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"So Big": The Development of Body Self-Awareness in Toddlers

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Early development of body self-awareness was examined in 57 children at 18, 22, or 26 months of age, using tasks designed to require objective representation of one's own body. All children made at least one body representation error, with approximately 2.5 errors per task on average. Errors declined with age. Children's performance on comparison tasks that required them to reason about the relative size of objects and about objects as obstacles, without considering their own bodies, was unrelated to performance on the body awareness tasks. Thus, the ability to represent and reflect on one's own body explicitly and objectively may be a unique dimension of early development, a distinct component of objective self-awareness that emerges in this age period.

In the latter half of the second year of life, children first exhibit clear evidence of reflective self-awareness, that is, that they represent and reflect on themselves as independent, objective entities. This is manifested in their ability to recognize themselves in mirrors, refer to themselves by name, point to themselves referentially, and express self-conscious emotions (Bullock & Lutkenhaus, 1990; Kagan, 1981; Lewis & Brooks-Gunn, 1979; Lewis & Ramsay, 2004; Lewis, Sullivan, Stanger, & Weiss, 1989; Stipek, Gralinski, & Kopp, 1990). Objective self-awareness lays the groundwork for later self-regulation, self-concept, and personal identity (Garcia, Hart, & Johnson-Ray, 1997; Harter, 1999; Mascolo & Fischer, in press; Moore & Lemmon, 2001), thus its development has been of interest to psychologists since William James' (1890) original distinction between the subjective and objective self.

Visual self-recognition has long been considered the gold standard for identifying the emergence of objective self-awareness, and its growth has been widely studied (e.g., Bahrick, Moss, & Fadil, 1996; Bertenthal & Fischer, 1978; Brooks-Gunn & Lewis, 1984; Nielsen, Dissanayake, & Kashima, 2003; Nielsen, Suddendorf, & Slaughter, 2006; Rochat, 1995b). Despite its universality (Priel & de Schonen, 1986) and robustness, however, visual self-recognition constitutes but one aspect of self-awareness, leaving a number of unanswered questions about the nature and development of objective self-awareness. The purpose of this study is to examine the early development of a distinct aspect of objective self-awareness referred to as body self-awareness (Moore, Mealiea, Garon, & Povinelli, 2006). Like previous researchers, we use this term to refer to the explicit representation of one's own body as an object, that is, with objectlike characteristics such as size, shape, solidity, and mass, and with the capacity to serve as an object in relation to other objects such as a tool, support, or container or as an obstacle, impediment, or encumbrance.

Scholarly interest in body perception has its roots in long-standing philosophical and psychological questions about mind – body relations beginning with Descartes' famous dictum. Early in the 20th century, the "body schema" construct (e.g., Reed, 2002) was introduced in response to psychiatric disorders characterized by aberrations in patients' awareness of their own bodies (Denes, 1999). The role of body image in healthy and pathological functioning has been of interest to psychologists since at least the time of Freud, who characterized the "body ego" in terms of body sensation, functioning, and image (Krueger, 1990). Developmental psychologists and pediatricians have also long been interested in childhood body image (Gardner, Sorter, & Friedman, 1997; Truby & Paxton, 2002) and its association with peer relations and self-esteem, most recently in relation to obesity (Ricciardelli & McCabe, 2001; Tiggemann,

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2005). Recent years have also witnessed increased focus on "embodied cognition" and, with it, renewed interest in the bodily foundations of self (e.g., Bermudez, Marcel, & Eilan, 1995; Gillihan & Farah, 2005).

Several theorists have conceptualized the bodily self as a distinct aspect of early self-development, either as a precursor of and contributor to objective self-awareness (Butterworth, 1992; Meltzoff & Moore, 1995; Povinelli & Cant, 1995; Rochat, 1995a) or as a component of the objective self (Barth, Povinelli, & Cant, 2006; Moore, in press; Piaget, 1952, 1954). Building on a recent empirical demonstration of the emergence of body self-awareness in 18–21-month-old children (Moore et al., 2007), the current study aims to provide a fuller and more systematic inquiry into early developments in young children's conscious awareness of their own bodies.

Objective Self-Awareness and Body Self-Awareness

The ability to think about oneself as an object of perception develops gradually over the first several years of life. During the first year, infants can discriminate their own real-time limb or facial movements from those of others in paired video presentations (Bahrick, 1995; Rochat, 1995a). This visual–kinesthetic matching and discrimination reflects an early form of self-world differentiation, sometimes referred to as the "ecological self" (Neisser, 1995; Rochat, 1998), that serves as the perceptual, sensorimotor, subjective foundation for later developing objective self-awareness (Butterworth, 1992; Rochat, 1995a, 2003) and conceptual knowledge of the body (Slaughter & Heron, 2004). Reflective self-awareness emerges between 15 and 18 months of age when children begin to match their own facial and/or body movements with the image of themselves in a mirror, exhibiting mirror self-recognition (for alternative interpretations, see Loveland, 1986; Mitchell, 1993; Rochat, 1995a). This ability is characteristic of nearly all typically developing children by 24–26 months of age (Lewis & Brooks-Gunn, 1979) and is associated with other features of the objective self such as self-reference and self-conscious emotions (Lewis & Ramsay, 2004; Lewis et al., 1989; Stipek et al., 1990). Thus, the bodily self of infancy appears to anchor the emergence of objective self-awareness in the second year of life, which continues to develop into the self-concept over the preschool years and beyond.

A recent model of the evolutionary origins of self-awareness suggests that the ability to reflect on one's own body as an object may constitute the most fundamental aspect of objective self-awareness. Povinelli and Cant (1995) argue that the large-bodied, arboreal common ancestor of the great apes faced unique locomotor challenges that required the ability to reflect objectively on the physical characteristics of its own body in relation to the characteristics of potential supports in the forest canopy. According to this conceptualization, the ability to hold information about one's own body in mind as an explicit object of attention in relation to other objects in the world forms the phylogenetic foundation for objective self-awareness. What's more, Povinelli and his colleagues suggest that objective awareness of one's own body may remain "phenomenologically primary" during ontogenesis as well (Barth et al., 2007).

