World Health Organization 1999 *The World Health Report 1999. Making a Difference*. World Health Organization, Geneva, Switzerland

M. Barbieri

Infant Development: Physical and Social Cognition

At the beginning of the twentieth century the received wisdom among psychologists was that human infants have virtually none of the cognitive skills they will later have as adults. Sigmund Freud had infants dreaming away their days in primary process (autistic) thinking, and William James described their phenomenal world as 'a blooming, buzzing confusion.' But since that time dramatic progress has been made in our understanding of infants' minds, and we now know that many of the basic structures of human cognition develop very early in infancy.

The modern era was ushered in primarily by the work of Jean Piaget. In a series of exquisitely detailed observations on his own three infants' ontogenies—first made in the 1930s but only made available to the international community in the 1950s—Piaget documented that from birth infants are actively and continuously exploring their environments, and that their cognition is already organized. On the basis of these observations, Piaget proposed a sequence of six cognitive stages, from birth to 18 months of age, that structured infants' interactions with the world. These stages were wholly general and governed the way infants could physically interact with the environment. He posited six levels of sensorimotor schemes (Piaget 1952), and for the kinds of knowledge infants could construct from these interactions, he posited six corresponding levels of knowledge of the physical world of space, time, causality, and objects (Piaget 1954).

Piaget's most general claim was that human infants are cognitive beings, it is just that their cognition is confined to the here-and-now of sensorimotor interactions with the world. Thus, for example, for very young infants objects only exist when they are interacting with them, and space is only experienced as self and other movement. The engine of Piaget's theory—the mechanism that takes infants beyond the sensorimotor level and on to more adult-like ways of conceptualizing the world—was action in the concrete sense of manipulation of objects. In Piaget's theory, neonates begin with their five senses totally uncoordinated and with objects as ephemeral perceptions only. But as they act on objects and perceive the effects of particular actions through the various different senses simultaneously, the senses become coordinated and so objects become objectified. Only by the end of the infancy period—after a vast number of sensorimotor interactions with the world—can infants cognitively and symbolically represent external entities in the absence of their own immediate perceptual contact with them.

1. Beyond Piaget

Although it gave infants credit for much more complex cognitive processes than its predecessors, Piaget's theory turned out to be still too conservative. The main problem was that Piaget depended almost exclusively on evidence provided by infants' spontaneously produced overt actions, and human infants are indeed very slow to develop motorically. But in the 1970s new methods were developed that enabled researchers to probe and test infants' cognitive competencies without relying on the production of complex motor sequences. These methods were much more experimentally rigorous than Piaget's, and exploited those few actions that infants are very skilled at and engage in frequently; for example, looking, sucking, kicking, and reaching.

The first of Piaget's proposals to fall was the proposal that infants possess five distinct and uncoordinated sensory modalities. In a seminal study, Spelke (1976) had young infants view two different films on adjacent monitors and at the same time listen to an audio recording that matched one of the two visual events (e.g., there was a noise every time an object banged the ground on one of the films). Infants as young as four months of age looked longer at the film that matched the audiorecording, suggesting at least some form of intermodal integration. At around the same time, Meltzoff and Moore (1977) discovered that newborn infants (less than 48 hours old) reliably imitated adult behaviors directed to them; such things as tongue protrusions and mouth openings. Given that infants perceive the adult face visually but perceive their own facial movements only proprioceptively, skills of intermodal integration were once again implied.

These two pioneering studies demonstrated that Piaget was wrong about early intermodal integration, but they did much more than that. First, if infants coordinate information from the different sensory modalities practically from birth, it is possible that this cross-modal information gives them a more objectified understanding of objects at an earlier age as well. These studies thus initiated a plethora of new research into infants' early understanding of the world of space and objects. Second, these studies and others that followed them demonstrated that infants possess considerable knowledge about the world before they can actively manipulate objects or anything else in their environments. Thus, Piaget's focus on action as the mechanism of development was called into serious question. Third, Meltzoff and Moore's study of

neonatal imitation in particular opened up exciting new questions about infants' early emerging skills for dealing with the social world—an arena of development about which Piaget had very little to say. Finally, and perhaps most importantly, Spelke's study demonstrated that infants' looking preferences could be used to ask very specific and very important questions about their cognitive skills. This new, child-friendly technique (along with the related technique of visual habituation–dishabituation) enabled researchers to answer questions about infant minds that Piaget never thought it possible to ask.

