III. OBJECT EXPLORATION STUDIES: INFANTS’ DISCRIMINATION OF TYPICAL AND SCRAMBLED DOLLS

A number of recent authors have questioned the wisdom of inferring underlying cognitive representations and processes from infants’ performance in visual paradigms alone (Bremner, 2000; Haith, 1998; Langer, Gillette, & Arriaga, 2003; Simon, 1997). One concern is that visual discrimination studies do not engage infants’ representational knowledge, but require only low-level, on-line perceptual and attentional processes. For some programs of research, this concern raises serious doubts about data interpretation (see Haith & Benson, 1998 for detailed discussion). As noted in Chapter I, Mandler (1997, 2000) argues that independent cognitive processes are revealed by experimental tasks that require infants to make visual and manual responses. She proposes that visual tasks assess perceptual categorization, a process based on surface properties like shape and texture, whereas manual tasks additionally reveal conceptual categorization, that is “based on what objects do” (Mandler, 2000; p. 3).

In this Monograph, we specifically investigate the development of visuo-spatial representations of the human body. These representations are arguably purely perceptual, as they specify information about the spatial layout of the human body, its parts in relation to each other and in relation to the whole form. With this as our target level of knowledge, we propose that inferring infants’ visuo-spatial human body knowledge from visual paradigms alone, like those reported in Chapter II, would be reasonable. What we are investigating, in Mandler’s terms, is perceptual categorization. However, as reviewed in Chapter I, human body knowledge is known to be represented at several different levels in the brain, and these levels of knowledge interact in some contexts (e.g., Reed & Farah, 1995). It seems likely that at some stage in development, the issues of what bodies look like (represented by visuo-spatial knowledge), and what bodies do (represented by sensori-motor and/or lexical–semantic knowledge) become intertwined. While we are not yet at the stage of investigating how levels of human body knowledge interact in development, we nevertheless chose to extend our study of the development of visuo-spatial body knowledge to include a
series of manual habituation studies, reported below. The basic logic of the manual studies is the same as in the previous chapter: We present infants with the opportunity to discriminate scrambled from typical bodies. The extension of this technique to a manual paradigm accomplishes two things. First, it allows us to engage infants in the task more thoroughly than in the visual studies. As mentioned previously 12- to 18-month-olds are relatively old to participate in visual habituation studies and in many of the looking trials in the Chapter II studies, infants were engaged with the stimuli for as few as 5 s or less. Manual tasks are inherently more interesting because they allow infants to freely manipulate the stimuli, so extension of our investigation to include manual tasks allows us to ensure that our pattern of findings, as robust as they were across studies in Chapter II, was not due to artifacts of the visual procedure. Second, the addition of manual tasks also allows us to further address the issue of how the realism of a given stimulus may interact with infants’ knowledge. As noted above, DeLoache (1995) and colleagues (DeLoache et al., 2003; DeLoache & Smith, 1999) have argued that some representations are easier for infants and toddlers to process than others. In line with this argument, the studies of Chapter II revealed an apparent stimulus realism effect such that 15-month-olds’ capacity to discriminate scrambled from typical human bodies was disrupted when the stimuli were relatively realistic human body photographs. This issue of stimulus realism can be further explored with comparison of performance in visual (involving two-dimensional images) and manual (involving three-dimensional dolls) discrimination tasks.

The following studies used a standard object examination paradigm in which the typical and scrambled body stimuli were dolls of various sizes that infants were allowed to explore and manipulate. The procedure in these studies was as follows: Infants were presented with a fixed number of typical doll experimental trials to establish familiarization to the typical human body shape, then a scrambled test doll was presented. Whereas the Chapter II studies used an infant-controlled procedure in which habituation was calculated on-line in the course of the experiment, the studies reported below presented infants with a fixed number of trials, and habituation was tested after the fact. The main reason for this change was that it was too difficult to code infants’ manipulative behavior of the dolls on-line. However, it can be argued that this change in procedure adds additional breadth to our project of exploring infants’ human body knowledge across different experimental paradigms.

In these studies, analyses focused on (a) infants’ examination of the typical dolls on familiarization trials and (b) infants’ recovery of interest (reflected in an increase in examination time) to scrambled dolls on the test trials. We also performed nonparametric analyses using the same criterion for noticing as was used in the Chapter II studies: Infants were classified as
noticing the scrambled doll if their examination times increased by a value that exceeded the standard deviation of examination on the final three familiarization trials.

STUDY 6: CATEGORICAL DISCRIMINATION OF THREE-DIMENSIONAL HUMAN BODY SHAPES

The purpose of this study was to further explore the development of visuo-spatial human body knowledge, by testing infants’ responses to typical and scrambled dolls. Three scrambled body shapes were created for these studies, loosely based on the scrambled human body pictures used in Chapter II. These were (a) arms raised above the head but attached at the temples, referred to as the “arms on head doll,” (b) arms hanging by sides but attached at hips, referred to as the “arms on hips doll,” and (c) arms removed completely, referred to as the “armless doll.” The armless doll was not “scrambled” in the strict sense that some body parts were moved to non-canonical locations, but for ease of reference all three test dolls are referred to as “scrambled.” The choice of these three shapes was largely determined by the physical characteristics of the dolls themselves, which were made of hard plastic that was not easily manipulated.

