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Patterns of 4-Month-Old Infant Responses to Hidden Silent and Sounding People and Objects

Maria Legerstee*
York University, Toronto, Canada

Responses of 4-month-old infants to hidden people and objects were investigated with equated task demands. Twenty-one 4-month-old infants were administered a combined task, in which they were shown a sounding stimulus that continued to sound after hiding, an auditory task, in which sound was the only source of information about the position of the object in space, and a vision task, in which a silent stimulus was shown to the infants prior to hiding. Five infant behaviours were coded: reaching, gazing, body movements, vocalizations and smiles. The infants reached significantly more for hidden objects than for people, to whom they vocalized instead. They further smiled, and moved their bodies more towards their invisible mother than to the other stimuli. Thus infants responded differentially to people and objects whether the stimuli were soundless (so that there was no cue to their presence) or not. This suggested that infants appreciated (a) that an object had been hidden; (b) this object was either animate or inanimate; and (c) different procedures were appropriate for the retrieval of, or for interacting with animate and inanimate objects. Discussion centres on the underlying representational system that allows for such appreciation.

Key words: Object search, person search, multimodal.

A question frequently addressed by Piaget (1954) concerned the developing understanding of the animate and inanimate distinction. As adults, we distinguish between people and things while knowing that all objects share certain fundamental properties. Both animate and inanimate objects have physical properties (size and shape), but only people act independently, have feelings and intentions. If we want to acquire knowledge about the two classes, we communicate with people and act on objects (Bretherton *et al.*, 1981; Gelman and Spelke, 1981; Glick, 1978; Hoffman, 1981).

Careful analyses of various infant responses to animate and inanimate objects in a series of controlled studies during the first year of life indicate that very young infants also attempt to communicate with animate objects and act on inanimate objects. Faced with a responsive person, infants smile, make pre-speech sounds and gesticulate with hand movements. Presented with a familiar object that sounds and moves when the infants look at it, they are more likely to make hand-and-reach movements while staring at the object intensely (Gelman and Spelke, 1981; Legerstee, 1991, 1992; Legerstee *et al.*, 1987, 1990). Thus, it appears that the ability to distinguish people from things begins early in life. Knowing how this ability develops in children is important since it may shed light on infants' formation of concepts.

*Address for reprints: Maria Legerstee, Department of Psychology, York University, 4700 Keele Street, Toronto, M3J 1P3, Canada.

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For instance, it is not clear whether this differential responsiveness towards visible stimuli is the result of perceptual or conceptual differentiation. Perceptual differentiation is based on a set of perceptual–motor schemas that would allow the infant to recognize a variety of objects and their functions when the objects are present. Conceptual differentiation on the other hand is based on some type of mental representation of objects and their functions, and entails some rudimentary notion of what a person or object is (Mandler, 1992).

Piaget (1954) felt that human infants go through a lengthy period during which they do not think. He suggested that only near the end of the sensorimotor stage of development, at about 18–24 months, do infants learn how to represent the world in a conceptual manner. Prior to that, infants represent the world by means of action schemas, but are not able to form concepts that can be recalled when the stimulus is absent. Thus, infants can learn to recognize things, and will smile at familiar people, or reach for objects. Recognition of the voice of the mother or of the functions of objects is evidence of a perceptual process which Piaget called 'recognitory assimilation'. Perceptual recognition includes several components: (1) discrimination, when for instance, the infant discriminates between various objects; (2) recognition, when infants know they have seen, felt or heard an object before; and (3) identification, as when the infant has learned that an object can be manipulated in a certain way. Recognitory assimilation is based on motor knowledge, and is only available when some aspect of the object is present. Thus, it should be distinguished from knowledge that can be brought to consciousness in the absence of perceptually available stimulation (Bremner, 1988; Sylvester-Bradley, 1985; Harris, 1983; Mandler, 1990). Conceptual or symbolic thought does not only mean that infants can use language, but the infants can now understand that objects continue to exist when perceptually inaccessible. Piaget proposed that only after infants have acquired the concept of permanence do they begin to differentiate people from objects on their 'innate' social dimensions (communication, feelings, intentions, etc.).

