	15	14	18
Girls	22	16	12
Total	37	30	30

Note. $X^2(2) = 2.57$, n.s.

Of those holding to the side, 55% held on the left and 45% on the right ($t(66) = 0.853$, n.s.). When boys and girls were analyzed separately, with middle holds excluded, girls were 2.20 times more likely than boys to hold on the left ($z = 1.57$, n.s.). Indeed, of those holding to the side, left-side holding was observed in the *majority* of girls (65%; $t(33) = 1.77, p = .086$) but in the *minority* of boys (45%; $t(32) = 0.516$, n.s.). Neither the within- or between-sex differences, however, were significant.

Finally, there were no age differences for the three hold location groups ($F(2,94) = .169$, n.s.). Age means and standard deviations for left holders were 52.95 months (S.D. = 5.52), for middle holders 52.47 months (S.D. = 5.309), and for right holders 52.23 months (S.D. = 5.12). Nor was there an interaction between age and sex for hold location ($F(2,91) = 2.610$, n.s.).

Trial 2: Non-Preferred Doll

Table 5 shows frequencies for hold location for Trial 2, the non-preferred doll. Sixty percent of the children held on the side (left and right combined), compared to 40%

in the middle, a significant difference ($t(96) = 1.96$, $p = .05$). The difference was significant for girls (64% held to the side; $t(49) = 2.04$, $p < .05$) but not for boys (55% held to the side; $t(46) = 0.73$, n.s.). Of the side-holders, 50% held on the left, 50% on the right. The difference in percentages between middle and left holders was not significant ($t(67) = 1.22$, n.s.).

Table 5. Trial 2: Non-Preferred Doll – Hold Location Frequencies for Boys and Girls

	Left	Middle	Right
Boys	11	21	15
Girls	18	18	14
Total	29	39	29

Note. $X^2(2) = 1.864$, n.s.

When boys and girls were analyzed separately, with middle holds excluded, girls were 1.75 times more likely than boys to hold on the left ($z = 1.05$, n.s.). For girls, left and middle holds also were equally likely (Left 36%, Middle 36%, Right 28%), whereas for boys, middle-holding increased to become the predominant style (Left 23%, Middle 45%, Right 32%). As on Trial 1, there were no age differences between the different hold location groups.

Table 6 shows a cross-tabulation of frequencies for Trials 1 and 2. The diagonal cells indicate the number of children who were consistent in hold location across trials, and the off-diagonal cells indicate the number who changed location. The table shows that most children (71%), regardless of hold location, were consistent across trials. Where change occurred, both left-holders and right-holders were more likely to change to the middle location than to the opposite side. However, middle-holders who changed were more likely to change to the right side than to the left side.

Table 6. Contingency Table for Hold Location on Trials 1 and 2

		Trial 2, Non-Preferred Doll			
		Left	Middle	Right	Total
Trial 1, Preferred Doll	Left	**25**	9	3	37
	Middle	2	**23**	5	30
	Right	2	7	**21**	30
	Total	29	39	29	97

Note. $X^2(4) = 66.53$, $p<.001$; bolded values represent numbers of participants who were consistent in their hold-side across the two trials.

Trial 3: Preferred Doll, Holding and Feeding

On Trial 3, as on Trial 1, when the child could choose the doll that he or she wanted to hold and feed, in most cases (75%) the preferred doll was the same for both trials. Consistency, however, varied, depending on which doll was chosen first: of those who chose the white doll first, 82% were consistent; for those who chose the black doll first, only 53% were consistent ($X^2(1) = 7.310$, $p = .007$). Girls also were more consistent than boys (82% vs. 68%).

Table 7 shows frequencies of hold location for Trial 3, the preferred-doll holding and feeding condition. Nearly every child (95%) held the doll on the side, with middle holding significantly less often observed ($t(96) = 19.87$, $p < .001$). This was equally true for boys (94% side-hold; $t(46) = 12.10$, $p < .001$) and girls (96% side-hold; $t(49) = 16.43$, $p < .001$). Of those who held on the side, 60% held the doll on the left and 40% on the right ($\underline{t}(91) = 2.58$, $\underline{p} = .012$). When boys and girls were analyzed separately, with middle holds excluded, girls were 2.02 times more likely than boys to hold on the left ($\underline{z} = 1.61$, n.s.). Of those holding on the side, the majority of girls held on the left (71%; $\underline{t}(47) = 3.14$, $\underline{p} = .003$) as did the majority of boys (55%; $\underline{t}(43) = 0.599$, n.s.). The bias was significant only for girls, but the sex difference itself was not significant ($\underline{t}(90) = 1.62$, p $= .110$).

Table 7. Trial 3: Preferred Doll While Feeding for Boys and Girls According to Hold Location

	Left	Middle	Right
Boys	24	3	20
Girls	34	2	14
Total	58	5	34

Note. $X^2(2) = 2.893$, n.s.

Table 8 shows a cross-tabulation of frequencies for Trials 1 and 3. As in Table 6, the diagonal cells indicate the number of children who were consistent across trials, and the off-diagonal cells indicate the number of children who changed their hold location. The table shows that most left-holders (73%) on Trial 1 did not change hold location on Trial 3. That is, they continued to hold on the left for the holding while feeding task. Most middle- and right-holders, on the other hand, were not consistent with their hold location and were observed holding the doll on the left while manipulating the feeding spoon with their right hand. All together, of the children who changed, in the majority of cases, it was to a left-side hold.

Table 8. Contingency Table for Hold Location on Trials 1 and 3

		Trial 3, Preferred Doll/Feeding			
		Left	Middle	Right	Total
Trial 1, Preferred Doll	Left	**24**	3	10	37
	Middle	17	**2**	11	30
	Right	17	0	**13**	30
	Total	58	5	34	97

Note. $X^2(2)=3.85$, n.s.; bolded values represent numbers of participants who were consistent in their hold-side across the two trials.

In sum, the results on the three hold location trials were significantly different from each other. Trial 1 provided perhaps the purest measure of holding-side bias as it was the first holding trial and involved the preferred doll. For children not consistent in location across the trials, there are three possible reasons for the changes: Trial order, doll characteristics (whether the doll was preferred or non-preferred), and change (on Trial 3) in the task itself (holding while feeding). Considering the differences between trials, it was decided that further analyses using a scale score for hold location (e.g., mean score of the three trials) would not be useful.

Hold Proximity

Along with hold location, hold proximity was assessed for each of the three holding trials. Each hold was rated on a three-point scale for proximity: Holding with the doll touching the body, holding with the doll close to but not touching the body, and holding the doll far from the body. Similar to hold location, analyses for the three categories of hold proximity primarily consisted of non-parametric analyses (e.g., Chi-square) and group-based analyses of mean differences (e.g., Student's T-test, Analysis of Variance).

Table 9 shows the distribution of frequencies and Chi-square values for hold proximities on the three trials. Both boys and girls, on all the three trials, showed a significant tendency to hold the doll in close proximity, that is, with the doll touching the body. For all three trials, this effect was stronger for girls (that is, proportionately more girls than boys held close to body), but the difference was not significant.

Table 9. Frequencies of Hold Proximity for Boys and Girls for Trials 1 to 3

		Doll Touching Body	Doll Not Touching Body	Doll Away From Body	X^2
Trial 1					
	Boys	27 (57%)	6 (13%)	14 (30%)	14.34
	Girls	37 (74%)	6 (12%)	7 (14%)	37.24
	Total	64 (66%)	12 (12%)	21 (22%)	47.77
Trial 2					
	Boys	26 (55%)	8 (17%)	13 (28%)	11.02
	Girls	34 (68%)	7 (14%)	9 (18%)	27.16
	Total	60 (62%)	15 (15%)	22 (23%)	36.27
Trial 3					
	Boys	26 (55%)	12 (16%)	9 (19%)	10.51
	Girls	37 (74%)	11 (22%)	2 (4%)	39.64
	Total	63 (65%)	23 (24%)	11 (11%)	45.86

Note. Chi-square values are calculated for each row; all p-values < .01.