On the basis of the pattern of data from the Chapter II studies, it was predicted that infants older than 12 months would discriminate scrambled from typical body shapes by showing a recovery of interest upon presentation of the scrambled dolls, following habituation to typical dolls. This pattern would further support the conclusion that a detailed visuo-spatial representation of the human body emerges in the second year of life.

Based on the stimulus realism effect found in Studies 1 versus 3, and also based on the work of DeLoache and colleagues, we expected that the scrambled body discrimination task involving three-dimensional stimuli might be more difficult than the task involving two-dimensional body pictures. Further, previous work has established that manual categorization tasks tend to be more difficult than visual tasks (Younger & Furrer, 2003). Based on these observations, we decided to include a group of 24-month-olds in Study 6, to ensure that at least one age group would demonstrate perfect or nearly perfect performance on the scrambled body discrimination task.

Method

Participants

Infants were recruited in a manner identical to that of Study 1. Statistical analyses were based on a total of 21 12-month-old infants
(M age = 11 months and 30 days: range 11 months 16 days to 12 months 14 days; 9 boys, 12 girls), 20 15-month-olds (M age = 15 months and 8 days: range 14 months 29 days to 15 months 20 days; 10 boys, 10 girls), 19 18-month-olds (M age = 17 months and 29 days: range 17 months 18 days to 18 months 12 days; 10 boys, 9 girls) and 18 24-month-olds (M age = 24 months and 5 days: range 23 months 17 days to 24 months 14 days; 10 boys, 8 girls). An additional two 12-month-olds, four 15-month-olds, four 18-month-olds and two 24-month-olds were tested but excluded from the final sample due to excessive fussiness or experimenter error. In the studies reported in this chapter, fussiness was behaviorally defined as inconsolable crying and/or refusal to look at or touch the dolls on three consecutive trials and/or throwing dolls off the testing table immediately after presentation on three consecutive trials.

**Materials**

The stimuli consisted of 13 human figures and one bowling pin (see Figure 7 for the dolls used in the study). The human figures represented humans of different ages (babies, adults), sizes (range: 6.5–24 cm); and

![Figure 7. Typical and scrambled dolls used in Studies 6 and 7.](image_url)
statures (slim, normal), thus variability was quite high. Ten of the dolls were normally shaped, and three were scrambled as described above. All of the dolls were made of hard plastic (excluding the dolls’ hair) and were presented naked. The bowling pin was made of yellow plastic and was 25 cm in height.

Procedure

The infant was seated in an infant seat at a table, across from the experimenter. The mother sat on the left of the infant, and a video camera was positioned to the right. Each object was hidden until the experimenter gave it to the infant. Individual trials began with the experimenter placing an object on the table directly in front of the infant and saying, “look what I’ve got” or “look at this.” As soon as the object became visible to the infant, the experimenter began timing the 20 s trial. Infants were allowed to handle and manipulate the objects freely. When the trial ended the experimenter removed the object and immediately presented the next one, beginning the next trial. On occasion, infants firmly pushed the object away, showing signs of boredom, and in this instance the object was removed before the full 20 s had lapsed.

During familiarization, each infant was presented with a total of 10 different dolls, in random order across shape conditions and infants. On the test trial, one scrambled doll was presented and again the infant was allowed to visually and manually explore it. The test trial continued until the infant firmly pushed the doll away or when 35 s had passed. Maximum examination time was set at 35 s for the test trial to avoid the possibility of ceiling effects. There was no risk of artificially inflating dishabituation time from trial 10 to the test trial (due to 20 s habituation trials and 35 s test trials) as no infant was anywhere near reaching ceiling (20 s) on the last habituation trial. If an object was thrown onto the floor at any time during the procedure, it was picked up as quickly as possible and placed back on the table.

Once the 11 doll trials were completed (10 familiarization trials with typical dolls and one scrambled doll test trial), a novel object (the bowling pin) was presented for 30 s. This gave infants a break from dolls before the next series of dolls was presented.

The doll familiarization-test procedure was repeated twice more. Each presentation involved a new random ordering of the same set of typical dolls, and a different scrambled doll on the test trial. Thus each infant participated in three scrambled doll conditions, in which they were familiarized with the series of typical dolls, then shown a novel scrambled doll to test for discrimination. Presentation order of the scrambled dolls was counterbalanced across infants. The entire session lasted approximately 10 min.
Coding

Examination time was the dependent variable in these studies, analogous to looking time in the visual habituation studies. Examination was defined as focused looking or concentration on the object in either the presence or absence of manipulation (Mandler & McDonough, 1993; Oakes, Madole & Cohen, 1991). This definition of examination excluded activities like mouthing and banging. Sessions were videotaped and coded by two independent observers, the second coder being naïve to the hypothesis under investigation. Twenty-five percent of the data were coded by a naïve observer to establish reliability; agreement between the two coders was 91%. For statistical analysis, values were taken from the examination times recorded by the first observer. All examination times reported are in milliseconds.