Piaget cited several reasons why the object concept would take such a long time to be constructed. First, infants need considerable motor activity and physical manipulations with objects before they can understand their permanence. Second, Piaget proposed that at birth the senses are unconnected. Until infants come to recognize correspondences between information perceived through different modalities, 'stable sensorimotor schemas of three-dimensional, solid, sound-producing, textured objects cannot be formed, and hence cannot be thought about' (Mandler, 1990, p. 237).

Several researchers have supported Piaget's accounts of animism, object permanence and intersensori-coordination. They have suggested that prior to stage IV of the sensorimotor period infants do not appear to distinguish between people and things (Decarie and Ricard, 1981; Frye *et al.*, 1983; Sylvester-Bradley, 1985; see Legerstee, 1992 for a review of these studies), nor do they search for people and objects (Bell, 1970; Jackson *et al.*, 1978). Furthermore, infants do not search for sounding objects until they begin to search for non-sounding objects (Bigelow, 1983; Uzgiris and Benson, 1980; Piaget, 1954).

However, the standard Piagetian recall tasks (lifting up clothes to retrieve objects) involve perceptual and motor skills that are only available in late infancy (cf. Mandler, 1990; Spelke, 1988). It is possible that the infant's motor limitations have been confounded with conceptual limitations. It seems that infants who have been allowed to show their understanding of objects in simpler tasks appear quite competent. First, they do use sound cues to guide their behaviour. Five-to-seven month-old infants not only oriented their gazes towards a sound, but reached towards it in the dark (Clifton *et al.*, 1991a, 1991b; Stack *et al.*, 1988; Wishart *et al.*, 1978). In addition to auditory–tactile coordination, much about the object appeared to be provided by the visual system alone. In recent reviews, Spelke (1988) and Baillargeon (1992) revealed that by 4 months, infants perceive boundaries of objects and they expect objects to be substantial, since they show surprise if objects move through other objects. Thus it appears that before infants have had extensive physical manipulations with objects they perceive them as solid, sound-producing and bounded. More importantly, however, very young infants appear capable of recall. Hood and Willatts (1986) presented 5- to 6-month-old babies with an object either to the right or to the left side. They were prevented from reaching by their mother until the lights went out. After the objects had become invisible and the infants' hands were released, the authors found that infants reached more to where the object had been seen than to the wrong side. Thus, infants remembered not only the position, but also the existence of invisible objects.

Thus the above data not only indicate considerable sophisticated perceptual knowledge about

objects but also suggest that such young infants represent absent information. That conceptual development is possible without the benefit of active experience with the object has been suggested by research with physically handicapped infants. Apparently, infants with motoric restrictions may show near normal conceptual development (Bebko *et al.*, 1992).

If very young infants represent knowledge about objects *qua* objects, then they should be able to conceptualize that there are different kinds of objects (Piaget, 1954; Mandler, 1988). As we have noted earlier, by 4 months of age infants communicate with people and manipulate things. If infants have learned that the out of sight transformations do not affect the status of the object, then infants may use these different types of responses when they want them to be recovered. Thus, they would call for people, but act on objects in order to bring them back to view.

The following experiment was conducted to investigate this hypothesis. To discern whether 4-month-old infants would react differently to hidden objects than to hidden people, their responses were observed in conditions where people and objects were hidden in silence. To discern whether infants would use sound in their behavioural manifestations, the infants were also presented with people and objects that continued to sound after hiding, and in conditions where sound was the primary source of information about the position and identity of the object in space. Because it has been shown that familiarity of stimuli influences search behaviour in infants (Bell, 1970; Jackson *et al.*, 1978), the infants were further presented with familiar and novel people and objects. The infants' gazes, smiles, vocalizations, body and arm movements to their disappearing mother, a female stranger, familiar and novel objects were measured. It was hoped that the use of this more elaborate coding scheme would tap the infants' growing understanding of the range of attributes that differentiates people from things and would reveal more detailed information about the developing strategies infants use in their search for different objects (Gelman and Spelke, 1981).

