Basic methods in infant research
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How do researchers figure out what non-verbal infants know and feel?

In just 3 years, infants change from totally dependent creatures to active children who understand much about their immediate social and physical world. Developmental science seeks to understand what infants know and feel, when and how they develop these capacities, and the processes of change. Because infants cannot tell us what they know and feel directly, researchers must devise ways to discover these answers. As you will know from Chapter 1, although infant research goes back several centuries, many of the techniques used to study infants were developed in the last half of the twentieth century. The tremendous increase in the amount and breadth of infant research occurring during this period was made possible, in part, by improvements in technology. Better recording equipment, electronic control and automation of stimulation, more accurate, automated measurement, and of course, the computer revolution, put new and more sophisticated tools into the hands of scientists. They have developed them into a wide range of innovative techniques for answering questions about how and why infants behave the way they do. This chapter surveys some of these methods and describes how they have been applied to questions about infant behaviour.

Even if you have limited experience with infants, you probably have many questions about how infants change from helpless, naive creatures to 'real' people. They are likely to be some of the same ones that researchers have asked over the years. Questions such as:

- Do very young infants see and hear the things we do?
- Can you tell how smart an infant is?
- What do infants learn and remember?
- How do infants learn to interact with others?
- How do infants react to stressful events?

1 The authors are listed alphabetically. Each contributed equally to this chapter.
• How do infants express emotion?
• Are infants born with different personalities?
• When and how do infants develop a sense of themselves as individuals?

Each of these and many related questions have been posed by those interested in understanding how infants develop. The answers to these questions are not at all simple or obvious. As you will see from the chapters in this book, many continue to generate active research and sometimes controversial findings.

The methods of study that researchers choose will depend, in part, on the particular question of interest. Researchers may choose to observe the everyday, spontaneous behaviour of infants, interfering as little as possible with the setting and participants. This form of observation, which is found in the baby diaries described in Chapter 1, is called naturalistic observation and is analogous to observations of animals in the wild made by ethologists. Researchers may choose to measure the progress infants are making toward attaining specific milestones. They then may compare an infant’s progress to the average age when developmental milestones are reached based on large representative samples of infants using standardized developmental tests, questionnaires, or scales developed for this purpose. Or, they may use experimental designs developed to observe infant behaviours under controlled conditions that the researcher manipulates. There are two basic forms of experimental methods. In one, researchers randomly assign infants to conditions that differ from each other in one critical way. The research question is answered by comparing infants in these conditions, known as experimental and control conditions. For example, to study how a mother’s presence affects her infant’s response to strangers, infants are randomly assigned either to have their mothers present (experimental) or not (control) when a stranger approaches. The two groups differ in just one way: the critical condition in this example is mother’s presence. Specific behaviours shown by the two groups of infants then are compared. Systematic differences can be attributed to whether or not the mother was there when the stranger approached.

In the other common experimental method, groups of infants are identified for study based on some characteristic of interest and the responses of this target group are compared with a similar group without the characteristic. For example, infants born prematurely would be compared with full-term infants under the same controlled conditions.

Whatever their approach, researchers always try to obtain information that is accurate and that can be replicated reliably. Reliability, validity, and generalizability of findings are three standards that mark good research methods. Reliability refers to whether the same behaviours will be observed if the study is repeated. Usually this is addressed by having a second observer record the same behaviour. Do two observers agree, for example, that a baby played with a particular toy for the same amount of time? Seem simple? Consider this case:
The baby pauses for 2 seconds and then resumes play. Is this counted as one continuous play period or two? Researchers make their decisions based on the questions they are asking, and determining whether such fine distinctions can be coded reliably. The observations are considered to be reliable only if the inter-rater agreement is high, usually at least 80%. The observations also must be valid or relevant to the research question posed. To ensure validity, researchers often will use behaviours shown to be relevant in previous work. Or, alternatively, they may figure out several ways to measure the same underlying behaviour. For example, (1) beginning to cry when a stranger approaches, (2) looking at mother anxiously, and (3) avoiding the stranger, are all behaviours that should measure stranger wariness—fearful behaviour that infants often display after about 7 months of age. Finally, the best studies generate knowledge about infant behaviour that can be extended beyond the specific context of the study. That is, the new finding explains behaviour under many conditions or for infants in general, not the particular groups of infants who were studied. This is called generalizability of findings. As we describe techniques researchers have used to obtain answers to some of the questions listed, keep in mind that each has met acceptable standards of reliability, validity, and generalizability.

Many of the techniques we will describe are experimental designs as these have been some of the most innovative methods and have led to important findings as well as new theories of infant development. We have organized the research questions into major areas of psychological functioning such as sensory capacity, mental abilities, and social-emotional behaviour, although some questions fall into more than one area.

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**Sensory capacities**

Sensation is the basis for taking in the world. Most of us have the full range of senses: seeing, hearing, feeling, tasting, touching. Unlike many other mammalian species, most of our senses are functional at birth, although some refinement occurs as a result of the development of the nervous system and exposure to environmental stimulation. It is important to find out if newborns have the basic sensory capacities and are developing properly, because if not, their further mental (cognitive) and emotional development may be compromised. Some methods can detect responses to stimuli presented in one or more sensory domains to even very young infants.

