II. VISUAL HABITUATION STUDIES: INFANTS' RESPONSES TO TYPICAL AND SCRAMBLED BODY PICTURES

This series of studies explores the early development of visuo-spatial human body knowledge in infancy. To achieve this, infants' responses to typical and scrambled human body shapes were tested. As reviewed above, previous work showed that in a preferential looking paradigm, only 18-month-olds appeared to discriminate scrambled from typical human body shapes. This pattern is inconclusive, however, because a lack of preference in younger infants is ambiguous with respect to whether they can discriminate the two types of body shapes. The studies reported below utilized habituation procedures in which infants were presented with typical body shapes until habituation was established, then on the test trials scrambled body shapes were presented, to test for discrimination of the two types of body shapes.

The habituation studies were designed to incorporate the six typical and six scrambled body shapes used in our previous work. This is because, as noted above, those body shapes were originally created such that they make basic-level cuts in the body part hierarchy, and they control for overall amount of contour as well as for symmetry. Given the results of the visual preference studies, it was hypothesized that 18-month-olds, who preferred scrambled body shapes in the visual preference paradigm, would also discriminate typical and scrambled human body shapes in the habituation paradigm. Younger infants' performance was not predicted based on previous findings; thus the performance of 12- and 15-month-olds, who showed no visual preference for typical or scrambled body shapes, was of particular interest.

Typically, habituation procedures have not been used with infants older than 12 months of age. The relatively mature age of the sample and the decision to incorporate the six typical and six scrambled body shapes from previous work, constrained the design of the habituation studies somewhat. In order to get relatively mature, easily bored one-year-olds though the procedure, a minimal habituation paradigm was used whereby infants were habituated to one type of body shape, then shown all six exemplars from the other body shape category.[2]

For all of the studies in this chapter, the basic procedure was similar: Infants were first habituated to a series of typical human body shapes. Habituation was defined as a 50% decrement in looking time during the first three trials over three subsequent trials. Once the habituation criterion was reached, then infants were shown the scrambled body test stimuli. In Studies 2 and 4, the test stimuli consisted of a single scrambled stimulus. In Studies 1, 3, and 5, the test stimuli consisted of a series of scrambled body shapes. Infants' looking times were coded into blocks: the first three trials (which represented the baseline for the habituation criterion), the final three habituation trials (which represented the 50% decrement in looking from baseline), and where appropriate, the first three dishabituation trials and the final three dishabituation trials. The analyses were conducted as follows: (a) a comparison of looking over the first three habituation trials compared to the final three habituation trials, to confirm that habituation genuinely occurred in any given condition, (b) a comparison of looking over the final three habituation trials compared to the first three dishabituation trials (where there was more than one scrambled test stimulus), to test for discrimination of the different body types, (c) a comparison of looking on the final habituation trial compared to looking on the initial dishabituation trial, to evaluate infants' initial responses to the new body type, and (d) comparison of looking on the first three dishabituation trials and the final three dishabituation trials (where there was more than one scrambled test stimulus), to explore infants' responses to repeated exposures to the new body types. The statistical analyses for each study reported below follow generally along these lines.

We also included nonparametric analyses to confirm the patterns found in the looking-time data. The idea was to classify infants as noticing or not noticing the transition to a new body type. One way to achieve this would have been to designate infants as noticing if they looked longer at the test stimuli. That would mean any increase in looking would constitute noticing, however that criterion struck us as too liberal because some infants recover looking by only 25 ms, whereas others recover by several seconds. Which infants genuinely noticed the new body type? We decided that the best approach would be to evaluate infants' looking patterns on previous habituation trials to assess how variable their looking was in the first place. To account for individual variation in looking behavior across infants, we used infants' own variability in looking as a criterion for passing. We therefore calculated the standard deviation of infants' final three habituation trials, and used that number to represent their individual looking variability when the patterns were all from the same body-type category (e.g., all typical bodies). If on the first test trial, their recovery in looking exceeded that standard deviation and their total recovery of looking was in excess of one second, then they were classified as noticing the new pattern. That means that they recovered interest to the new body type by an amount that exceeded their own established baseline variability in looking on the previous three trials. We took this as an acceptable measure of increase in looking; it is arbitrary but it takes infants' own looking patterns into account. For example, data for one 18-month-old's final three looking trials were 3388, 1294, and 384 ms, respectively. The *SD* for these scores is 1540 ms. This 1540 ms represents the average variation in looking when the patterns are similar. For this infant to qualify as a noticer, his looking time on the initial test trial had to increase by more than 1540 ms over the final habituation trial. This infants' looking time on the first test trial was 3873 ms, an increase in looking compared to the final habituation trial, but more importantly also an increase on his average variation in looking over the previous three trials.

We also included walking experience as a subject variable, based on the idea that sensori-motor, visuo-spatial and lexical–semantic levels of body knowledge may interact. As noted above, some authors suggest that the visuo-spatial and lexical–semantic levels of body knowledge may derive from or depend upon earlier-developing sensori-motor representations (Buxbaum & Coslett, 2001; Lefford, Birch, & Green, 1974; Poeck & Orgass, 1975). While there is currently no direct evidence for such an interaction of body knowledge in development, research with adult participants confirms that body knowledge may interact across levels. For example, Reed and Farah (1995) found that when adults moved their own bodies, their performance on a body picture matching task improved. Reed and Farah offered two interpretations of their data: They suggested that this might implicate a supramodal representation that codes simultaneously for one's own moving body and the spatial layout of the bodies of others, or alternatively it may implicate an interaction of sensori-motor and visuo-spatial representations of the body. On either interpretation, moving one's own body improves recognition of the bodies of others; by including walking as a variable in the visual discrimination studies, we investigate whether a similar effect might be evident in development.

Finally, gender was also included as a subject variable in all studies, based on reports that girls tend to outperform boys on body part localization tasks (e.g., MacWhinney, Cermak, & Fisher, 1987). This suggests that girls may acquire visuo-spatial body knowledge earlier than boys do.

STUDY 1: CATEGORICAL DISCRIMINATION OF SCHEMATIC HUMAN BODY SHAPES

The purpose of this study was to establish at what age infants first discriminate scrambled from typical human body shapes. Infants were shown a series of line drawings of typical human bodies in various postures, until they were habituated. Next, they were presented with a series of scrambled human body shapes. Looking times to all human body pictures were measured. On the basis of previous research (Slaughter et al., 2002) it was predicted that 18-month-olds, and possibly also younger infants, would show a recovery of interest upon presentation of the scrambled human body shapes. Such a discrimination would implicate the presence of a visuo-spatial representation of the body, as it involves infants' noticing violations of the canonical spatial layout of the human body.

Method

Participants

These were 20 12-month-olds (mean (*M*) age, 12 months and 4 days; range, 11 months 17 days to 12 months 16 days; 13 boys, 7 girls), 20 15-month-olds (*M* age, 15 months and 2 days; range, 14 months 16 days to 15 months 30 days; 9 boys and 11 girls), and 20 18-month-olds (*M* age, 18 months and 13 days; range 18 months 2 days to 18 months 21 days; 10 boys, 10 girls). An additional 12-month-old and two 15-month-olds were tested but excluded from the final sample due to excessive fussiness or experimenter error. In this study and the studies reported in the remainder of this chapter, excessive fussiness was defined behaviorally as a refusal to face forward in the highchair, and/or refusal to fixate the pictures on three consecutive trials, and/or inconsolable crying. Fussiness resulted in immediate termination of testing and all data were discarded.

Infants' names were taken from birth announcements of a local newspaper, or from an existing subject pool. Parents were contacted via mail and telephone and anyone who volunteered to participate did so. The sample was mainly Caucasian, living in suburbs around the Brisbane metropolitan area.

Materials

The stimuli consisted of six pictures depicting typical human bodies, and six pictures depicting scrambled human bodies. Pictures were black line drawings on white paper (30 cm $\times$ 21.5 cm). Excluding body shape and posture all drawings were identical. The six typical body pictures (left to right, top row of Figure 1) represented the human body in a variety of postures, including: (a) left leg bent at knee, shin parallel to the ground and right arm extended at 70°, left arm hanging by side, (b) feet shoulder width and arms hanging by sides, (c) feet shoulder width and arms extended from shoulders at 90°, forearms raised, (d) feet shoulder width and arms extended from shoulders at 70°, (e) feet shoulder width and arms raised above the head and (f) feet spread wide and arms hanging by sides. The scrambled body pictures (left to right, bottom row of Figure 1) represented violations of the typical human body shape, and were constructed by moving the limbs to noncanonical locations on the body, including (a) legs attached at shoulders and arms attached at hips, (b) feet shoulder width and arms attached at ears and raised upwards, (c) feet shoulder width and arms hanging by sides but right arm and leg switched, (d) feet shoulder width and arms attached at ears and hanging down, (e) feet shoulder width and arms hanging by sides but attached at hips, (f) arms, legs and head disconnected from the torso and floating in canonical positions.

Pictures were presented to the infant using a viewing screen (90 cm × 120 cm) that contained a single picture on the left-hand side of the screen. A piece of cardboard was used to cover the picture between trials. A hole in the middle of the screen allowed video recording of the infant.

An iMac was used to run the timing program that calculated infants' looking over trials and signalled with a single quiet beeping sound when the habituation criterion was met.

Procedure

On arrival at the university, the infant and mother were escorted to a room where the infant could play to warm up. Following this, they were brought to the testing room where the infant was seated in a high chair facing the viewing screen that was situated 1.5 m in front of the infant. The mother sat on the right of the infant facing away from the viewing screen. If the infant began to cry, or refused to stay seated in the infant seat, he/she was transferred to the mother's lap with both mother and infant facing the screen. In both instances mothers were requested not to speak or interact with their infants while the experiment was in progress. The experimenter was behind the apparatus (not visible to the infant). Individual trials began with the experimenter shaking a rattle to direct the infant's attention to the viewing screen, then lifting the covering cardboard to reveal the first human body picture. As soon as the picture was visible to the infant, the 15-second trial began. Once 15 s were passed the experimenter replaced the covering cardboard, changed pictures, then removed the cardboard again to begin the next trial. An infant controlled habituation method was employed (see Coding section for details). Infants viewed a minimum of six typical bodies, and a maximum of 12 typical bodies. Once habituation to typical bodies had occurred, the six scrambled body pictures were presented individually. The order of the typical body pictures presented was the same for each infant (if more than six were required to reach habituation the order of presentation of typical bodies was repeated). The order of scrambled bodies presented was rotated through a Latin Square across infants, so that the first scrambled picture shown to the infant moved to the last position and the second picture moved to the first position for the next infant and so on. The entire session lasted approximately 5–10 min.