METHOD

Subjects

Twenty-eight 4-month-old infants (17 girls and 11 boys) had been randomly selected from birth lists provided by the Grace Maternity Hospital in Halifax (Nova Scotia, Canada). Of this initial sample, the data from two girls were lost because they cried excessively. The data from another four girls and one boy had to be discarded since these infants had emitted reaches, vocalizations and body movements prior to the closing of the exit door. Because it is possible that the infants' subsequent behaviours to the invisible stimulus were continuations of behaviours to the visible stimulus, these data could not therefore be used. The final data set consisted of responses from 21 infants (10 boys, 11 girls), at 4 months (mean age = 4.3 months, SD = $\pm$3.2 days), from mostly white, middle-class families as judged from parental educational levels. Most infants had one or more siblings.

Apparatus

A large wooden box, fastened on four wooden legs, was used for hiding. It measured 75 cm high, 75 cm wide and 62 cm in depth. The legs were 65 cm in height. Total playbox height was 140 cm. The playbox was open in the front. The two sides were made of solid wood with a door (28 cm high) each that when opened was large enough for a person's head or a toy to be put through. The back of the playbox was also made of solid wood. An opening of 23 x 75 cm allowed an adult to hold the infant from behind by the waist (see Figure 1).

Infant behavioural activities and facial expressions at either hiding place were filmed with two video cameras mounted on a wall facing the front of the box, but above and to the side of the infant's head and therefore out of their visual field. One camera had a zoom lens, and was remotely controlled by a camera operator from a separate control room. This enabled her to continue filming the baby's responses whenever the baby changed position. Using a split-screen generator, the pictures of the two cameras were recorded on one VCR (JVC BR 905OU) that contained a date–time generator to record onset and offset of the sessions and of the various behaviours.

Type of Objects

The infants were presented with their mother, a female stranger and a familiar and novel object in the vision, auditory and combined tasks. The unfamiliar objects used for the sessions consisted of a bright orange and yellow snorkel doll, a blue and white smurfette (see Figure 1), a bright pink and white doll and a brown and yellow bear. Two

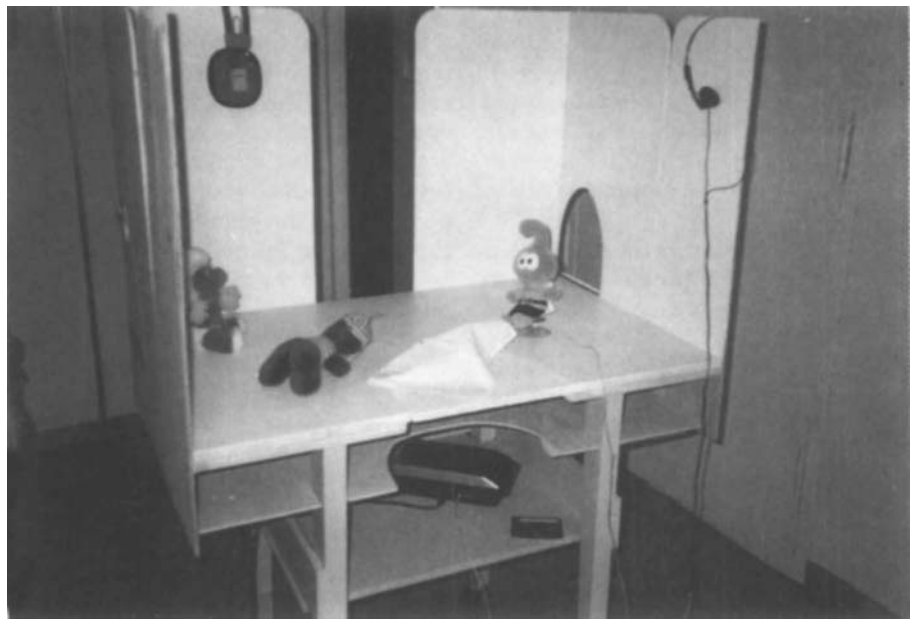

Figure 1. Playbox used to equate task demands in search for people and objects.

