When do infants know about objects?
It may seem obvious to researchers in adult perception that discrimination and knowledge are not the same thing. One can detect that two perceptual patterns differ without necessarily knowing why they differ. That is, in the absence of explicit understanding and awareness. Sometimes differences are not available to explicit scrutiny or, if they are, not fully appreciated. There are many examples of phenomena where individuals discriminate events that do not achieve explicit awareness. This seems fairly unremarkable for sensory events where stimulation does not evoke explicit awareness. As Weiskrantz (1988) points out, there are more bodily processes that we are unaware of than those to which we are able to provide a commentary.

But, even when we can provide a commentary, it may be incomplete, misguided, or completely wrong. One of my favourite examples published in this journal is Peter Thompson's “Thatcher Illusion” (Thompson 1980). Here we have a case where two inverted faces appear similar and yet different. Close inspection allows us to detect that the individual features of the eyes and mouth are in a different orientation, but that discrimination cannot compare with the radically explicit perception that occurs when the configurational information is provided by turning the face into the correct upright orientation. However, this explicit awareness is lost when the faces are inverted, again providing a dramatic example of how configurational information plays a role in face perception. Face perception provides a number of examples of dissociation between implicit and explicit processing. We can distinguish mirror-image faces from normal asymmetrical faces without being aware of the basis for the dissociation. We can tell that someone looks different after a trip to the hairdressers without being aware of the haircut. The point is that detecting that there is a difference is not the same as being explicitly aware of what that difference is.

So readers of Perception may be surprised to hear that discrimination is proving to be an extremely thorny issue in the world of infancy research, because telling that there is a difference and knowing what that difference is have become confused. Traditionally, discrimination measures have been the bedrock of perceptual-development studies. One of the earliest measures of infant discrimination, pioneered by Robert Fantz in the late 1950s and early 1960s, was the technique of preferential looking. By measuring the amount of time spent looking at different stimuli, Fantz (1961) demonstrated that, contrary to the wisdom of the day, not only were very young infants capable of seeing, but they also preferred to look at certain types of visual patterns in comparison to others. In later years, a refinement was made to the preferential-looking technique by adding an initial habituation phase (Caron and Caron 1968). Preferences could be experimentally induced by habituating the infant to one stimulus until his or her interest dropped back to some predefined baseline, and then presenting a novel stimulus to invoke a recovery of interest. If this novel stimulus produced a significant increase in duration of looking, the experimenter could be reasonably sure that the infant could discriminate the first habituated stimulus from the second novel one. This enabled researchers to investigate infant discrimination of stimuli for which there may be no inherent preferences. Although there have been subsequent further refinements concerned with how the habituation criterion is defined, the habituation–recovery technique has remained relatively the same for the past 30 years and is used to investigate infant perception in every modality.
In recent years, developmental psychologists have used the habituation–recovery technique to investigate infants’ understanding of the physical world. This focus of interest arises from Piaget’s theorising on the origins of knowledge (Piaget 1954). For Piaget, cognitive development began with the first interactions of the infant within his or her world. Initially, world knowledge was confined to sensory stimulation derived from the relatively limited repertoire of the reflexes. However, from these simple beginnings, knowledge in the form of sensorimotor representations emerged as a consequence of the child’s interaction with the world, and therefore was strictly tied to the infant’s ability to act on the world. Piaget constructed his theory around the central issue of action, and used examples of the infant’s behaviour to illustrate his main stages of development. In particular, he described manual retrieval of objects on search tasks, or more often the failure to do so, as indicative of the infant’s limited ability to form representations of the object during the hiding sequence.

However, as pointed out by his critics, infant’s manual search is constrained by a number of factors other than the ability to form a mental picture of the hidden object. To begin, young infants are motorically immature and so search is likely to underestimate their true capacity to retrieve the object. Likewise, search requires planning behaviour in order to anticipate the sequence of actions necessary for recovering the object. Again, failure does not necessarily reflect an absent or inaccurate representation of the hidden object; rather, it could be due to a number of performance limitations. With these problems in mind, a new paradigm based on the habituation–recovery technique was developed to investigate infants’ representations of objects (Baillargeon et al 1985). Like the early Fantz studies, this paradigm used changes in looking time as an index of discrimination; but, instead of showing infants simple stimuli, these experimenters measured whether infants could discriminate between sequences of events involving objects that were either consistent or inconsistent with the object’s physical attributes. Initially, these sequences addressed the issue whether infants understood that objects continued to exist when out of sight, as this had been one of Piaget’s initial milestones on the road to representation. However, sequences in which objects moved and interacted with other objects enabled experimenters to study the infant’s appreciation of a number of object properties, including numerosity, animacy, transformations, and so on.

