DOCTOR OF PHILOSOPHY

A behavioural analysis of rapid word learning in infants

Gurteen, Paula May

Award date:
2003

Awarding institution:
University of Wales, Bangor

University of Wales

Prifysgol Cymru

A Behavioural Analysis of Rapid Word Learning in Infants

Paula May Gurteen

A thesis submitted to the School of Psychology, University of Wales, Bangor, in partial fulfilment of the requirements of the Degree of Doctor of Philosophy.

1st July 2003

Acknowledgements

This Ph.D. studentship was funded by the Economic and Social Research Council. I would like to thank:

My supervisors, Dr. Pauline Horne and Prof. Fergus Lowe, for their commitment to this research;

Dr. Satsuki Nakai, Dr. Pam Martin, and Ms. Tracey Bywater, for their help in recruiting participants;

Mr. Chris Whitaker, for his statistical advice;

Dr. Llinos Spencer and Dr. Margaret Bell, for their provision of the Bangor Communicative Development Inventory;

Mr. Ed Ingram, for his writing advice and proofreading;

All the parents and babies who took part in this research (and who made it so much fun!);

Dr. Mihela Erjavec, for her friendship and staunch support;

My family: Mum, Stuart , David, and Ellen, for their encouragement, love and humour;

Chris Gardiner for his patience and love.

Table of Contents

SUMMARY

The recent cognitive developmental literature on *rapid word learning*, using either preferential looking or reaching methodologies, suggests that 12- to 18-month-old infants can learn novel label-object listener relations after as few as five exposures to a novel word-object relation. But methodological limitations of such studies render their conclusions equivocal; several studies fail to control, for example, for infants' prior learning of a behavioural preference for labelled objects, and several fail to report the extent to which individual performances are consistent with group findings. Further, none of these studies investigated the effectiveness of contingent positive reinforcement as an alternative means of establishing novel listener behaviours in preverbal infants.

Experiments 1 and 2 were conducted to reassess the effectiveness of exposure in establishing novel label-object listener relations under carefully controlled conditions, using both looking *and* reaching measures of comprehension. Contrary to previous findings, in Experiment 1, 13- and 17-month-olds did not learn to comprehend novel object names after up to 12 exposures to each of two novel objects accompanied by its verbal label. Only after between 18 and 24 such exposures in Experiment 2 was there evidence of listener learning in young infants on the looking measure.

Experiment 3 compared the effectiveness of positive reinforcement and exposure in infants' listener learning. Here, 13- and 17-month-olds, on the looking measure, showed evidence of learning novel label-object listener relations after up to 10 reinforced training trials, but not after up to 10 exposure training trials. Results with the reaching measure were equivocal in all three experiments.

These findings provide initial support for the effectiveness of positive reinforcement, and question the role of exposure, as a means by which 13- and 17-month-old infants can be taught to comprehend novel object-labels after very few training trials. Further investigation of these findings is merited, particularly within a longitudinal, single-subject research paradigm.

HOW DO INFANTS LEARN TO COMPREHEND WORDS BEFORE THEY CAN SPEAK?

> When [my elders] named any thing, and as they spoke turned towards it, I saw and remembered that they called what they would point out by the name they uttered. And that they meant this thing and no other was plain from the motion of their body, the natural language, as it were, of all nations, expressed by the countenance, glances of the eye, gestures of the limbs, and tones of the voice, indicated the affections of the mind, as it pursues, possesses, rejects, or shuns. And thus by constantly hearing words, as they occurred in various sentences, I collected gradually for what they stood and having broken in my mouth to these signs, I thereby gave utterance to my will. (Augustine, 398/1961, p.11)

How do infants come to learn words? This question has been debated for centuries. Six hundred years ago, Augustine proposed an answer that still informs today's research (e.g. Baldwin and Moses, 2001; P. Bloom, 2001); no complete explanation has yet emerged.

Until recently, the focus of experimental attention in attempts to answer this question was on word production. Infants' and young children's early productive verbal repertoires were studied exhaustively. But to study an 18-month-old's production of words is to start a book halfway through. Infants are responsive to speech from birth (and possibly even earlier). They can distinguish between native and non-native language sounds from three months. And they start to respond as listeners to verbal stimuli, or to comprehend words, as early as eight months.