**Do young infants see and hear the things we do?**

**Tracking**

One of the earliest signs that an infant can see and hear is tracking behaviour. Normally, newborns will turn their eyes and heads in the direction of an in-
interesting sound or sight, especially the human voice and face. Many assessments of newborns and infants observe tracking to determine the infant’s early visual integrity. Similarly, newborns, as well as older infants, show reactions to sounds that are made from objects out of view. A startle is a normal reaction to an unexpected loud noise. A reduction in movement and head turning indicate the ability to hear softer sounds.

Tracking ability often is examined using a standardized instrument called the Neonatal Behavioural Assessment Scale (NBAS; Brazelton, 1984). The examiner attempts to elicit the best performance by bringing the infants through a careful progression of states designed to arouse and then calm them. The NBAS has six orientation items to measure the infant’s attention and tracking of inanimate stimuli and the examiner’s voice and face. A failure to orient to any of these stimuli indicates that a newborn may have a serious vision or hearing problem.

Habituation

Experimental methods also have been used to examine an infant’s ability to see and hear. One of the most often used is based on the principle of habituation. This and related procedures rely on the observation that infants prefer to pay attention to novel sights and sounds rather than familiar ones. This has been used in assessment by presenting the same stimulus repeatedly (familiarization) to see if the infant stops paying attention to it. Then a novel stimulus is introduced. If the infant has habituated to the familiarized stimulus, the novel stimulus will re-engage the infant’s attention (Sokolov, 1963; Lewis, 1971). This procedure can easily be used to test sensory abilities by varying specific characteristics of the familiar and novel stimuli, for example, the shape of a visual stimulus, or different speech sounds. In an early study Barrera and Maurer (1981), for example, showed that 3-month-old infants can discriminate between smiling and frowning expressions by using one expression as the familiar and the other as the novel stimulus in an habituation procedure.

High amplitude sucking

It is a bit more difficult to find a reliable measure of an infant’s attention to sound. One response that has been used extensively is called high amplitude sucking. Young infants can control the rate as well as the pressure at which they suck, and will suck even if they are not obtaining food, as on a pacifier or dummy. Researchers have capitalized on this voluntary response system. Infants are given a non-nutritive nipple to suck that is connected to a pressure transducer. When the sucking pressure reaches a predetermined level a stimulus will go on. This has been used in habituation procedures designed to determine if infants can tell the difference between two sounds. A sound is turned on when the infant sucks sufficiently strongly. Once the sucking pressure declines and remains below that level, it can be assumed that the infant
has habituated to the redundant stimulus. When a new sound is introduced, researchers know that the infant is able to tell the two sounds apart if he or she starts sucking strongly again. For example, if we were interested in knowing if infants can distinguish between two similar speech segments, one (‘Hello, Baby!’) would be used as the familiarization stimulus and the other (‘Hi, Sweetie!’) as the novel. If the infant habituated to ‘Hello, Baby!’ and then increased sucking pressure when the ‘Hi, Sweetie!’ was presented, it indicates that he or she can distinguish these two samples of maternal speech. The procedure would be presented to infants of different ages and with different characteristics to determine whether and at what age they were capable of hearing the distinction (see Chapter 9 for a detailed account of speech perception in infancy).

**Preference paradigms**

The preference paradigm is based on an infant’s tendency to attend to the more complex of two novel visual stimuli. In preferential looking procedures, the infant is shown two targets side by side (see Figure 2.1). An observer who cannot see the stimulus makes a judgement about which target the infant is looking at. This procedure has been used to study visual acuity in very young infants. The infant is presented with one stimulus that contains black vertical stripes that have specific widths corresponding to a level of visual acuity, and another target that is a uniform grey. If infants can distinguish the stripes, they
will prefer to look at that more complex target. If not, both targets will look grey, and there will be no preference over a series of trials (Teller, 1979).

**Conditioned head turning**

The conditioned head turning technique is used to assess hearing thresholds in young infants (see Kuhl, 1985, for a review). In this procedure a sound is presented through a speaker away from the infant's gaze. If the infant turns toward the sound, an animated toy beside the speaker is activated to reward the head turn response, as in Figure 2.2. The volume of the sound is varied systematically and an estimate of the hearing threshold is obtained by comparing head turns toward the speaker in the presence versus the absence of the sound. This procedure can also be used to find if infants can detect a change in sounds, e.g., from one rhyming sound to another (Hayes et al., 2000).

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**Cognition and learning**

Sensory capacities have to do with an infant's ability to take in the stimulation afforded by the world, while cognition has to do with how the infant makes sense of those sensations. Cognition is therefore about what infants learn, think, remember, and know. There are many methods used to measure cognition and learning, including standardized instruments and ingenious experimental procedures.