Coding

Looking time was defined as the amount of time infants spent looking at the picture presented. Looking times were coded on line during the experiment using a computer program that calculated and averaged ongoing looking times. Habituation was defined as a 50% decrement in looking time during the first three trials over three subsequent trials. Thus the minimum number of typical body looking trials was six (the three first trials, then three more trials to reach the 50% looking time criterion). Infants' looking times were recoded after the experiment was complete.

Twenty-five percent of the data were randomly recoded for reliability by a second coder who was naïve to the hypotheses under investigation. The agreement between the two coders was 88%. For statistical analysis, values were taken from the looking times recorded by the first observer. All looking times reported are in milliseconds.

Results and Discussion

Four 12-month-olds, one 15-month-old and two 18-month-olds did not provide data for the final 3 scrambled body trials. Their data on other trials were retained for analysis.

To confirm that the habituation criterion was met for the typical bodies, the mean looking times for the first three trials where typical bodies were presented were compared with mean looking times for the final three typical body trials. The respective means were as follows: 4390.73 ms (SD = 2121.97 ms) and 2296.20 ms (SD = 1396.73 ms) for the 12-month-olds, 7592.28 ms (SD = 2675.05 ms) and 3837.97 ms (SD = 2276.94 ms) for the 15-month-olds, and 8628.90 ms (SD = 3297.68 ms) and 3790.13 ms (SD = 2472.45 ms) for the 18-month-olds. These data indicate that infants showed a decrement in looking to the typical body pictures prior to presentation of the scrambled body pictures. The mean number of typical body trials required for the habituation criterion to be met was 8.35 (SD = 2.31), 7.90 (SD = 2.42) and 7.40 (SD = 1.80) for the 12-, 15- and 18-month-olds, respectively.

Next, infants' looking over the final three typical body trials was compared with their looking over the first three scrambled body trials, to test whether they noticed the transition from typical to scrambled body shapes. Looking times on the final three typical body trials and the initial three scrambled body trials were averaged and then treated as a repeated measure. To test whether infants dishabituated upon presentation of the scrambled body shapes, a 2 (gender) × 3 (age group: 12-, 15- and 18-month-olds) × 2 (body type: typical bodies vs. scrambled bodies) mixed model ANOVA was computed, where body type was a repeated measure and looking time was the dependent variable. This analysis revealed significant main effects for age, $F(2,54) = 23.30$, $p < .001$, $\eta^2 = .46$ and body type, $F(1,54) = 34.39$, $p < .001$, $\eta^2 = .39$, qualified by a significant age × body type interaction, $F(2,54) = 15.27$, $p < .001$, $\eta^2 = .36$. The interaction indicated that infants of different ages showed distinct patterns of responding to the introduction of scrambled bodies following the typical body presentations. Follow-up *t*-tests revealed significantly longer looking times for the scrambled bodies compared to the typical bodies for the 15-month-old infants, $t(19) = 2.73$, $p < .025$, (*M*, typical bodies 3837.96 ms, scrambled bodies 5360.36 ms; *SD* = 1805.77 ms, 2565.67 ms, respectively) and the 18-month-old infants, $t(19) = 6.25$, $p < .001$, (*M*, typical bodies 3790.13 ms, scrambled bodies 7503.12 ms; *SD* = 1456.10 and 3257.25 ms, respectively). The 12-month-olds showed no significant difference in looking to the typical and scrambled bodies $t(19) = .81$, *ns*, (*M*, typical bodies 2296.20 ms, scrambled bodies 2092.68 ms; *SD* = 822.76 and 798.50 ms, respectively). This pattern indicated that infants of 15 and 18 months of age were sensitive to the transition from typical human bodies to scrambled human bodies. The 12-month-olds, in contrast, did not notice that transition.

Next a similar analysis was performed comparing infants' looking on the final typical body presentation and the first scrambled body presentation. This comparison is less conservative than the previous one, because it compares looking on the final, most "boring" typical body trial, with looking on the initial scrambled body trial, where a novel stimulus has first been introduced. A 2 (gender) × 3 (age group: 12-, 15- and 18-month-olds) × 2 (body type: typical vs. scrambled body) mixed model ANOVA was computed, where body type was a repeated measure and looking time was the dependent variable. Results revealed significant main effects for age, $F(2,54) = 15.60$, $p < .001$, $\eta^2 = .37$, and for the repeated measure body type, $F(1,54) = 37.83$, $p < .001$, $\eta^2 = .41$, qualified by a significant age × body type interaction, $F(2,54) = 8.98$, $p < .001$, $\eta^2 = .25$. Again, the significant age by body type interaction indicated that infants' change in looking times from the typical to scrambled body pictures varied by age group. Follow-up *t*-tests indicated significantly longer looking times for the first scrambled body compared to the final typical body for the 15-month-old infants,

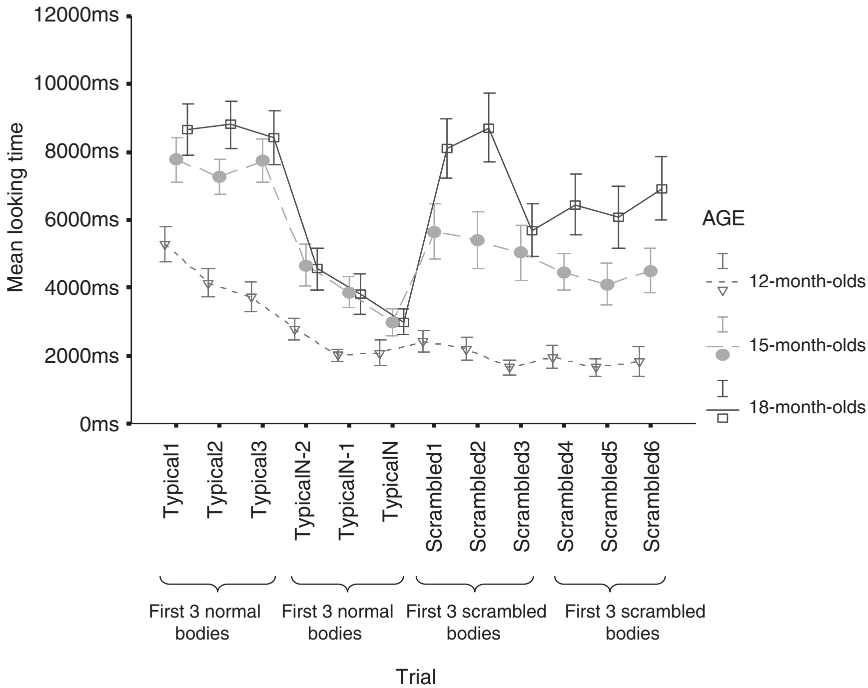

FIGURE 2.—Looking times for the first 3 typical body trials, the last 3 typical body trials and the 6 scrambled body trials by age group in Study 1.

$t(19) = 2.98$, $p < .005$ (*M*, typical body 2976.55 ms, scrambled body 5655.20 ms; *SD* = 1744.85 and 3626.38 ms respectively) and the 18-month-old infants, $t(19) = 5.58$, $p < .001$, (*M*, typical body 2999.75 ms, scrambled body 8101.70 ms; *SD* = 1727.86 and 3879.83 ms, respectively). Thus the older infants were immediately sensitive to the transition from typical to scrambled human body shapes. The 12-month-olds showed no significant difference in looking upon presentation of the first scrambled body, $t(19) = 1.08$, *ns*, (*M*, typical body 2082.25 ms, scrambled body 2422.80 ms; *SD* = 1738.37 and 1461.52 ms, respectively). Figure 2 shows the looking times for the first three typical body trials, the last three typical body trials and the six scrambled body trials, by age group. This figure makes it graphically clear that the 12-month olds, in contrast to the older infants, did not dishabituate, even upon presentation of the initial scrambled human body.

An examination of individual infants' looking patterns to the typical and scrambled body line drawings revealed that of the 12-month-old infants, three of the 20 infants (15%) looked longer (by our criterion described above) at the first scrambled body picture than the final typical body picture. In contrast, 10 of the 20 15-month-old infants (50%) looked longer at the first scrambled body picture compared to the final typical body picture, and 18 of the 20 18-month-old infants (90%) noticed the first scrambled body picture by our criterion. This pattern confirms that seen in the looking-time data, and indicates that sensitivity to scrambled human body shapes is not evident at 12 months of age, but increases between the ages of 15 and 18 months.

As noted above, there is reason to hypothesize that sensori-motor and visuo-spatial body knowledge may interact, so in accordance with this idea, the results for the 12-month-olds were further analyzed with respect to whether or not the infants had begun walking. A 2 (walking or not) × 2 (body type: final typical versus first scrambled) mixed model ANOVA with body type as the repeated measure was run on the 12-month-old's looking time data. The purpose of this analysis was to explore whether upright motor experience would be related to infants' capacity to discriminate scrambled from typical bodies. The ANOVA revealed a significant walking by body shape interaction, $F(1,18) = 7.82$, $p < .02$, $\eta^2 = .08$, suggesting that infants' walking status was related to their dishabituation responses. Follow-up paired t-tests indicated that infants who were walking showed a significant increase in looking to the scrambled body shape, paired $t(9) = 2.56$, $p < .05$, (M, typical body 1729.70 ms, scrambled body 2826.90 ms; $SD = 845.32$ and 1297.43 ms respectively), while infants who were not yet walking did not significantly dishabituate to the scrambled body, paired $t(9) = 1.26$, *ns*, (M, typical body 2434.80 ms, scrambled body 2018.70 ms; $SD = 1569.50$ and 2321.39 ms, respectively). Further, all three 12-month-olds who noticed the transition to scrambled body shapes according to the nonparametric analysis presented above, were already walking. These data indicate that that those 12-month-olds who were walking were more likely to be sensitive to the transition from typical to scrambled human body shapes than their nonwalking peers, suggesting that walking experience may be related to the early development of a visuo-spatial human body representation. However, it should be noted that those infants who were relatively early walkers may also have been relatively accelerated in a number of developmental domains besides gross motor development. Thus while this analysis tentatively suggests a link between sensori-motor body representations, implicated in motor development, and visuo-spatial body representations, implicated in the visual discrimination of scrambled from typical body shapes, the issue requires further study.