At the age of 12 months, when infants have learned only one or two *speaker relations*, they may already demonstrate 50 or more listener relations (Fenson et al., 1994). An infant too young to speak, for example, may turn consistently towards a ball, as opposed to any other object, when asked, "Where's your ball?" And by the start of the *"vocabulary spurt"* — the period that, according to many researchers (Benedict, 1979; L. Bloom, 1973; Dromi, 1987; Mervis and Bertrand, 1993)[1], begins at around 18 months, in which infants show a rapid increase in the speed with which they learn new spoken words — an infant can already respond to hundreds of words as a listener.

The consistent finding that listener learning precedes and outstrips speaker learning has led researchers to focus on young children's and infants' listener behaviour in their efforts to explain how infants come to learn words. Whether infants' listener behaviour is verbal in its own right is debatable; what is not debatable is the key role listener behaviour plays in the development of verbal behaviour.

When an infant learns to respond as a listener, she[2] takes her first step into a wider verbal world. Although she cannot yet speak, through

---

[1] Whether all infants undergo a vocabulary spurt is debated (see Goldfield and Reznick, 1990). P. Bloom (2000) suggests that there may be no vocabulary spurt at all; according to him, infants may instead show a steady increase in their rate of word learning, which is mistakenly identified by some researchers as a spurt.

[2] Throughout this thesis, for ease of expression, the female pronoun is used.

listener behaviour an infant's attention can be directed by the caregiver to objects and events. Through listener behaviour, an infant learns to respond to *arbitrary* relations between spoken labels and objects or events. And through listener behaviour, an infant learns to respond to *classes* of objects or events; even when members of a class are perceptually dissimilar. For example, when she hears the spoken word *animal*, an infant learns to orient to such different creatures as an elephant, a blackbird, and a dolphin. Some theorists believe that this is what gives spoken language its categorising function (Horne and Lowe, 1996, 1997; Lowe and Horne, 1996; Lowe, Horne, Harris and Randle, 2002).

It is clear that the roots of verbal behaviour are in listener behaviour. To understand verbal behaviour, we must first understand how infants come to learn listener relations, or how they come to comprehend words. This thesis analyses one way by which young infants might learn new listener relations.

There is no doubt that infants are prepared by early learning to start to learn listener relations at around eight or nine months. Brain imaging studies demonstrate that, soon after birth, infants show a preference for speech over non-speech sounds (Molfese, 1977), and research using high-amplitude sucking techniques suggests that newborns are capable of discriminating speech sounds at adult levels. For example, they perceive a categorical difference between the sounds /ba/ and /pa/ (Eimas, Siqueland, Jusczyk, and Vigorito, 1971), and they perceive the same phonemes as equivalent when they hear them from different speakers (Kuhl, 1987). Aldridge, Braga, Walton, and Bower (1999) present evidence for intermodal speech perception in 4-hour-old infants; such infants discriminate (through eye gaze) between matched and mismatched speech sounds and lip configurations in an adult speaker.

These early skills may be innate, although research by DeCasper and Fifer (1980) suggests that there may be learning of a speech preference—a preference for the mother's voice in particular—in the womb; and some research reports categorical speech perception in non-humans (Kuhl and Miller, 1975). Regardless of the provenance of these skills, from very early in life, infants are sensitive and responsive to speech sounds.

By the age of two or three months, infants have learned sophisticated social behaviour. They reinforce the attention of others to themselves by responding to positive attention and mutual gaze with smiles and pre-speech. Later, they learn to elicit caregiver attention through a vocal "call", which is distinct from other forms of infant vocalisation, and to produce other actions that attract positive attention or laughter in others, such as waving or clapping (Reddy, 1999).

By the age of about six months, infants can follow another's gaze (Butterworth, 1991; Butterworth and Jarrett, 1991; Morales, Mundy and Rojas, 1998; Scaife and Bruner, 1975). Infant and caregiver can engage in joint attention to the same object. Corkum and Moore (1995) found that infants can be conditioned to turn the head and eyes in the direction of another's gaze; this may explain the origins of joint attention. Gaze-following behaviour greatly facilitates the learning of listener behaviour in normally-developing infants, because it allows the infant access to a wide range of social cues, and means that she no longer responds to the caregiver alone but, at the same time, to objects and events in the world beyond the caregiver. With further learning, the infant learns discriminate the caregiver's focus of attention—from body posture, voice direction, pointing and reaching gestures, and the intonational quality of the caregiver's voice, for instance (Baldwin and Moses, 2001).