Table 10 shows a contingency table for hold proximity on Trials 1 and 2. The purpose of this table is to demonstrate the consistency of hold proximity over the two trials. The majority of children (84%) held in the same proximity on Trial 1 as on Trial 2 (88% for those with doll touching body, 75% for those with doll not touching body, and 76% for those with doll away from body).

Table 10. Contingency Table for Hold Proximity on Trials 1 and 2

		Trial 2, Non-Preferred Doll			
		Doll Touching Body	Doll Not Touching Body	Holding Away From Body	Total
Trial 1, Preferred Doll	Doll Touching Body	**56**	3	5	64
	Doll Not Touching Body	2	**9**	1	12
	Holding Away From Body	2	3	**16**	21
	Total	60	15	22	97

Note. Bolded values represent numbers of participants who were consistent in hold proximity across the two trials.

Similarly, but by a smaller margin, 69% of the children were consistent for hold proximity between Trials 1 and 3. As shown in Table 11, 81% of those holding the doll so that it touched their body and 75% of those who held the doll close but not touching the body were consistent with their hold proximity. For those children who held the doll away from the body on Trial 1, only 29% were consistent with their hold proximity. Of this latter group, 29% switched to a doll close but not touching the body proximity and 43% switched to a doll touching body proximity for Trial 3.

Table 11. Contingency Table for Hold Proximity on Trials 1 and 3

		Trial 3, Preferred Doll/Feeding			
		Doll Touching Body	Doll Not Touching Body	Holding Away From Body	Total
Trial 1, Preferred Doll	Doll Touching Body	**52**	8	4	64
	Doll Not Touching Body	2	**9**	1	12
	Holding Away From Body	9	6	**6**	21
	Total	63	23	11	97

Note. Bolded values represent numbers of participants who were consistent in hold proximity across the two trials.

Tables 12 is a contingency table comparing the frequencies for hold location and hold proximity for the three trials. The table shows that location and proximity are

Table 12. Hold Proximity as a Function of Hold Location for Trials 1 to 3

		Doll Touching Body	Doll Not Touching Body	Holding Away From Body
Trial 1				
	Left	30 (81%)	4 (11%)	3 (8%)
	Middle	12 (40%)	2 (7%)	16 (53%)
	Right	22 (73%)	6 (20%)	2 (7%)
Trial 2				
	Left	23 (79%)	5 (17%)	1 (3%)
	Middle	15 (38%)	5 (13%)	19 (49%)
	Right	22 (76%)	5 (17%)	2 (7%)
Trial 3				
	Left	43 (74%)	10 (17%)	5 (9%)
	Middle	2 (40%)	0 (0%)	3 (60%)
	Right	18 (53%)	13 (38%)	3 (9%)

Note. Percentages are based on total frequencies for each row.

dependent upon each other. Specifically, on Trials 1 and 2, left-side holds were more likely to be close (doll touching body) while middle holds were more likely to be far (doll away from body). On Trial 3, on the other hand, only left-side holds were more likely to be close.

Hold Duration

Trial 1: Preferred Doll

Hold duration for the preferred doll (Trial 1) ranged from 0.01 to 60 seconds[5]. For all children, the average duration was 26.19 seconds. Girls held appreciably and significantly longer than boys (32.71 vs. 19.25 seconds; $t(95) = 3.933$, $p < .001$).

Table 13. Trial 1: Preferred Doll Hold Duration for Boys and Girls According to Hold Location

Hold Location	Sex	N	Mean	Standard Deviation
Left	Boys	15	22.37	14.17
	Girls	22	31.64	17.14
	Total	37	27.89	16.45
Middle	Boys	14	18.33	17.08
	Girls	16	33.41	21.68
	Total	30	26.37	20.79
Right	Boys	18	17.35	11.72
	Girls	12	33.74	20.33
	Total	30	23.91	17.43
Total	Boys	47	19.25	14.11
	Girls	50	32.71	19.06
	Total	97	26.18	18.07

Note. Significance tests: location ($F(2,91) = .07$, n.s), sex ($F(1,91) = 14.69$, $p < .001$), location x sex interaction ($F(2,91) = .40$, n.s)

[5] The score 0.01 seconds meant that the child picked the doll up and put it down immediately, literally before the observer could start the stopwatch. The score 60 seconds meant that the child held the doll for the maximum amount of time set for the trial.

When duration was assessed across hold location, no differences were found for the group as a whole ($F(2,94) = .398$, n.s.) or for either sex alone (both F's < 1.0). Table 13 shows the durations according to sex and hold location.

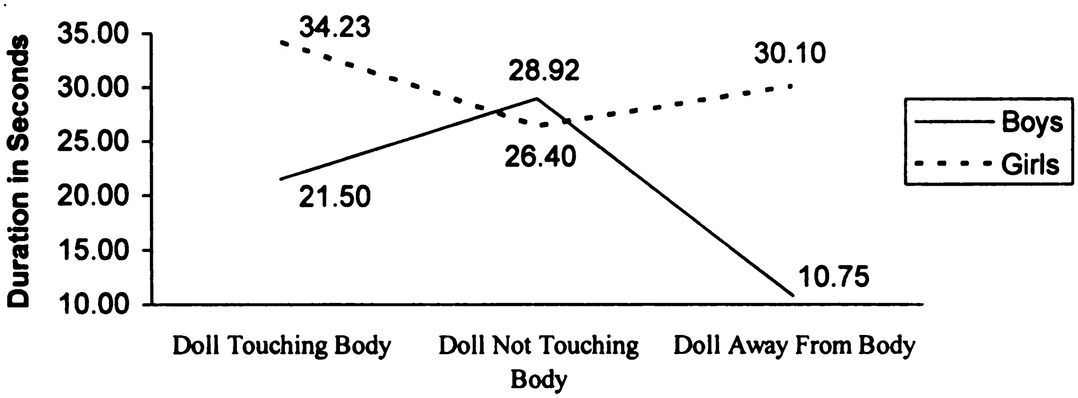
When duration was assessed across the different hold proximities, as shown in Table 14, a significant difference was found ($F(2,94) = 3.51$, $p = .034$), with "doll touching body" holds being significantly longer than "doll away from body" holds (Fisher's LSD, $p < .01$).

Table 14. Trial 1: Preferred Doll Hold Duration for Boys and Girls According to Hold Proximity

Hold Proximity	Sex	N	Mean	Standard Deviation
Doll Touching Body	Boys	27	21.50	12.71
	Girls	37	34.23	18.98
	Total	64	28.86	17.68
Doll Not Touching Body	Boys	6	28.92	19.26
	Girls	6	26.40	17.98
	Total	12	27.66	17.81
Doll Away From Body	Boys	14	10.75	10.37
	Girls	7	30.10	21.78
	Total	21	17.20	17.31
Total	Boys	47	19.25	14.11
	Girls	50	32.71	19.06
	Total	97	26.19	18.07

This effect, though, was primarily driven by the boys. Figure 1 shows a line graph of the interaction between sex and proximity for length of hold. When analyzed separately, girls' duration scores did not differ across the hold proximities ($F(2,47) = 0.502$, $p=.608$). Boys' duration scores did differ ($F(2,44) = 5.050$, $p = .011$). For boys, post hoc comparisons using Fisher's LSD revealed that hold duration for "doll touching body" and "doll not touching body" were not significantly different, but both were significantly different from "doll away from body".