In the next analysis, infants' dishabituation was investigated with respect to the specific scrambled body shape presented in the first scrambled body trial. This analysis was performed in order to explore whether any

TABLE 1

MEAN DIFFERENCE SCORES (IN MILLISECONDS) COMPARING LOOKING TIMES TO FINAL TYPICAL BODIES VERSUS THE FIRST SCRAMBLED BODIES, BY SCRAMBLED BODY SHAPE IN STUDY 1

Scrambled Shape	Mean Difference (ms)	*df*	*t*-Value
Averaged total	– 2707.05	59	– 5.40**
Arms raised from head	– 3959.00	8	– 2.44*
Arms hanging from hips	– 3513.50	7	– 2.34*
Limbs disconnected	– 1871.89	8	– 1.63
Both arms/legs switched	– 3924.83	11	– 3.30**
One arm/one leg switched	– 277.22	8	– .33
Arms hanging from head	– 2480.31	12	– 2.60*

*$p < .05$.
**$p < .01$.

particular scrambled body shape was more or less salient than the others. Infants of all ages were included in this analysis to increase power. Table 1 shows that infants dishabituated significantly to all of the scrambled body shapes except the one leg/arm switch figure (third from left, bottom row Figure 1) and the limbs disconnected figure (far right, bottom row Figure 1). These two scrambled bodies, therefore, appear to be less salient than the other four scrambled bodies; this is not surprising as these two scrambled bodies are arguably less monstrous than the rest; the one leg/arm switch figure requires detailed inspection to notice the limb switch, and the limbs disconnected figure does not violate the canonical locations for the head and limbs, it simply disconnects them from the torso. Thus this analysis provides some evidence for a continuum of saliency for human body violations; all scrambled bodies are not created equal.

Finally, infants' responses to the six scrambled bodies in the dishabituation phase were investigated. A 2 (gender) × 3 (age group: 12-, 15- and 18-month-olds) × 2 (presentation: first three scrambled bodies vs. final 3 scrambled bodies) ANOVA was computed with presentation as the repeated measure and looking time as the dependent variable. This analysis revealed a significant main effect of age, $F(2,47) = 30.55$, $p < .001$, $\eta^2 = .57$, and a marginal effect of presentation, $F(1,47) = 3.60$, $p < .07$, $\eta^2 = .07$. Follow-up t-tests investigating the effect of presentation revealed that infants at all ages looked longer at the first three scrambled bodies compared to the final three scrambled bodies, $t(52) = 2.02$, $p < .05$ (*M*, first three scrambled bodies 9082.16 ms, last three scrambled bodies 4370.16 ms, *SD*s = 3239.89 ms and 2687.06 ms, respectively). This pattern reflects a new habituation process (to the category of scrambled bodies) for the older infants, and continuing decrement in looking for the 12-month-olds.

Overall, the results of Study 1 confirm that, as predicted from the visual preference work, 18-month-olds discriminate between typical and scrambled human body shapes. The results further indicate that 15-month-olds are sensitive to violations of the typical human body shape, evidenced by their recovery of interest following the transition from typical to scrambled body shapes. Infants of 12 months, on the other hand, did not, as a group, show recovery of interest when scrambled body shapes were presented, although the subset of 12-month-olds who were walking did show evidence of discrimination of scrambled from typical body shapes. This walking effect is reminiscent of Reed and Farah's (1995) finding of a facilitating interaction between body movement and body perception in adults, but as noted above, the developmental data must be interpreted with caution.

Thus it appears that both 15- and 18-month-olds have a visuo-spatial representation of the human body that supports a categorical discrimination between typical body shapes and scrambled body shapes. We argue that this is a categorical discrimination because in order to notice a difference between the first set of (typical) bodies and the second (scrambled) set, infants had to generalize across exemplars (e.g., the six individual typical bodies in different poses) and then recognize the scrambled bodies as non-members of the typical human body category. This means that the visuo-spatial knowledge of infants 15 months of age and older, is flexible enough to allow generalized recognition of the typical human body shape across different postures. Infants may acquire this human body knowledge on-line during the experimental procedure, or alternatively they may have come to the experiment with an already established visuo-spatial representation of the human body. This study does not allow us to distinguish between these two developmental alternatives; we return to this issue in Study 5 below.

The 12-month-olds' failure to discriminate between scrambled and typical human body shapes suggests two interpretations. The first is that at 12 months of age infants (as a group—we are putting aside the walking effect for the moment) have some visuo-spatial knowledge of the body, but it is not detailed enough to do the scrambled versus typical body discrimination task. Alternatively, it is possible that 12-month-olds have not yet acquired any human body knowledge at the visuo-spatial level. We discuss these two alternatives in more detail below.

STUDY 2: 12-MONTH-OLDS' DISCRIMINATION OF INDIVIDUAL SCHEMATIC HUMAN BODY SHAPES

The results of Study 1 suggested that infants develop a detailed visuo-spatial representation of the typical human body by age 15 months. This conclusion was based on the fact that infants of that age made a categorical discrimination between typical and scrambled bodies in the visual habituation task. However, in order to confirm that the 15- and 18-month-olds make a such a discrimination, that the 12-month-olds fail to make, it is necessary to run a control study showing that young infants are capable of discriminating between individual exemplars within the two categories.[3] If the youngest infants discriminate between two different typical bodies or two different scrambled bodies, but not between typical and scrambled bodies by group, that would demonstrate that they are capable of perceptually discriminating human body shapes, but lack a visuo-spatial human body representation that engenders categorization of those shapes as being typical or scrambled. It would also support the claim that older infants' discrimination of scrambled versus typical body shapes is indeed categorical, as older infants should be able to make a simple perceptual discrimination between individual bodies as well as their younger counterparts. Thus Study 2 addressed the following question: Can 12-month-old infants make a simple perceptual discrimination between two individual human body shapes, even though they do not make a categorical discrimination between typical and scrambled body shapes in general?

Method

Participants

Infants were recruited in a manner identical to that of Study 1. For the typical body discrimination task, there were 12 infants ranging in age from 11 months 20 days to 12 months 20 days, *M* age 12 months 5 days. There were five boys and seven girls. For the scrambled body discrimination task there were 12 infants ranging in age from 11 months 14 days to 12 months 14 days, *M* age 12 months 2 days. There were four boys and eight girls.

Materials

Stimuli were the human body line drawings used in Study 1 (see Figure 1).

Procedure

Study 2 used a standard habituation/dishabituation procedure. In the typical body discrimination task, infants were presented with a single typical human body shape (from the top row of Figure 1) repeatedly until the habituation criterion was met. Trials were seven seconds each in length (shorter than the previous experiment because the task was more boring). Habituation was defined as a 50% decrement of looking from the first two trials (averaged) to a subsequent two trials. Thus four was the minimum habituation trials, and infants were shown a maximum of 10 trials; even if the habituation criterion was not met after 10 trials, the test stimuli were presented.

On the first test trial, a novel typical body shape (also from the top row of Figure 1) was presented. Following this, the familiar typical body picture was again presented. These trials were also seven seconds long.

The scrambled body discrimination task was identical with the exception that the two pictures presented to infants were scrambled bodies from the bottom row of Figure 1. Thus, one scrambled body picture was presented repeatedly during the habituation phase and a novel scrambled body picture was presented for the test trial. Following this, the familiar scrambled picture was again presented.

Given that in each condition (typical and scrambled) there were six different body pictures, it was not possible to exhaustively pair the pictures within categories. Therefore each infant saw two pictures (one as the habituation stimulus and one as the test stimulus) and counterbalancing ensured that each picture served once as the habituation stimulus and once as the test stimulus, across infants. Aside from this constraint, the pairing of pictures was random.

Coding

Infants' looking across all trials was timed and a naive viewer recoded all trials (because the looking times were quite short in this study, we performed reliability on 100% of the data to ensure that the results were accurate). Inter-coder reliability was 87% and as before, values were taken from the looking times recorded by the first observer. All looking times reported are in milliseconds.

Results and Discussion

Three infants were omitted due to fussiness (two from the typical discrimination task and one from the scrambled discrimination task).

The mean number of trials to habituation across both tasks was 5.13 (*SD* = 1.15). To ensure that infants were genuinely habituated, the means for the first two typical body trials and the final two typical body trials were compared. We compared the first and last two trials, rather than three as in Study 1, because habituation occurred more quickly in this procedure. For the first two trials of the typical discrimination task, the mean looking time was 3387.3 ms (SD = 1063.9 ms) and for the final two trials the mean looking time was 1228.7 ms (SD = 813.6 ms). For the first two trials for the scrambled discrimination task, the mean looking time was 2313.5 ms (SD = 1045.5 ms) and for the final two trials the mean looking time was 1150.1 ms (SD = 885.9 ms). These numbers confirm that infants met the habituation criterion of 50% decrement in looking before they were presented with the test trials.