The possibility that body self-awareness is a distinct component of the broader construct of objective self-awareness is further suggested by findings in adults with localized brain damage. Often their own-body representations have been disrupted whereas they remain both motorically competent and fully self-aware. For example, parietal lobe damage sometimes impairs adults' ability to localize particular parts of their own bodies, even causing them to search for a given body part on another person's body or under a table (Denes, 1999). Such patients can still localize comparable parts on animal bodies and can name human body parts without error after hearing dictionary definitions of them (Guariglia, Piccardi, Puglisi, & Traballesi, 2002). They can also recognize themselves, indicating that the deficit is specific to representations of their bodies and not a general problem with self-awareness. Some patients with parietal damage find it difficult to imitate unfamiliar gestures positioned at particular locations on the body; for example, a meaningless hand gesture modeled next to the ear by the examiner is imitated next to the nose by the patient (Buxbaum & Coslett, 2001; Goldenberg, 1996). Still others become oblivious to one side of the body (Bisiach, 1999) or lose the sense of ownership of particular body parts so that they sometimes claim that that one of their own limbs belongs to someone else (Graziano & Botvinick, 2002). Recent findings from cognitive neuroscience research with normal adults confirm that one's own-body representations are processed in distinct regions of the intact brain (Chaminade, Meltzoff, & Decety, 2005; Ehrsson, Kito, Sadato, Passingham, & Naito, 2005). These varied findings in otherwise self-aware adults point to *body awareness* as a unique component of general self-awareness, dissociable from motoric competence in moving the body and from semantic and lexical representations of the body. Body self-awareness may thus serve as a developmental bridge between the kinesthetically based awareness and discrimination of one's own body evident in infancy and the more complex psychological self that develops over childhood and adolescence.

Development of Body Representations and Body Self-Awareness

There is reason to believe that body representations develop over the toddler years and thus are worth systematic examination. Recent work by Slaughter and colleagues has shown that children cannot discriminate canonical versus scrambled human body forms until the middle of the second year or later (Slaughter & Heron, 2004). For example, 12-month-olds could not discriminate violations of canonical body form in dolls, 15 – 18-month-olds could discriminate only the most egregious violations (i.e., arms protruding from the head), whereas 24-month-olds discriminated both more and less subtle transformations of the canonical body form; similar results were obtained using drawings of the human body. Slaughter and Heron (2004) concluded that children's representations of the human body are incomplete until relatively late, especially in comparison to their representations of the human face.

This research does not address the child's awareness of or representation of his or her *own* body, however. It would be reasonable to expect that developments in children's representation of their own bodies would coincide with changes in representation of others' bodies, at least insofar as children are capable of reflecting on themselves. Three previous studies have reported findings consistent with this conjecture. As part of a study of early self-awareness, Bullock and Lutkenhaus (1990) asked toddlers first to sit on a mat and then to pick it up and hand it to the experimenter. In a variant of this task, Moore and colleagues (2007) asked toddlers to push a shopping cart while they were standing on a blanket attached to its rear axle. Both groups of authors reported that 18- to 21-month-old children figured out how to remove themselves as obstacles, but that younger children did not. These studies were inspired in part by Piaget's observations of similar errors made by his 1-year-old children, such as 18-month-old Jacqueline's trying to pick herself up by her own feet to get herself out of a hole (Piaget, 1954, obs. 122) and failing to move herself from a rug on which she was standing as she tried to pick it up (Piaget, 1952, obs. 168), or 14-month-old Lucienne's trying to force a lid down over her head like the necklace she had just placed around her neck (Piaget, 1954, obs. 118). A recent study of "scale errors" in young children has also found that toddlers up to 30 months of age try to fit themselves onto or into miniature doll toys that are clearly too small for them (DeLoache, Uttal, & Rosengren, 2004). These toddlers tried to do things that their body size made impossible, thus implying that their objective representations of their own body dimensions were still nascent.

The Current Study

The purpose of the current study is to build on these suggestive findings on the early development of body self-awareness by expanding the tasks and the ages studied. This permits us to determine whether performance on superficially different but conceptually similar tasks is related, that is, whether body self-awareness is a coherent construct. It also provides a fuller developmental perspective on these phenomena. Further, the tasks index children's awareness of two different physical characteristics of the body so that we can determine whether children's awareness of the physical properties of their bodies develops similarly or differently for different attributes. Finally, because the body awareness tasks in the current study rely on relative-size understanding and reasoning about obstacles in addition to self-representation, we include a set of comparison tasks to determine whether children's reasoning about their own bodies can be distinguished from reasoning about other objects.

We presented children between 17 and 30 months of age with a set of five tasks, most of which were adapted from those used in previous research (Bullock & Lutkenhaus, 1990; DeLoache et al., 2004; Moore et al., 2007). Three of the tasks were meant to assess children's awareness of the size of their own bodies in relation to objects in the world; two were meant to assess children's awareness of their bodies as obstacles or encumbrances. Each task encouraged children to do something for which they could consider the properties of their own body or not. For example, they were offered a small doll's hat to wear, given a choice of two doors to pass through, one of which was too small, or encouraged to push a stroller while they were standing on a blanket attached to its rear axle. In each case, failure to represent the objective characteristics of their own body would result in an error: trying to put on the too small hat; trying to go through the too small door; trying to push the stroller while standing on the blanket and preventing it from moving. We thus observed and recorded the number and types of errors that children made on each task. We expected that body representation errors would decline with age if children's objective awareness of their own bodies is developing over the second year. Further, we expected that children who produced more errors on one task would also do so on other tasks if body self-awareness represents a coherent construct. Finally, we expected that children's performance on similar tasks that do not require self-representation would be only modestly related to their performance on the body representation tasks if the latter rely on objective self-awareness in addition to reasoning about objects.

Method

Participants

Participants were 57 children (29 girls) in three age groups of 19 children each: 18 months (*M* = 18.4 months, *SD* = 0.92; 9 girls), 22 months (*M* = 22.5 months, *SD* = 1.2; 9 girls), and 26 months (*M* = 26.9 months, *SD* = 1.5; 11 girls). Families were from a medium-sized urban area and varied from working class to upper middle class by parent report; 88% were Caucasian, 7% African-American, and 5% Asian. All children were walking and were healthy and developing normally by parent report. Several additional children were recruited, but their data could not be used for various reasons: sibling interfered during task administration (1), equipment failure (4), experimenter error (6), and child fussy or uncooperative and failed to complete several tasks (six 18-month-olds, seven 22-month-olds, and one 26-month-old).