different objects were used during the combined and vision novel object condition; the other two were used during the familiarization condition. During the object conditions that required sound, the toys produced a sound through speakers stuffed into their bodies and wired to a recorder that played the various sounds (squeaky, rattle-like, bells or melody). All objects were approximately 9–10 in. in height, similar to a medium-sized head of a female person. The familiar object was a toy that the mother brought from home that would make sounds when handled. In the laboratory these sounds were recorded prior to testing and then played through a small speaker attached to the back of the toy (invisible to the infant) in the auditory conditions. Thus both the novel and familiar toys provided *simultaneous* visual and auditory stimulation in the combined conditions. Mothers and female strangers said 'Hello (name of baby), where am I?'. The women continued to repeat this phrase while hiding. Pilot work had indicated that all sounds were clearly audible to the infants, since all infants would turn their heads to the onset of the sounds. Different female strangers were used for each condition.

Procedure

All babies were tested when they were in an alert and attentive state. Prior to testing the infants were familiarized with the table and the hiding procedures by playing games of hide and seek with the experimenter and some toys, while the mother held the infant from behind. Stimuli used during the familiarization session did not interact with the infant during the experimental sessions. During testing, the infants were placed in the box facing the cameras at either the right or the left door of the table. These positions were randomly determined. A research assistant held the infant from behind. In order to prevent her from biasing the responses of the infant she wore stereophonic earphones through which music played. She was further instructed to watch over her shoulder and away from the infant to a video that recorded the infant's face. Thus, she was in a sense deaf and blind to the location of the various stimuli. At the beginning of each task, the infants were turned at a ¾ angle towards the door; the other ¼ of their body was turned towards the front of the playbox facing the cameras. This way the infant's gaze (head and nose aligned to the exit door) to where the object was shown or/and sounded was easily scored. The stimuli were presented to the infants at a reaching distance of approximately 30 cm. During the social and non-social vision tasks, the person's face or the object was shown to the infant through the door. As soon as the infant fixated the stimulus and before the infant was able to respond, the door was closed. The stimulus was then hidden for 15 seconds.

During the social and non-social auditory tasks, the person would say 'Hi (baby's name), where am I?', or the object would sound behind the closed door. The door was then opened and closed (without showing the stimulus) while the person or object continued to sound without becoming visible for 15 seconds. In the social and non-social combined tasks, the person's face or the toy respectively would be shown to the baby through the door while sounding until the infant fixated the stimuli. Then the door would close while the stimuli continued to sound for another 15 seconds.

Infants were given only one trial of each task to eliminate a practice effect. The 12 tasks were also randomly presented.

Data Scoring

The videotapes were coded by two trained students naïve to the experimental hypotheses from a TV monitor with a 53 cm screen. Although the coders were able to see the various stimuli when the doors opened, they were not aware of the experimental hypotheses and therefore could not influence the results one way or the other. The durations of the following infant-dependent variables were coded for each of the 12 tasks: (1) reaching; (2) body movements; (3) gazing; (4) smiling; and (5) vocalizing. Although filming had begun as soon as the stimulus was presented to the infant, scoring of the dependent variables commenced with the closing of the door or after the infants turned their heads towards the sounding invisible stimulus (in the auditory condition).

Interobserver reliabilities using the scoring method were calculated for 30% of the data. Cohen kappas were calculated on agreement of the durations (± 1 seconds) and frequencies of each behaviour and ranged between 0.81 and 0.82. Values greater than 0.75 are considered 'excellent agreement' (Fleiss, 1981).