**Can you tell how smart an infant is?**

**Standardized assessment**

The Bayley Scales of Infant Development (BSID; Bayley, 1993) have the longest history of use in infant assessment and are the most widely used of contemporary tools in assessing the general cognitive level of infants. The BSID presents test items arranged in a developmental sequence. The child's responses to these tasks determines his or her developmental level. The BSID has a set of items tapping mental capacity that is summarized by the Mental Development Index (MDI), and a motor skill set summarized by the Psychomotor Development Index (PDI). These scores are like IQ scores, where 100 designates average performance for age, with a range of 50–150. It is these norms for the MDI and PDI that make this assessment instrument so popular. The most recent revision (BSID-II) has test items appropriate for ages 1–42 months. Although several items are observational (e.g., 'vocalizes four different vowel-consonant combinations'), the majority have specified administration procedures and often require standard materials. Examples include determining if the infant turns to the sound of a bell, how many cubes
Figure 2.2 An infant performing in the Conditioned Headturn Procedure. The top picture was taken when the reinforcer (a bouncing toy) was not activated, and the bottom picture when it was.
can be stacked, and if all pegs can be put in a board within a certain amount of time.

MDI scores are often used by investigators to provide information about developmental level or as a measure of the effects of intervention. For example, the BSID has been used to assess the general impact of prenatal drug exposure on cognitive development, as well as the effects of early intervention programmes (Lewis & Sullivan, 1994; Alessandri et al., 1998).

Rate of habituation

Standardized instruments such as the BSID have not been found to predict later outcomes from early infancy very well. Other methods, designed to tap basic cognitive processes, such as learning and memory, may do a better job. One such method is based on how quickly an infant habituates. The rate of habituation is an indication of brain integrity and fundamental cognitive competence. For example, Lewis (1969) showed that older infants needed less looking time to habituate to repeated trials of a visual display than younger infants over the age range 3–24 months. Furthermore, infants who had medical complications in the newborn period, continued to need relatively long looking times through 12 months of age. Rate of habituation is thought to reflect the fundamental cognitive processes of sensing, perceiving, and remembering.

What do infants learn and remember?

Infants at very young ages learn and remember a lot more than we typically realize. Habituation and conditioning procedures often are used to explore this question. Infants learn early in life that certain events in the environment are associated with their behaviour. Researchers can study this in two ways. They use classical conditioning methods to study how infants learn associations between environmental signals or cues. They use contingency (operant) learning methods to study how infants learn that their actions have consequences. Learning procedures have particular appeal for researchers. Unlike habituation, which essentially measures passive behaviour (i.e., not looking at or attending to something), learning procedures inform researchers how infants act on what they know.

Classical conditioning

Even very young infants learn signals or environmental cues that are related to events important to them. For example, in the first weeks of life they learn the many auditory, olfactory, and sensory cues that predict being fed (Rovee-Collier, 1986). This form of learning is called classical conditioning. Studies of this type of conditioning are based on the principle that repeated pairings of one stimulus with another allow the infant to learn that one event predicts the occurrence of the other. Because the sound of mother’s voice, and the smell of her milk are associated with her touch and being fed, infants learn not only to
nurse efficiently but also that the world is a predictable place. Researchers know that the infant has learned an association when they respond to the previously novel cue. For example, newborn infants will turn toward the breast and begin rooting when the cheek is stroked (the rooting reflex). Noirot and Algeria (1983) preceded the touch of the infant’s cheek by the taped sound of their mother’s voice. After several pairings of voice and touch, newborns anticipated the touch. Cued by mothers’ voices alone they began to root! Classical conditioning methods such as these show the types of stimulus information the youngest infants learn, how rapidly they learn, and how long they remember (Fitzgerald & Brackbill, 1976; Ivkovich et al., 1999).

Expectancy violation
After the newborn period, a more complex procedure can be used to assess infants’ abilities to predict events in the world. Because young infants will readily watch and track moving objects, their visual and facial responses when an object deviates from a path are good ways to infer what infants expected to happen. Increased looking, search behaviour, and sometimes a wide-eyed, surprised expression (Charlesworth, 1969), allow researchers to infer that an infant’s understanding of a visual event has been violated. These procedures have been used extensively in studying young infants’ understanding of the physical world because they require only visual tracking and no other motor responses. Infants typically watch an event, for example, an object appearing in different locations successively. The same action sequence is then repeated several times so that infants can learn to predict the object’s location. On the test trial, the object’s appearance in the expected location is delayed. Monitoring of eye movements allows researchers to observe whether infants anticipated the next location, indicating that they have understood that there is a sequence and are able to predict the object’s next appearance (Haith et al., 1988).