Buoyed by these spectacular new findings and powerful new methodologies, researchers in the 1980s and 1990s opened up a number of new and exciting windows on infants' cognitive development. These may be grouped, roughly, into findings about: (a) perception and learning, (b) understanding of the physical world, and (c) understanding of the social world.

2. Early Perception and Learning

Infants' perception of the world is surprisingly adult-like from a surprisingly early age. This general fact has been established mostly with habituation and paired-comparison techniques. In the typical habituation paradigm, infants are repeatedly exposed to a stimulus until their visual attention to the stimulus decreases to a pre-established level, essentially until they become bored with the stimulus. During a test phase, the infant is then shown a novel stimulus and the familiar stimulus simultaneously (i.e., paired comparison method) or one after the other (habituation method) and visual attention is again measured. If infants look longer to the novel stimulus, but continue to look away from the familiar stimulus, it is inferred that they can discriminate between the two stimuli. In such habituation studies, young infants discriminate among various properties of stimuli such as color, size, and shape (see Johnson 1998), perceive voices and sounds (e.g., Kuhl et al. 1992, Pegg et al. 1992), and even particular odors (Marlier et al. 1998). Other research has shown that much of this performance is based on cross-modal information. For instance, newborns manifest a visual preference for a novel image that corresponds to the shape or texture of an object that was previously orally explored (i.e., Meltzoff and Borton 1979, Gibson and Walker 1984). In addition, they reliably turn their head and eyes in the direction of a sound source, meaning that spatial location from this early age is specified by both auditory and visual information (Muir and Clifton 1985). By four months of age infants reach for an object that they see in the light, but will also reach when they only hear the object making a sound in the dark (Clifton et al. 1993).

Infants also are able to learn new things quite rapidly from soon after birth. Using instrumental learning paradigms, infants are reinforced for producing a particular type of behavioral response such as kicking their legs or sucking at a particular rhythm or speed. Infants readily learn such associations and are generally eager to modulate their actions to produce interesting outcomes. In one of the first studies to use such a paradigm, 4–12-month olds sucked on a dummy nipple to turn on a visual light display. With only three minutes of experience with such response–stimulus conjugation, infants significantly increased their rates of sucking compared to infants whose sucking produced no contingent outcome (e.g., Siqueland and DeLucia 1969, Kalnins and Bruner 1973, Lewis et al. 1985). In addition, newborn infants learn to modulate their actions to see an image of their mother as opposed to a stranger (Walton et al. 1992), to hear their mother's familiar voice or a story that was repeatedly read to them while in utero (DeCasper and Fifer 1980), and even to hear speech sounds from their native language (Eimas et al. 1971). Indeed, eight-month-old infants are so skilled at learning that they are able to pick up statistical patterns in their perceptual input with two minutes or less of exposure to a disembodied voice, played while the infant is playing on the floor and seemingly paying little attention (e.g., Saffran et al. 1996). Infants can extract these same kinds of patterns from other kinds of perceptual inputs as well; for example, sequences of arbitrary tones or even lights (Saffran et al. 1999).

3. Understanding the Physical World

Going a step beyond the perceptual abilities of infants, researchers have also designed paradigms to assess infants' physical knowledge at an age before they can even reach for or manipulate objects. Using one or another variation of the habituation technique, infants typically are familiarized with some event as they watch it several times; for instance, seeing one object pass behind a screen. Then during a testing phase, the infant sees the same event, but this time the screen is removed and the infant sees one of several possibilities. For example, they might see the original object in an improbable position, two objects, perhaps a different object in the position, or no object at all. As young as three months, infants look reliably longer at improbable compared to probable outcomes. From these kinds of studies, researchers have found that infants as young as two or three months possess much physical knowledge of the world and readily engage in physical reasoning about objects, relying upon principles such as object solidity, object continuity, the notion that two objects cannot be in the same location at one time, and the notion that objects exist continuously in space (see Spelke 1994, Spelke et al. 1992).