Pre-planned paired t-tests were conducted to evaluate infants' responses to the novel picture presented in the test trial compared with their responses to the last picture presented during habituation. For the typical body discrimination task, this analysis revealed that infants looked significantly longer at the novel typical body compared to the familiar typical body, $t(11) = 3.03$, $p < .02$, (M = familiar typical body 1113.42 ms, novel typical body 2954.00 ms; SD = 1198.06 ms, 1692.51 ms, respectively). This indicated that infants noticed the difference between the two individual typical body pictures. A comparison between the novel typical body and the subsequent familiar typical body (presented directly after the novel typical body) revealed that infants showed a significant decrement in looking to the repeated presentation of the familiar typical body compared with their previous looking time to the novel typical body, $t(11) = -4.03$, $p < .01$, (M novel typical body 2954.00 ms, familiar typical body 912.42 ms; SD = 1692.51 and 1195.67 ms, respectively). This indicated that infants' recovery of interest to the novel typical body on the previous trial was a genuine recovery of interest to a new pattern, rather than a response to the novelty of the picture changing procedure.

The scrambled body discrimination task revealed the same pattern of responding: Infants looked significantly longer at the novel scrambled body compared to the final presentation of the familiar scrambled body, $t(11) = 3.03$, $p < .02$ (M, familiar scrambled body 1197.00 ms, novel scrambled body 2448.42 ms; SD = 618.77 and 1257.65 ms, respectively). They also showed a decrement in looking to the re-presentation of the familiar scrambled body, compared with their previous looking at the novel scrambled body, $t(11) = -2.14$, $p < .057$, (M, novel scrambled body 2448.42 ms, familiar scrambled body 1452.92 ms; SD = 1257.65 and 1522.61 ms, respectively).

This pattern of responding was confirmed with our nonparametric analysis. An examination of individual infants' looking patterns to the last familiar individual body picture and the novel individual body picture revealed that for the typical body discrimination task, 10 of the 12 infants (83%) looked longer at the novel body compared to the last familiar body. For the scrambled body task, eight of the 12 infants (67%) looked longer at the novel scrambled body compared to the last familiar scrambled body.

Thus the pattern of data from Study 2 demonstrated that 12-month-old infants can discriminate between two individual human body pictures. Comparing the result of Studies 1 and 2, it appears that at 12 months, infants can detect a change in the configuration of the human body shape; they notice when an individual typical body changes postures (in the typical body discrimination task) or when an individual scrambled body looks different (in the scrambled body discrimination task). However, 12-month-old infants do not have access to a categorical representation of the typical human body shape that could support discrimination of scrambled from typical human body shapes, as required in Study 1.

We did not include older infants in this study because Study 1 showed that by 15 months, infants are capable of making the more complex discrimination between scrambled and typical human body shapes. Additionally, pilot testing indicated that this simple task was so boring that 15-month-olds would not sit through it. We, therefore, assume that if 12-month-olds can make the simple perceptual discrimination between two individual body shapes, then so should 15- and 18-month-olds. This assumption supports our claim that the older infants in Study 1 were responding categorically to the typical and scrambled body shapes presented. Again, these data suggest that by 15 months, infants possess a visuo-spatial representation of the typical spatial layout of the human body that allows them to discriminate scrambled from typical human bodies.

STUDY 3: CATEGORICAL DISCRIMINATION OF HUMAN BODY PHOTOGRAPHS

The pattern of data in the previous two studies suggests that 12-month-olds, perhaps surprisingly, do not categorically discriminate scrambled from typical human body shapes. Our interpretation of these data is that before 15 months of age, infants lack a detailed representation of the spatial layout of the human body. There is an alternative interpretation, however. It is possible that in the previous studies, 12-month-old infants did not recognize the schematic line drawings as portraying human bodies. This interpretation implies that whatever knowledge infants have about the human body, it did not come to bear on their performance in Studies 1 and 2, instead they were simply responding to meaningless black and white patterns on paper.

Our purpose is to understand how knowledge about the human body originates and develops, with a particular focus on the visuo-spatial level of body knowledge. This knowledge should be relevant to all sorts of human bodies, from the schematic stimuli we have thus far presented, to real human bodies, although ultimately the question of whether and when human body knowledge generalizes across stimulus types is an open empirical one. As reviewed in Chapter I, there is good reason to believe that in older children and adults, human body knowledge does generalize across all sorts of stimulus types: 2-year-olds localize body parts equally well on their own bodies and dolls' bodies (Witt et al., 1990), and autotopagnosic adults similarly show equivalent responding across different types of human body stimuli (Denes et al., 2000; Guariglia, et al., 2002; Ogden, 1985). However, the two studies presented in this monograph thus far involve infants and toddlers younger than age two, and this may be important because the third year of life marks important changes in the development of children's capacity to understand and make use of external representations (DeLoache, 1995; Perner, 1991; Suddendorf, 2003). While the human body line drawings used in Studies 1 and 2 are easily recognized by adults as depictions of human bodies, it is possible that the same is not true of young infants. Casual observation from our lab suggests that at least some of the infants in Studies 1 and 2 immediately recognized the line drawings as human male figures; a number of infants responded to the line drawings with excited pointing that suggested recognition of the typical human as such, and more than one infant responded to the first typical body by declaring "Daddy."

Despite these observations, it remains a possibility that infants would respond differently if the stimuli were real humans. It is conceivable that the poor performance of 12-month-olds on the discrimination task derives somehow from a failure to recognize the line drawings in Figure 1 as representations of human bodies. It is also conceivable that the good performance of older infants could be affected if the task involved more realistic human body stimuli. Since it is not possible to scramble real human bodies, we addressed this issue by replicating Study 1, with an important difference, namely, the human body stimuli in Study 3 were color photographic images (instead of black and white line drawings), projected on large viewing screens to create relatively realistic, closer to life-sized, human body images. This procedure was also carried out in Slaughter et al.'s (2002) studies; there we found no difference in responding when the stimuli were human body line drawings versus photographs, but that study was limited in that it involved only a small sample of 12- and 18-month-olds, who were tested in a visual preference procedure. Thus Study 3 addressed the question of whether 12-, 15- and 18-month-olds' discrimination of scrambled from typical body shapes would be influenced by the realism of the human body stimuli.

Method

Participants

Infants were recruited in a manner identical to that of Study 1. Statistical analyses were based on a total of 59 infants. These included 20 12-month-olds (*M* age, 12 months and 7 days; range, 11 months 17 days to 12 months 20 days; 11 boys, 9 girls), 20 15-month-olds (*M* age, 15 months and 4 days; range, 14 months 14 days to 15 months 19 days; 10 boys, 10 girls) and 19 18-month-olds (*M* age, 18 months, 10 days, range 18 months 0 days to 18 months 21 days; 10 boys and nine girls). An additional five 12-month-olds and seven 15-month-olds were tested but excluded from the final sample due to excessive fussiness.

Materials

The stimuli were identical to those of Study 1 with respect to body shape (both typical and scrambled). However, these human body images were enlarged color photographs projected onto a screen instead of line drawings. Typical body photographs depicted a young adult human male of average stature and weight wearing black boy-leg swimming togs. Scrambled photos were created by scrambling the photograph of the typical human body using Adobe Photoshop software. See Figure 3 for the typical and scrambled human body photographs.

Procedure

The procedure was identical to Study 1 with the following exceptions. Images of body shapes were projected onto a large screen (100 cm ×

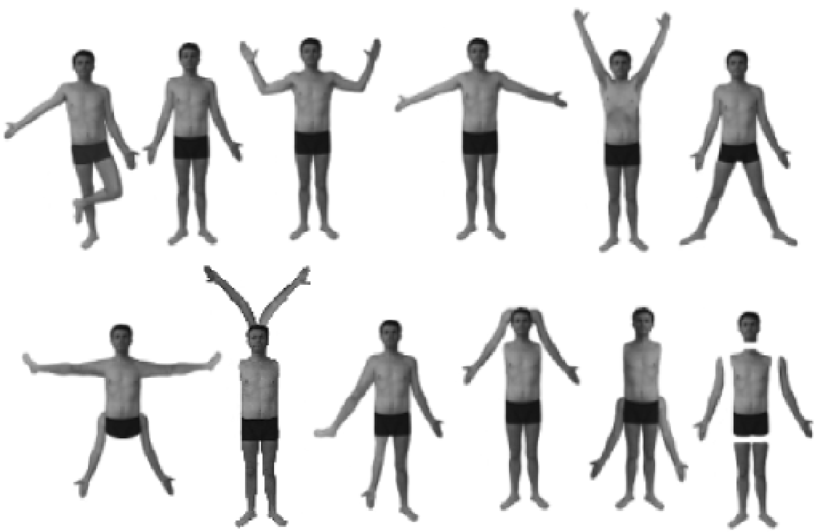

FIGURE 3.—Typical and scrambled body photographs used in Studies 3 and 4.

130 cm) thus pictures were substantially larger in size (42 cm × 55 cm) than in Study 1. Room lighting was dimmed to provide clearer images on the screen. Infants' attention was directed to the pictures by the clicking sound of the pictures being changed by the projector, thus the rattle was not necessary. The infant laboratory layout was identical to that of Study 1, with the exception that the video camera was positioned to the right of the screen and the infant. The entire session lasted approximately 5–10 min.

Coding

Coding of data was identical to that of Study 1. Inter-coder reliability on 25% of the data was calculated at 89%. All looking times reported are in milliseconds.

Results and Discussion

Six infants did not finish all trials; three 12-month-olds and three 15-month-olds provided no data for the final three scrambled body trials. Their data were retained for partial analysis.

To check that infants were successfully habituated to the typical body images, the average looking times for the first three typical body trials were compared to the average looking times for the final three typical body trials. The respective means were as follows: 4519.78 ms (*SD* = 1979.71 ms) and 2448.37 ms (*SD* = 1717.11 ms) for the 12-month-olds, 4391.17 ms (*SD* = 1780.34 ms) and 2171.83 ms (*SD* = 1005.06 ms) for the 15-month-olds, and 7690.38 ms (*SD* = 1843.83 ms) and 3275.42 ms (*SD* = 1420.01 ms) for the 18-month-olds. These numbers indicate that all infants habituated successfully to the typical body pictures. The average number of typical body trials to habituation was 8.39 (*SD* = 2.47) across all three age groups.