Results and Discussion

To establish that infants habituated to the typical dolls presented during familiarization, ANOVAs were conducted on infants’ looking times across habituation trials. The studies reported in Chapter II did not require statistical analyses to establish habituation as the infant control procedure ensured that each infant was presented with the exact number of trials required for habituation (as the reported means indicated). Because the object exploration procedure was conducted with a fixed number of familiarization trials (corresponding to the number of unique typical body dolls), it was necessary to statistically establish that infants habituated to the typical body shapes.

Two mean-scores were computed: block A refers to mean examination during the first five trials on which typical bodies were presented, and block B refers to mean examination time during the final five typical body examination trials. These were collapsed across the three scrambled doll conditions. A 4 (age: 12, 15, 18 and 24 months) × 2 (blocks: block A vs. block B) × 3 (order: first, second or third presentation) mixed-model ANOVA was computed on examination time to investigate the extent to which infants in the different age groups habituated from block A to block B. The ANOVA revealed a significant main effect of age, $F(3,74) = 6.46, p < .01$, $\eta^2 = .21$, reflecting the fact that older infants examined the dolls longer in general. A main effect of block was also found, $F(1,74) = 110.48, p < .01$, $\eta^2 = .60$, indicating that examination times declined overall from block A to block B. There was no effect of presentation order, indicating that the pattern of declining interest in the typical dolls was similar across the three consecutive scrambled doll conditions. A significant age × block interaction was also found, $F(3,74) = 3.74, p < .05, \eta^2 = .13$ indicating that the decline in
examination of the dolls from block A to block B varied as a function of age. The age by block interaction was followed up with a series of paired \( t \)-tests comparing examination times on block A to block B examination times, separately for each age group. This analysis revealed that at all ages, there was a significant decline in examination times from block A to block B, all \( t > 3.17 \), all \( p < .01 \). Thus infants in all four age groups habituated to the typical body dolls prior to presentation of the scrambled dolls.

Two different procedures for analyzing infants’ responses to the scrambled dolls were considered: (a) conducting a repeated measures ANOVA between the trial 10 examination time and the test trial examination time (similar to the analyses conducted on visual dishabituation in the Chapter II studies), or (b) subtracting the trial 10 examination time from the test trial to create a difference score. Both methods of analyses are appropriate; the difference score method was selected. The reasons for this choice were as follows: Main effects (overall age differences, unqualified differences in examination times across trials) were not of primary interest, power was sufficient, and because this study included an additional factor of scrambled body shape (e.g., arms on head doll, arms on hips doll, armless doll), difference scores provided a simpler conceptualization of the results. Thus, a difference score for each infant in each condition was created by subtracting the trial 10 examination time from the test trial examination time, thereby representing the magnitude of infants’ recovery of interest to the scrambled body shape. This difference in looking time was termed dishabituation, and served as the dependent variable in the main analyses.

Results of a 2 (gender) × 4 (age group: 12, 15, 18 and 24 months) × 3 (scrambled body shape: arms on head, arms on hips, armless) mixed-model ANOVA revealed several significant effects. The main effect of age on dishabituation scores, \( F(3,70) = 21.71, p < .001, \eta^2 = .48 \), indicated that dishabituation scores (e.g., recovery of interest to the scrambled dolls) varied across age groups (see Table 2). The significant main effect of scrambled doll shape on dishabituation scores, \( F(2,140) = 17.76, p < .001, \eta^2 = .19 \), indicated that infants recovered interest more strongly to some of the scrambled dolls compared to the others. There was also a marginally significant main effect of gender, \( F(1,70) = 3.49, p < .062, \eta^2 = .05 \) indicating that girls’ dishabituation to the scrambled dolls was greater than that of boys.

Finally, there was a marginally significant interaction of scrambled doll shape by age, \( F(6,140) = 2.07, p < .061, \eta^2 = .08 \), which indicated that infants’ recovery of interest to the three different scrambled doll shapes varied by age group. Since the purpose of this study was to investigate the development of visuo-spatial knowledge of the human body, this marginal interaction was followed up to establish which scrambled dolls were salient to infants of different ages. Follow-up \( t \)-tests compared the differences in examination times between trial 10 (the final typical doll) and the test trial
(the scrambled doll) by scrambled doll condition in each age group. These analyses revealed that for the 24-month-old infants there was a significant recovery of interest to all three scrambled doll shapes, all $t$’s(17)$>2.78$, $p$’s$<.01$, such that examination time in the test trials were significantly greater than examination times in the final typical doll familiarization trials. Paired $t$-tests showed that 18-month-old infants dishabituated from trial 10 to test only in response to the arms on head doll, $t$(18) = 3.45, $p < .01$, but not for the armless doll, $t$(18) = 1.72, $ns$, or the arms on hips doll, $t$(18) = 1.78, $ns$. Similarly, paired $t$-tests indicated that 15-month-old infants dishabituated from trial 10 to test only for the arms on head doll, $t$(19) = 3.82, $p < .01$, but not for the armless doll ($t$(19) = .99, $ns$), or the arms on hips doll ($t$(19) = .55, $ns$). There was no significant difference between trial 10 and test for the 12-month-olds in any of the scrambled doll conditions, all $t$’s$<1.57$, $ns$, indicating that there was no significant dishabituatation to the scrambled dolls in the youngest age group.