Similar techniques have also been used to assess infants' object concept more directly. In one classic study, commonly referred to as the Draw Bridge Study

(Baillargeon et al. 1985), infants were familiarized to a screen rotating alternately from upright to flat on a table. Following this familiarization phase, infants saw a solid object that was placed behind the screen, making it impossible for the screen to rotate flat onto the table. During a test phase, they saw either a possible event—the screen stopped moving at the position where the solid object would have obstructed its motion—or an impossible event—the screen rotated flat to the table, seemingly passing through the solid object. Infants as young as three months of age—before they are reaching for, grasping, or manipulating objects—looked reliably longer at the impossible event. These findings suggest that infants have a rudimentary concept of objects that enables them to reason about and predict their basic physical transformations. In a related series of studies, Wynn (1992) has shown that infants are surprised when they see one object disappear behind a screen and then, when the screen is removed, two objects are there (or they see two objects behind a screen but later only one is there). These studies evidence some basic understandings of quantities of objects as well.

Habituation paradigms have more recently been extended to assess the ability of young infants to relate objects to one another, to categorize them, and to recall information about them. In a study of infants' understanding of basic causal relations, six-month olds were habituated to either a noncausal event in which two objects moved independently or to a causal event in which one object collided into the other. Following habituation, infants then observed a reversal of the event. Infants who were habituated to the causal event looked longer when the causal event was reversed. In contrast, those infants who had watched the noncausal event did not seem to notice the role reversal (Leslie 1984). Dishabituation to role reversal only in the causal sequence suggests that infants detected the relations among these objects in the original events. Of course, the question of whether infants are endowed with an understanding of causal relations from birth or whether such understanding develops in a more progressive manner remains open (e.g., Oakes and Cohen 1990). In any case, such findings point to the precocious inclination of infants to perceive the relations and potential meaning among objects and events in the world.

In studies of categorization, infants are pre-exposed to one or more members of a particular category. They are habituated to these members and then shown a novel stimulus that does not belong to the category. As with traditional habituation paradigms, it is assumed that infants classify the stimulus as different from the familiarized category if they look longer to the new test stimulus as compared with a within category exemplar. Impressively, at least by the middle of the first year, infants come to represent a variety of categories such as spatial relations, geometric patterns, faces, and animals (e.g., Eimas and Quinn 1994, Quinn and Eimas 1987, Roberts 1988, Sherman 1985). Other common paradigms used to investigate infants' ability to categorize information have relied upon sequential touching or object manipulation. The sequential touching paradigm exploits infants' inclination to touch and explore objects, and is considered analogous to an adult-like object sorting behaviour. By 9–12 months infants simultaneously touch the objects from one category before touching objects from the other category and differentially categorize objects from global and basic-level categories (Mandler and McDonough 1993, Sugarman 1981).

In terms of early memory, using conjugate reinforcement paradigms in which they are reinforced to kick their legs in order to learn about the features of objects hanging from a mobile, young infants readily learn and recall experiences and retain this information over several days and sometimes weeks (i.e., Rovee-Collier 1995).

4. *Understanding the Social World*

Modern research has found that young infants also exercise impressive cognitive skills in understanding their social world. Soon after Meltzoff and Moore (1977) found that young infants would match some adult behaviors, Trevarthen (1979) and others discovered that they also interact with adults reciprocally in patterned ways. The first research of this type simply noted that young infants and their mothers interact with one another in a kind of turn-taking sequence, sometimes called a protoconversation (see Bullowa 1979 for a review). This discovery was followed by more rigorously controlled investigations.