To test whether infants dishabituated upon presentation of the scrambled body shapes, a 2 (gender) × 3 (age group: 12-, 15- and 18-month-olds) × 2 (body type: typical bodies versus scrambled bodies) mixed model ANOVA was computed, where body type was the repeated measure. The dependent variable was looking times averaged over the last three typical body trials and the first three scrambled body trials. This analysis revealed a pattern similar to that seen in Study 1: there were significant main effects for age, $F(2,53) = 14.56$, $p < .001$, $\eta^2 = .36$ and body type, $F(1,53) = 13.59$, $p < .001$, $\eta^2 = .20$, as well as a significant age × body type interaction, $F(2, 53) = 12.49$, $p < .001$, $\eta^2 = .32$. This interaction indicated that infants of different ages showed distinct patterns of responding to the scrambled bodies following the typical body presentations. Follow-up *t*-tests comparing the average looking times over the final three typical body trials versus looking over the initial three scrambled body trials indicated that the 18-month-olds looked significantly longer at the scrambled bodies compared to the typical bodies, $t(18) = 4.54$, $p < .001$, (*M*, typical bodies 3275.42 ms, scrambled bodies 5621.88 ms, $SD = 1420.01$ and 2279.32 ms, respectively). This finding replicates the performance of 18-month-olds in Study 1. Neither the 15-month-olds nor the 12-month-olds looked significantly longer at the scrambled bodies compared to the typical bodies in this study: both $t(19) = 1.55$, *ns*, (15-month-olds *M*, typical bodies 2171.83 ms, scrambled bodies 2650.07 ms; $SD = 1005.06$ and 1618.55 ms, respectively and 12-month-olds *M*, typical bodies 2448.37 ms, scrambled bodies 2089.27 ms, $SD = 1717.11$ and 1468.56 ms, respectively). This pattern differs from that found in Study 1; here the 15-month-olds failed to make the scrambled body-typical body discrimination, though they were successful in Study 1 when the stimuli were schematic line drawings. The performance of 12-month-olds did not change as a function of presenting realistic human body photographs; they failed to discriminate scrambled from typical bodies in both studies, even though a comparison of average looking times on the first three typical body trials in Study 1 compared to those in the current study indicated that 12-month-olds looked nearly twice as long at the photographs compared to the line drawings, $t(38) = 5.05$, $p < .01$. Thus although the 12-month-olds were apparently interested in the photographic images, this did not affect their performance on the discrimination task. This pattern of similar performance in responses to human body line drawings and photographs was also found in Slaughter et al. (2002).

Next the less conservative discrimination analysis was performed by comparing infants' looking at the final typical body picture versus the first scrambled body picture. A 2 (gender) × 3 (age group: 12-, 15- and 18-month-olds) × 2 (body type: final typical vs. first scrambled) mixed model ANOVA was computed, where body type was a repeated measure and looking time was the dependent variable. Results again revealed significant main effects for age, $F(2,53) = 14.13$, $p < .001$, $\eta^2 = .35$, and body type, $F(1,53) = 16.36$, $p < .001$, $\eta^2 = .24$, qualified by a significant interaction of age and body type, $F(2,53) = 9.21$, $p < .001$, $\eta^2 = .11$. There was also a three-way age by gender by body type interaction, $F(2,53) = 3.30$, $p < .05$, but given that gender was nonsignificant in all other studies and analyses, this effect was not interpreted. The significant age by body type interaction indicated that infants' looking to the initial scrambled body pictures varied by age group. Follow-up paired *t*-tests comparing infants' looking at the final typical body picture versus the first scrambled body picture confirmed the pattern from the previous analysis: only the 18-month-olds significantly increased their looking from the final typical body to the initial scrambled body, $t(18) = 3.36$, $p < .025$ (*M*, typical body 2820.11 ms, scrambled body

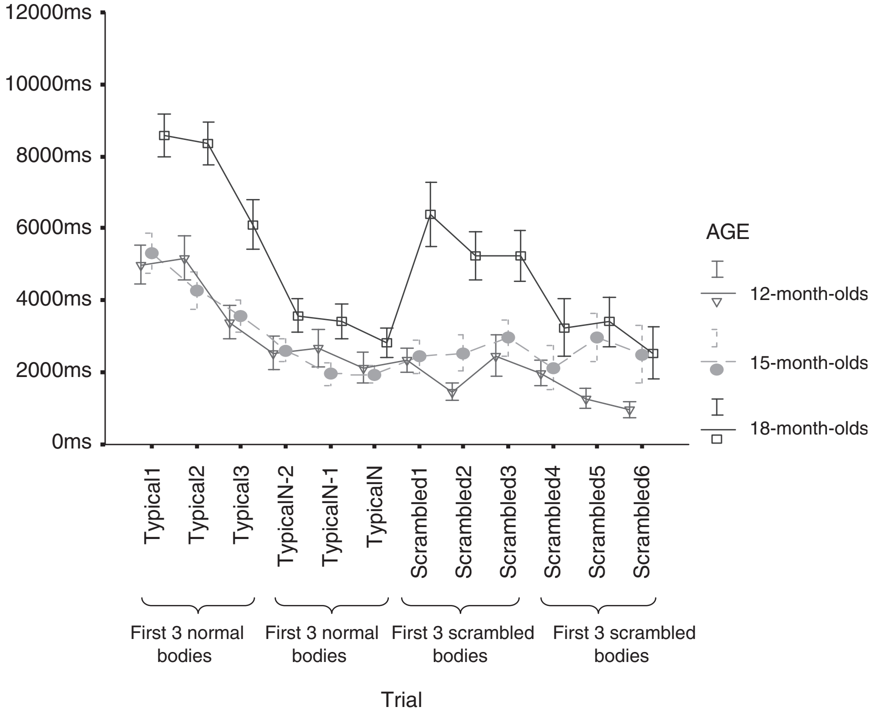

FIGURE 4.—Mean looking times (in milliseconds) for the first 3 typical body trials, the last 3 typical body trials and the 6 scrambled body trials for each age group in Study 3.

6394.53 ms; *SD* = 1777.62 and 3859.04 ms, respectively). The 15- and 12-month-olds again showed no significant increase in looking upon presentation of the first scrambled body, both $t(19) = 1.20$, *ns* (15-month-olds' *M*, typical bodies 1946.15 ms, scrambled bodies 2443.25 ms; *SD* = 1134.02 and 2070.11 ms, respectively and 12-month-olds *M*, typical bodies 2132.45 ms, scrambled bodies 2348.40 ms, *SD* = 1909.16 and 1499.17 ms, respectively). Figure 4 portrays the looking times across the first three typical body trials, the last three typical body trials and the six scrambled body trials, by age group.

An examination of individual infants' looking patterns to the typical and scrambled body photographs revealed that of the 12-month-old infants, three of the 20 infants (15%) looked longer at the first scrambled body picture than the final typical body picture. For the 15-month-old infants, five of the 20 infants (25%) looked longer at the first scrambled body picture than the final typical body picture. For the 18-month-old infants, 10 of the 19 infants (53%) looked longer at the first scrambled body picture than the final typical body picture. These data confirmed that younger infants did not notice the transition to scrambled bodies, and also indicated that older infants were less likely to meet the criterion for noticing the transition to scrambled bodies in this study, compared with Study 1. Overall, the data suggest that the use of photographic human body images made the discrimination task somewhat more difficult for the older infants.

Next, the results for the 12-month-olds were analyzed with respect to whether or not the infants had begun walking, to attempt to confirm the finding from Study 1 that 12-month-old walkers were more likely to discriminate scrambled from typical body shapes. A 2 (walking or not) × 2 (body shape: typical versus scrambled) mixed model ANOVA with body shape as the repeated measure was computed for the 12-month-olds' looking-time data. Contrary to the results of Study 1, no main effects or interactions were significant (walking × body shape interaction, $F(1,18) = .001$, *ns*, $\eta^2 = 0$. Given that the 15-month-olds in this study also failed to dishabituate to the scrambled bodies, a similar analysis was run whereby 15-month-olds were classified as early walkers (more than 12 weeks experience walking at the time of testing; $n = 10$) or late walkers (fewer than 12 weeks experience at the time of testing, $n = 10$). A 2 (early vs. late walker) × 2 (body shape: typical vs. scrambled) mixed model ANOVA with body shape as the repeated measure was computed for the 15-month-olds' looking-time data. Again, no main effects or interactions were significant; walking × body shape interaction, $F(1,18) = 1.28$, *ns*, $\eta^2 = .07$. These results indicated that in the current sample and task, there was no relation between upright motor experience and discrimination of scrambled from typical human body shapes.

Finally, infants' looking at the first three scrambled bodies versus the final three scrambled bodies was investigated with a 3 (age group) by 2 (gender) by 2 (presentation: first three scrambled vs. final three scrambled) repeated measures ANOVA. This analysis revealed main effects for age, $F(2,47) = 9.45$, $p < .01$, $\eta^2 = .28$ and body type, $F(2,47) = 19.14$, $p < .001$, $\eta^2 = .29$, as well as a significant interaction of age and body type, $F(2,47) = 6.62$, $p < .01$, $\eta^2 = .22$. Follow-up *t*-tests indicated that there was a significant decrease in looking time for the final three scrambled body trials compared to the first three scrambled body trials for the 12-month-olds, $t(16) = 2.54$, $p < .025$ (*M*, first three scrambled bodies 2089.27 ms, last three scrambled bodies 1451.45 ms, $SD = 1468.56$ and 881.99 ms, respectively) and for the 18-month-olds, $t(18) = 4.12$, $p < .001$, (*M*, first three scrambled bodies 5621.88 ms, last three scrambled bodies 3061.18 ms, $SD = 2279.32$ and 2691.58 ms, respectively). The 15-month-olds, in contrast, showed no decrement in looking over the six scrambled body trials, (*M*, first three scrambled bodies 2650.07 ms, last three scrambled bodies

2537.72 ms, *SD* = 1618.55 and 2422.42 ms, respectively). This pattern indicates that the 15-month-olds, as a group, retained interest in the scrambled body photographs across the six test trials; this is different from their responses to the schematic body line drawings in Study 1. This pattern is hard to interpret but could indicate that the 15-month-olds in this study were actively processing the scrambled body photographs in an attempt to make sense of the images.