A 'reach' was defined as the forward extension of one or both arms away from the body, in the direction of the stimulus and while the infants were gazing at the stimulus (von Hofsten, 1984). A 'gaze' was calculated when the infants turned their eyes towards the sound or the invisible stimulus behind the exit door. A 'body movement' was defined as a gaze towards the stimulus with the upper torso leaning forward. 'Smiles' were coded when babies turned up the corners of their mouth without vocalizing (mouth may be open or closed). 'Vocalizations' were scored when babies made vocal sounds. Physiological sounds (burping, hiccups, and cries, etc.) were not scored.

RESULTS

The mean durations and standard deviation of each of the infant responses are presented in Table 1. To determine whether infants would display reliably different responses to hidden social and non-social stimuli, and whether sound and familiarity of the two classes would influence the responses of the infants, their responses were submitted to a repeated measures ANOVA that would evaluate the effect of condition (combined, auditory, vision), stimulus (person, object) and familiarity (familiar, novel). Interactions were analysed *post hoc* by planned orthogonal contrasts.

Reaching

A significant main effect for stimulus $F(1,20)=91.54$, $p<0.0001$ indicated that infants reached significantly more for hidden objects than for hidden people. There was also a significant main effect for condition $F(2,19)=9.46$, $p<0.001$ and a subsequent significant stimulus × condition interaction $F(2,19)=7.33$, $p<0.004$. *Post hoc* analyses indicated that infants reached significantly more to inanimate objects in the combined condition than in the auditory $F(1,20)=7.49$, $p<0.012$ and vision $F(1,20)=22.45$, $p<0.0001$ conditions. This interaction is depicted in Figure 2.

Body Movements

Main effects for stimulus $F(1,20)=8.08$, $p<0.01$ and familiarity $F(1,20)=10.43$, $p<0.004$ indicated that these variables influenced the body movements of the infants. These main effects were qualified by a significant stimulus × familiarity interaction $F(1,20)=12.54$, $p<0.002$. Subsequent analyses indicated that the infants moved their body more to where their mother was hiding $F(1,20)=15.20$, $p<0.0009$ than to where the stranger and the objects were hiding, between which there was no difference. This interaction is depicted in Figure 3.

A significant main effect of condition $F(2,19)=4.55$, $p<0.02$ indicated that overall, the infants moved their body more towards the stimuli in the combined condition ($M=4.00$) than in the auditory ($M=2.56$) and vision ($M=2.93$) conditions, between which there was no significant difference.

Table 1. Mean durations and standard deviations of infant responses to familiar and novel, people and objects, in vision, auditory and combined conditions ($N=21$)

	Reach	Body	Gaze	Smile	Vocalization
Condition					
Vision					
M	2.36	2.94	6.73	0.85	0.90
SD	1.50	1.44	1.56	0.39	0.36
Auditory					
M	2.62	2.56	10.02	1.35	0.85
SD	1.60	1.86	2.42	1.28	0.61
Combined					
M	3.57	4.00	11.53	1.62	0.70
SD	1.72	2.66	1.79	1.18	0.33
Stimulus					
Person					
M	0.86	3.65	9.53	2.36	1.32
SD	0.67	2.09	1.74	1.62	0.78
Object					
M	4.84	2.68	9.33	0.18	0.31
SD	2.25	1.71	1.57	0.03	0.22
Familiarity					
Familiar					
M	2.62	3.71	9.57	1.67	1.11
SD	1.76	1.89	1.36	0.85	0.61
Novel					
M	3.08	2.63	9.29	0.87	0.51
SD	1.29	1.82	1.57	0.20	0.44

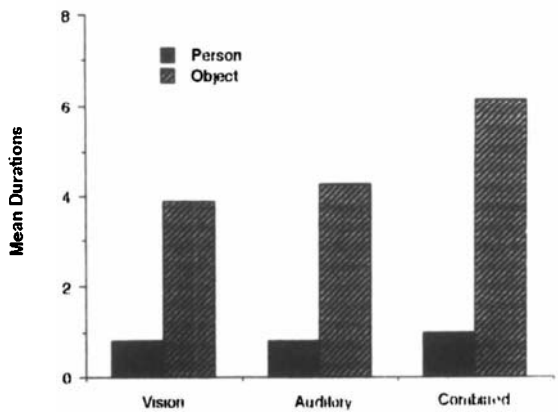

Figure 2. Mean durations of reaches to people and objects as a function of vision, auditory and combined conditions.