Contingency or operant learning
A major developmental task is understanding that certain behaviours have consequences. Infants use many responses to explore, or operate on the environment, including vocalizing, touching, kicking, pulling, banging, etc. The relation between such behaviours (called operants) and the consequences they produce is called a contingency. Operant behaviour will increase when it is followed by a rewarding consequence. Contingency methods assess whether infants’ behaviours increase and decrease systematically, indicating learning of the relation between behaviour and the rewarding consequence. For example, infants were taught to pull a ribbon to see a colour slide of a happy baby and hear children singing (Bendersky et al., 1995). The infants were placed in the apparatus shown in Figure 2.3. The spontaneous level of pulling was recorded but was not rewarded in any way (baseline). During the next phase
(contingency), pulls were followed immediately by 3 seconds of the slides and music. For many infants from about 8 weeks on, this contingency results in increased pulling as the infant learns that arm action turns on an interesting event. In the next 2-minute phase pulling no longer turned on the pleasant stimulus. This period of non-reward is called extinction because it ultimately leads to reduction of the learned response. However, infants by this time may have some expectation that their pulling results in reward. Not only does it take time to learn to suppress a previously learned response, but several studies have shown that infants initially respond somewhat more during extinction (Alessandri et al., 1990; Sullivan et al., 1992). Increased response during this phase may reflect mild frustration. Imagine your own behaviour when money inserted into a soda machine does not result in the expected outcome. The absence of the soda may cause you to press rapidly a number of the selection buttons and then the coin return before you become angry. So, it was with the infants, who fortunately in this experiment were treated to another phase of contingency. With the return of the reward they settled back to their previous level of responding. Through procedures such as this researchers can focus on what is learned, how long it takes infants to 'make the connection', whether certain groups of infants learn more rapidly than others, as well as what motivates infants to respond.
**Imitation**

Imitation is another way that infants learn how to act in the world. It is more common after about 6 months, although some have reported imitation of certain facial actions in newborns (Meltzoff & Moore, 1977, 1983; Field et al., 1982). Researchers are interested in what behaviours infants will imitate (e.g., facial actions, sounds, or gestures) and who (or what) they will imitate at a given age. Facial expressions, familiar and novel gestures, and actions on objects, such as talking on the telephone have been modelled by live or televised people, and even objects. Imitation shows what infants regard as interesting or important behaviour, as well as their ability to perceive and process similarities between their own actions and those of others.

Several different target actions may be used in an imitation study to see if infants might be more likely to copy some actions than others. For example, facial movements seem to be easier to imitate than manual gestures because infants lack the necessary fine motor skills for gestures, and some facial movements seem to be more readily matched than others. Mouth opening and tongue protrusion are the most frequently copied facial movements by newborns. To study imitation, a model typically displays a target action following a baseline period. The baseline is used to determine how often infants perform the modelled action spontaneously, that is before they ever see the model do it. After seeing the model, the infant has the opportunity to reproduce the target action. If the behaviour occurred more frequently after exposure to the model then the infant imitated it. For example, Lewis and Sullivan (1985) studied young infants' ability to imitate several different models performing such familiar actions as head turning and hand waving. There was a baseline period during which no model was present. Then they examined how well infants imitated each of the target actions in response to the different models. They found that young infants were likely to become active when anything moved, but their actions did not match the modelled ones up to 6 months of age, the endpoint of the study.

In studies of delayed imitation, several days or weeks may pass between an infant's initial exposure to a novel modelled action and a test (Meltzoff, 1988; Bauer & Hertsgaard, 1993). For example, infants observe a model using a banana like a hammer during a play session. During the test, a banana is present among other toys and researchers observe if the infant uses it as a hammer. The focus of these studies is to see how long infants are able to remember the novel action, and the level of prompting needed to recall the behaviour. Imitation has also been used to study the development of early communicative gestures (e.g., waving bye-bye, pointing) and vocalizations (Masur-Frank & Ritz, 1983; Poulson et al., 1991).

**Memory**

Both habituation and conditioning procedures are used to study memory. Using habituation to study memory is very straightforward. A particular stim-
ulus is repeatedly shown to an infant, and then is presented again on the memory test after a delay as brief as several minutes or as long as several days. The response on the memory test lets infants answer the question ‘Have you seen this before?’. If the infant pays a lot of attention to the old repeatedly presented stimulus, effectively treating it as ‘novel’, then researchers infer that infants do not recognize that they have seen it before. The amount of time between the habituation and memory trials is varied to see how long infants of different ages remember. In just such an experiment researchers found that 3½ month-old infants could remember a familiar stimulus for at least 24 hours (Martin, 1975).

When memory is tested using contingency learning procedures, the time between initial learning of the contingency and the memory test is varied (Rovee-Collier, 1999). For example, infants learn to jiggle colourful mobiles hung above their cribs by means of a ribbon attached to one ankle (Figure 2.4). Different infants are then tested after days or weeks with either a dissimilar mobile (a large colourful butterfly chime or a mobile composed of different coloured and shaped objects) or an identical one to see if they will attempt to jiggle it (Grecco et al., 1990). The research shows that infants initially remember exact details about the mobile for at least a few days because they will only activate an identical one during the memory test. After 4 days, although the specific mobile appears to be forgotten, infants still remember that mobiles are for jiggling. For 2 weeks or longer after original learning, they will activate any mobile hung above their crib!