Overall, this study fairly closely replicated the pattern of data found in Study 1; 12-month-olds showed no evidence of discrimination between scrambled and typical human body shapes, while 18-month-olds demonstrated a healthy recovery of interest when presented with scrambled human body shapes following habituation to typical human body shapes. In the current study, 15-month-olds did not significantly dishabituate to scrambled human body shapes and this is in contrast to the results of Study 1 in which 15-month-olds showed weak but significant recovery of interest when scrambled body line drawings were presented. This indicates that 15-month-olds' capacity to discriminate scrambled from typical human bodies is affected by the realism of the body stimuli. The nonparametric analyses suggest that the same is true of 18-month-olds; fewer of the oldest infants met the criterion for noticing the first scrambled body photograph than met the criterion for noticing the first scrambled body line drawing in Study 1. Several features of the Study 3 display may be relevant to this stimulus effect: The photographs were larger, colorful and more detailed. It may be that a single one of these features affected 15-month-olds' responding. Alternatively it may be that the combination of features, which all contributed to the realism of the photographs of Study 3 compared to the line drawings of Study 1, was effective. As noted, 12-month-olds looked longer at the first typical body image when it was a color photo (Study 3) compared to a line drawing (Study 1); suggesting that the color photos were indeed more complex, more interesting or both. However, despite this stimulus effect, 12-month-olds' performance on the discrimination task was unaffected. Further, 15-month-olds' looking times to the initial three typical body stimuli were not significantly different in Study 1 and Study 3, but their discrimination performance did change across studies. This complex pattern suggests that stimulus realism is an important variable to consider, even if it does not account for the 15-month-olds' change in performance from Study 1 to Study 3.

Felician et al. (2003) also found a stimulus realism effect for human body task performance in their case study of an autotopagnosic individual. The patient was unusual in that she was unable to localize body parts on another person, but at the same time could localize body parts on a human body picture or video image. Relevant to the issue at hand, this pattern suggested a possible dissociation in visuo-spatial knowledge of real human bodies and representations of human bodies. Felician et al. (2003) discounted the idea of separate visuo-spatial body knowledge stores for real bodies and representations of bodies, and instead suggested that this apparent dissociation stemmed from the fact that real bodies are more perceptually complex and therefore likely to require more attention for visual processing. They hypothesized that the task dissociation they found may reflect a continuum of stimulus complexity, with more complex stimuli (e.g., real human bodies) engendering poorer performance, especially when the underlying visuo-spatial representations are damaged or weak. This argument could also apply to the performance of 15-month-olds in the current series of studies: When the body stimuli are relatively simple, schematic images, then 15-month-olds' visuo-spatial knowledge can be recruited to make the scrambled body versus typical body discrimination. However, when the stimuli are complex photographs, their human body knowledge may be overwhelmed by the perceptual and attentional demands of the task.

DeLoache, Pierroutsakos, and Uttal (2003) also make a case for a continuum of stimulus complexity that has developmental implications for performance on various types of tasks. Based on their studies of toddlers' understanding of the nature of external representations, DeLoache and colleagues propose that young children's performance on some cognitive tasks changes as a function of stimulus realism, with more realistic representations (especially three-dimensional models) being harder for toddlers to interpret as representations. We return to this issue in the General Discussion, after we present a series of studies involving typical and scrambled three-dimensional dolls, in the next chapter.

The results of Study 3 suggest that visuo-spatial body representations are intact but relatively weak at 15 months of age. This conclusion derives from data indicating that at 15 months of age, infants' capacity to discriminate scrambled and typical body shapes is influenced by the complexity of the stimuli (they discriminated scrambled from typical human body line drawings but not color photographs), and by task demands (they showed no preference for typical or scrambled body line drawings when presented simultaneously in Slaughter et al., 2002 but did discriminate them in Study 1 in the habituation paradigm). This pattern suggests that detailed visuo-spatial representations of the human body first emerge, perhaps as relatively fragile representations, at 15 months of age.

Study 3 did not replicate the effect of walking that was found in Study 1. In the current study there was no evidence that 12- or 15-month-olds' capacity to discriminate scrambled from typical human bodies was linked to their experience of walking upright. This failure to replicate the effect of motor experience may relate to the issue of stimulus complexity; if the scrambled versus typical body discrimination is easier when the stimuli are schematic line drawings, then the effect of upright sensori-motor experience may be easier to demonstrate in that task compared to the more difficult photograph discrimination task.

STUDY 4: A COMPARISON OF 12-MONTH-OLDS' RESPONSES TO BODIES AND FACES

In Studies 1 and 3, 12-month-olds were insensitive to a transition from typical to scrambled human body shapes. Study 2 established that this insensitivity was not due to 12-month-olds' inability to discriminate two distinct human body images. Thus at 12 months of age, infants do not make a categorical discrimination between scrambled and typical human body shapes, suggesting that they do not have access to a detailed visuo-spatial representation of the human body.

This conclusion contrasts sharply with the data on face perception in infancy, reviewed in Chapter I. When it comes to faces, discrimination of scrambled from typical stimuli is evident in infants as young as a few days old (in visual tracking and preferential looking tasks; Goren et al., 1975; Johnson & Morton, 1991). The apparent difference in developmental trajectories for face and body processing is intriguing. However, the data cannot be directly compared because they involve different experimental techniques. In a previous study, we provided the only direct comparison of face and body visual tasks; in visual preference tasks 12- and 15-month-olds preferred a typical face to a scrambled face, but looked equally long at the typical and scrambled bodies, and 18-month-olds preferred the scrambled body but looked equally long at typical and scrambled faces (Slaughter et al., 2002).

Thus there is some evidence to suggest that visuo-spatial knowledge of the human face develops separately from visuo-spatial knowledge of the whole human form, and it appears that infants' knowledge of faces emerges much earlier in development. Study 4, reported below, directly tests these hypotheses. In this study, 12-month-olds were presented with two habituation conditions: one in which they were habituated to a variety of typical bodies then presented with a scrambled body, and one in which they were habituated to a variety of typical faces then presented with a scrambled face. All stimuli in this study were photographic images, projected on large viewing screens as in Study 3.

Method

Participants

Infants were recruited in a manner identical to that of Study 1. Eighteen infants participated. However, statistical analyses were based on a total of nine 12-month-olds (*M* age, 12 months, 15 days; range, 11 months 20 days to 12 months 25 days; 6 boys, 3 girls), as there was high attrition due to fussiness.

Materials

The body stimuli were a subset of those from Study 3: photographic images of the six typical human bodies, and one scrambled body (the arms extending up from head scrambled body figure (second from left, bottom row Figure 1)), projected onto a screen. This figure was chosen because, as Table 1 shows, across the age groups tested, it was the most salient scrambled body pattern and therefore perhaps the most likely to attract 12-month-olds' attention and engender discrimination in the current study. (It will also been seen in the next chapter that three-dimensional scrambled human body stimuli where the arms extend up from the head are significantly more salient than other three-dimensional scrambled body patterns.)

The typical face stimuli were photographic images depicting six faces of different genders and ages. The scrambled face image was created with Adobe Photoshop software, and had the internal features manipulated to match the configuration of the symmetrical scrambled schematic face used by Goren et al. (1975) and Johnson and Morton (1991). Figure 5 shows the scrambled face photograph used in the study. Note that this design equates the face and body discrimination tasks; both require a categorical discrimination of a scrambled image following habituation to a series of typically configured (face and body) images.

Procedure

The procedure was identical to Study 3 with the following exceptions: Infants were presented with a series of typical body or face images until they reached the habituation criterion, then they were presented with a single scrambled stimulus. Infants' looking to the pictures was measured. Infants were also presented with typical versus scrambled feet and hand images, but the results of these conditions are not presented here. The full procedure lasted approximately five minutes. The order of condition presentation was randomized across infants.

Coding

Coding of data was performed in a manner similar to that of Study 3. Inter-coder reliability on 25% of the data was calculated at 94%. All looking times reported are in milliseconds.

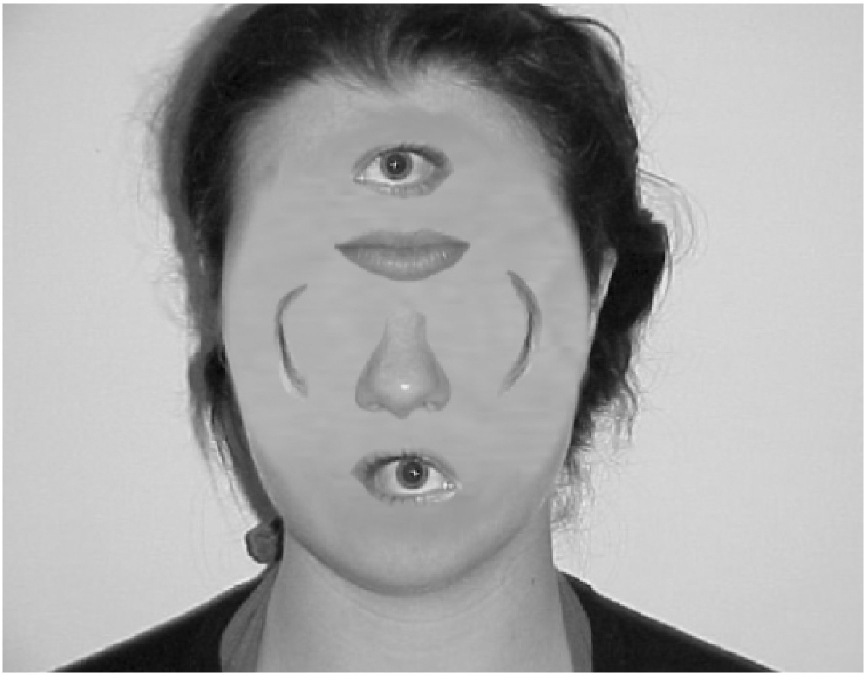

FIGURE 5.—Scrambled face photograph used in the face condition test trial in Study 4.