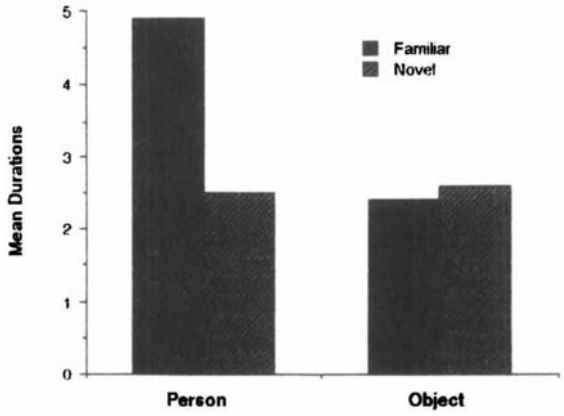

Figure 3. Mean durations of body movements as a function of familiar and novel people and objects.

Gaze

A significant main effect for condition $F(2,19)=74.80$, $p<0.0001$ showed that the infants gazed significantly more to the exit door in the combined ($M=11.52$) and auditory ($M=10.02$) conditions than in the vision ($M=6.73$) condition. This effect is shown in Figure 4.

Smiles

A significant main effect of stimulus $F(1,20)=45.94$, $p<0.0001$ revealed that the infants smiled significantly more at people than at objects. A subsequent significant main effect of familiarity $F(1,20)=11.35$, $p<0.003$, a significant stimulus × familiarity interaction $F(1,20)=17.71$, $p<0.0004$ and

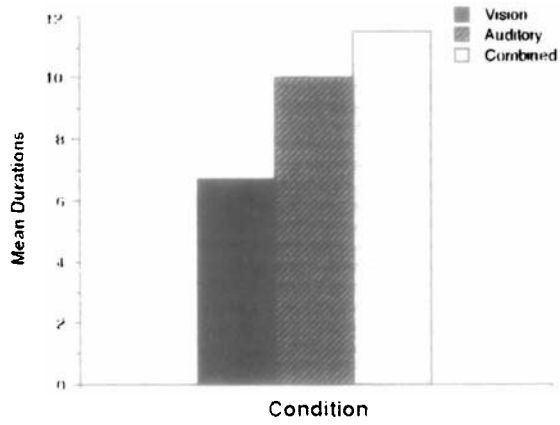

Figure 4. Mean durations of gazes as a function of vision, auditory and combined conditions.

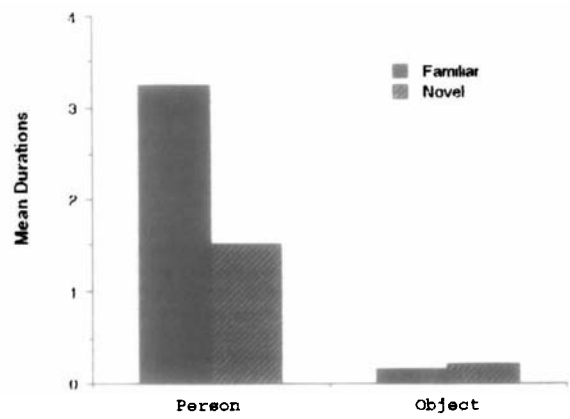

Figure 6. Mean durations of vocalizations as a function of familiar and novel people and objects.