The bringing of objects and events into a social context continues with the involvement of infants in the exchange of objects in turn-taking games and routines between 8 and 11 months (Bruner, 1975). The infant begins to reach and point towards objects, and to offer them to a social partner. At this age, infants also show social referencing: their responses to ambiguous stimuli are conditional on the facial expressions of caregivers (Sorce, Emde, Campos, and Klinnert, 1985). Perner (1991) explains this development with reference to the infant's conditioning history, suggesting that, when a parent looks fearful, fear may be evoked in the infant, or the infant may remember a fearful look as usually preceding negative events.

Reports of these early social and object-related behaviours *describe* how well infants are prepared to learn listener relations. But they do not *explain* the emergence of listener behaviour in young infants: they do not specify the mechanism by which infants learn to respond to an arbitrary relation between a spoken label and an object or event.

This thesis investigates an operant account of the emergence of listener behaviour in human infants (Horne and Lowe, 1996; Skinner, 1957). According to this account, an infant's appropriate responses to a caregiver's verbal stimulus are reinforced; in this way a verbal stimulus becomes discriminative for the infant's production of conventional, object-related behaviours. For example, when an infant responds appropriately to a verbal stimulus (e.g. looks at a ball when she hears the words /where's the ball?/) the caregiver delivers social praise (e.g. "Good girl! There's the ball"), and other, nonverbal, reinforcers (e.g. cuddles and play with the ball).

There are rival accounts, both within behaviour analysis, and outside of it—particularly in the field of developmental psycholinguistics. Several recent behaviour analytic papers have taken a cross-disciplinary perspective on issues in child psychology (e.g. Wilkinson, Dube and

McIlvane, 1996; 1998). Often, developmental and behaviour-analytic findings can inform one another—behaviour analysis provides interpretive rigour, but is short on research with infants and young children (but see Bell, 1999; Erjavec, 2002; Harris, 2002; Hughes, 2000; Randle, 1999). Conversely, developmental psychology is rich in research, but is often less stringent in interpretation. The research presented in this thesis capitalises on certain of the developmental research methodologies and findings to examine how well each of these accounts explains the emergence of listener behaviour in human infants. For this reason, developmental accounts of early word learning are considered and evaluated alongside behaviour analytic perspectives in this chapter.

How Do Infants Learn Listener Relations? Theoretical Perspectives.

Listener behaviour arises when the verbal community "establishes a correspondence between a vocal or other conventional stimulus produced by a speaker and behavior evoked in the listener" (Horne and Lowe, 1996, p.192). How is such a correspondence established? This section considers four different accounts of the beginnings of listener learning in infancy. *Constraints* and *social pragmatic* perspectives are the two most popular in the developmental psycholinguistic literature. *Associative learning* and *operant learning* are the two most popular in the behaviour-analytic tradition.

Developmental Psycholinguistic Perspectives

Developmental approaches to early word learning tend not to differentiate between an infant's listener and speaker behaviours. They assume that, when an infant points to a ball on hearing "Where's your ball?" this behaviour taps into the same underlying understanding of language as when an infant answers "ball" to the question, "What's this?" Thus listener behaviour is viewed as nothing less than early word learning. This assumption is flawed and is discussed later (see *behaviour analytic perspectives,* p. 30); for now, it is important simply to appreciate that when developmental accounts talk of "early word learning", they refer interchangeably to speaker and listener behaviours.

Constraints Accounts

> Intuitively, it seems an insurmountable task for children to acquire language from the cacophony of linguistic input that confronts them without some guiding principles. (Hirsh-Pasek, Golinkoff and Reeves, 1994, p.244)

When an infant is presented with a spoken label, how does she know to what it refers? How does she know that the word *dog* refers to a dog, for example, rather than a dog's tail, or a running dog? How does she even know that words *refer* at all? This question, first posed by Wittgenstein (1953; and see Quine, 1960), still awaits an answer. Some theorists argue that the only way that infants can learn appropriate relations between labels and their referents is through the presence of language-specific assumptions that direct their learning.

These *constraints*, or *lexical principles*, accounts suggest that infants approach word learning already equipped with certain lexical biases, which increase their accuracy and speed in learning the relation between a word and its referent. The infant can learn new words because she is biased to assume that some aspects of the word learning situation are more relevant than others.