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**Social–emotional behaviour**

**How do infants learn to interact with others?**

Most studies of early social behaviour focus on mother–infant interaction. This makes good sense because up until the infant is about 6 months of age, most social contact takes place face-to-face during play or caregiving with a primary or limited set of caregivers. The importance of the early relationship between mother and infant is a cornerstone of developmental theory (see Chapter 12). The focus of mother–infant interaction research has grown from what the mother does to the infant, to how she responds to the infant’s cues, to what both members of the pair (dyad) are doing together (Lewis & Goldberg, 1969; Beckwith, 1971; Lewis, 1978; Kochanska, 1997; Kochanska & Murray, 2000). However, the procedures used to measure these interactive behaviours have remained fairly constant.

Many studies of mother–infant interaction are observations in naturalistic settings such as the home or in settings designed to be home-like, such as a laboratory playroom. Typically the mother and infant are observed while playing
or during feeding. The interaction is coded as it occurs, or is videotaped and later coded for a variety of mother and infant behaviours of interest. Coding schemes vary depending on the focus of the study. Often a list of specific behaviours is used. For example, several studies have used a list developed by Lewis and Lee-Painter (1974), in which the occurrence of 13 maternal and infant behaviours is noted every 10 seconds (Lewis & Coates, 1980; Greene et al., 1983; Bendersky & Lewis, 1986). An additional aspect of the interaction that is often of interest is the sequence, i.e., was the behaviour an initiation or a response to behaviour of the other member of the dyad? More complex methods of analysing response patterns, such as conditional probability, and sequential analysis also are used (Lewis & Freedle, 1973; Lester, Hoffman & Brazelton, 1985; Bakeman & Gottman, 1989). Another common approach is to have observers rate the dyad on more global categories of be-
haviour, for example maternal warmth (Ainsworth et al., 1974; Greenberg & Crnic, 1988; Isabella, 1993). Once a sample of mother–infant behaviour is obtained, researchers can compare the infants to see if different interactive patterns are related to the child's development.

Several more structured procedures have become fruitful methods for studying particular aspects of mother–infant interaction. These procedures examine how infants react when their mother's usual pattern of responding changes.

**Still-face procedure**

Think of a mother playing with her young infant. Mothers usually assume an animated style, coaxing the baby to interact by using exaggerated facial and verbal expressions. At very early ages infants come to expect this sort of reciprocal social behaviour from their mothers. The still-face procedure was designed to see how infants react when this expectation is violated (Tronick et al., 1978). The mother is seated facing her infant who is in an infant seat. She is asked first to play with her infant briefly as she normally would at home, and then to assume an expressionless, unresponsive facial expression. After a few minutes of this ‘still-face’ period, she is told to resume face-to-face play. Both mother and infant are videotaped and observers code vocalizations, facial expressions, direction of gaze, and head and body position of the two participants. Typically, when the mother assumes the unresponsive still-face the infant attempts to get her to respond by smiling and talking. When these behaviours that usually engage the mother fail, the infant withdraws and turns away. Turning away is one way for young infants to regulate their emotional arousal. Typically, infants quickly resume play when their mothers re-engage following the still-face period. This procedure is used to explore normal parent–infant interaction, as well as deviations due to high-risk conditions affecting the infant, such as being exposed prenatally to drugs of abuse, or conditions affecting the mother, such as depression (Field, 1984; Bendersky & Lewis, 1998).

**Desynchronized interaction**

The still-face procedure violates the infant’s normal expectation about social contingencies with its mother. Several other ingenious experiments have ‘uncoupled’ infant and maternal behaviour to examine the importance of the contingent quality of maternal interactions (Murray & Trevarthan, 1985; Cohn & Tronick, 1987; Bigelow et al., 1996). In one such study (Bigelow, 1998), mothers responded to their infants via closed circuit video for a brief period. This allowed the infants to ‘interact’ with their mothers shown on ‘live’ TV. The mothers’ behaviour was taped during this period. The baby then viewed the taped mother on the monitor but maternal behaviour was no
longer tied to what the infant did—the two were 'out of sync'. This procedure elegantly controls the level and distribution of maternal stimulation. As the infant views its own mother, the stimulation is exactly the same in both phases. However, the responsivity or contingent quality of the social interaction for the infant has been lost. Studies tend to agree that infants detect this disruption in maternal contingency rather quickly and become upset.