Figure 8 portrays the mean examination times, collapsed across scrambled body shape condition, on each trial by age group. This graph shows that recovery of interest in the scrambled dolls increased with age, but as the preceding $t$-tests revealed (see also Table 2), the 15- and 18-month-olds showed recovery of interest only to the arms on head doll. The particular salience of the arms on head scrambled body shape is also reflected in Table 1 where dishabitation to the arms raised from head human body line drawing was most pronounced. Again, this pattern indicates that some

### Table 2

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Scrambled shape</th>
<th>Mean (SD) for Trial 10 (ms)</th>
<th>Mean (SD) for Test (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-month-olds</td>
<td>Arms on head</td>
<td>6354.21 (5211.12)</td>
<td>18440.21 (11138.12)</td>
</tr>
<tr>
<td></td>
<td>Armless</td>
<td>6235.45 (5361.21)</td>
<td>13235.12 (10360.01)</td>
</tr>
<tr>
<td></td>
<td>Arms on hips</td>
<td>3791.21 (3060.12)</td>
<td>8611.54 (7550.21)</td>
</tr>
<tr>
<td>18-month-olds</td>
<td>Arms on head</td>
<td>3551.21 (3091.12)</td>
<td>11021.75 (10340.10)</td>
</tr>
<tr>
<td></td>
<td>Armless</td>
<td>3342.12 (3441.21)</td>
<td>3892.82 (3411.09)</td>
</tr>
<tr>
<td></td>
<td>Arms on hips</td>
<td>2511.21 (2632.01)</td>
<td>3423.21 (3752.14)</td>
</tr>
<tr>
<td>15-month-olds</td>
<td>Arms on head</td>
<td>3333.12 (2355.12)</td>
<td>6963.53 (5251.05)</td>
</tr>
<tr>
<td></td>
<td>Armless</td>
<td>4571.54 (4261.21)</td>
<td>3731.42 (3578.94)</td>
</tr>
<tr>
<td></td>
<td>Arms on hips</td>
<td>4385.12 (2841.21)</td>
<td>4754.12 (3518.70)</td>
</tr>
<tr>
<td>12-month-olds</td>
<td>Arms on head</td>
<td>4855.12 (2652.12)</td>
<td>5911.12 (3467.12)</td>
</tr>
<tr>
<td></td>
<td>Armless</td>
<td>3521.21 (1624.12)</td>
<td>2703.62 (1534.12)</td>
</tr>
<tr>
<td></td>
<td>Arms on hips</td>
<td>3847.12 (3511.21)</td>
<td>3932.12 (401.13)</td>
</tr>
</tbody>
</table>

**OBJECT EXPLORATION STUDIES**
human body shape violations are more obvious than others; however it appears that by 24 months of age, infants’ visuo-spatial body knowledge is sufficiently developed such that they were sensitive to all of the scrambled dolls presented.

The nonparametric analyses confirmed these patterns. An examination of individual infants’ looking patterns to the typical and scrambled dolls revealed that of the 12-month-old infants, seven of the 21 (33%) looked longer at the arms on head doll than the last typical doll presented, three of the 21 infants (14%) noticed the armless doll, and five of the 21 infants (24%) noticed the arms on hips doll. Among the 15-month-olds, 14 of the 20 (70%) looked longer at the arms on head doll compared to the last normal doll presented, four of the 20 infants (20%) noticed the armless doll and four of the 20 infants (20%) noticed the arms on hips dolls. Of the 18-month-old infants, 15 of the 19 (79%) noticed the arms on head doll, three of the 19 infants (16%) noticed the armless doll and five of the 19 infants (26%) noticed the arms on hips doll. Finally, of 24-month-old infants, 16 of the 18 (89%) noticed the arms on head doll, 14 of the 18 infants (78%) noticed the armless doll and 10 of the 18 infants (56%) looked longer at the arms on hips doll than the last typical doll presented. This pattern again shows that the youngest infants in this study did not notice any of the three scrambled body shapes presented in the test trials, while 15- and 18-month-olds noticed only the arms on head body shape violation. By 24 months, most infants noticed all violations of the human body shape.

Figure 8.—Mean examination times for the typical and scrambled dolls (collapsed across scrambled body shape) by age group in Study 6.
Next, 12-month-olds’ dishabituation scores were analyzed with respect to their status as walkers, as was done in Study 1. Walking status was unfortunately not recorded for three of the infants. A one-way ANOVA with walking (yes, \( n = 10 \) or no \( n = 8 \)) as the between-subjects factor was computed on the 12-month-olds’ dishabituation scores, collapsed across scrambled body type. No significant effect of walking on infants’ dishabituation to the scrambled dolls was found, \( F(1,17) = .74, \eta^2 = .04, \text{ns} \). This failure to find a walking effect was also evident in Study 3 and suggests two interpretations: It could reflect an interaction of task difficulty with a genuine walking effect, such that it is harder to establish the (perhaps subtle) effect of upright locomotor experience on infants’ developing visuo-spatial body knowledge when the task is made difficult for 12-month-olds. This could explain why the walking effect disappeared in Study 3 and in the current study when the human body stimuli were more complex and realistic. Alternatively, the waking effect found in Study 1 could simply be Type I statistical error.