Figure 1. Trial 1: Interaction Between Sex and Proximity for Hold Duration



Trial 2: Non-Preferred Doll

Hold duration on Trial 2, for the non-preferred doll, was similar to hold duration on Trial 1, for the preferred doll, and both were significantly correlated with each other ($r = .615$, $p < .001$). Hold duration for the non-preferred doll ranged from 0.01 to 60 seconds, with the average duration dropping slightly to 22.39 seconds. As they had with the preferred doll, girls held appreciably and significantly longer than boys (28.08 vs. 16.34 seconds; $t(95) = 3.38$, $p = .001$).

As shown in Tables 15 and 16, hold duration did not vary significantly for either hold location ($F(2,91) = 1.026$, n.s.) or hold proximity ($F(2,91) = 1.773$, n.s.) but did vary significantly with sex of child, as noted above.

Table 15. Trial 2: Non-Preferred Doll Hold Duration for Boys and Girls According to Hold Location

Hold Location	Sex	N	Mean	Standard Deviation
Left	Boys	11	21.50	17.07
	Girls	18	30.88	21.21
	Total	29	27.32	19.97
Middle	Boys	21	16.23	12.17
	Girls	18	24.98	20.04
	Total	39	20.27	16.64
Right	Boys	15	12.71	13.39
	Girls	14	28.47	17.79
	Total	29	20.32	17.34
Total	Boys	47	16.34	13.89
	Girls	50	28.08	19.64
	Total	97	22.39	18.00

Note. Significance tests: location ($F(2,91) = 1.026$, n.s), sex ($F(1,91) = 9.998$, $p < .01$), location x sex interaction ($F(2,91) = .389$, n.s).

Table 16. Trial 2: Non-Preferred Doll Hold Duration for Boys and Girls According to Hold Proximity

Hold Proximity	Sex	N	Mean	Standard Deviation
Doll Touching Body	Boys	26	19.16	15.47
	Girls	34	29.60	21.27
	Total	60	25.08	19.54
Doll Not Touching Body	Boys	8	16.91	13.51
	Girls	7	28.40	12.91
	Total	15	22.27	14.07
Doll Away From Body	Boys	13	10.35	08.82
	Girls	9	22.11	17.95
	Total	22	15.16	14.22
Total	Boys	47	16.34	13.89
	Girls	50	28.08	19.64
	Total	97	22.39	18.00

Note. Significance tests: location ($F(2,91) = 1.773$, n.s), sex ($F(1,91) = 7.387$, $p < .01$), location x sex interaction ($F(2,91) = .014$, n.s).

Table 17 shows the reduction at the group level in hold duration from Trial 1 (preferred doll) to Trial 2 (non-preferred doll) as a function of hold location and sex of child. In all cases, there was a reduction in hold duration, but the magnitude of the reduction varied according to hold location and roughly equally for boys and girls. The greatest difference was in the middle location. On average, middle-holders on Trial 1 held 23% longer than their counterparts on Trial 2. Similarly, right-holders on Trial 1 held 15% longer than their counterparts on Trial 2. Left-holders on Trial 1, however, held only 2% longer than their counterparts on Trial 2. In other words, the reduction was trivial only for left-holders but was substantial for right- and middle-holders. It should be noted that there are small variations in sample size for each of the hold locations on the different trials.

Table 17. Mean Hold Duration Scores for Boys and Girls According to Hold Location for Trials 1 and 2

Hold Location	Sex	Preferred Doll (Sec.)	Non-Preferred Doll (Sec.)	Difference (Sec.)	% Reduction
Left	Boys	22.37	21.50	0.87	4%
	Girls	31.64	30.88	0.76	2%
	Total	27.89	27.32	0.57	2%
Middle	Boys	18.33	16.23	2.10	11%
	Girls	33.41	24.98	8.43	25%
	Total	26.37	20.27	6.10	23%
Right	Boys	17.35	12.71	4.68	27%
	Girls	33.74	28.47	5.66	17%
	Total	23.91	20.32	3.59	15%
Total	Boys	19.25	16.34	2.91	15%
	Girls	32.71	28.08	4.63	14%
	Total	26.18	22.39	3.80	15%

Note: There are different numbers of individuals (also different individuals) between the cells. Table 6 reports the consistency of hold side (Left 68%, Middle 77%, Right 70%).

Table 18 shows the reduction at the group level in hold duration from Trial 1 (preferred doll) to Trial 2 (non-preferred doll) as a function of hold proximity and child's sex. Now, in all but one case, there was a reduction in hold duration, but no clear pattern of reduction was obvious across the proximities. This is most likely the result of small sample sizes in most of the cells.

Table 18. Mean Hold Duration Scores for Boys and Girls According to Hold Proximity

Hold Proximity	Sex	Preferred Doll (Sec.)	Non-Preferred Doll (Sec.)	Difference (Sec.)	% Reduction
Doll Touching Body	Boys	21.50	19.16	2.34	11%
	Girls	34.23	29.60	4.63	14%
	Total	28.86	25.08	3.78	13%
Doll Not Touching Body	Boys	28.92	16.91	12.01	42%
	Girls	26.40	28.40	-2.00	-8%
	Total	27.66	22.27	5.39	19%
Doll Away From Body	Boys	10.75	10.35	0.40	4%
	Girls	30.10	22.11	7.99	27%
	Total	17.20	15.16	2.04	12%
Total	Boys	19.25	16.34	2.91	15%
	Girls	32.71	28.08	4.63	14%
	Total	26.19	22.39	3.80	15%

Note: There are different numbers of individuals (also different individuals) between the cells. Table 6 reports the consistency of hold side (Left 68%, Middle 77%, Right 70%).

Handedness and Footedness

Handedness

Table 19 shows the frequencies of hand use for the 14 tasks (9 different tasks) comprising the handedness measure for the 97 children in the sample. For each task, the right hand was used more often than either the left hand or both hands together. The tasks also varied significantly in strength of bias. The draw-free and draw-shapes tasks, for example, showed the strongest right bias, and the hang-monkey task showed the weakest right bias, with a larger proportion of both hands use.

Table 19. Hand Use Frequencies Across Tasks

	Hand Used		
Task	Left	Both	Right
Hang a small monkey onto the string of monkeys	31	16	50
Hang another small monkey onto the string of monkeys	27	19	51
Throw the ball to me	15	15	67
Throw the ball to me, again	12	16	69
Draw shapes	8	1	88
Point to a Lego	20	0	77
Place one Lego on top of another	18	6	73
Push a car quickly from here to there	15	1	81
Push a car slowly from here to there	17	1	78
Push a car quickly from here to there, again	16	0	81
Push a car slowly from here to there, again	16	1	80
Use a spoon to stir a bowl of imagined cereal	17	1	79
Use a spoon to feed a doll	27	1	69
Draw a picture	8	2	87

For each task, left-hand use was scored as -1.0, both-hands use as 0.0, and right-hand use as +1.0. The construction of an overall handedness scale score can be calculated by simply summing the scores for all of the tasks. As such, a child's handedness score could range from -14 to +14, where a negative value would indicate a bias for left-hand use and a positive value a bias for right-hand use. Prior to analyses using a scale score, task inter-correlations and scale statistics were evaluated.