**Attachment**

*Strange situation*

Sometime after 6 months, most infants develop a strong emotional attachment to the primary caregiver, usually their mother. One of the most influential procedures used to study the development, the quality, and outcomes related to this first emotional relationship is the 'the Strange Situation' (SS; Ainsworth et al., 1978). The SS shows that, although the infant is able to move freely about the environment, the mother serves as a 'secure' base that the infant will seek when stressed (Bowlby, 1973, 1982). The procedure is comprised of eight increasingly stressful episodes in which a stranger interacts with the infant in the mother's presence and alone. The most stressful episode is when the infant is left entirely alone (separation). The reunion episode that follows assesses the calming effect of the mother's return. The infant's behaviour during the separation and reunion allows researchers to classify the maternal–child relationship into one of three major attachment types. During reunion, infants who easily calm while showing little resistance to being comforted are called securely attached. About 65% of middle class infants fall into this category. This type (B) is considered the ideal form of emotional attachment at 1 year of age. In contrast, insecurely attached infants may be avoidant (A) or ambivalent (C). The type A infant does not seek to contact mother upon her return, and may not have become severely distressed at her leaving. The type C infant seeks contact but remains upset throughout the reunion episode (Ainsworth et al., 1978). Sometimes an additional classification (D, disorganized) or subcategories have been used (Main & Solomon, 1990; Schneider-Rosen, 1990; Braungart & Stifter, 1991). These classifications are frequently used as the basis of grouping infants whose subsequent or earlier behaviour is examined in relation to attachment classifications. Most researchers agree that attachment is related to both maternal and infant factors. Major issues in the latest studies are determining the process through which attachment develops, the relative contribution of specific maternal and infant behaviours to the classification, and the stability over time of the attachment classification (Lewis & Feiring, 1989; DeWolf & Ijzendoorn, 1997).

**Social referencing**

Social referencing procedures are designed to present the infant with a potentially distressing or ambiguous situation in which mother is available. This al-
allows researchers to study if and how infants use maternal behaviour and signals to regulate their emotions or guide their responses. Social referencing occurs when the infant attends and then behaves in a manner consistent with mother’s message in the ambiguous situation. The approach of a stranger, originally designed to study fearfulness, has been adapted to study social referencing because it mimics a common dilemma in the lives of infants: should the infant accept the stranger as a friend or not? In these studies, when the stranger enters the room, mother greets and interacts with the stranger in one of three ways. She responds either positively, negatively, or not at all. Subsequently, the stranger interacts with the infant offering a toy in some studies, or picking the child up in others. At about 1 year of age, the infant will respond positively to a stranger when mother’s reaction to the stranger is positive (Feinman, 1982; Feinman & Lewis, 1983; Feiring et al., 1984; Walden & Baxter, 1989). The results for negative reactions are more mixed. It also is not yet clear if infants pick up cues simply from observation of the mother–stranger interaction or require more direct social/emotional cues from mother to accept the stranger’s overtures (Saarni et al., 1998).

Other studies have used potentially frightening situations to study whether infants use maternal cues to guide their behaviour. The Visual Cliff, originally designed to study depth perception, was adapted to study infants’ monitoring of maternal facial expressions (Sorce et al., 1985). Infants were placed on a raised glass surface in which the visual pattern beneath the glass made it appear that there was a deep drop-off in the surface just ahead. Their mothers, positioned on the opposite side, tried to coax the infants across the ‘chasms’. Infants were more likely to cross the cliff when mothers looked happy, and less likely to cross when mothers looked fearful (Feinman et al., 1992). The Noisy Toy procedure (Klinnert, 1984) uses a variety of novel, familiar, and somewhat unusual toys likely to elicit mixed or negative reactions from infants (for example, a robot). In one experiment, mothers are told to remain neutral or to show either positive or neutral vocal or facial responses to each toy. At 1 year of age, only maternal vocal cues influenced the infants’ responses (Mumme et al., 1996).

**How do infants react to stressful events?**

There are two ways that all people, including infants, react to stress. Our behaviour changes, and we have internal, bodily changes as well. Researchers examine both stress response systems to understand how infants react to stress.

**Behavioural stress reactivity**

We usually react to stressful situations by changes in behaviour. For example, you might clench your fists and grimace when the dentist performs a painful procedure. While adults may be able to mask their stress levels and not show too much outward reaction, infants usually cannot. Infants will show
different levels of distress in response to a painful event, such as inoculation, and also will calm down at different rates. Typically, infants are videotaped during the inoculations until they are completely calm. The intensity of crying and fretting, as well as facial expressions, are coded from the tapes (Lewis & Ramsay, 1995a). Of interest is that the initial reaction and the return to calm do not necessarily go together. Intensely negative reactions, as well as difficulty calming in stressful situations have widespread implications for social interactions and learning (Lewis & Ramsay, 1999).

Physiological responses

Think of how you feel when you are in the middle of a big exam and time is running out, or while in your car, you suddenly hear the brakes of the car behind you screeching just before it hits your rear bumper. Your body will react to these kinds of stressful situations, first with a rush of adrenaline, the 'fight or flight' hormone, that makes your heart pound and your hands sweat. About half an hour later you are still in an agitated state because the level of another more long-acting stress hormone, cortisol, has risen. Production of stress hormones and heart rate changes are other ways to study infant reactions to stress.

Cortisol is a hormone released by the adrenal glands in response to stress. It is easily extracted from saliva and has become a popular measure of the physiological stress response due to ease of collection from subjects of all ages. Cortisol typically has been collected during painful medical procedures such as circumcision (Gunnar, 1986, 1989) and inoculation (Lewis & Thomas, 1990; Lewis & Ramsay, 1995a,b). A baseline level is obtained prior to and a post-stimulation level obtained following the procedure. The post-stimulation sample is usually obtained about 20 minutes after the painful procedure because that is when the cortisol reaction is at its peak. The mouths of infants are swabbed with cotton pads to absorb saliva that is then squeezed into test tubes and assayed for cortisol. Both baseline levels and the change from base to post-stimulation (reactivity) are used in analyses. Cortisol measures have been associated with behavioural inhibition (Kagan et al., 1987; Nachmias et al., 1996; Schmidt et al., 1997), other temperamental qualities (Rothbart, 1981; Gunnar et al., 1997), insecure attachment (Spangler & Grossman, 1993; Hertsgaard et al., 1993), and emotion regulation (Stansbury & Gunnar, 1994).