General Procedure

Five tasks were administered to assess body self-awareness and five comparison tasks that did not require body representation. Each task required about 5 min to administer; all children received all tasks. Procedures took place in two adjacent playrooms and were videotaped for later coding. Parents remained with their children at all times.

Body Self-Awareness Tasks

Three of the body self-awareness tasks indexed the ability to reason about one's own body size relative to objects in the world and two indexed the ability to reason about one's body as an obstacle that had to be moved in order to move something else.

Doll clothes task (body-size). In this task children were offered much too small doll clothes to wear. The child watched as the experimenter dressed a 30-cm doll in a doll-sized hat, jacket, and shoes. After placing each piece of clothing on the doll, the experimenter handed the child an identical piece of doll clothing and said simply, "Here's your [hat, jacket, shoe]." If the child did not spontaneously attempt to wear a piece of clothing, the experimenter said, "That's your [hat, jacket, shoe]." The child was not asked explicitly to put the doll clothing on, and neither adult commented on the size of the clothing. If the child requested help, it was provided as much as possible, for example, holding the jacket open so the child could try to fit an arm into a sleeve. Attempts by children to put the doll clothes on themselves as if the clothing were full-sized were scored as errors (coding details below).

Door choice task (body-size). This task was adapted from Garon and Moore (2002; with thanks to Chris Moore for sharing the details of this task) and required the child to choose one of two doors to reach a parent on the other side of a wall, only one of which was the right size. The parent was seated behind a 1-m × 2-m foamboard wall equidistant between two "doors," which were holes cut into the wall (see Figure 1). One door was short and wide, 30 cm × 30 cm, with a 10-cm square "window" above it aligned with the top of the second door and through which the child could see the parent. Children could easily crawl through this door. The second door was tall and narrow, 10 cm wide × 80 cm tall, and the child could also see the parent through this door; however, it was much too narrow for a child, or even the child's head, to fit through. The parent played peek-a-boo with the child from behind the wall through each door, then returned to a seat centered between the doors about 1 m behind the wall. The child was placed equidistant between the doors and the parent called the child. Once the child had joined the parent on the other side, the experimenter called the child to return. Children's attempts to squeeze their bodies through the too small door were scored as errors.

Figure 1. Door-choice task.

Replica toys task (body-size). This was an adaptation of the ''scale error'' task used by DeLoache and colleagues (2004), in which children play with a standard set of child-sized toys and then several minutes later play with small, doll-sized replicas of the same toys. At the beginning of the session, children played with three child-sized Little Tykes toys: a slide, a toddler chair, and a cozy-coupe car that they could climb into, move with their feet, and steer. The experimenter encouraged and helped the child to use each one as intended for approximately 10 min. Then, while the child was in the second playroom completing another task, the child-sized toys were replaced with a set of identical, doll-size Little Tykes replicas approximately 8–14 cm high, and one-fifth to one-sixth the height of the child-sized toys (see Figure 2).

The experimenter escorted the child back into the first playroom, asking the parent not to comment on the replica toys. Children were unprompted and free to play with the replica toys however they wished for approximately 5 min. If no play occurred after 1 min, the experimenter drew the child's attention to the toys and suggested that the child play with them without noting the toys' size. If a child requested help from either adult, it was provided if possible. For example, in trying to go down the doll-size slide, children would sometimes ask an adult to pick them up or to hold their hand as the adult had done when the child had previously used the child-size slide. Help was not always possible as, for example, when children asked an adult to open the door on the doll car wider so they could better fit one of their feet inside. Children's attempts to use the replica toys as if they were the full-sized versions without considering that their bodies are too big for such small toys (e.g., trying to sit in the doll chair), were scored as errors.

Figure 2. Replica toys task.

Stuck stroller task (body-as-obstacle). Adapted from Moore et al. (2007), this task required the child to remove herself from a blanket on which she was standing so that she could push an attached stroller forward unobstructed. A 45-cm $\times$ 60-cm blanket was pinned to the rear axle of a play stroller and spread out on the floor behind the stroller so that standing on it prevented the stroller from moving forward. The experimenter placed the child, standing, on the blanket behind the stroller within reach of the handles and encouraged the child to push the stroller. Attempts to push the stroller without first stepping off the blanket were coded as errors.

Mat pick-up task (body-as-obstacle). This task was adapted from Bullock and Lutkenhaus (1990) and required children to remove themselves from a 45-cm $\times$ 60-cm mat on which they were seated so that they could give it to the experimenter when she requested it after ''storytime'' was finished. Children's attempts to pull the mat out from under themselves without first getting up and moving their bodies out of the way were counted as errors.

Comparison Tasks

The five comparison tasks did not require explicit body representation. Three indexed children's reasoning about relative size of objects, and two indexed reasoning about objects as obstacles that had to be moved in order to move something else. These were meant to parallel the body self-awareness tasks, with the primary difference being that all objects were fully visible (unlike the child's body) and none required the child to reflect objectively on his or her own body.

Parent's doll clothes task (relative size). In this task children were asked to put the doll clothes on a parent. Parents were instructed to cooperate with the child's efforts. Adults did not comment on the size of the clothing or its fit. Any attempts to put the clothes on the parent were scored as errors (details below).

Shapes door choice task (relative size). For this task children had to choose a door in the same foamboard wall used for the child's door choice task. In this case children had to pass a round character (stuffed Pooh, approx 20 cm tall) and a flat character (Cookie Monster painted onto a piece of 45-cm $\times$ 60-cm posterboard) through one of the doors to the parent on the other side of the wall. For each shape only one of the doors was the correct size; the round character could fit only through the shorter, wider (30-cm $\times$ 30-cm) door whereas the flat character could fit only through the taller, narrower (10-cm $\times$ 80-cm) door. Once the characters were on the other side, the experimenter retrieved them and repeated the procedure. Children's attempts to fit the character shapes through the wrong-size door were scored as errors.