Table 20 shows both the correlation matrix of the handedness tasks and the statistics for the overall handedness scale. The overall reliability of the measure (alpha) was 0.791 with only item #3, the hand used to feed the doll, having an item-scale correlation (squared multiple correlation) lower than 0.5. Note that this item was paired with the Trial 3 holding task so that it was confounded with preference for side of hold. It, therefore, was removed from the construction of the overall handedness score, resulting in an overall reliability (alpha) of 0.815.

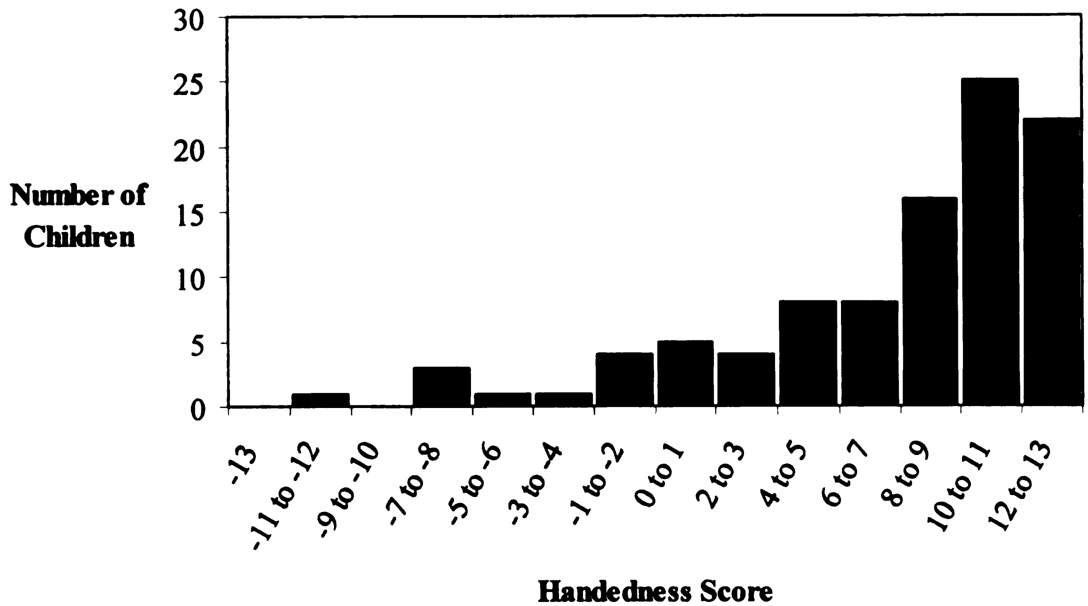
Table 20. Correlations and Scale Characteristics for Handedness Items

Item #	Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Hang Monkey 1	1.000													
2	Hang Monkey 2	0.674	1.000												
3	Throw Ball 1	0.214	0.130	1.000											
4	Throw Ball 2	0.162	0.101	0.778	1.000										
5	Draw Shapes	0.215	0.198	0.276	0.238	1.000									
6	Point to Lego	0.083	0.058	0.127	0.100	0.389	1.000								
7	Place Lego	-0.041	0.006	0.097	0.163	0.157	0.530	1.000							
8	Push Car Fast 1	-0.015	0.011	0.259	0.167	0.270	0.127	0.047	1.000						
9	Push Car Slow 1	-0.014	0.077	0.240	0.119	0.284	0.086	0.162	0.920	1.000					
10	Push Car Fast 2	-0.027	0.063	0.245	0.175	0.259	0.117	0.109	0.914	0.911	1.000				
11	Push Car Slow 2	0.147	0.147	0.235	0.166	0.304	0.041	0.171	0.715	0.793	0.730	1.000			
12	Stir Cereal	0.119	0.152	0.213	0.224	0.580	0.294	0.152	0.425	0.443	0.446	0.438	1.000		
13	Feed Doll	-0.003	0.008	-0.085	-0.143	0.214	0.133	0.003	-0.025	-0.067	-0.033	-0.042	0.138	1.000	
14	Draw Picture	0.216	0.201	0.261	0.199	0.951	0.330	0.192	0.208	0.272	0.199	0.293	0.614	0.160	1.000
Mean		0.196	0.247	0.536	0.588	0.825	0.588	0.567	0.680	0.629	0.670	0.660	0.639	0.433	0.814
Standard Deviation		0.897	0.866	0.751	0.704	0.559	0.813	0.789	0.730	0.768	0.746	0.748	0.766	0.900	0.565
Squared Multiple Correlation		0.531	0.500	0.665	0.683	0.938	0.517	0.490	0.910	0.930	0.884	0.679	0.548	0.156	0.941
Alpha if Item Deleted		0.794	0.792	0.778	0.784	0.767	0.785	0.793	0.764	0.761	0.763	0.762	0.762	0.815	0.769

Note. Scale Reliability (Alpha) = .7907

With item #6 omitted, the handedness scores ranged from -11 to +13 with the average being +7.64 (S.D. = 5.45). Figure 2 shows a graphical display of the distribution of scores. As expected, the distribution is skewed toward the positive end, indicating an overall bias towards right-handedness.

Figure 2. Distribution of Total Handedness Scores



Note. Negative values indicate left hand preferences, positive values indicate right hand preferences.

When handedness scores were calculated separately for boys and girls; boys' average score was +7.12 (S.D. = 5.73) and girls' average score was 8.08 (S.D. = 5.18). Using the arbitrary cut-off value of 0.0 as the basis for classifying handedness, 7 boys (15%) and 3 girls (6%) were left-handed. This difference, however, was not significant ($X^2(1)$ = 1.145, n.s.).

Degree of handedness, independent of direction, was correlated with child's age in months but not significantly (r = .166, p = .105). When the same correlation was repeated for boys and girls separately, the correlation was stronger for girls (r = .237, p = .098) than for boys (r = .064, p = .670), but as neither correlation was statistically significant, any interpretation of an interaction between sex and age for the development of handedness should be preliminary.

Table 21 shows the mean handedness scores as a function of hold location, sex of child, and trial. Overall handedness scores were not related to hold location on Trial 1 ($F(2,94)$ = .176, n.s.) or Trial 2 ($F(2,94)$ = 1.442, n.s.) but were related to hold location on Trial 3 ($F(2,94)$ = 3.440, p = .036).

Table 21. Mean Handedness Scores for Boys and Girls According to Hold Location and Trial Number

Hold Location	Sex	Trial 1	Trial 2	Trial 3
Left	Boys	5.20 (7.48)	3.73 (8.21)	6.58 (4.76)
	Girls	8.91 (4.70)	8.33 (5.29)	7.91 (4.85)
	Total	7.41 (6.17)	6.59 (6.80)	7.36 (4.82)
Both	Boys	7.50 (5.17)	7.76 (4.87)	0.00 (11.53)
	Girls	7.36 (6.39)	7.06 (5.99)	6.00 (4.24)
	Total	7.43 (5.75)	7.44 (5.35)	2.40 (9.04)
Right	Boys	8.56 (4.12)	8.87 (3.62)	8.95 (5.13)
	Girls	7.50 (4.40)	9.07 (3.89)	8.79 (6.24)
	Total	8.13 (4.19)	8.97 (3.69)	8.88 (5.52)
Total	Boys	7.17 (5.73)		
	Girls	8.08 (5.18)		
	Total	7.64 (5.45)		

Post hoc analysis (Fisher's LSD) revealed that left holders and right holders were significantly different from middle holders on handedness scores but not from each other.

That is, although all hold locations were associated with right-handed biases, middle holders had significantly lower handedness scores. Strength of handedness, irrespective of direction, followed the same pattern of results, which was to be expected given the small number of children with left-handed scores.