Results and Discussion

The data from nine infants who did not complete both face and body conditions were omitted. The high attrition rate appeared to be due to the nature of the task, as infants became fussy when required to habituate in a second condition, even though the stimuli were different. The decision was made to maintain a within-subjects design (rather than moving to a between-subjects design) as the study was intended to directly compare dishabituation responses to scrambled faces versus scrambled bodies in the same group of infants.

The mean number of trials to habituation was 9.85 ($SD = 1.80$) in the face condition and 9.36 ($SD = 1.60$) in the body condition. To ensure that infants were genuinely habituated, the means for the first three typical face and body trials and the final three typical stimulus trials were compared. For the first three typical face trials, the mean looking time was 8181.44 ms ($SD = 3160.89$ ms) and for the final three typical face trials the mean looking time was 5679.28 ms ($SD = 3396.41$ ms). For the first three typical body trials the mean looking time was 6486.49 ms ($SD = 3400.12$ ms) and for the final three typical body trials the mean looking time was 3546.82 ms ($SD = 2415.95$ ms). These data confirm that infants met the habituation criterion of 50% decrement in looking to the typical image in both conditions, before they were presented with the scrambled image.

To evaluate infants' responses to typical and scrambled faces and bodies, a 2 (gender) × 2 (condition: faces versus bodies) × 2 (stimulus type: typical versus scrambled) mixed model ANOVA was computed, where looking time was the dependent variable and stimulus type was a repeated measure. This analysis revealed a marginally significant effect of condition, $F(1,7) = 4.54$, $p = .07$, $\eta^2 = .39$, that indicated infants looked longer at faces than bodies overall. There was also a significant condition by stimulus type interaction, $F(1,7) = 6.40$, $p < .05$, $\eta^2 = .48$, indicating that looking times across the transition to a scrambled pattern was different for faces versus bodies. Follow up paired *t*-tests revealed that infants looked significantly longer at the scrambled face than at the final typical face, $t(8) = 3.13$, $p < .01$, (*M*, typical face 4337.25 ms, scrambled face 7437.67 ms; *SD*s = 2004.65 and 3096.67 ms, respectively), but there was no significant change in looking times from the final typical body to the scrambled body, $t(8) = .42$, *ns*, (*M*, typical body 3635.80 ms, scrambled body 3175.47 ms; *SD*s = 3732.90 and 2809.77 ms, respectively).

An examination of individual infants' looking patterns to the typical and scrambled face pictures supported the looking time analyses: that six of the nine infants (67%) looked longer at the scrambled face than the typical face, whereas only two of the nine infants (22%) looked longer at the scrambled body than the typical body. Thus infants noticed the scrambled face, but failed to notice the scrambled body.

The results of this study replicate the findings from Studies 1 and 3 that 12-month-olds do not dishabituate to a scrambled body following habituation to typical bodies. However, in the current study the same infants did dishabituate to a scrambled face following habituation to typical faces. This within-subjects pattern confirms the conclusion that young infants are sensitive to configural changes to human faces, but they do not exhibit the same sensitivity to configural changes to the human body. With respect to the issue of developing visuo-spatial body knowledge, there are two interpretations for this pattern. One possibility is that faces and bodies are represented separately, and the visuo-spatial representation for faces develops earlier, or is innate in a schematic form. This hypothesis is in line with neuroimaging research that has revealed what appear to be dedicated face processing areas in the adult brain that do not respond to other complex patterns (Kanwisher et al., 1997; McCarthy, Puce, Gore, & Allison, 1997). An alternative interpretation is that the face is part of a complete visuo-spatial representation of the body, not a distinct representation, but face processing develops earlier because that element of visuo-spatial body knowledge is acquired in detail prior to that of the rest of the human body. Either of these hypotheses is possible and we return to them in Chapter IV below; the point we wish to highlight here is that this study demonstrates that 12-month-old infants can make a categorical discrimination in our procedure, even one relevant to a human body stimulus (the face). The specificity of infants' failure in the scrambled versus typical body discrimination task therefore means that what 12-month-olds specifically lack, is detailed visuo-spatial knowledge of the whole human form.

STUDY 5: CATEGORICAL DISCRIMINATION OF ABSTRACT HUMAN BODY ANALOGS

Study 4 demonstrated that 12-month-olds categorically discriminated scrambled from typical faces, while at the same time failing to make a similar discrimination for the whole human body. The purpose of Study 5 was to further test the specificity of young infants' responses to human bodies, by exploring their responses to abstract forms that could be manipulated to create human body analogs.[4]

In Studies 1 and 3, it was established that 18-month olds discriminated scrambled from typical human body shapes. These data indicate that older infants have, or can form on-line, a visuo-spatial representation of the human body that specifies the typical spatial layout of the body, its parts relative to each other and to the whole. This representation allows infants to discriminate scrambled from typical human body shapes. One-year-olds, on the other hand, apparently do not have access to such a representation, as they repeatedly failed to discriminate scrambled from typical human body shapes. Study 4 established that 12-month-olds can nevertheless make a categorical discrimination, between scrambled and typical faces, further indicating that it is specifically a detailed visuo-spatial body representation that is unavailable to infants at 12 months of age. Study 5 was designed to explore 12-month-olds' responses to abstract patterns that were designed to be analogous to human body shapes, in order to explore further the specificity of human body knowledge. For this study we created a series of completely novel geometric forms that we dubbed "geobodies." These pictures consisted of a central geometric "body" with four geometric "limbs" and a "head" that could articulate from the "body" as if on joints (see Figure 6). A series of geobodies in different "postures" was presented, then three scrambled geobodies were shown in the standard experimental design used in the previous studies. This test was designed to reveal what type of knowledge, and what cognitive processes, young infants bring to the human body experiments. We reasoned that if 12-month-olds failed the human body discrimination tasks of Studies 1, 3, and 4 because they are

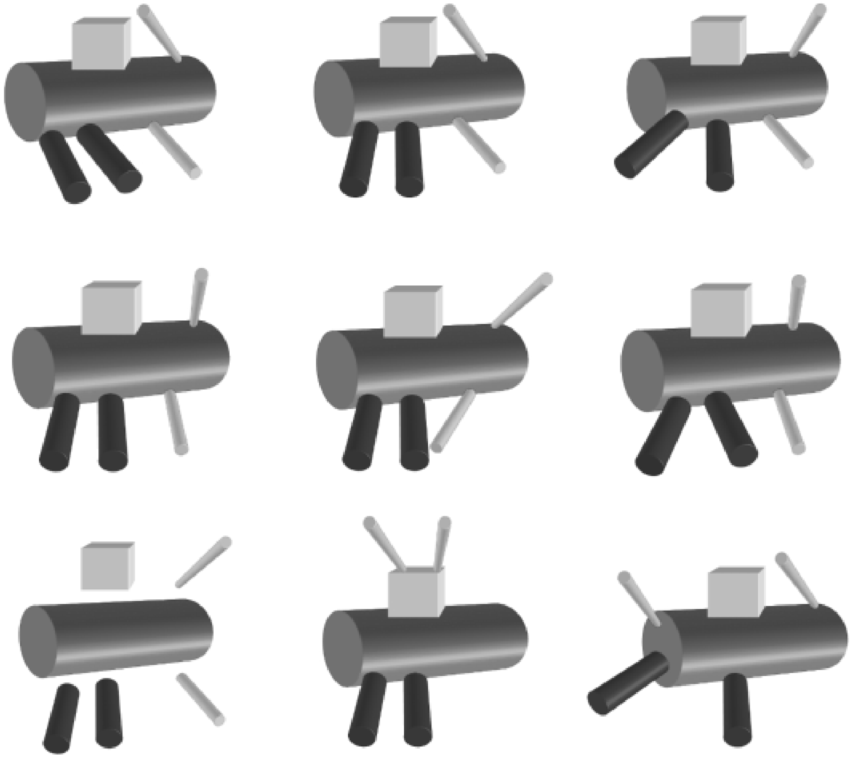

FIGURE 6.—Six “typical” geobodies (in the top two rows) and three “scrambled” geobodies (in the bottom row) used in Study 5.

incapable of analyzing complex patterns similar to human body shapes (e.g., with a number of articulating parts) then they should fail the “geobodies” discrimination task because it requires a similar visual analysis. However, if 12-month-olds succeed in the “geobodies” discrimination task, then it would indicate that a different cognitive process is engaged when infants are presented with human body shapes as opposed to novel geometric patterns.

Method

Participants

Infants were recruited in a manner identical to that of Study 1. There were 14 infants ranging in age from 11 months 10 days to 12 months 10 days, mean age 11 months 30 days. There were five boys and nine girls.

Materials

The stimuli consisted of nine pictures of brightly colored three-dimensional geometric shapes ("geobodies"), constructed for the purposes of this research. Each shape consisted of a large cylindrical red "torso," two medium-sized blue cylindrical "legs," two small green cylindrical "arms," and a yellow square "head." Pictures were presented on white paper (30 cm × 21.5 cm). The typical geobodies were presented in a variety of configurations, with the following constraints: the large red torso and the yellow head stayed fixed, whereas the blue and green arms and legs articulated at differing angles from the torso so that the overall shapes changed configuration in a manner analogous to the postural changes of the typical human body stimuli used in previous studies (e.g., arms extended up versus out versus down from the torso in different postures). Three scrambled geobodies were constructed for the test phase, each of which violated the standard configuration of the typical geobodies by moving the "arms" and "legs" to different locations on the figure. Figure 6 shows the six typical geobodies and the three scrambled geobodies used in the study.

Pictures were presented to the infant using the viewing screen described in Study 1. A halogen lamp was positioned directly below the picture, pointed upwards, to create a spotlight effect on the pictures. This was found to be necessary because pilot testing indicated that 12-month-olds were loathe to sit through this task, but spotlighting the pictures increased their attention to the images. A hole in the middle of the screen allowed video recording of the infant's looking behavior.