Doll's toys task (relative size). After having played with a 30-cm doll and a set of appropriately doll-sized toys, children were offered the same doll and a set of miniature toys that were too small for the doll (adapted from Ware & Wetter, 2002). The toys were meant to appeal to both boys and girls (sofa, bed, bathtub, convertible car, dump truck), and differed from those used in the replica toys task. The experimenter first played together with the children to help them place the doll in or on each of the doll-sized toys. Then, while the child was in the second playroom completing another task, the doll-sized toys were replaced with a set of very similar but much smaller toys (''miniature toys''), approximately 5 – 10 cm in size, and one-quarter the size of the doll-size toys; the doll remained with these miniature toys but was too large to fit into or onto any of them. The experimenter then escorted parent and child back into the first playroom, asking the parent not to comment on the miniature toys. Children were unprompted and free to play with the doll and miniature toys however they wished. If no play occurred after 1 min, the experimenter drew the child's attention to the toys and the doll and suggested that the child play with them without noting their size. Children's attempts to fit the doll into the miniature toys as if they were the doll-sized versions (e.g., trying to squeeze the doll into the miniature car), without considering that the doll was too big for such small toys, were scored as errors.

Stroller-with-box task (objects-as-obstacles). This task required the child to remove a heavy box from a blanket attached to the rear axle of a play stroller so that the stroller could be pushed forward. The procedure was identical to the stuck stroller task except that a 21-cm × 28-cm × 10-cm heavy box (6.5 lbs.) wrapped in white vinyl was placed on the blanket instead of the child him- or herself. The child was encouraged to push the stroller from behind. Attempts to push the stroller without first removing the box were coded as errors.

Lion's mat pick-up task (objects-as-obstacles). In this task children had to remove a stuffed lion (45 cm tall) weighted with sand (10.5 lbs.) from a mat on which it was seated so that they could give the mat to the experimenter. Sandy-the-lion had joined the children for storytime and the children saw the heavy lion placed on his mat. After the children were asked to hand their own mat to the experimenter, they were then asked to hand the lion's mat to the experimenter so she could put it away also. They were not told that they had to move the lion first. If children tried to move the lion, the experimenter helped them because it was too heavy for children to move on their own. Attempts to pull the mat out from under the lion without first trying to move the lion were counted as errors.

Measures

Children's behavior was coded from the videotapes. The primary measure for each task was the number of errors children made. Based on DeLoache et al. (2004), and using their conservative criteria, an error was defined as a serious, nonpretend attempt. This was determined by the child's facial expression and effort. For example, a serious attempt to wear the doll jacket meant attempting with clear effort to put the hand and forearm fully into the sleeve, a serious attempt to sit in the doll-sized replica chair involved positioning the body appropriately and then sitting with one's full weight on the chair with a neutral facial expression (and perhaps surprise at the outcome), a serious attempt at pushing the stroller while standing on the blanket required pushing it with enough force to pull the blanket taut with postural or facial expressions of effort, and so on. Each independent attempt was counted as an error. Interobserver reliability for the number of errors on each task was established by independent coders on 16 children (28% of the sample) approximately equally distributed over age and sex. Because the codes were not mutually exclusive and exhaustive, percent agreements rather than kappas were calculated for the individual tasks and are shown in Table 1.

Several additional scores were obtained to capture other qualities of children's responses in addition to their errors. Children were scored for the number of times they sought help from either a parent or the experimenter on those tasks for which help seeking ever occurred, specifically the doll clothes and replica toys tasks (interrater agreement = 75% and 93%, respectively). Persistence in attempting the task was also rated using 5-point scales for the replica toys and the door choice tasks (1 = *quickly gave up*; 5 = *tried several different times and asked for help*; interrater agreement within one point = 100%). Frustration during unsuccessful attempts was rated for the replica toys task (1 = *no frustration*; 5 = *intense, crying or very upset*) and was scored as none versus some (0/1) for the door choice task. Children's interest in the full-size toys, the replica toys, and the stroller during testing was also rated separately for each task (1 = *low*; 5 = *high*; interrater agreement within one point = 100%).

Table 1
Descriptive Statistics for the Number of Errors on Body Self-Awareness and Comparison Tasks

	Mean	*SD*	Min/Max	Reliability
Body self-awareness tasks				
Body size				
Replica toys	2.86	3.84	0–23	86%
Doll clothes	2.05	2.32	0–10	86%
Door choice	2.65	2.45	0–10	87%
Body-as-obstacle				
Stuck stroller	0.70	1.05	0–2	83%
Mat pick-up	1.24	0.78	0–5	90%
Comparison tasks				
Size reasoning				
Doll's toys	3.26	3.0	0–11	90%
Mom's doll clothes	0.88	1.38	0–6	96%
Shapes thru doors	1.89	1.53	0–6	93%
Obstacle reasoning				
Stroller with box	0.93	0.25	0–1	86%
Lion on mat	0.95	1.48	0–7	77%

Results

Means and standard deviations for children's errors on each task are presented in Table 1. Every child committed at least one body representation error (M = 11.3 across all tasks), and most children committed multiple errors on each task. As Figure 3 indicates, for each of the five primary tasks, most children made one or more errors (range = 66%–85% of children). Even on the doll toys used in the comparison tasks, for which children also had a doll

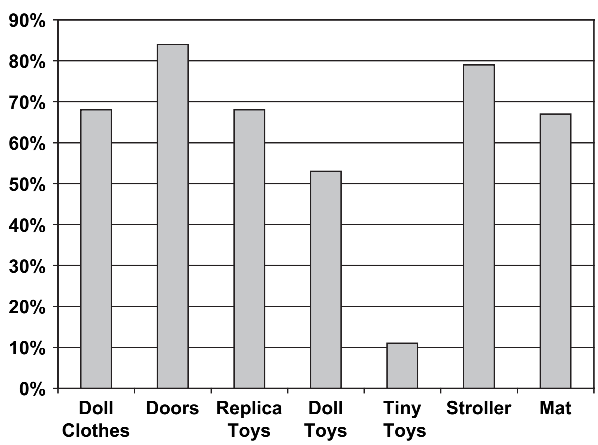

Figure 3. Percent of children who produced at least one body representation error for each task. "Doll toys" and "tiny toys" were used only in the comparison tasks, but children were free to play with them however they wished and some children produced body representation errors with them.

to play with, 53% of the children attempted to sit on, lie on, or get into the doll toys themselves; 11% of the children also attempted to use the miniature doll toys (~5–10 cm in size) as if they were full sized. There were no sex differences on any measure, with one exception; boys made more errors on the door-choice task than did girls (Ms = 3.69 and 1.66, respectively), $t(55) = 3.41, p < .001$. Thus, body representation errors were common in this age range and occurred on all tasks.