Finally, we tested whether 12-month-old infants’ failure to discriminate the typical and scrambled dolls could be explained by a general fatigue effect, brought on by the fixed number of familiarization trials (recall the visual habituation studies were infant-controlled, so that familiarization trials were terminated once infants reached the habituation criterion). To test this possibility, we examined 12-month-olds’ responses to the bowling pin that was presented directly after the scrambled doll. A paired \( t \)-test comparing examination of the first scrambled doll presented and the bowling pin presented immediately afterwards revealed significantly greater examination for the bowling pin than the scrambled doll \( (t(20) = 2.269 \ p < .05; \ M = 5657.33, 4107.42; \ SD = 1855.81 \) and \( 2216.03, \) respectively). This indicated that 12-month-old infants in this procedure did recover interest to a perceived novel object, meaning that they were not fatigued and therefore unable to respond to novelty in the previous scrambled body trial. A paired \( t \)-test comparing examination of the second scrambled doll presented and the second presentation of the bowling pin also revealed significantly greater examination for the bowling pin than the scrambled doll even though by this time the bowling pin was no longer completely novel \( (t(20) = 3.529 \ p < .01; \ M = 4102.05, 2314.57; \ SD = 1774.95 \) and \( 1575.10, \) respectively). Again, this indicates that infants significantly recovered interest to what they perceived as a novel and interesting object (this just happened not to be a scrambled doll). Unfortunately, this analysis was not possible after presentation of the third scrambled doll, as the purpose of presenting the bowling pin was to reduce boredom by interrupting the sequence of dolls so the bowling pin was not presented after the final set of dolls. Overall, these analyses provide evidence that 12-month-old infants’ failure to discriminate scrambled from typical dolls was not due to fatigue; when presented with a
novel bowling pin, 12-month-olds recovered interest, despite failing to notice the scrambled body doll on the previous trial.

The pattern of results from Study 6 is reasonably consistent with findings from the visual habituation studies reported in Chapter II. Fifteen-month-olds in the visual habituation paradigm showed some sensitivity to scrambled body shapes, and similarly showed limited sensitivity to scrambled bodies in the object examination task. Eighteen-month-olds demonstrated robust discrimination of scrambled body shapes in the visual habituation studies, but like the 15-month-olds, dishabituated only to the arms on head scrambled doll in the object examination task. In the current study, 24-month-olds showed robust discrimination of scrambled from typical body shapes. The age discrepancy for robust discrimination of scrambled from typical body shapes across the visual and manual experimental paradigms was not unexpected, as noted, much previous work has established that infants’ categorization abilities appear to vary with the type of task used to assess them. In general, infants make categorical distinctions earlier when tested with visual tasks (visual preference, visual habituation) compared to manual tasks (object examination, sequential touching; Younger & Furrer, 2003; see Mareschal & Quinn, 2001 for a brief review). The reason for this task effect is debated; it may reflect distinct categorization processes as proposed by Mandler (1997, 2000), or it may simply reflect differential sensitivity of visual versus manual paradigms (Younger & Furrer, 2003, Quinn & Eimas, 2000). The point we wish to highlight is that the overall pattern of data from the current study is remarkably consistent with that of the Chapter II studies, with infants’ performance on manual categorization tasks reasonably in line with their visual task performance, and data from both types of task indicating that detailed visuo-spatial human body knowledge develops sometime in the second year of life.

STUDY 7: 12-MONTH-OLDS’ DISCRIMINATION OF INDIVIDUAL THREE-DIMENSIONAL HUMAN BODY SHAPES

Studies 1, 3, 4, and 6, using both human body pictures and dolls as stimuli, indicated that 12-month-old infants, unlike their older peers, did not exhibit recovery of attention when presented with scrambled human body shapes following habituation to typical body shapes. This pattern suggested that at 12 months of age, infants do not make a categorical discrimination between scrambled human bodies and typical human bodies, leading to the conclusion that infants younger than 15–18 months do not possess a detailed visuo-spatial human body representation.

In Study 2, it was established that 12 months olds could discriminate two individual typical human body shapes, or two individual scrambled
human body shapes. These data supported our conclusions, because they indicated that young infants can make simple perceptual discriminations of different body shape patterns, but what they fail to do is to discriminate between typical and scrambled bodies in general. Study 7 was designed to further test 12-month-old infants’ perceptual discrimination of two different body shapes. In Study 7, infants were habituated to a single typical doll then on the test trial they were presented with the highly salient arms on head doll used in Study 6. They were also presented with an abstract human body analog (a variant of the bowling pin figure used in Study 6 manipulated to loosely resemble a body), followed by a “scrambled” version of the bowling pin. The purpose of this study was to evaluate 12-month-olds’ capacity to make a simple perceptual discrimination between a typical object (in two conditions: doll and bowling pin) and a scrambled version of the same object. We argue that this is a purely perceptual discrimination because it does not involve generalization; infants simply have to respond to a change in the spatial configuration of individual objects. We hypothesized that 12-month-olds would dishabituate to a scrambled shape following familiarization with an individual typical shape, and that this would be demonstrated in both the human body and bowling pin conditions. Thus this study allowed us to directly test whether infants’ perceptual responses to the dolls would be different from their perceptual responses to an abstract shape. If not, then that would suggest that similar perceptual processes were involved in both tasks.