Strength of handedness, likewise, was not related to consistency of hold for Trials 1 and 2. Although consistent holders had slightly higher scores on the handedness measure, this difference was not significant ($t(95) = .182$, n.s.).

Footedness

Table 22 shows the frequencies of foot use for the 7 tasks (5 different tasks) comprising the footedness measure for the 97 children in the sample. For each task, the right foot was used far more than either the left foot or both feet together. There also were significant variations in foot preference across the different tasks. The kick ball tasks, for example, showed the strongest right bias, and the balance on one foot task showed the weakest right bias, with an almost equal number of right-foot and left-foot preferences.

Table 22. Foot Use Frequencies Across Tasks

	Foot Used		
Task	Left	Both	Right
Kick a ball to me	6	0	91
Kick a ball to me, again	8	1	88
Kick the Lego tower over with your foot	13	0	84
Stomp on the bag with one foot	21	6	70
Point to the red Lego with your foot	22	2	73
Stand on one foot for as long as you can	45	0	52
Hop on one foot for as long as you can	32	1	64

For each task, left-foot use was scored as -1.0, both-feet use as 0.0, and right-foot use as +1.0. The construction of an overall footedness scale score can be calculated by summing the scores for all of the tasks. As such, an individual's footedness score could range from -7 to +7, where a negative value would indicate a bias for left-foot use and a positive value a bias for right-foot use. Prior to analyses using a scale score, task intercorrelations and scale statistics were evaluated.

Table 23 shows both the correlation matrix of the footedness tasks and the statistics for the overall footedness scale. The overall reliability of the measure (alpha) was 0.421.

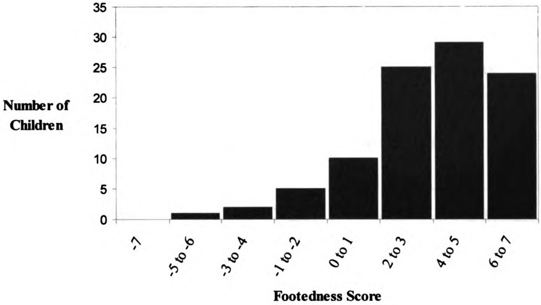
Table 23. Correlations and Scale Characteristics for Footedness Items

Task		1	2	3	4	5	6	7
1	Kick ball to me	1.000						
2	Kick ball to me, again	0.842	1.000					
3	Kick Lego tower over	0.025	0.094	1.000				
4	Stomp on bag	0.157	0.125	0.131	1.000			
5	Point at Lego with foot	0.263	0.175	0.283	0.212	1.000		
6	Stand on one leg	0.104	0.116	0.059	0.043	0.041	1.000	
7	Hop on one foot	-0.092	-0.027	-0.023	-0.055	-0.220	0.349	1.000
Mean		0.876	0.825	0.732	0.505	0.526	0.072	0.330
Standard Deviation		0.484	0.559	0.685	0.831	0.483	1.003	0.943
Squared Multiple Correlation		0.735	0.721	0.117	0.063	0.215	0.151	0.185
Alpha if Item Deleted		0.344	0.337	0.391	0.398	0.392	0.350	0.494

Note. Alpha = .421

Footedness scores ranged from -5 to +7 with the average being +3.87 (S.D. = 2.60). Figure 3 shows a graphical display of the distribution of footedness scores. As expected, the scores are skewed toward the positive end.

Figure 3. Distribution of Total Footedness Scores



Note. Negative values indicate left foot preferences while positive values indicate right foot preferences.

Footedness scores were calculated separately for boys and girls: Boys' average score was 4.28 (S.D. = 2.58) and girls' average score was 3.48 (S.D. = 2.60). This difference, however, was not significant ($\underline{t}(95) = 1.516$, n.s.). Using the arbitrary cut-off value of 0.0 as the basis for classifying footedness, 2 boys (4%) and 7 girls (14%) were left-footed. This difference, however, was not significant ($X^2(1) = 2.733$, $\underline{p} = .098$).

Strength of footedness, independent of direction, was not correlated with child's age in months for either boys ($\underline{r} = -.024$, n.s.) or girls ($\underline{r} = .031$, n.s.). It was, however, related to the consistency of hold location for Trials 1 and 2 in girls ($\underline{t}(48) = 3.43$, $\underline{p} = .001$) but not boys ($\underline{t}(45) = 1.26$, n.s.).

Table 24 shows the mean footedness scores as a function of hold location, sex of child, and trial. Overall footedness scores were related to hold location for Trial 1

($F(2,94) = 4.315$, $p = .016$), Trial 2 ($F(2,94) = 2.783$, $p = .067$), and Trial 3 ($F(2,94) = 3.664$, $p = .029$). Post hoc analysis (Fisher's LSD) for the first and third trials revealed that middle holders had significantly stronger right-footedness scores than left holders but not right-holders. Footedness scores did not differ between left- and right-holders.

Table 24. Mean Footedness Scores for Boys and Girls According to Hold Location and Trial Number

Hold Location	Sex	Trial 1	Trial 2	Trial 3
Left	Boy	3.80 (3.19)	2.64 (3.08)	5.29 (1.71)
	Girl	2.68 (2.82)	3.28 (2.91)	3.53 (2.62)
	Total	3.14 (2.91)	3.03 (2.93)	4.26 (2.43)
Both	Boy	5.00 (2.18)	5.29 (2.00)	-0.33 (4.16)
	Girl	4.88 (1.46)	3.61(2.57)	3.50 (3.54)
	Total	4.93 (1.80)	4.51(2.40)	1.20 (4.03)
Right	Boy	4.11 (2.30)	4.07 (2.37)	3.75 (2.40)
	Girl	3.08 (2.78)	3.57 (2.38)	3.36 (2.65)
	Total	3.70 (2.51)	3.83 (2.35)	3.59 (2.48)
Total	Boy	4.28 (2.58)	4.28 (2.58)	4.28 (2.58)
	Girl	3.48 (2.60)	3.48 (2.60)	3.48 (2.60)
	Total	3.87 (2.61)	3.87 (2.61)	3.87 (2.61)

DISCUSSION

The discussion begins with a review of the background and purpose of the current study. It then provides a summary of the results as they pertain to the major predictions and some general conclusions. Finally, it identifies some limitations of the study and outlines directions for further research.

As described in the Introduction, most adults hold infants to their left. This bias has been observed in a wide range of individuals who vary in parental status, sex, handedness, nationality, and even species. Moreover, it is stable over time – at both the population-level and individual-level – and it is selective in that it occurs for infants but not for inanimate objects of similar size. In virtually all studies of the phenomenon, women have shown the bias, whereas men have been more variable, sometimes showing the bias as strongly as women, sometimes more weakly, sometimes not all.

Each of the several of explanations of the bias has found some measure of support, including explanations based on the holder's handedness, postural asymmetries, heart-beat, emotional monitoring / direction of attention, and on the infant's own resting head position. So far, however, no combination of explanations, much less any one explanation, has proven to be sufficient to explain the bias, due, at least in part, to inadequacies in the methods for assessing the bias and in the handling of data.

In contrast to the many studies of the bias in adults, there have been only a few investigations in children. All have found the left bias, and, although the age of its first appearance remains unsettled, the evidence suggests that it appears between the ages of 3 to 6 years and that when it does appear, it occurs earlier in girls than in boys. For these reasons, the current study tested 3- to 5-year-old boys and girls to assess the emergence of the bias. For testing the contribution of handedness, this age range had the further advantage of bracketing the period when reliable handedness was emerging.