Substantive analyses were conducted to address the following: (1) age differences in error frequency on the three body-size tasks and the two body-as-obstacle tasks; (2) children's persistence, frustration, and help-seeking; (3) relations among the body representation tasks for the frequency of errors; (4) correlates of performance on the body representation tasks, such as interest and walking experience, and relations between errors on the comparison tasks and errors on the body-representation tasks. We report the results of each of these sets of analyses in turn.

Age Differences in Body Representation Errors

Repeated measures analyses of variance (ANOVA) were conducted separately for the three body-size tasks (doll clothes, door choice, and replica toys) and the two body-as-obstacle tasks (stroller and mat). The dependent measure in each analysis was the number of errors. Separate analyses were conducted for the body-size versus body-as-obstacle tasks for conceptual reasons, because the two types of task may require different kinds of representation or reasoning about one's body, and for statistical reasons, because there was missing data for the latter two tasks but not for the former. The number of errors on the replica toys was truncated to 7 to reduce the effects of extreme scores (actual maximum = 23); independent analyses without truncation produced equivalent findings.

Body-size tasks. Most children made at least one error on the three body-size tasks (100% at 18 months, 95% at 22 months, and 90% at 26 months), with a mean of 2.5 errors per task. A two-factor repeated measures ANOVA was conducted with age group as the between-subjects factor (18 months, 22 months, and 26 months) and task as the within-subject factor (doll clothes, door choice, and replica toys) on the number of errors each child produced. As shown in Figure 4, there was a significant main effect for age, $F(2, 54) = 3.52, p = .037$ ($\eta^2 = .12$). Post hoc comparisons (Tukey) indicated that 26-month-olds produced fewer errors (M = 1.56) than did 18-month-old ($M = 2.61, p < .10$) and 22-month-old children ($M = 2.79, p < .05$); 22-month-olds did not differ from 18-month-olds. There

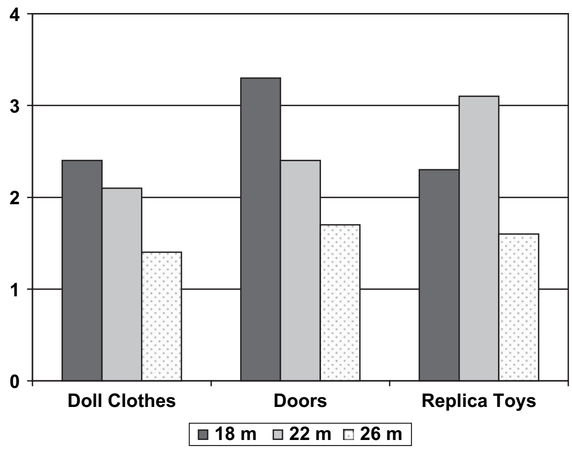

Figure 4. Age differences in number of errors for the three body-size tasks.

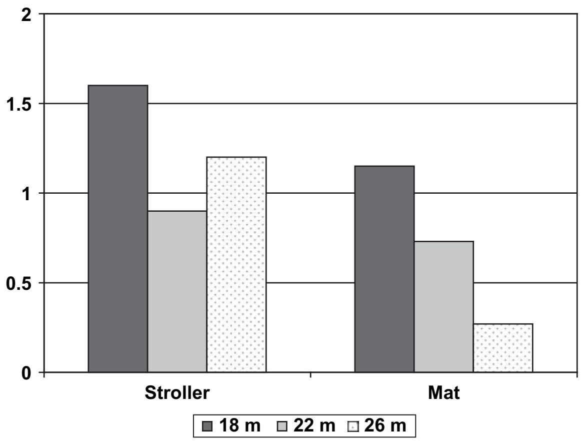

Figure 5. Age differences in number of errors for the two body-as-obstacle tasks.

was no significant task effect, nor was the interaction between task and age significant.

For individual tasks, between 14% and 32% of children made no errors, with an average age of 23.6 months. Only three children (5%) were errorless on all three of the body size tasks. Their average age was 27 months. Thus, for individual tasks, the earliest mastery appears to be about 24 months of age on average, but many children continue to make errors as late as 30 months of age.

Body-as-obstacle tasks. Most of the children produced at least one error on the obstacle tasks (100% at 18 months, 79% at 22 months, and 77% at 26 months). As above, a two-factor repeated measures ANOVA was conducted with age group as the between-subjects factor and task as the within-subject factor (stroller task and mat task). As shown in Figure 5, there was a significant main effect for age, $F(2, 34) = 4.14$, $p = .025$ ($\eta^2 = .20$). Post hoc comparisons (Tukey; $p < .05$) indicated that the 18-month-old children produced significantly more errors across the two tasks ($M = 1.41$) than did 22-month-olds ($M = .69$) and 26-month-olds ($M = .73$). There was also a main effect for task, $F(1, 34) = 7.39$, $p = .01$ ($\eta^2 = .18$). Children made significantly more errors on the stroller task ($M = 1.19$) than on the mat task ($M = .65$).

Twenty children had missing data on one of the two body-as-obstacle tasks. This was because not all children were willing to sit on a mat for "storytime" long enough for the experimenter to ask for the mat, some children sat in the stroller themselves instead of pushing it, or because the experimenter failed to administer a task. The sample size for the repeated measures analysis was accordingly reduced. Therefore, we followed up the significant age effect (above) with separate one-way ANOVAs with age as the factor for each task because there was less missing data for each individual task than for both together ($n = 49$ and 43 for stroller and mat task, respectively, with no age or sex differences in the number of children with missing data, χ^2 *ns*). There was a significant age effect for the stroller task, $F(2, 46) = 3.83$, $p = .03$, and a marginally significant age effect for the mat task, $F(2, 40) = 2.65$, $p = .08$. Post hoc comparisons ($p < .05$) indicated that on the stroller task, 18-month-olds produced significantly more errors ($M = 1.59$) than did 22-month-olds ($M = .87$), but did not differ from 26-month-olds ($M = 1.24$). On the mat task, 18-month-olds produced significantly more errors ($M = 1.15$) than did 26-month-olds ($M = .27$), but did not differ from 22-month-olds ($M = .73$). For each individual task, 21%–56% of the children made no errors, with an average age of 23.9 months. Six children (18%) made no errors on either of the two obstacle tasks. Their average age was 25.2 months.