Most important is the so-called still-face paradigm. In the traditional paradigm, infants engage for several minutes in a normal face-to-face interaction with an adult social partner. Then dyadic interplay is halted when the adult suddenly adopts and holds a neutral still face for about one to two minutes. Infants as young as two months respond to such perturbation with increased negative affect and gaze aversion (Tronick et al. 1978). This reaction to the still face is interpreted as the expression of social expectations by the infant and the sense of a disruption of positive coregulation (Muir and Hains 1993). Other evidence derives from the interpersonal contingency paradigm designed by Murray and Trevarthen (1985), in which infants interact with their mothers over a television monitor. In this study, infants sometimes watched their mothers interacting with them live, and at other times watched a replay of their mothers' behavior. At two months of age, infants reacted more positively to their mother interacting with them 'live' compared to watching a replay video.

The development of social expectations and the social behavioral repertoire of human infants develops rapidly over the course of the first year. It is also

important to note that subsequent work has established a number of compelling phenomena concerning neonatal imitation; for example, the fact that six-week-old infants will seek to reproduce even extremely novel behaviors (Meltzoff and Moore 1994). Nevertheless, there are still some investigators who are not convinced that what infants are doing in these studies is truly imitation, rather than something much less cognitively sophisticated such as preparing for object exploration (e.g., Anisfeld 1991, Jones 1996).

At around 9 to 12 months of age infants begin to engage in a new type of social interaction. Specifically, they begin to engage in interactions that are triadic in the sense that they involve the referential triangle of child, adult, and some outside entity to which they share attention. Thus, infants at this age begin to flexibly and reliably look where adults are looking (gaze following; Scaife and Bruner 1975), use adults as social reference points (social referencing; Sorce et al. 1985), and act on objects in the way adults are acting on them (imitative learning; Meltzoff 1988)—in short, to 'tune in' to the attention and behavior of adults toward outside entities. At this same age, infants also begin to use communicative gestures to direct adult attention and behavior to outside entities in which they are interested—in short, to get the adult to 'tune in' to them (Bates 1979). This revolution in the way infants relate to their worlds begins when infants understand other persons as intentional agents like the self who have a perspective on the world that can be followed into, directed, and shared (Tomasello 1995, Carpenter et al. 1998)—and it presages the emergence of symbolic language, the ultimate tool of joint attention (Tomasello 1999).

5. Conclusion and Prospects

The overall picture is thus of an infant much more cognitively competent than James or Piaget ever imagined. From the first few months of life, in many cases before they even reach for or manipulate objects, human infants perceive a world of stable objects, and they soon can categorize, quantify, and perceive causal relations among these objects in some fundamental ways. They also are especially attuned to other persons and interact with, and even imitate, them in special ways.

It is not the case, however, that all researchers agree totally on this picture. Of most immediate concern, some researchers have questioned the interpretation of studies based on preferential looking or habituation. The question is not about the findings themselves, but rather about whether they might be more parsimoniously interpreted as evidence of perceptual strategies and expectations, not high-level cognition (Bogartz et al. 1997, Haith 1998). Thus, while looking time measures indicate that four-month-olds show sensitivity to the solidity of physical objects (i.e., Spelke et al. 1992), if children are asked to physically interact with the exact same experimental arrangement they do not evidence the same sensitivity to solidity until two to three years of age (Hood et al. 2000). A major challenge for future research in infant cognition is thus to determine whether such findings simply reflect different extraneous task demands placed on relatively fragile cognitive beings or whether, instead, they reflect different processes of human cognition. Perhaps relevant to this question is recent research into the cognitive processes of nonhuman primates, who show many—but not all—of the same cognitive skills as human infants (Tomasello and Call 1997).

In all, recent research in infant cognition has been among the most exciting in all of the behavioral and cognitive sciences, unearthing on a regular basis infant competencies that few would have expected just a few decades ago. Research in the coming decades will be aimed both at making more such discoveries and also at determining what these discoveries mean in the larger context of human evolution and ontogeny.