Method

Participants

Infants were recruited in a manner identical to that of Study 1. Statistical analyses were based on a total of 18 12-month-old infants, ranging in age from 11 months 15 days to 12 months 14 days, M age 12 months 4 days. There were 10 boys and eight girls. Five infants were omitted due to not habituating during the familiarization trials.

Materials

A subset of the dolls used in Study 6 was presented; these included one of the typical dolls and the arms on head scrambled doll constructed from an identical typical doll. The yellow plastic bowling pin from Study 6 was manipulated so that the typically shaped bowling pin had four protruding plastic “limbs” extending out from the body. These were constructed from the tops of identical bowling pins such that all four “limbs” were the same color and shape as the top of the bowling pin. The “scrambled” bowling pin
had two of the “limbs” moved to the top of the pin, analogous to the arms on head doll scrambled shape.

Procedure

The procedure was identical to that of Study 6 with two exceptions. First, there were four instead of 10 familiarization trials in which the typical shape was presented, to minimize attrition rates. Second, infants were presented with only the one scrambled shape in each of the two conditions (e.g., doll and bowling pin). The entire session lasted no more than five minutes.

Coding

Coding of data was identical to that of Study 6. Reliability was calculated on 25% of the data coded by a naïve observer. Agreement was 89%, and as before values were taken from the examining times recorded by the first observer. All examination times reported are in milliseconds.

Results and Discussion

To ensure that infants habituated, the means for the first two typical body trials (block A) and the final two typical body trials (block B) were compared for both doll and bowling pin conditions. Paired t-tests revealed a significant difference in examination times between block A and block B for the doll, \( t(17) = 5.63, p < .001 \) (\( M \), block A 7258.21 ms, block B 4762.02 ms; \( SD = 2924.25 \) and 2533.35 ms) and also for the bowling pin, \( t(17) = 5.13, p < .001 \) (\( M \), block A 7095.22 ms, block B 4662.19 ms; \( SD = 2572.81 \) and 2400.29 ms). These data indicated that in both conditions, examination times in block A were significantly larger than those in block B, thus infants habituated successfully to both the typical doll and the “typical” bowling pin.

To evaluate infants’ responses to the introduction of a scrambled shape in both conditions, pre-planned paired t-tests were calculated. These tests showed that in both conditions, there were significant increases in examination times from the final habituation trial to the test trial. For the dolls, \( t(17) = 4.68, p < .01; M, \) final habituation trial 3656.11 ms, test trial 6809.83 ms; \( SD = 2265.73 \) and 2719.04 ms respectively). For the bowling pins, \( t(17) = 5.13, p < .01; M, \) final habituation trial 4387.33 ms, test trial 7249.33 ms; \( SD = 2524.41 \) and 3802.46 ms, respectively).

An examination of individual infants’ looking patterns to the dolls revealed that 12 of the 18 infants (67%) looked longer at the scrambled doll than the final typical doll. Similarly, 13 of the 18 infants (72%) looked longer at the scrambled bowling pin compared to the final typical bowling pin.

These results indicated that, consistent with Study 2, 12-month-olds discriminated between two individual human body shapes. That is, 12-
month-olds noticed when the human body shape changed, but as Study 6 showed, they did not notice the categorical distinction between typical body shapes and scrambled body shapes. This study also established that 12-month-olds discriminated between two individual nonsense shapes, and their recovery of interest to a configural change in bowling pin shapes was equivalent to their recovery of interest in configural human body changes (mean difference between final familiarization trial and test trial for the doll was 3153.72 ms and for the bowling pin was 2862.00 ms; these differences are not significantly different, $t(18) = .29, ns$). As with Study 5, this suggests that infants were simply responding to the configural changes in the objects; a human body shape violation was no more salient than a change to the spatial properties of a nonsense figure.

The pattern of data indicates that at 12 months, infants are sensitive to featural changes in a single human body exemplar, such that they noticed when an individual doll’s body shape was changed, but they do not generalize across exemplars to make the categorical discrimination between scrambled and typical human body shapes. This finding further supports our hypothesis that at 12 months, infants do not yet have access to a detailed visuo-spatial human body representation.

STUDY 8: INFANTS’ RESPONSES TO A SCRAMBLED VERSUS A SHAPE-CONTROL DOLL

In Study 6 the investigation of three different violations of the human body shape revealed that the arms on head scrambled doll was more salient than the other two scrambled dolls (armless and arms on hips) for 15-, 18- and 24-month-old infants (with 15- and 18-month-olds dishabituating only to the arms on head scrambled body shape).