Persistence and Help Seeking on Body Representation Tasks

In addition to scoring the number of errors children made, persistence and frustration were rated for the replica toys and door choice tasks. The average persistence rating was 2.2 on the replica toys and 1.7 on the door choice task, indicating low to moderate persistence. Considering that many children made multiple errors, itself an indication of persistence, we created a persistence score by multiplying the child's average persistence on a given task by the child's total errors on that task ($M = 6.2$, $SD = 8.2$ for replica toys; $M = 3.3$, $SD = 3.6$ for door choice task). There were no age differences on any of the persistence scores. With respect to frustration, 28% of the children exhibited some frustration on the replica toys (*M* rating = 1.56, *SD* = 1.07), with two children (4%) becoming extremely upset when they couldn't fit into the car. On the door choice task 16% of children exhibited some frustration when they couldn't make themselves fit through the too narrow door. There were no age differences in frustration. Thus children at each age were persistent in trying to make themselves fit and they occasionally exhibited frustration when they couldn't do so.

Children also sought help from the parent or experimenter on the doll clothes and replica toys tasks, such as asking for help in putting the doll's jacket on themselves or asking to be lifted onto the replica slide. For the doll clothes task, 23% of children asked for help at least once, and for the replica toys task, 40% of children sought help. Total number of help-seeking attempts varied by age for both tasks, $F(2, 54) = 3.76$, $p = .03$, and $F(2, 54) = 2.69$, $p = .07$, respectively for the doll clothes ($M = 0.26$, 0.53, 0.05 requests at 18, 22, and 26 months) and replica toys ($M = 1.63$, 0.89, 0.47 requests at 18, 22, and 26 months). Post hoc comparisons ($p < .05$) for the doll clothes task showed that 22-month-olds differed significantly from 26-month-olds but not from 18-month-olds in help-seeking frequency; for the replica toys task 18-month-olds differed significantly from 26-month-olds but not from 22-month-olds, who did not differ from each other.

Relations Among Tasks

There were no age differences in the mean number of different tasks on which children made errors ($M = 3.0$, 2.7, 2.4 at 18, 22, and 26 months, respectively), indicating that children who made errors on one task also did so on others. Table 2 shows the correlations among the five body-representation tasks for the number of errors per task. As evident in the table, children who produced more errors on one of the size tasks (doll clothes, door choice, replica toys) also produced more errors on the others, and children who produced more errors on one of the obstacle tasks (stroller, mat) also tended to do so on the other. But there were no significant associations between the three body-size tasks and the two body-as-obstacle tasks ($r = -.06$ $-.02$, *ns*). This was also true when the sum of errors on the three size tasks was correlated with the sum of errors on the two obstacle tasks ($r = .07$, *ns*).

Table 2
Correlations Among the Five Body Self-Awareness Tasks

	Doll clothes (S)	Door choice (S)	Stuck stroller (O)	Mat pick-up (O)
Replica toys (S)	.56**	.31**	*ns*	*ns*
Doll clothes (S)		.19⁺	*ns*	*ns*
Door choice (S)			*ns*	*ns*
Stuck stroller (O)				.21⁺

Note. S: Body-size task; O: Body-as-obstacle task.
⁺$p < .10$; **$p < .01$.

Correlates of Body Self-Awareness Errors

We conducted a series of analyses on several potential correlates of children's performance on the body representation tasks: (1) interest in the toys, (2) walking experience, (3) reasoning about the relative size of objects, and (4) reasoning about objects as obstacles. These were chosen because they could credibly serve as contributors to errors on the body-awareness tasks or to the development of objective body awareness itself, although the design of the study does not permit such inferences directly.

Interest. Age was unrelated to the amount of time children played with the full-size toys or to children's rated interest in any of the toys. Children with higher rated interest in the full-size toys were also rated as more interested in the replica toys ($r = .40$, $p = .002$), and they made more errors on the replica toys ($r = .42$, $p = .001$). Greater interest in the replica toys was also related to the number of errors ($r = .67$, $p < .001$), but age differences in the number of errors remained when children's interest in the full-size toys was controlled (ANCOVA), $F(2, 53) = 3.40$, $p = .04$, and when their interest in the replica toys was controlled, $F(2, 53) = 2.84$, $p = .06$. Children's interest in the stroller was unrelated to their performance on that task.

Walking experience. It might be expected that children who had been walking longer would have been confronted with more challenges and opportunities to reflect on the physical characteristics of their own bodies in relation to other objects and to spaces in the world as they locomoted. To determine whether amount of walking experience was associated with fewer body-representation errors, we correlated parent reports of the number of months their children had been walking with children's body-size errors and body-as-obstacle errors. Children who had been walking longer produced fewer total body-size errors ($r = -.27$, $p = .02$) and fewer total body-as-obstacle errors ($r = -.47$, $p = .001$). The correlation between walking experience and body-size errors was no longer significant with age controlled, but the correlation between walking and body-as-obstacle errors remained significant ($r = -.38$, $p = .02$).

Reasoning about relative size. Like the tasks that required children to reason about the size of their own bodies, the object-size tasks proved difficult (see Table 1 for means and *SD*s). Most children (42%–82%) made errors, and the number of errors did not differ significantly between the comparison and body-size tasks ($ps > .10$). Importantly, however, there was no significant association between errors on the comparison tasks and errors on the body-size tasks ($r = .01$, *ns*), including with age controlled ($r = -.01$, *ns*). Thus, children who were better at reasoning about size relations between physical world objects were not necessarily better at reasoning about the size of their own bodies in relation to objects in the world and vice versa.

Reasoning about obstacles. Like the tasks that required children to reason about their bodies as obstacles, these tasks were also difficult (see Table 1 for means and *SD*s), with most children making at least one error (48% and 93%). There were no significant differences between the comparison and body-as-obstacle tasks for the number of errors ($ps > .10$). Again, however, performance on the comparison tasks was unrelated to performance on the body-awareness tasks ($r = .22$, *ns*), including with age controlled ($r = .16$, *ns*). Thus, as was the case for reasoning about relative size, being better able to reason about and remove a physical obstacle to achieve a goal was generally not associated with children's performance on similar tasks that required them to reason about their own bodies as obstacles.