The logic of using looking time to study object knowledge is based on the principle of the magic trick. Magic tricks are appealing because the magician creates an illusion that violates our belief systems. Magicians make objects vanish, materialise, transform, jump across space and time, and so on. Because these sorts of events contravene the rules of the physical world that we appreciate as adults, our expectations are violated and we gasp, stare in disbelief, applaud, and so on. Likewise, infants have been shown to look significantly longer at event sequences that violate physical laws, in comparison to control sequences that do not. (There is little evidence that they show any discriminating behaviour other than increased fixation.) For example, if a ball is dropped behind an occluder from which protrudes a previously seen shelf, 4-month-old infants will look longer—once the occluder is removed—at the outcome of the ball under the shelf, compared to the ball on top (Spelke et al 1992). This visual preference is measured against a series of control conditions, to ensure that the difference only emerges when there is an apparent violation. This, and many other studies, has been interpreted as evidence for an early appreciation of the physical constraints operating on objects. In this regard, these findings go beyond the simple issue whether infants can form a mental picture of an invisible object but, rather, address the nature of invisible objects and how they should behave in a Newtonian world. Indeed, the methodology is no longer referred to as the preferential-looking technique, but more
commonly known as the violation-of-expectancy paradigm; a title which reflects the
cognitive baggage believed to accompany longer looking.

Findings from these studies are not universally accepted, and there are many
criticisms which can be categorised into methodological, statistical, procedural, and
interpretation issues (Haith 1998). However, there is now a substantial weight of
evidence from replication studies that strongly support that infants look longer at
impossible events. As indicated by the opening gambit, this editorial will concentrate
on the interpretation issue. The habituation–recovery technique is a powerful method-
ology so long as the central question is: “Are X and Y different?” Problems arise
when habituation–recovery technique is used to tackle a different type of question:
“Why are X and Y different?” The first question requires a yes/no discrimination,
whereas the second requires yes/no plus an explicit formulation for that distinction.
If we accept that discrimination is taking place in these experiments, then we must
accept that this discrimination is on the basis of violation of physics. In one sense,
the 4-month-old knows something about shelves and balls. But can we say that this
knowledge is the same as that of an older child, or adult, as some of the theorists
using the new paradigm would argue? How can we ever measure this? I don’t think we
can, so long as the infants are unable to provide a commentary for what they have
just witnessed. We cannot make the inference that infants look longer because their
expectations have been violated.

A simple example demonstrates the flaw. Many adults and most children hold
misconceptions about object motion (McCloskey 1983) but can detect that motions
that conform to their naïve theories are in fact anomalous (Proffitt and Gilden 1989).
Do they have an understanding about object motion, or not? Their commentaries
based on naïve theories would suggest not, but their reports and looking behaviour on
viewing impossible trajectories may indicate the contrary. Consider a thought experi-
ment. Imagine that these same adults were infants in a looking-time experiment and
that they looked longer at the impossible motion relative to the possible motion. How
could one interpret their longer looking at impossible object motions? Clearly, it would
not be due to a violation of their expectancy, as their expectancy based on their beliefs
was otherwise. This example points out the danger of inferring knowledge states in
the absence of a commentary.

In their haste to abandon Piaget, developmental psychologists may be forced to return
to his fold. Clearly, infants are never going to provide a commentary related to their
knowledge. The word derives from the Latin (ins—without; fari—past part; ‘to speak’).
But actions speak louder than words, and—before the advent of language—actions
would have to had reflected world knowledge in an adaptive way, or otherwise the
individual would have been selected against. In spite of the problems of limited ability
to execute actions, they may still provide a useful channel to investigate the developing
knowledge of the physical world. What kinds of action reflect world knowledge? There
is not an immediate answer for this, but infant cognitive development may need to
find new ways of thinking about measuring action rather than abandoning it in
favour of looking time. Supporters of looking-time experiments could retaliate that
looking is an action; but, as noted earlier, this only reflects discrimination between
two event sequences.

When the criticisms of Piaget’s action-based paradigms were voiced, the limita-
tions of the action system were considered impediments to demonstrating object
knowledge. The violation of expectancy was seen as a means for avoiding these
impediments—but, in turn, has generated its own controversy, about what looking
time truly reflects. It seems to me that both search and looking-time studies reflect
knowledge of sorts. It is up to the field of cognitive development to decide what is the acceptable criterion for determining when the child knows something.

Bruce Hood  
Department of Experimental Psychology, University of Bristol, Bristol BS8 1TN, UK;  
e-mail: Bruce.Hood@bris.ac.uk

References
Baillargeon R, Spelke E S, Wasserman S, 1985 “Object permanence in five-month-old infants”  
_Cognition_ **20** 191 – 208
Caron R F, Caron A J, 1968 “The effect of repeated exposure and stimulus complexity on visual fixation in infants”  
_Psychonomic Science_ **10** 207 – 208
Fanz R L, 1961 “The origin of form perception”  
_Scientific American_ **204** 66 – 72
Haith M H, 1998 “Who put the cog in cognition? Is rich interpretation too costly?”  
_Infant Behavior & Development_ **21** 167 – 179
Piaget J, 1954 _The Construction of Reality in the Child_ (New York: Basic Books)
McCloskey M, 1983 “Intuitive physics”  
_Scientific American_ **284** 122 – 130
Proffitt D R, Gilden D L, 1989 “Understanding natural dynamics”  
_Journal of Experimental Psychology_ **15** 384 – 393
Spelke E S, Breinlinger K, Macomber J, Jacobson K, 1992 “Origins of knowledge”  
_Psychological Review_ **99** 605 – 632
Thompson P, 1980 “Margaret Thatcher: A new illusion?”  
_Perception_ **9** 483 – 484
Weiskrantz L, 1988 “Some contributions of neuropsychology of vision and memory to the problem of consciousness”, in _Consciousness in Contemporary Science_ Eds A J Marcel, E Bisiach (Oxford: Oxford Science Publications) pp 183 – 199