See also: Brain Development, Ontogenetic Neurobiology of; Cognitive Development: Child Education; Cognitive Development in Childhood and Adolescence; Cognitive Development in Infancy: Neural Mechanisms; Infancy and Childhood: Emotional Development; Infant and Child Development, Theories of; Infant Education; Memory Development in Children; Piaget's Theory of Child Development; Prenatal and Infant Development: Overview; Social Cognition in Childhood; Socialization in Infancy and Childhood; Visual Development: Infant

Bibliography

Anisfeld M 1991 Neonatal imitation. *Developmental Review* **11**: 60–97

Baillargeon R, Spelke E S, Wasserman S 1985 Object permanence in five-month-old infants. *Cognition* **20**: 191–208

Bates E 1979 *The Emergence of Symbols: Cognition and Communication in Infancy*. Academic Press, New York

Bogartz R S, Shinskey J L, Speaker C J 1997 Interpreting infant looking: The event set by event set design. *Developmental Psychology* **33**(3): 408–22

Bullowa M 1979 *Before Speech*. Cambridge University Press, New York

Carpenter M, Nagell K, Tomasello M 1998 Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development* **63**(4, Serial No. 255)

Clifton R K, Muir D W, Ashmead D H, Clarkson M G 1993 Is visually guided reaching in early infancy a myth? *Child Development* **64**: 1099–110

DeCasper A J, Fifer W P 1980 Of human bonding: Newborns prefer their mothers' voices. *Science* **208**: 1174–6

Eimas P D, Quinn P C 1994 Studies on the formation of perceptually based basic-level categories in young infants. *Child Development* **65**: 903–17

Eimas P D, Siqueland E R, Jusczyk P, Vigorito J 1971 Speech perception in infants. *Science* **171**: 303–6