Heart rate changes

Heart rate and variability of heart rate are other measures of emotional response that are relatively easily measured. The variation in heart rate due to breathing, called vagal tone, is related to control by the brain of cardiac acceleration and deceleration in response to arousal. It is considered more reflective of brain activity than other measures of heart rate change (Fox & Porges, 1985) and has been used frequently as a measure of physiological
self-regulatory capacity (Porges, 1985, 1996; Porges & Droussard-Roosevelt, 1997; Bornstein & Suess, 2000). In order to measure heart rate, a small number of sensors are placed on the infant’s chest and a count of the heart rate is obtained. These data are processed to obtain the desired cardiac baseline and reactivity measures. Some studies have been interested in resting measures (e.g., Fox & Porges, 1985; Fox, 1989), and others have examined changes in response to stimulation (e.g., Fox, 1989; Bornstein & Suess, 2000). Both resting and reactivity measures have been shown to relate to and predict cognitive and social-emotional competence (Fox & Lewis, 1983; Fox & Porges, 1985; Kagan et al., 1987; Richards, 1987; Porges et al., 1996).

Relation between measures

Behavioural responses and physiological reaction to the same event are not necessarily related. Lewis et al. (1993) for example, found that infants fell into four groups in their reactions to inoculation: (1) ‘cry babies’ had low physiological reactions, but took a long time to quiet; (2) ‘stoics’ had high physiological reactions, but quieted quickly; (3) ‘high reactors’ had both strong physiological reactions and took a long time to calm; (4) and finally, ‘low reactors’ had neither strong physiological nor behavioural responses. These findings suggest that behavioural and physiological stress reactions have different meanings, and are likely to relate to development in different ways.

How do infants express emotion?

Infants express emotion by crying and vocalizing, by their body posture, and by their facial expressions. Parents no doubt make use of all of these cues in attempting to figure out what their infants are feeling.

Facial expressions

However, and as we will see in Chapter 11, researchers have been particularly interested in facial expressions as a way of understanding how emotions are organized early in life and develop. Infants make a variety of facial expressions that can be scored by observing the muscle movements in the brow, eye/cheek, and mouth regions of the face (Oster, 1978; Izard, 1995). Movements in each of these three regions are scored from videotape and the combination of particular movement patterns is used to identify the particular emotion expressed. For example, pretend for a moment that you are surprised. How did your face change? Probably, you raised and arched your brows, your eyes widened and your jaw dropped—the typical surprised expression. Now, pretend to express anger and notice the contrast. Your brows are now lowered and drawn together; your eyes narrowed, and your mouth, if open, was wide and squared, and if closed, your lips and teeth were strongly compressed, chin drawn up. All of the basic emotions that adults express (e.g.,
enjoyment, surprise, anger, fear, sadness, and disgust) can be distinguished by these or similar distinctive patterns of facial movements in infants and are observable from the opening weeks of life. However, infants do not always make the facial expressions that adults expect in a given situation and they may show several different emotions in rapid succession. These observations have triggered a lively debate on the meaning of the various expressions, particularly the negative ones. Researchers have developed situations designed to produce such emotions as disgust (tasting of sour and bitter solutions—Steiner, 1979; Rosenstein & Oster, 1988) and anger (arm restraint—Stenberg & Campos, 1990; inability to activate pleasant sights and sounds—Lewis et al., 1990). Some of the newest, and potentially groundbreaking work in measuring emotional expression has been the addition of physiological measures such as heart rate, cortisol, and electroencephalograms (EEG) to the study of facial expression to see how both relate to emotion in infants.

Are infants born with different personalities?

Most of us would agree that adults have different personalities. Some people are easily excited, while others are easy-going; some seem to be eternal optimists, while others seem to see only the dark side of a situation. Perhaps you know what type of personality you have. The key is that people seem to behave in similar ways no matter what the circumstances. Thus, personality is thought of as a 'trait', or an unchanging characteristic. Are we born that way, or do our environments contribute to the development of our personalities? The term personality is generally reserved for adults. In infants and children, the concept most closely related to personality is temperament. Definitions vary, but there is general agreement that temperamental differences appear relatively early in life and seem independent of social experience, cognitive ability, or learning; they later interact with family and other environmental experience; are relatively enduring, and contribute to behaviour across a variety of situations (Kochanska, 1993; Rothbart & Bates, 1998). The intensity of emotions, thresholds to react to environmental stimuli, and the ease with which an infant calms down, are important emotional and self-regulation components of temperament (Bates, 2000). It is easy to understand how powerful a contributor temperament is to developing social interactions. Difficult temperament, i.e., low threshold to react, intense negative reactions, poor adaptability to new situations, and difficulty calming, presents a particular challenge to caregivers.