Discussion

In this systematic inquiry into young children's objective awareness of their own bodies, we found that 1- and 2-year-olds frequently made body representation errors and that these declined with age across a variety of tasks. This is consistent with the notion that the ability to reflect on one's own body as an object in relation to other objects in the world emerges in the second year of life and continues to develop into the third year (Moore, in press). The findings also suggest that there may be two distinct aspects of early body self-awareness, that is, the ability to represent one's body size and a related but separate ability to represent one's body as an obstacle or encumbrance. Children's performance on a set of comparison tasks that required them to reason about the relative size of objects and about objects as obstacles was unrelated to their performance on the body awareness tasks. This suggests that the ability to represent and reflect on one's own body explicitly and objectively may be a unique dimension of early development, a component of the larger construct of objective self-awareness that emerges in this age period.

Emergence and Growth of Body Self-Awareness

Toddlers were presented with several tasks to index awareness of the size of their own bodies and awareness of their bodies as obstacles that had to be moved out of the way to achieve an end. Body representation errors were common and numerous on these tasks. All children made at least one body representation error, most children made errors on two or more tasks, and the average number of errors over all of the tasks was more than 10. Children tried systematically and repeatedly to put on very small doll clothes, to squeeze through a too small door, to use doll-size furniture and toys as if they were fully child sized, to pick up a mat while still sitting on it, and to push a stroller while standing on a blanket that impeded its movement. A number of children even attempted to use the tiny chair, sofa, or bed (approximately 5–10 cm in size) from one of the comparison tasks as if they were full sized. Indeed, in a task that offered a subset of children a choice between a 3-in. or a 6-in. tall doorway to get to their mothers, all of the children tried one or both of them without hesitation (however, because they found this task so frustrating we abandoned it). It took no encouragement to elicit such errors; they generally occurred naturally as children played with or attempted to use the toys and objects. Parents were frequently amused by their children's errors in the laboratory, but they also often reported that their children exhibited similar behavior at home. Thus, these are not unusual or artificial phenomena but appear to be a regular part of early development.

Interestingly, children were persistent and made repeated errors on the same task, sometimes displaying frustration or distress while persevering in their unsuccessful attempts. We observed anecdotally that they tried multiple alternative means for achieving their ends. For example, children would sometimes try to move the blanket that was attached to the stroller out of the way, but then would stand squarely on it again as they tried once more, impossibly, to push the stroller, impeded by the position and weight of their own body. Or they would try different ways to fit into the doll-size car or through the too small door, first with their head, then with a hand (or arm), and finally with a foot (or leg). Children also often removed their shoes when their first attempts to slide down the doll-size slide or to slip into the small car foot-first didn't work (for similar observations, see DeLoache et al., 2004). These multiple, varied attempts appeared to be a sort of trial-and-error problem-solving approach, without consideration of the factor of their own body's size or relative position and without awareness of the impossibility of making their bodies fit into too small spaces or of the fact that their bodies were themselves serving as barriers or obstacles. Thus, as a group, 1-year-olds appear frequently unaware of their bodies as entities, unable to reflect objectively on their own bodies' physical properties. This soon begins to change, however.

Body awareness errors declined with age, with slightly different patterns of change for the body-size and the body-as-obstacle tasks. On the body-as-obstacle tasks, 18-month-old children produced the most errors; 22-month-olds did not differ from 26-month-olds, who produced the least. This suggests that children begin representing their bodies as obstacles late in the second year, taking them explicitly into account as something that can get in the way and interfere with the action of other objects and that must sometimes be displaced or moved out of the way. Interestingly, children who had been walking longer produced fewer errors on the body-as-obstacle tasks, regardless of their age. Although a considerable literature on young children's locomotor decisions suggests an implicit understanding of their own bodies at these ages (for a review, see Adolph & Berger, 2006), the current study approaches the development of body representation from the perspective of reflective self-awareness. This is akin to the distinction made by Butterworth (1995) between ''primary'' or ''direct'' consciousness, that is, perception of self in the world, versus ''higher order'' consciousness or self as an object of thought. From this perspective we can speculate that children who have been walking longer may have encountered more of the sorts of experiences that demand explicit representation of their own bodies as whole objects with physical attributes like size, shape, and mass, as well as demanding them to reason about their bodies as independent means, causes, or obstacles in planning and completing sequences of goal-directed activity.

For the body-size tasks, the age-related decline in errors appears to occur somewhat later. For these tasks, both 18-month-olds and 22-month-olds made more errors than did 26-month-olds. Thus, representing one's body size may be somewhat more difficult than reflecting on one's body as an obstacle, and it appears to become more regular starting in the third year of life. Walking experience was unrelated to errors on the body-size tasks once age was controlled. Perhaps children's experience navigating over, around, and through the world of objects provides more opportunity to encounter their bodies serving as hindrances or impediments than it does the need to judge their body size. The ability to bring one's body size into objective awareness may be a function of other experiences or it may be related to developments in early self-concept in which one's appearance takes on a larger role (Harter, 1999).

In any case, it appears that body self-awareness begins to emerge in the latter half of the second year of life, at about the same age as mirror self-recognition and other indices of reflective self-awareness. This is consistent with the findings of Moore and colleagues (2007), who found that toddlers' ability to remove themselves from a rug attached to the rear of a shopping cart before pushing it was related to their ability to recognize themselves in a mirror. Similarly, Bullock and Lutkenhaus (1990) found that toddlers who removed themselves from the mat they were sitting on before handing it to an adult were more likely to recognize themselves in mirrors and to refer to themselves verbally. It should be noted, however, that mirror self-recognition and self-reference are evidenced by 90% of children by 24 months of age (Lewis & Brooks-Gunn, 1979), whereas in the current study children were still making many body representation errors at 24 months and even as late as 30 months of age. Thus, the development of body self-awareness appears to follow a more extended course than these other aspects of early self-awareness.

The more protracted development of body self-awareness is not altogether surprising. Self-understanding is constituted of multiple components that develop partly independently throughout childhood. Children's recognition of themselves in time-delayed videos is mastered months or years after the emergence of immediate, contingency-based self-recognition in mirrors (Moore & Lemmon, 2001; Povinelli, 1995). Gender identity, autobiographical memory, and self-presentational concerns, as distinct aspects of the developing self, also follow different developmental trajectories in older children (Banerjee, 2002; Martin, Ruble, & Szkrybalo, 2003; Povinelli, 2001; Welch-Ross, 1995). It might be expected that children's differentiated knowledge of their own body's appearance and physical characteristics would develop over several months or more following the earliest evidence of body self-awareness. An important direction for future inquiry will be to identify the full course of these developments and their correlates. Ultimately, children will be able to manipulate their own-body representations, consider their own body's characteristics from multiple perspectives, mentally compare their own body to others, and evaluate and reason about it, all as part of the developing body image and its eventual integration with the psychological self over childhood and adolescence.