Procedure

The procedure was identical to Study 1 with some minor changes. The looking trials were eight seconds long to minimize attrition. The infant control habituation method was used as in previous studies and as before habituation was defined as a 50% decrement of looking from the first three trials (averaged) to a subsequent three trials. Once habituation to typical geobodies had occurred, the three scrambled geobody pictures were presented individually on consecutive trials. Typical geobody pictures were presented in a fixed order across infants. The order of presentation of scrambled geobodies was counterbalanced across infants with a partial Latin Square. The entire session lasted approximately 5 minutes.

Coding

Infants' looking across all trials was timed and a naive viewer recoded 100% of trials (again, because the looking times were very short in this procedure, we did full reliability coding to ensure accuracy). The inter-coder reliability was 90% and as before, values were taken from the looking times recorded by the first observer. All looking times reported are in milliseconds.

Results and Discussion

The mean number of trials to habituation was 7.86 ($SD = 1.92$). To ensure that infants were genuinely habituated, the means for the first three typical geobody trials and the final three typical geobody trials were compared. For the first three typical trials the mean looking time was 4461.73 ms ($SD = 1495.21$ ms) and for the final three typical trials the mean looking time was 2999.89 ms ($SD = 984.49$ ms). These data confirm that infants met the habituation criterion of 50% decrement in looking to the typical geobodies before they were presented with the scrambled geobodies.

To test whether infants dishabituated upon presentation of the scrambled geobodies, a 2 (gender) × 2 (geobody type: typical geobodies versus scrambled geobodies) mixed model ANOVA was computed, where body type was the repeated measure. The dependent variable was looking time averaged over the last three typical geobody trials and the first three scrambled geobody trials. This analysis revealed a significant main effect for geobody type, $F(1,12) = 8.02$, $p < .02$, $\eta^2 = .40$), that indicated significantly longer looking times for the scrambled geobodies than the typical geobodies (M last three typical geobodies 2999.89 ms, M first three scrambled geobodies 3594.21 ms; $SD = 984.49$ and 1257.64 ms, respectively). No other main effects or interactions were significant. These data show that 12-month-olds were capable of discriminating scrambled from typical geobody shapes, despite typically failing a similar discrimination task for human body shapes (in Studies 1, 3 and 4).[5]

Next the less conservative discrimination analysis was performed by comparing infants' looking at the final typical geobody picture versus the first scrambled geobody picture. A 2 (gender) × 2 (geobody type: final typical vs. first scrambled) mixed model ANOVA was computed, where body type was a repeated measure and looking time was the dependent variable. Results again revealed a significant main effect for geobody type ($F(1,12) = 5.12$, $p < .05$, $\eta^2 = .30$), indicating significantly longer looking times for the first scrambled geobody compared to the final typical geobody ($M =$ 3496.14 ms, 2709.00 ms; $SD = 1699.74$ and 1462.17 ms). No other main effects or interactions were significant. Again, this pattern shows that infants were sensitive to the transition from typical to scrambled geobodies. Thus 12-month-olds noticed when the "limbs" of a nonsense geometrical figure were moved from their pre-established cannonical locations, even though infants of that age in the previous studies did not notice a similar change applied to human bodies.

An examination of individual infants' looking patterns to the typical and scrambled body line drawings revealed that 6 of the 14 infants (43%) looked longer at the first scrambled geobody picture than the final typical geobody picture. This pattern suggests that the geobodies discrimination is not especially robust, but given that these were nonsense figures and looking times were relatively short, it is perhaps not surprising that only a minority of infants met our criterion for noticing the transition from typical to scrambled geobody shapes.

The results of this study suggest that different representations or processes underlie infants' performance in the human body and geobody discrimination tasks. In this study, 12-month-olds made a categorical discrimination between scrambled versus typical geobodies, even though the same age infants (and indeed, the very same sample of 12-month-olds; see Footnote 5) failed to make the same discrimination for human bodies in all our previous studies. What accounts for this difference in performance across the two similar discrimination tasks? In both tasks, infants were required to visually analyze a series of typical shapes, and then take note when the typical shapes were scrambled. This was achieved in the geobodies task, but not in the human body task. We suggest that the difference has to do with the knowledge that infants bring to each procedure. When presented with the geobodies task, infants viewed the patterns from a naïve perspective, and accordingly constructed a mental representation of the typical shape of geobodies during the familiarization trials. In the human body task, in contrast, we believe that infants came into the experiment with pre-established knowledge about the human body shape, and that led them to classify all the bodies, including the scrambled ones, as being members of the same category. We propose that this pre-established knowledge was in the form of a schematic visuo-spatial human body representation that was inclusive enough to allow categorization of typical and scrambled bodies as being similar. In this we support Quinn and Eimas' (1998) hypothesis that infants' early representation of humans, (in our terms, the visuo-spatial human body representation), originates as a broad, inclusive pattern characterized by a head on top of an elongated, symmetrical body. With such a human body representation in mind, 12-month-olds may have failed the human body discrimination task because all the bodies, both typical and scrambled, conformed to this pattern. We return to this hypothesis and elaborate on it in the final chapter.

SUMMARY

The results across the five studies in this chapter paint a clear picture of the development of infants' developing visuo-spatial body knowledge, reflected in their responses to typical and scrambled human bodies. At twelve months, infants showed little discrimination of scrambled from typical human bodies (Studies 1, 3 and 4). This insensitivity was not due to (a) an inability to discriminate between different human body pictures (as shown in Study 2 when 12-month-olds discriminated between two individual human body pictures), or (b) to an inability to discriminate scrambled from typical images in general (as shown in Studies 4 and 5 when they discriminated scrambled from typical human faces, and scrambled versus typical abstract geobodies, but not human body shapes). Thus at 12 months, detailed knowledge of the spatial layout of the human body is apparently not yet available to infants.

In contrast to 12-month-olds, 18-month-old infants reliably discriminated scrambled from typical human bodies (Studies 1 and 3). At 15 months of age, infants showed a fragile capacity for discriminating scrambled from typical human bodies; they discriminated scrambled from typical bodies when the stimuli were schematic line drawings (Study 1), but failed to similarly discriminate human body photographs (Study 3). Taken together, these studies indicate that detailed visuo-spatial knowledge of the human body begins to emerge between 15 and 18 months of age. Before that age, we suggest that infants possess a highly schematic, inclusive representation of the spatial attributes of the human body, that leads them to treat scrambled and typical human body shapes as being categorically similar. This conclusion is bolstered by the fact that when presented with abstract geobodies in Study 5, 12-month-olds discriminated scrambled from typical shapes, presumably because the geobodies were unfamiliar and therefore subject to naïve perceptual categorization processes. Categorization of human body shapes, on the other hand, appeared to be influenced by preexisting knowledge; what we propose is a highly inclusive, schematic visuo-spatial human body representation.

The foregoing visual habituation studies lead to the conclusion that visuo-spatial knowledge of human bodies is first evident sometime between 15 and 18 months of age in normal infants. In the next chapter, we seek to further support and refine this conclusion by carrying out a series of studies using a different experimental paradigm, the object exploration technique, in which infants are presented with typical and scrambled three-dimensional human body shapes.

NOTES

2. Bertenthal, Haith, and Campos (1983) introduced the partial lag design to address the potential problem of spontaneous regression in the infant control procedure. They note that "chance habituators" show a certain amount of pseudo-response recovery to the familiar

stimulus even after the habituation criterion is reached, whereas infants who demonstrate true habituation will have a response curve that remains flat.

The partial lag design controls for chance recovery of interest by introducing a lag condition in which half of the infants are presented with two additional familiarization trials (lag trials) after reaching the habituation criterion. Following the two lag trials, infants are presented with the novel stimulus. The other half of the infants (the nonlag group) are presented with the novel stimulus immediately after they reach the habituation criterion. Looking times on the last two familiarization trials and the first two test trials are compared across groups to assess genuine recovery of interest (in the nonlag group) versus chance recovery of interest (in the lag group; Bertenthal et al., 1983).

While we recognized the value of using a partial lag design in visual habituation studies like those presented in Chapter 2, we chose not to adopt the technique, mainly because the current studies involved testing infants that were relatively old to be enduring a habituation procedure (12- to 18-month-old infants). Pilot testing indicated that infants in this age range became quite restless towards the end of the habituation phase, and it was sometimes difficult for infants to complete the entire experiment. For this reason, it was considered too high a risk to include two additional habituation (lag) trials, for fear of substantially increasing attrition rates.

As the infants' looking times were coded on line (and therefore subject to greater error than post-experimental coding), if there was any ambiguity that the habituation criterion may not have been met while the experiment was in progress, the infant received additional habituation trials. While this increased the chances of attrition, it was thought to be the best option since infants who did not reach habituation criterion would not provide interpretable data. Therefore, a small percentage of infants received the equivalent of lag trials unintentionally. Of the infants who received lag trials and completed the experiment, examination of their looking times revealed flat response curves over these "lag" trials, indicating genuine habituation.

Additionally, we have had the opportunity to observe the behavior of infants ranging in age from 6 to 18 months in this experimental paradigm. These observations revealed age-related changes in looking behavior during habituation. On average, infants 12 months and older (like those in the studies reported in Chapter 2) tended to become bored with the familiarization stimuli rapidly and looking times decreased steadily during the familiarization phase. In contrast, younger infants (6- and 9-month-olds) tended to respond more sporadically during the habituation phase, with looking times fluctuating slightly (decreasing and increasing) until they eventually declined and the habituation criterion was reached. Thus, the partial lag design may be important in controlling for spontaneous regression in younger infants' looking times; but it appears that the looking behavior of older infants can be accurately assessed with a standard serial habituation procedure like that used in the Chapter 2 studies.

3. We are indebted to an anonymous reviewer for suggesting this study.

4. We thank Thomas Suddendorf for his creative input to the design of this study.

5. In fact, a subset ($n = 12$) of the 12-month-old infants who successfully discriminated scrambled from typical geobodies in Study 5 was also subsequently presented with a human body discrimination task similar to that reported in Study 3 (this was a control condition for work not reported in this monograph, in which typical and scrambled body photographs were used). Examination of those data revealed that the infants failed to make the scrambled versus typical body discrimination, replicating the 12-month-old results from Studies 3 and 4.