Parent reports

The most widely used method of measuring temperament in infancy is standardized parent questionnaires. The starting point for most of these is the nine dimensions of temperament derived from extensive parent interviews done
as part of the New York Longitudinal Study (Thomas et al., 1963). These are: (1) activity level, (2) rhythmicity (regularity), (3) approach/withdrawal, (4) adaptability, (5) intensity of reaction, (6) attention span/persistence, (7) distractability, (8) quality of mood, and (9) threshold of responsiveness. These dimensions are used to characterize infants as difficult, easy, or slow-to-warm-up. Several questionnaires have been derived from these dimensions (Infant Characteristics Questionnaire, ICQ—Bates et al., 1979; Infant Temperament Questionnaire, ITQ—Carey, 1970; Carey & McDevitt, 1978). The Infant Behavior Questionnaire (IBQ—Rothbart, 1981; Rothbart & Derryberry, 1981), also designed for infants under 1 year of age, measures six dimensions of temperament: activity level, soothability, fear, distress to limitations, smiling/laughter, and duration of orientation. This instrument has a broader conceptual base than the others and is widely used. Rothbart (1981) used not only the Thomas et al. (1963) perspective, but also those of perceptual-cognitive, neurophysiological, genetic, interactional, and adult temperament work. There are temperament questionnaires for older infants as well (Toddler Temperament Scale—Fullard et al., 1984; Toddler Behavior Assessment Questionnaire—Goldsmit, 1996).

These questionnaires have similar formats. The parent is asked to rate how much a statement about a child’s behaviour applies to her child. For example, ‘Before falling asleep at night during the last week, how often did the baby show no fussing or crying?’ (choices range from never to always, IBQ), or ‘The infant is fussy on waking up and going to sleep’ (almost never to almost always, ITQ). There are large numbers of questions worded in different ways on these instruments that ask about the same underlying temperament dimension across various situations in order to obtain a reliable report from the parent.

Despite the popularity of parent reports of temperament, these instruments tend to have relatively poor validity, test–retest and inter-rater reliability (Bornstein et al., 1986). Moreover, responses reflect what the mother thinks about the infant’s temperament, which is not necessarily objective (Sameroff et al., 1982). However, several researchers have pointed out that how the mother perceives her infant’s temperament may be as important to mother–child interactions and social development as a more objective measure (Bates, 1983; Bornstein et al., 1986).

Observational methods

Observational procedures have been devised for certain aspects of temperament, especially behavioural inhibition. In general, researchers study reactions to unfamiliar stimuli. Brightly coloured toys, tape recordings of voices, and unpleasant odours have been used in young infants; interactions with unfamiliar adults, being shown frightening toys, and being encouraged to participate in novel activities have been used in the second year of life (Garcia-Coll et al., 1984; Calkins et al., 1996; Ramsay & Lewis, 1999). These
procedures indicate to what extent infants exhibit the temperamental quality of being withdrawn and inhibited.

**When and how do infants develop a sense of themselves as individuals?**

Infants acquire a good deal of knowledge about objects and about others during the first 2 years of life. Infants' ability to know and think about themselves also develops between 1 and 2 years (Bertenthal & Fischer, 1978; Lewis & Brooks-Gunn, 1979; Lewis, 1992). Its appearance has important implications for social–emotional behaviour, as well as motivation and personality development (Lewis, 1998). In a classic series of studies using mirrors, videotaped playback, and photographs, Lewis and Brooks-Gunn (1979) established that visual recognition of the self emerges by 18 months. The most widely known of their procedures is the Mirror Rouge Task. Infants are first placed before a mirror and the infants' responses are recorded. Next, the mother surreptitiously puts a dot of rouge on her child's nose. After a short interval the infant is placed again in front of the mirror. Infants who look in the mirror and then touch their noses, or indicate that there is something different about it, are classified as showing self-directed behaviour. Self-directed behaviour never occurs before 15 months of age and increases dramatically between 18 and 24 months, with virtually all 24 month olds showing this behaviour.

Recent studies in the area of self-recognition are beginning to focus on its antecedents and consequences. For example, infants who were classified as showing self-recognition in the Mirror Rouge Task were more likely to show embarrassment (Lewis et al., 1989). Embarrassment is elicited by procedures that call the children's attention to the fact that they are being observed by others, such as being pointed to, being paid elaborate compliments, or being asked to behave in an unusual way while watched by others. It has been shown that greater physiological reactivity to stress and less soothability in infants is related to earlier self-recognition (Lewis & Ramsay, 1997). These findings suggest that self-recognition is related to other aspects of the child's social and emotional life.

**Conclusions**

This overview has described how researchers go about answering questions about infant development. Many of the methods described will no doubt continue to be used, refined, and revised as we learn more about how infants become 'real people'. In addition, new procedures based on advances in technology will be developed, as new questions challenge the next generation of researchers to find ways of understanding why and how infants behave the way they do.