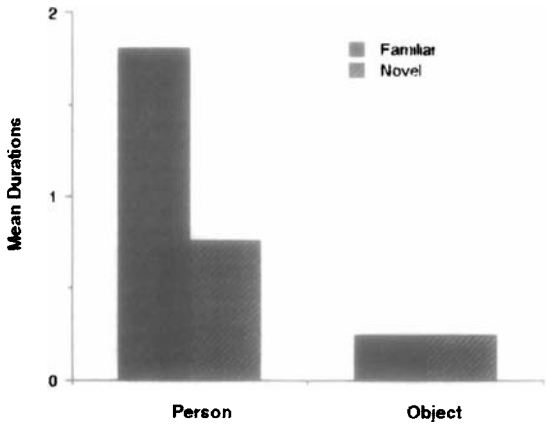

Figure 5. Mean durations of smiles as a function of familiar and novel people and objects.

post hoc analyses revealed that infants smiled significantly more at their mother than at the stranger $F(1,20)=15.00$, $p<0.0009$, and significantly more at the stranger than at the familiar and novel objects $F(1,20)=8.72$, $p<0.007$, between which there was no difference. The interaction is shown in Figure 5.

Vocalizations

A significant main effect of stimulus $F(1,20)=41.51$, $p<0.000$ showed that the infants vocalized significantly more to people than to objects. A further main effect of familiarity $F(1,20)=30.53$, $p<0.0001$, a stimulus × familiarity interaction $F(1,20)=10.06$, $p<0.003$ and subsequent *post hoc* analyses showed that infants vocalized significantly more when their mother was hiding than when the stranger $F(1,20)=34.72$, $p<0.0001$ was hiding, but more to the stranger than to the objects $F(1,20)=9.30$, $p<0.0063$ between which there was no difference. This interaction is shown in Figure 6.

A stimulus × familiarity × condition $F(2,19)=5.01$, $p<0.017$ interaction and subsequent *post hoc* analyses showed that the infants vocalized more to their mother in the combined ($M=2.26$) and auditory ($M=2.10$) conditions than in the vision condition ($M=1.38$).

In summary, infants reached significantly more towards hidden objects than towards hidden people. In contrast, they vocalized, smiled and moved their bodies more towards hidden people, in particular their mother, than to other stimuli. Thus, infants responded differentially to hidden people and objects, whether the stimuli were soundless (so that there was no cue to their presence) or not.

DISCUSSION

The main purpose of this study was to determine whether infants would use different patterns of responses to bring different kinds of objects to view. It was proposed that since young infants communicate with people and manipulate toys when they are present (Legerstee *et al.*, 1987, 1990), they should continue to use such actions if they expect the stimuli still to exist when they are no longer in sight. The results showed that 4-month-old infants responded with consistently different types of behaviours to the hidden stimuli. They reached significantly more to where objects had been hidden and they vocalized, smiled and moved

their body more in the direction where people were hiding. This differential responsiveness to the hidden stimuli implies that such young infants have enduring representations of animate and inanimate objects that are no longer visible. Thus not only were infants aware of the continued existence of people and things, but also of their properties. In particular, the infants seemed to acknowledge that one communicates with people and acts on objects. Although this is only a small segment of the information that differentiates people from things, it indicates that the concept of animism is developing early in life.

Other researchers have demonstrated a global concept of animism in very young infants. Apparently, 2-month-old infants will imitate facial gestures of people, but not of objects simulating these gestures (Legerstee, 1991), and 7-month-old infants differentiated between animals and vehicles as different kinds (McDonough and Mandler, 1992). These data cannot be explained on the basis of perceptual differentiation, since the animate and inanimate stimuli were kept perceptually similar in these studies.

As expected, infants benefited from prior visual input when searching for sounding objects. Significantly more infants reached and gazed for inanimate objects, and significantly more infants moved their body to their mother in the combined condition than in the vision or auditory conditions. Thus the added effects of visual and auditory stimulation aided infants in their search for hidden objects. This finding supports studies on intersensory coordination in infancy showing that the different modalities function in a coordinated way in infants (Spelke, 1979; Stack *et al.*, 1988).