The current study expanded on prior studies by using improved methods for assessing holding-side bias. Location, proximity, and duration of hold were assessed using realistic-looking dolls in a repeated-measures design. Handedness and footedness/posture were assessed through performance-based, multi-task measures. Analyses of group and individual differences were performed to test the following predictions.

Summary of Results

Prediction 1

The first prediction was that children would show a left-side bias for holding the dolls but that the bias would be weaker than that typically found in adults, or at least in adult women. In light of de Château and Andersson's (1976) finding that the majority of their youngest age groups, the 2- and 4-year-olds, held the doll "in-hands", that is, in the middle, the first consideration in answering this question was whether, in the current sample, most children displayed a lateralized hold (i.e., side hold) rather than a middle hold. Across the three trials, the results indicated that side holds were, in fact, more common. The next question, then, for side-holders, was whether the bias was to the left (as in adults), to the right, or to each side equally. The results for Trials 1 and 2 by and large did not indicate a left-side bias. On Trial 1, of children holding to one side, 55% held to the left, but this was not a significant majority, and on Trial 2, left- and right-side holds occurred equally. In Trial 3, however, when the child was asked to hold and "feed the baby," 60% of the side-holders, now a significant majority, held to the left. There were no significant differences across the age range of the sample. In sum, the children displayed wide variability in their hold location preferences. Although more children (on Trial 1) were side-holders than in de Château and Andersson's (1976) 4-year-old group, fewer showed a left-side bias than in Saling and Bonert's (1983) and Souza-Godeli's (1996) samples. In combination with de Château and Andersson's (1976) findings, the current results thus do not show a clear left-side bias in young children. They therefore throw into question Souza-Godeli's (1996, p. 1422) conclusion that left-side holding is "a behavior emerging in the early stages of human ontogenesis," and, instead, suggest that the bias follows a different and more gradual developmental course - from undifferentiated middle-location holding in early childhood to lateralized holding in either direction around the age of 4 years, to group-level biases to the left in later childhood.

Prediction 2

The second prediction was that degree, or strength, of handedness, independent of direction, would predict lateralized holding. This prediction was based on the hypothesis that the emergence of lateralized holding would follow the development of lateralized motor functioning. For Trials 1 and 2, no evidence for this relationship was found. Strength of handedness was nearly identical for middle- and lateralized-holding boys and girls. The predicted relationship did appear, however, on Trial 3, where handedness strength was positively related to the existence of a lateralized hold. That no relationship was found for Trials 1 and 2 therefore suggests that lateralized motor development in children is not related to lateralized infant holding. The significant relationship on Trial 3, while supporting the hypothesis, is confounded, however, by the pairing of the handedness task (feeding) with the holding task. That is, although it is clear that handedness influenced hold location on Trial 3 (93% of the middle-holding children switched to a side hold, and 57% of right-holders switched to a left-hold), it is not clear whether handedness influenced hold side directly or indirectly through the feeding component of the trial.

Prediction 3

The third prediction extended the second in that it predicted that strength of handedness, again as a measure of motor development, would be related to flexibility in hold side from Trial 1 to Trial 3. That is, for those who held the doll with the dominant hand and arm for Trial 1, whether they were right-handers who held on the right or left-handers who held on the left, the prediction was that children with more complete motor development would be more likely to switch hold locations to free their dominant hand for the feeding component of the holding-while-feeding condition. The results failed to support this prediction as there were no strength of handedness differences between children who switched (left to right, right to left, in-hands to left, in-hands to right) and those who did not switch. Furthermore, handedness was as strong in children who switched to a left hold as it was in children who switched to a right hold.

Prediction 4

The fourth prediction was that direction of handedness would predict direction of hold. There was no direct evidence to support this prediction for any of the three trials. That is, there were no indications that right-handers were more likely to hold on the left, left-handers on the right. Curiously, however, on all three trials, the subgroup of children holding on the right did have stronger right-handedness scores than the subgroup of left-holders, which is the reverse of the predicted direction, but these differences were significant only for the holding-while-feeding trial. One possible interpretation of this finding is that children at this age do not yet understand the conditional nature of infant holding. Rather than viewing the act of holding an infant as serving the larger goal of interacting with the infant or providing it with care and nurturance, young children may view infant holding as a skilled act, similar to the handedness tasks, where the only relevant component of the task is the holding behavior itself.

Prediction 5

The fifth prediction was that postural biases, as measured by footedness, would predict hold location above and beyond handedness by itself. As handedness was not predictive of hold side for the first two trials, footedness was assessed independently. Like handedness, the results did not clearly support the prediction that posture would be related to side of hold. For Trials 1 and 3, left side holding was associated with weaker footedness scores than was middle-holding. Footedness scores, however, did not differentiate right-side holding from either middle-holding or left-holding. These results thus provide tentative corroboration of Erber et al.'s (2001) results that left-holders showed an increased tendency to balance (i.e., place their weight) on the left foot than on the right foot. While posture may still add predictive power to a model of holding bias that is above and beyond handedness, the present sample was too small to detect the differences.

Prediction 6

The sixth prediction, pertaining to sex differences, had three parts: that girls would show stronger left-side biases, closer holds, and longer holds than boys. The first part was not supported: there were no significant sex differences in the likelihood of lateralized holding on any of the three trials. Likewise, there were no significant sex differences for holding to either the left or right side. Girls, however, did show a clear but non-significant left-bias on all three trials, whereas boys showed a non-significant right bias on Trials 1 and 2 and a left bias only on Trial 3. The second part of the prediction, pertaining to proximity, also was not supported. Although proportionately more girls than boys held the doll close, the difference was not significant. Unfortunately, if these differences exist, their effect size is too small for the current sample size to detect significant differences. Finally, the third part of the prediction was supported unequivally: girls held significantly longer than boys (nearly twice as long on average).

There are several possible interpretations of these significant and trend-level sex differences. The first is that the boys were less engaged in the holding tasks, as suggested by their tendency to hold the doll farther away from their body and for shorter periods of time. Anecdotal reports from the experimenters, however, were that the boys seems equally engaged in the tasks and did not behave in a way that suggests they found the tasks disagreeable (e.g., verbal taunts, throwing the doll) as was found in de Château and Andersson's (1976) study. Nevertheless, the possibility exists that the sex differences are due to the social stigma against boys playing with dolls. Future studies may be well advised to provide control holding conditions using gender-neutral stimuli such as stuffed animals, footballs, small animals, such as kittens or puppies, or, perhaps, even real infants.

A second interpretation is that girls have more experience with dolls and/or more training from others in the act of holding or cradling dolls and infants. Based on the adult data (Harris, Almerigi, & Kirsch, 2000), it is unlikely that experience plays a direct role in the bias. It may, however, play an important role in its *acquisition* – if not generally, then as a moderator for its expression (e.g., increased trajectory, earlier age of acquisition). As such, it would be worthwhile for future studies to use methods to ascertain the child's level of experience with infants and/or dolls (e.g., using such methods as ratings of the home environment, listings of personal effects or toys or time with infants, or parents' estimation of time with dolls or infants).

Consistency of Hold Side

The results for hold location showed substantial differences across the three trials. In the case of the shift from a weak left-bias on Trial 1 to no bias on Trial 2, there may be several reasons. One is that, unlike adults, young children's holding-side biases are still unstable, meaning that they would be expected to show different patterns of results across any number of repetitions of the task. Another reason may be that the temporal order of the two tasks was the important factor. That is, a subgroup of children may have decided to use the other arm to hold the doll as a way to introduce variety or novelty to the now-familiar task.