There are three explanations for the relative saliency of the arms on head doll. The first is purely perceptual: the arms on head shape may have been particularly salient because the arms extending upward from the head made the whole doll appear longer and larger than the majority of the other dolls. The second relates to infants’ expectations about the human head/face: the arms on head scrambling resulted in a violation of the typical shape of the head/face region, and this violation, rather than a violation of the expected body shape, may have captured infants’ attention. As Study 4 demonstrated, infants’ sensitivity to scrambled faces emerges earlier than sensitivity to scrambled bodies, so the relative salience of the arms on head violation could be related to infants’ well-established knowledge about the human face. A final possibility is that the arms on head scrambled doll represents a biologically impossible human body shape (in contrast to the armless doll, which is biologically possible, and the arms on hips doll which
appears highly atypical to adults but is closer to being biologically possible than arms on head). Thus infants’ earlier-developing sensitivity to the arms on head scrambled doll may have been a matter of general perceptual saliency, violation of expectations about the human face/head shape, or violation of expectations about the human body shape. Study 8 was designed to untangle these three possibilities.

In Study 8, infants were tested in two conditions: a scrambled doll condition and a control condition in which the test doll had a similar, but biologically possible, body shape compared to the scrambled doll. In both conditions infants were habituated to a series of typical dolls, then on the final trial they were presented with the test doll. In the scrambled body condition the test doll was an arms on head scrambled doll similar to the one that was used in Studies 6 and 7. In the control condition, the doll had a typical body shape and its hair was arranged in piggy-tails that were wired to extend upright from the head, creating an overall shape that was identical to the scrambled doll. Thus the control piggy-tail doll was perceptually similar to the scrambled body doll, but it did not represent a violation of the typical human body shape as it still had its arms attached to its shoulders. If infants in Study 6 dishabituated to the arms on head scrambled doll on the basis of perceptual saliency or on the basis of an unexpected face/head shape, then it was predicted that they would dishabituate to the piggy-tail doll equally compared to the scrambled doll. If, on the other hand, infants in Study 6 were sensitive to the violation of the human body shape that the arms on head doll represented, then it was predicted that they would dishabituate more strongly to the scrambled body doll compared to the control doll.

**Method**

**Participants**

These included 20 in each age group of 15-month-olds (M age = 15 months and 12 days, range 15 months 0 days to 15 months 21 days; 11 boys, 9 girls), 18-month-olds (M age = 18 months and 2 days, range 17 months 20 days to 18 months 14 days; 10 boys, 10 girls) and 24-month-olds (M age = 24 months and 4 days, range 23 months 14 days to 24 months 14 days; 10 boys, 10 girls). An additional 15-month-old, three 18-month-olds and two 24-month-olds were tested but excluded from the final sample due to excessive fussiness.

**Materials**

The stimuli consisted of eight dolls plus the bowling pin used in Study 6. The typical dolls were a subset of those used in Study 6; they represented
humans of different ages (babies, adults), sizes (range: 16–28 cm); and stat- 
ures (slim, average). Six typically shaped dolls were used for familiarization, 
similar to Study 6 (there were fewer familiarization trials included in this 
study, based on habituation curves established in Study 6, to minimize atr-
trition). The two test dolls were (a) an arms on head scrambled doll and (b) a 
doll with a typical body shape but whose shape resembled the arms on head 
doll because its piggy-tails were wired to extend straight up from her head. 
Figure 9 shows the set of dolls used in this study.

Procedure

All infants completed two testing conditions: scrambled doll and piggy-
tail doll. In both conditions infants were presented with six different typical 
dolls in 20 s familiarization trials. The typical dolls were randomized for 
order of presentation across condition and across infants. If the infant 
pushed the doll away or said “no,” the doll was removed before 20 s had 
elapsed. On the test trials (trial 7 in both conditions), one of the test dolls was 
presented. The test doll was given to the infant until the infant pushed it 
away or if 35 s had passed. Infants were allowed to explore the dolls freely. If

Figure 9.—Typical dolls and arms on head and piggy tail test dolls used in Study 8.
a doll was thrown onto the floor, it was retrieved as quickly as possible and placed back on the table.

Upon completion of the first condition, the bowling pin was presented for 30 s to refresh the infants’ attention to dolls. Then the second condition was run, in the same manner as the first one. The order of presentation of the scrambled doll and piggy-tail doll conditions was counterbalanced across infants. The entire session lasted approximately 5 min.

**Coding**

Coding of data was identical to that of Study 1. Reliability coding by a naïve observer was performed on 25% of the data and was calculated at 94%. Examination times are reported in milliseconds.