Reasoning About Object Characteristics Versus Reasoning About One's Own Body

In parallel tasks that did not require children to represent and reflect on their own bodies but that did involve reasoning about object size and obstacles, toddlers also frequently made errors. Thus, comparing and thinking about the relative size of objects and about objects as obstacles is generally difficult for 1- and 2-year-olds. However, being able to reason successfully about object size and obstacles did not enhance children's reasoning about their own bodies or prevent them from making errors in representing their own body size or in thinking about their own bodies as obstacles. In fact, performance was not related across the two kinds of tasks. The fact that performance on one kind of task was not predicted by performance on the other suggests that they were tapping different abilities. In particular it is consistent with the argument that reasoning about one's body is not reducible to reasoning about other objects in the world, but depends on objective self-awareness as well (e.g., Moore, in press). It is also consistent with evidence showing that the neural mechanisms underlying mental own-body transformations in adults are different from those involved in mental rotations of objects (Blanke et al., 2005).

Other Contributors

What other processes or developments might contribute to children's performance on these tasks? DeLoache et al. (2004) raise the possibility that young children's errors such as trying to slide down a small slide or put on a doll's hat may be due, in part, to their failure to inhibit motor routines that are triggered by the perceptual similarity of the small objects to their full-size counterparts. These possibilities may reasonably account for some of the errors on the various body-size tasks in the current study as well. But the fact that the children made multiple errors on each task as well as across different tasks, and that they sought help from adults, became frustrated, tried alternative strategies when their first attempt failed, and engaged in overt problem-solving efforts suggests that the failure to inhibit automatic motor processes may not be the sole contributor. Children's systematic, repeated responses suggest deliberate, even strategic efforts to force their bodies to fit into places and spaces that are obviously impossible from an observer's perspective. Glover (2004) speculates that immaturities in the cognitive contributors to children's action planning could produce such errors. The findings from the current study raise the possibility that body self-awareness may be such a contributor. That is, children do not appear to be considering their own body size in relation to the objects' size in their action planning, thus producing impossible action plans. Until they are able to reflect explicitly on their own size in relation to the size of the objects on which they are about to act, there is no reason for them to inhibit their impossible plans or even to recognize them as impossible; thus they persevere in their errors.

The findings from neuropsychology and neuroscience research with adults, reviewed previously, raise the possibility that different brain regions may underlie objective representations of one's body and the selection and performance of actions. DeLoache et al. (2004) similarly called on a model of action planning (see Milner & Goodale, 1995) as another possible explanation of toddlers' "scale errors," specifically, that the brain regions for object identification may not yet be fully integrated with those for action control. The question raised here is what role the identification and representation of self as an object might play in the planning of actions. That is, in the current study the child must not only access relevant information about the toys and objects to plan appropriate responses, but he must also identify *himself* as an independent object within the same space and in relation to the other objects, accessing information about himself relevant for action selection and planning. In this case, to avoid trying to slide down a too small slide, even though he knows that slides are for sliding, the child must explicitly reflect on and consider his own size in relation to the slide's size. This means that he must see himself through others' eyes, relying on a third-person representation of himself. As others have argued, toddlers' representational systems are immature when it comes to integrating third-person perspectives on themselves, such as how big they are or where they are in space, with their own first-person perspectives on themselves and their actions as they engage the world (Barresi & Moore, 1996; Moore et al, 2007; Perner, 1991; Piaget, 1954). Thus, perhaps children who make multiple, repeated body-awareness errors do not yet process the objective physical information about their own bodies in the same way or in the same representational format as they do other objects; objective information about the child's own body may not yet be available to the representational systems that process information about object characteristics and that generate appropriate action selection and planning. In a sense, the conceptual self, or self-as-object, must come to inform the implicit self, or self-as-subject.

Another possibility is that these very young children can and do explicitly represent and reflect on the size of their own bodies in relation to things in the world, but they are especially poor at estimating just how big they actually are; in effect, they underestimate their own size (G. Michel, personal communication, April 2005). Toddlers' rapid physical growth could conceivably contribute to such estimation errors. We cannot rule out this possibility with the results of the current study, although it is telling that the youngest children were also very poor at two quite different body-awareness tasks that required them to reason about their bodies as obstacles rather than to estimate their body size. Indeed, it is likely that many factors contribute to children's performance on these tasks, and that body self-awareness is but one.

Conclusions and Implications

Based on the findings from the current research, body self-awareness appears to be a distinct dimension of reflective self-awareness that emerges in the second year of life in concert with other aspects of the objective self (Barth et al., 2006; Moore, in press). Recent research in neuroscience and neuropsychology implicates several unique cortical regions in adults' conscious awareness of their own bodies and body movements (e.g., Berti et al., 2005; Chaminade et al., 2005; Ehrsson et al., 2005). As developmental neuroscience acquires the tools for studying brain structure and function in young children, it will be interesting to explore associations between developmental changes in brain and corresponding age-related changes in body self-awareness, both as cause and as effect.

Emergence of a conscious, reflective awareness of self represents one of the central social-cognitive achievements of early childhood. Toddlers demonstrate their growing self-awareness as they recognize themselves in mirrors and photos, use their given name or personal pronouns to refer to themselves, claim first-person ownership (''Mine!''), represent themselves symbolically in pretend play, and express personal preferences for what to wear or eat, where to go, and what they are willing to do. Included in these dimensions of self is objective body self-awareness. Although infants exhibit an implicit awareness of their bodies in the first year of life (Rochat, 2001), watching and playing with their hands and feet, directly perceiving themselves acting and interacting, and discriminating their own bodies from others, they do not appear to reflect on and conceptualize themselves as distinct objects, with objective physical characteristics like size, mass, solidity, and extent until late in the second year. This developmental achievement, with a more protracted course than some other measures of objective self-awareness, marks the beginning of the child's representation of his or her own specific, coherent three-dimensional shape and appearance. Because this means imagining oneself from a third-person perspective, it also, interestingly, provides the wherewithal to begin to use one's own body deliberately as a tool and to manipulate or alter one's body as a ''means of personal expression'' (Muller & Liebermann, 2004, p. 111) via dance, posture, facial expression, and other movement, as well as by adornment and intentional modifications of one's size, shape, or appearance.

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