Still another possibility may be related to doll choice prior to holding. The children were allowed to hold the "preferred" doll on Trial 1 but then were asked to hold the "non-preferred" doll on Trial 2. The increased frequency of middle holding therefore may reflect the child's preference for a certain doll rather than any instability per se. That is, the children may have adjusted their holding style in accord with the values associated with the doll. If so, then, as suggested previously, it is the results on Trial 1 that provide the closest measure of the holding-side bias.

The two doll-holding conditions also differed in the average amount of time the doll was held in arms. The preferred doll was held 3.8 seconds longer, on average, than the non-preferred doll. The difference was largest for middle holders, who, overall, showed a 23% reduction in hold duration from the preferred to non-preferred doll. Right-holders showed a 15% reduction, and left-holders showed only a 2% reduction. When these difference were assessed separately for boys and girls, girls showed the greatest reduction (at least among those children who were consistent in hold location for the two trials). This may mean that the girls were more discriminating about the thing being held, just as Almerigi et al. (2001) found with college students imagining themselves holding infants and inanimate objects.

Limitations and Future Directions

The current study provides a good start in tracking the development of the holding-side bias and in elucidating the contributions of the task and of the child's handedness, posture, and sex, but the study also is limited in several respects.

The first limitation was that a left bias was not clearly found in the present sample of children. It is unlikely that this is the result of the methods used to assess the bias as dolls have been used successfully in prior child studies. Rather, it is likely that the age range was not sufficiently broad to clearly identify the age at which the left-side holding bias appears. At best, the results suggest that the bias is just beginning to emerge in 4-year-old girls. Increasing the upper age range would have allowed for a better estimation of the point at which the bias is established, thereby providing the "baseline" on which to compare facets of holding for the earlier ages.

The second limitation was that significant differences were observed across the holding conditions. Although some variability was desired for analyses, the magnitude of differences between the first two trials, for example, prevented richer analyses involving scale scores, thereby reducing measurement error, or analyses of the factorial structure of "infant holding," in general. Further, administering only three trials of the task over a short period may have capitalized on state characteristics of the child or situational characteristics of the context. More repetitions over greater intervals of time would provide a more exact measurement of the intra-individual continuity of the bias.

A third limitation was that only handedness and footedness were assessed to account for the bias. Based on what is known from studies of adults, the model of the current study is empirically and theoretically under-identified. That is, for a proper assessment of the origins of holding bias, many additional variables, such as cerebral asymmetries and emotional state, would need to be measured. A more proper analysis of the contribution of handedness would then be conducted in the statistical "presence" of these other variables.

A fourth limitation is sample size. Several analyses lacked the power to yield significant results. Specifically, power to detect subgroup differences in the current study was minimal. While power is a function of sample size, it is also a function of effect size. For example, this study may indicate, like adult studies, that handedness is not a major contributor to holding side biases. While the contribution of handedness may exist and be measureable, its effect is too small for the current sample size to reliably estimate. Furthermore, a larger sample would be needed for more complex analyses that would explore such topics as subgroup differences, especially left-handers, and of the relationship between children's handedness and their consistency of hold across the tasks. One potential analysis would be symmetry analysis of contingency tables or turn-over tables (e.g., Schuster & von Eye, 1998). In consideration of the categorical nature of "side-of-hold," other possible analyses would be latent class analysis (e.g., von Eye & Clogg, 1994) and/or item-response theory (Hambleton, Swaminathan, & Rogers, 2001).

Finally, the most critical limitation of the current study is that, being a cross-sectional study, it did not assess the intra-individual development of the bias. Inasmuch as the goal of the current study was to uncover the developmental origins of the left-side holding bias, a prospective longitudinal study would have been required to observe intra-individual change in holding patterns and to identify causal predictors of the left-side holding bias. The current study is limited to non-directional associations between the variables independent and dependent variables.

In summary, the results of the analyses of the relation between strength and direction of handedness and style and side-of-holding indicate at best a modest role for handedness in the development of the holding-side bias. In retrospect, these results are compatible with the shape of the distribution of the children's handedness scores, which look similar to the distributions found in studies of adults. Inasmuch as the left-side holding bias was not yet established in these children, it seems unlikely that handedness and the holding-side bias co-develop, contrary to one of the main hypotheses of the study. Instead, the results suggest that the major roles in the development of the holding-side bias are more likely to be played by other variables.

APPENDIX A

Date Prepared: October 4, 2002

Project Title: Evaluation of Ready Set Grow Passport: Passport Outcomes Study

Date of Approval: October 31, 2002

This informed Consent Form is valid for a period not to exceed one year from the date of approval appearing above.

Purpose:
You are being asked to participate in a research study to help us find out how helpful the Passport Program is to its members. The researchers are interested in determining how being a part of Passport affects your behavior as a parent and how it affects your child's development.

Procedure and Duration:
You will be participating in a home visit that lasts an hour and a half. During the home visit, one project staff person will ask you questions from surveys about your child's behavior, and your own beliefs about parenting and child development. During this time, a second project staff person will work with your child to get information about your child's social and cognitive development.

Risk and Discomfort:
There are no significant risks involved in being a participant in this study, aside from the amount of time the home visit will take away from your busy schedule.

Benefits:
Participation in this study will assist the Passport Program in determining how effective their services have been and what types of improvements need to be made.

Refusal or Withdrawal of Participation:
Taking part in this study is completely your choice. You can withdraw from the study at any time for any reason. It will not affect your membership in Passport or the services you receive from Passport.

Privacy and Confidentiality:
Your name will not be used in any reports on this study. The records will be kept private to the maximum extent allowable by law. The information gathered will be used to make recommendations to the Passport Program as to how they can better serve their members and to inform others as to how programs such as Passport impact the lives of children and families.

We will strictly avoid any disclosure that may identify you to any persons not related to this research program. The consent form, which is the only identifier linking participants to data, will be kept in locked files at the Passport office.

Therefore, not even the researchers will be able to connect your data with your name.

Additional Information:
If you would like to discuss any questions related to this research, please feel free to contact Jessica Barnes or Dr. Hiram E. Fitzgerald. If you have any questions regarding your rights as research participants, please contact Ashir Kumar, M.D., Chair of Michigan State University's Committee on Research Involving Human Subjects, at 517-355-2180.

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I have read the information above and have been given explanations about my participation and my child's participation in the study. The project staff has satisfactorily answered all questions concerning the study. I agree (hereby consent) to participate in the home visit.

____________________________ ________________
Participant Signature Date

____________________________ ________________
Project Staff Date

APPENDIX B

Date Prepared: October 4, 2002

Project Title: An empirical evaluation of the theoretical model of affective social competence

Date of Approval: October 31, 2002

This informed Consent Form is valid for a period not to exceed one year from the date of approval appearing above.

Purpose:
The purpose of this research is to understand the effectiveness of the Passport program and to understand how children's development of the understanding and regulation of emotions is related to their behavior. We are asking that we be able to use the data that is collected for the evaluation of Passport in order to inform the scientific community about these processes. No additional data will be collected for this purpose. Therefore, the risks involved in participating in this study are limited to those involved in the participation of the Passport Evaluation study. By participating in this study of affective social development and parenting factors, you are helping us to understand more about children's development.

Refusal or Withdrawal of Participation:
Taking part in this study is completely your choice. You can withdraw from the study at any time for any reason. It will not affect your membership in Passport or the services you receive from Passport.

Privacy and Confidentiality:
Your name will not be used in any reports on this study. The records will be kept private to the maximum extent allowable by law. The information gathered will be used to report on the effectiveness of Passport and children's social competence.