Gibson E J, Walker A S 1984 Development of knowledge of visual–tactual affordances of substance. *Child Development* **55**: 453–60
Haith M M 1998 Who put the cog in infant cognition? Is rich interpretation too costly? *Infant Behavior & Development* **21**: 167–79
Hood B, Carey S, Prasada S 2000 Predicting the outcome of physical events: Two year olds fail to reveal knowledge of solidity and support. *Child Development* **71**: 1540–54
Johnson S 1998 Object perception and object knowledge in young infants: A view from studies of visual development. In: Slater A (ed.) *Perceptual Development: Visual, Auditory, and Speech Perception in Infancy*. Psychology Press, Hove, UK, pp. 211–41
Jones S S 1996 Imitation or exploration? Young infants' matching of adults' oral gestures. *Child Development* **67**: 1952–69
Kalnins I V, Bruner J S 1973 The coordination of visual observation and instrumental behavior in early infancy. *Perception* **2**: 307–14
Kuhl P K, Williams K A, Lacerda F, Stevens K N, Lindblom B 1992 Linguistic experiences alter phonetic perception in infants by 6 months of age. *Science* **255**: 606–8
Leslie A M 1984 Spatiotemporal continuity and the perception of causality in infants. *Perception* **13**: 287–305
Lewis M, Sullivan M W, Brooks-Gunn J 1985 Emotional behaviour during the learning of a contingency in early infancy. *British Journal of Developmental Psychology* **3**: 307–16
Mandler J M, McDonough L 1993 Concept formation in infancy. *Cognitive Development* **8**: 291–318
Marlier L, Schaal B, Soussignan R 1998 Neonatal responsiveness to the odor of amniotic and lacteal fluids: A test of perinatal chemosensory continuity. *Child Development* **69**: 611–23
Meltzoff A N 1988 Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology* **24**: 470–6
Meltzoff A N, Borton R W 1979 Intermodal matching by human neonates. *Nature* **282**: 403–4
Meltzoff A N, Moore M K 1977 Imitation of facial and manual gestures by human neonates. *Science* **198**: 75–8
Meltzoff A N, Moore M K 1994 Imitation, memory, and the representations of persons. *Infant Behavior and Development* **17**: 83–99
Muir D, Clifton R 1985 Infants' orientation to the location of sound sources. In: Gottlieb G, Krasnegor N (eds.) *Measurement of Audition and Vision in the First Year of Postnatal Life: A Methodological Overview*. Ablex, Norwood, NJ, pp. 171–94
Muir D, Hains S M 1993 Infant sensitivity to perturbations in adult facial, vocal, tactile, and contingent stimulation during face-to-face interactions. In: de Boysson-Bardies B (ed.) *Developmental Neurocognition: Speech and Face Processing in the First Year of Life*. Elsevier, Amsterdam, pp. 171–83
Murray L, Trevarthen C 1985 Emotional regulation of interactions between two-month-olds and their mothers. In: Field T M, Fox N A (eds.) *Social Perception in Infants*. Ablex, Norwood, NJ, pp. 177–97
Oakes L M, Cohen L B 1990 Infant perception of a causal event. *Cognitive Development* **5**: 193–207
Pegg J E, Werker J F, McLeod P J 1992 Preference for infant-directed over adult-directed speech: Evidence from 7 week-old infants. *Infant Behavior and Development* **15**: 325–45
Piaget J 1952 *The Origins of Intelligence in Children*. International Universities Press, New York
Piaget J 1954 *The Construction of Reality in the Child*. Norton, New York
Quinn P C, Eimas P D 1987 On categorization in early infancy. In: Oates J, Sheldon S (eds.) *Cognitive Development in Infancy*. Lawrence Erlbaum, Hove, UK, pp. 131–61
Roberts K 1988 Retrieval of a basic level category in prelinguistic infants. *Developmental Psychology* **24**: 21–7
Rovee-Collier C 1995 Time windows in cognitive development. *Developmental Psychology* **31**: 147–69
Saffran J, Aslin R N, Newport E L 1996 Statistical learning by 8-month-old infants. *Science* **274**: 1926–8
Saffran J R, Johnson E K, Aslin R N, Newport E L 1999 Statistical learning of tone sequences by human infants and adults. *Cognition* **70**: 27–52
Scaife M, Bruner J S 1975 The capacity for visual joint attention in the infant. *Nature* **253**: 265–6
Sherman T 1985 Categorization skills in infants. *Child Development* **56**: 1561–73
Siqueland E R, DeLucia C A 1969 Visual reinforcement of nonnutritive sucking in human infants. *Science* **165**: 1144–6
Sorce J, Emde R N, Campos J J, Klinnert M D 1985 Maternal emotional signaling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology* **21**: 185–200
Spelke E S 1976 Infants' intermodal perception of events. *Cognitive Psychology* **8**: 553–60
Spelke E S 1994 Initial knowledge: Six suggestions. *Cognition* **50**: 431–45
Spelke E S, Breinlinger K, Macomber J, Jacobson K 1992 Origins of knowledge. *Psychological Review* **99**: 605–32
Sugarman S 1981 The cognitive basis of classification in very young children: An analysis of object-ordering trends. *Child Development* **52**: 1172–8
Tomasello M 1995 Joint attention as social cognition. In: Moore C D P J (ed.) *Joint Attention: Its Origins and Role in Development*. Lawrence Erlbaum, Hillsdale, NJ, pp. 103–30
Tomasello M 1999 *The Cultural Origins of Human Cognition*. Harvard University Press, Cambridge, MA
Tomasello M, Call J 1997 *Primate Cognition*. Oxford University Press, New York
Trevarthen C 1979 Communication and cooperation in early infancy: A description of primary intersubjectivity. In: Bullowa M M (ed.) *Before Speech. The Beginning of Interpersonal Communication*. Cambridge University Press, New York, pp. 321–47
Tronick E Z, Als H, Adamson L, Wise S, Brazelton T B 1978 The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child Psychiatry* **17**: 1–13
Walton G E, Bower N J, Bower T G R 1992 Recognition of familiar faces by newborns. *Infant Behavior and Development* **15**: 265–9
Wynn K 1992 Addition and subtraction by human infants. *Nature* **358**: 749–50

T. Striano and M. Tomasello

Infant Education

Infant education in the family context, without any intervention program, is largely understood as a nondirective and caring activity for a baby to secure survival, to meet physiological as well as psychological needs, and to provide both emotional warmth and

Copyright © 2001 Elsevier Science Ltd. All rights reserved.
International Encyclopedia of the Social & Behavioral Sciences ISBN: 0-08-043076-7