**Results and discussion**

To test whether infants habituated to the typical dolls presented during familiarization, two mean-scores were computed: block A refers to mean examination during the three trials where typical bodies were presented, and block B refers to mean examination time during the final three typical body examination trials. A 3 (age: 15, 18, and 24 months) by 2 (blocks: block A vs. block B) mixed-model ANOVA was computed on examination times to investigate the extent to which infants in the different age groups habituated from block A to block B. The ANOVA revealed a significant main effect of age, $F(1,57) = 3.25$, $p < .05$, $\eta^2 = .10$, that indicated older infants examined the dolls longer in general. A main effect of block was also found, $F(1,57) = 20.09$, $p < .001$, $\eta^2 = .26$, indicating that examination times declined from block A to block B. No other main effects or interactions were significant. This analysis indicated that all age groups successfully habituated to the typical body dolls, reflected in the overall decrease in examination times from block A to block B.

Next, we analyzed infants’ responses to the scrambled and control test dolls. As in Study 6, a difference score for each infant in each condition was created by subtracting the trial 6 examination time from the test trial examination time, this dishabituation score represented the magnitude of infants’ recovery of interest when presented with the test doll.

Results of a 3 (age group: 15-, 18- and 24-month-olds) $\times$ 2 (gender) $\times$ 2 (condition: scrambled versus control) mixed model ANOVA with condition as the repeated measure and dishabituation score as the dependent variable was computed. This analysis revealed a main effect of condition, $F(1,54) = 18.17$, $p < .001$, $\eta^2 = .25$, and no other significant main effects or interactions. This result indicated that infants at all ages dishabituated more strongly to the scrambled body doll compared to the control doll: $M$
dishabituation score for the arms on head doll = 5901.37 ms, and for the control piggy tail doll = 2553.73 ms; SD = 5326.26 and 4291.28 ms, respectively.

Individual infants’ looking patterns were similar to the overall pattern of the dishabituation scores. Of 15-month-old infants, 16 of the 20 (80%) noticed the arms on head doll whereas 12 of the 20 infants (60%) noticed the piggy-tail doll. For the 18-month-old infants, 16 of the 20 (80%) noticed the arms on head doll whereas seven of the 20 infants (35%) noticed the piggy-tail doll. Finally, for the 24-month-old infants, 15 of the 20 (75%) looked longer at the arms on head doll compared to the last typical doll presented and 11 of the 20 infants (55%) looked longer at the piggy-tail doll than the last normal doll presented. Thus at each age, a greater number of infants noticed the doll that represented a human body shape violation, than noticed the shape control doll.

The results of this study indicated that infants dishabituated to the scrambled body doll significantly more strongly than to the control doll. The control piggy-tail doll had a similar overall shape compared to the scrambled doll, with the exception that the piggy-tail doll had arms attached at the shoulders. However, since Study 6 demonstrated that 15- and 18-month-olds did not dishabituate to an armless scrambled doll, the presence/absence of arms presumably was not salient to the younger infants in this study.

Thus the piggy-tail doll controlled for perceptual salience (it was equally as long as the scrambled doll) and for violation of the typical head/face shape (it had extensions raising up from the head) but the difference was that the piggy tail doll did not violate the typical human body shape. Fifteen-and 18-month-old infants’ may have dishabituated more strongly to the scrambled doll compared to the control doll because even though both dolls had similarly shaped heads (with protrusions extending upwards) the arms on head scrambled doll had obvious flesh-colored arms terminating in recognizable hands extending from her head, while the piggy tail doll had unusual, but obvious and allowable hair in the same location. Thus even though the overall head shape of the two test dolls was similar, the texture and detailed features of the head additions must have been salient to infants. In line with this, Guajardo and Woodward (2002) reported that 9-month-old infants’ interpretation of human hands depended on surface qualities like skin color and texture. The fact that infants dishabituated more strongly to the arms on head doll compared to the piggy tail doll indicates that they were more sensitive to a violation of the typical human body shape compared to a change in overall size and shape of the doll, or to a violation of the expected shape of the face/head. Thus the results of this study further support the conclusion that infants of 15–18 months of age have begun to develop a detailed visuo-spatial representation of the human
body, evidenced in their principled expectations about the typical human body shape.

**SUMMARY**

The results of the three studies reported in this chapter add confidence and some complexity to the developmental picture painted in the previous chapter. This series of object examination studies fairly closely replicated the pattern of results established with the visual habituation studies of Chapter II; with the following similarities noted:

(a) 12-month-olds showed no sensitivity to scrambled human body shapes following habituation to typical body shapes (Study 6) and this lack of responsiveness was not due to an inability to make perceptual discriminations between two individual dolls (Study 7).

(b) Infants older than 12 months discriminated between scrambled and typical human body shapes (Study 6) and this discrimination was shown to be significantly stronger than a similar shape discrimination that did not involve an impossible human body shape (Study 8).

The main difference noted between Chapters II and III results was that in the object examination studies, it was not until 24 months of age that infants demonstrated robust discrimination of all types of scrambled bodies from typical bodies, while in the visual habituation studies robust discrimination was apparent by 18 months of age. As noted however and discussed in more detail below, this pattern was not unexpected because previous categorization research has established that categorical discriminations tend to be made in visual paradigms before they are demonstrated in similar manual paradigms. In the big picture, the studies in Chapters II and III reveal remarkable agreement on the early development of visuo-spatial body knowledge: The ability to discriminate scrambled from typical human bodies initially emerges sometime around 15–18 months of age.