We will strictly avoid any disclosure that may identify you to any persons not related to this research program. The consent form, which is the only identifier linking participants to data, will be kept in locked files at the Passport office. Therefore, not even the researchers will be able to connect your data with your name.

Additional Information:
If you would like to discuss any questions related to this research, please feel free to contact Jessica Barnes or Dr. Hiram E. Fitzgerald. If you have any questions regarding your rights as research participants, please contact Ashir Kumar, M.D., Chair of Michigan State University's Committee on Research Involving Human Subjects, at 517-355-2180.

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I have read the information above and have been given explanations about my participation and my child's participation in the study. The project staff has satisfactorily answered all questions concerning the study. I agree (hereby consent) to have the information collected for the Passport Evaluation used for this study.

____________________________ ________________
Participant Signature Date

____________________________ ________________
Project Staff Date

APPENDIX C

List of Parent Questionnaires

1. Consent Form for Study of Child Development
2. Consent Form for Evaluation of Community Intervention
3. Demographics
4. Passport Usage Survey
5. Knowledge of Child Development Inventory
6. Parenting Questionnaire
7. Child Behavior Checklist for Ages 1 ½ - 5

List of Child Tasks (in order)

1. Three-Bag-Task: Gift 1 (neutral gift)
2. Handedness 1: Add a small plastic monkey to a string of monkeys
3. Handedness 2: Add another monkey to the string of monkeys
4. Behavioral Regulation: Keep the M&M on your tongue
5. Footedness 1: Kick the ball to me
6. Footedness 2: Kick the ball to me, again
7. Handedness 3: Throw the ball to me
8. Handedness 4: Throw the ball to me, again
9. Emotion Display Task
10. Emotion Perception 1: DANVA2 – first 8 items

11a. Lollipop Test (Cognitive Tests)

11b. Handedness 5: Hand used to draw shaped recorded in Lollipop Test

12. Handedness 6: Point to the red Lego

13. Handedness 7: Put the red Lego on the black Lego

14. Footedness 3: Point to the red Lego with your foot

15. Footedness 4: Kick the Lego tower over with your foot

16a. Handedness 8: Roll the car as *quickly* as you can from here to there (which hand)

16b. Motor Dev. 1: Roll the car as *quickly* as you can from here to there (duration)

17a. Handedness 9: Roll the car as *slowly* as you can from here to there (which hand)

17b. Motor Dev. 2: Roll the car as *slowly* as you can from here to there (duration)

18a. Handedness 10: Again, roll the car as *quickly* as you can from here to there (which hand)

18b. Motor Dev. 3: Again, roll the car as *quickly* as you can from here to there (duration)

19a. Handedness 11: Again, roll the car as *slowly* as you can from here to there (which hand)

19b. Motor Dev. 4: Again, roll the car as *slowly* as you can from here to there (duration)

20. Wally Test 1 (Social Competence)

21a. Footedness 5: Stand on one foot for as long as you can (which foot)

21b. Motor Dev. 5: Stand on one foot for as long as you can (duration timed)

22. Motor Dev. 6: Stand on your other foot for as long as you can (duration timed)

23a. Footedness 6: Hop on one foot for as long as you can (which foot)

23b. Motor Dev. 7: Hop on one foot for as long as you can (duration)

24. Motor Dev. 8: Hop on the other foot for as long as you can (duration)

25. Wally Test 2 (Social Competence)

26. Doll Choice 1: Pretend these dolls are real babies. Point to the baby you want to pick up

27. Doll 1: Pretending the doll is a real baby, pick up and hold the baby (Side, Closeness, & Duration)

28. Doll 2: Now, pretend this doll is a real baby. Pick up and hold the baby (Side, Closeness, & Duration)

29. Handedness 12: Pretend the bowl has cereal for the babies in it. Stir the cereal with the spoon.

30. Doll Choice 2: Point to the baby you want to pick up

31a. Doll 3: Pick up, hold, and feed the baby (Side & Closeness)

31b. Handedness 13: Hand used to feed doll.

32. Emotion Perception 2 : DANVA2 – second 8 items

33. Motor Dev. 9: Stop/Go Task

34. Motor Dev. 10: Whisper Task

35. Handedness 14: Draw a picture

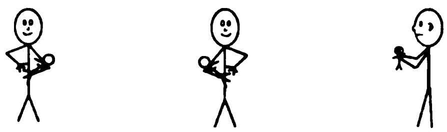
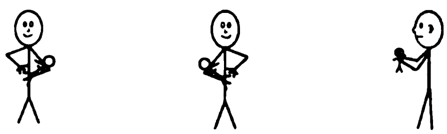
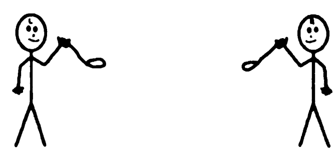
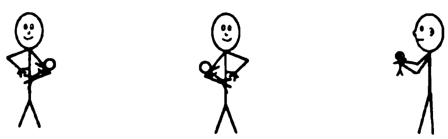
36. Emotion Perception 3: DANVA2 – third 8 items

37. Three-Bag-Task: Gift 2 (bad gift)

38. Three-Bag-Task: Gift 3 (good gift)

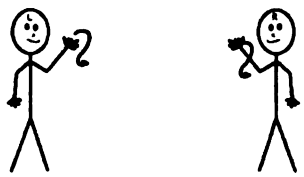
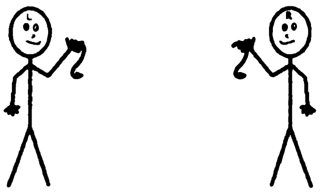
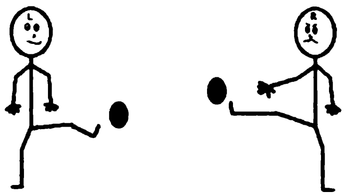
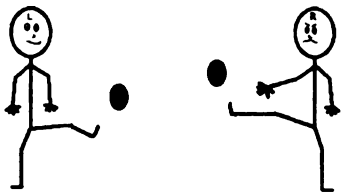
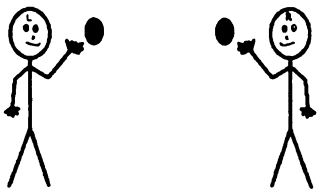
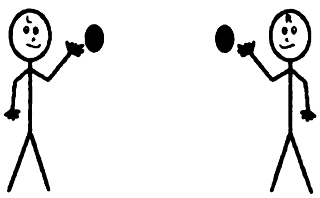
APPENDIX D

Example Doll Holding Coding Form

TASK	CODING
Pretend these dolls are real babies. Point to the baby you want to pick up.	White Doll Black Doll
Pretending the doll is a real baby, pick up and hold the baby (up to one minute).  L R B	L R B A CTB C~TB HOAB ________:_______ sec m.sec
Now, pretend this doll is a real baby. Pick up and hold the baby (up to one minute).  L R B	L R B A CTB C~TB HOAB ________:_______ sec m.sec
Pretend the bowl has cereal for the babies in it. Stir the cereal with the spoon.  L R	L R B A
Point to the baby you want to pick up.	White Doll Black Doll
Pick up, hold, and feed the baby.  L R B	FEED: L R B A HOLD: L R B A CTB C~TB HOAB

APPENDIX E

Example Handedness and Footedness Coding Form

TASK	CODING
Add a monkey to the string of monkeys.  L R	L R B A
Add another monkey to the string of monkeys.  L R	L R B A
Kick the ball to me.  L R	L R B A
Kick the ball again to me.  L R	L R B A
Throw the ball to me.  L R	L R B A
Throw the ball again to me.  L R	L R B A

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