Familiarity of the social stimulus appeared to have a significant influence on the search activities of the infants. The infants smiled, vocalized and turned their body significantly more to where their mother was hiding than to where the other stimuli were hidden. Thus infants seemed more sensitive to the absence of their mother than to the disappearance of the other stimuli. Bell (1970), studying infants between 9 and 12 months of age, found increased search for mother over inanimate objects. There are several reasons why search for mother would be more intense. The mother is in tune with the gestures of her infant and her actions are often in synchrony with them (Kaye and Fogel, 1980; Murray and Trevarthen, 1985). The developing elaboration of mother–infant interactions, facilitated by familiarity with each other, results in the mother becoming the most important and stimulating object for the infant (Stern *et al.*, 1985). It should therefore not be surprising that her disappearance carries greater consequences to the infant than the disappearance of inanimate objects or unfamiliar people (Gelman and Spelke, 1981; Legerstee, in press).

It could be argued that the various responses to people and objects were simply continuations of actions that had already been set in motion when the stimulus was shown to the infant. However, only gazing and smiling were behaviours that had their onset prior to the response period. The vocalizations, reaches and body movements were behaviours that had been produced *after* the stimulus had been hidden. If the infant responses had been continuations of actions produced to the visual stimulus, then no differential responsiveness should have been produced during the auditory condition in which no prior visual association with the stimulus had been provided to the infants. Our results showed that the infants responded differentially according to the meaning of the sound. They reached significantly more to the sound emitted by objects and they produced more body movements, vocalizations and smiles to the sound produced by people, in particular their mother. Thus, sound had come to indicate the position and the identity of a *specific* object, a realization that is likely to come with the understanding that objects continue to exist in space even when out of sight (Uzgiris and Benson, 1980).

It is also difficult to explain these data as the result of conditioning. Although 4-month-old infants must have had plenty of experience in bringing back their caretakers through vocalizing, and none doing the same with objects, it is unlikely that pre-crawling, 4-month-old infants have had practice bringing back invisible inanimate objects through reaching. Therefore, the infants' differential responsiveness to the invisible stimuli suggests that infants in these situations appreciate that: (a) an object has been hidden; (b) this object is either animate or inanimate; and (c) different procedures are appropriate for the retrieval of, or for interacting with animate and inanimate objects. Thus, rather than a conditioned response, the infants' differential responsiveness to the invisible stimuli suggests the beginnings of the object concept. That infants are capable of such representations has been indicated in previous work by Hood and Willatts (1986). The present study provides new information about infants' conceptions of people.

If such young infants are able to remember the location and existence of hidden people and objects, what does proper search for stimuli depend on?

According to Gelman and Spelke (1981) and Mandler (1990), an understanding that people and objects can be returned in different ways should depend in part on a knowledge of objects and of the various distinctions between them. Thus an appreciation of the object's separate and permanent existence should not be seen as the end result of lengthy interactions with people and things, but as the *foundation* from which might develop an idea of animism which would lead to a further refined conceptual differentiation of people and objects (Mandler, 1990).

If young infants are able to conceptualize things, the foundations of such thoughts cannot lie in the physical actions with objects since young infants have not acquired much control over their actions until 4–5 months of age (Bebko *et al.*, 1992; Bushnell, 1985). In a recent review, Mandler (1988) offers a theoretical account for the early appearance and further development of these conceptualizations. She suggests that rather than from physical actions, early concept formation derives from certain perceptual analyses which are defined as 'a symbolic process (probably conscious) by which one perception is actively compared with another' (Mandler, 1988, p. 126). As an example of how infants might begin to form conceptions of animate and inanimate objects, she proposes that infants may perceive the movement of animate objects to be different in some important and specific way from inanimate objects. This perception is stored, and in subsequent processes animate and inanimate objects are compared with this representation. Thus, conceptions develop from internal abstractions that are made specific by the perceptual system (Mandler, 1992). In order to determine whether these speculations have any truth, an investigation about animate and inanimate objects should be of interest to all concerned with the infant's earliest cognitive development.

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