It is said, for example, that infants assume, when confronted with a label for some aspect of their environment, that words refer to objects (Golinkoff, Mervis and Hirsh-Pasek, 1994), that words refer to whole objects, rather than to parts or properties of objects (Markman, 1992; Markman and Wachtel, 1988), that new words refer to categories that do not already have a name (Golinkoff et al., 1994), that no two words have exactly the same meaning (Clark, 1987), and that each object can have only one name (Markman, 1987, 1989, 1992; Markman and Wachtel, 1988). These lexical principles are said to compensate for inconsistencies and noise in the word learning environment; they provide a head start in infants' learning of the relation between word and object.

Markman (1992) suggests that lexical principles should not be viewed as deterministic rules, but as "probabilistic biases that can be overridden" (p.67). These biases provide the infant with good "first guesses" as to the meaning of a word, but they are not absolute. Markman compares the constraints approach to imprinting in bird species. Birds can imprint onto a member of a different species, or even a human, and later show mating displays towards the foster species. But these birds imprint *most easily* onto a member of their own species.

Different theorists offer different formulations of constraints or lexical principles, and within the field, there is argument as to whether constraints are innate or learned (see Markman, 1992; Woodward, 2000). But all agree that the emergence of new constraints on word learning provides a qualitative change in the way that children go about that task.

There is debate over which principles are essential for the learning of first words, and which develop with linguistic experience. Some researchers (Golinkoff et al., 1994; Hirsh-Pasek et al. 1994; Mervis and Bertrand, 1993, 1994) posit a *developmental lexical principles framework*. Infants start word learning equipped with three word learning principles, described below. These allow them to learn some basic relations between labels and their referents. Later, more sophisticated lexical principles emerge; these increase the efficiency of word learning. When all six principles are in place, they work in concert, such that the infant becomes a fast, efficient word learner.

The three basic principles that launch infants' word learning, according to the developmental lexical principles framework, are *reference, extendibility,* and *object scope.*

Reference is the infant's assumption that words map onto objects or events in the world. An infant understands that a word stands for, or symbolises, a referent. But, according to Golinkoff et al. (1994), the principle of reference moves from an immature to a mature state, such that young infants start by assuming simply that words "go with" referents, and only later come to appreciate that words "stand for" referents. Extendibility is the infant's bias to extend a word to referents that are similar to the initial referent. Object scope is the infant's assumption that words label whole objects, rather than object parts, attributes, or objects in context.

Together, these three first-tier learning principles enable infants to produce and comprehend their first words. But word learning is slow and laborious at this stage; this is reflected in the slow learning of spoken labels between 12 and 18 months. Second tier principles must come into play for infants to demonstrate the rapid productive word learning that occurs after the vocabulary spurt.

Second tier principles evolve from first tier principles. Thus *conventionality* extends the principle of reference, by making it clear that words should take conventional forms, not forms defined by the child alone. *Categorical scope* refines the principle of extendibility, such that the child learns to assume that words refer to basic-level categories of objects. *Novel-name-nameless-category (N3C)* develops from object scope, and leads the child to assume that novel labels apply to objects for which they have not yet learned a label; N3C represents the child's new-found understanding that all objects in the world have a name (Mervis and Bertrand, 1994; Gopnik and Meltzoff, 1993).

Once all six principles are in place, at around 18 to 24 months, the developmental lexical principles framework predicts that word learning becomes rapid and efficient.

In another popular formulation, Markman (1991, 1992, 1994) suggests that, at the start of word learning, infants' learning is unconstrained. Prior to the naming explosion, she suggests, words are acquired in a laborious, paired-associate manner. Other theorists agree. Prior to the naming explosion, word learning is thought to be non-referential (Snyder et al., 1981), and associative (Lock, 1980, and see *associative learning accounts*, this chapter).

According to Markman, it is only at around 18 months that lexical principles come into play, and bring about radical changes in the way infants learn new words. *Taxonomic* (similar to categorical scope), *whole* *object* (similar to object scope) and *mutual exclusivity* (similar to N3C) assumptions work together to promote the fast, efficient acquisition of new words. This is why, according to Markman, there is a vocabulary spurt at around 18 months.

Most constraints theorists emphasise that lexical principles are not the only means by which infants learn new words. They acknowledge the importance of social cues in word learning, for example (see *social pragmatic accounts,* next section). But, theorists argue, without constraints on word learning, children could form any number of hypotheses about what aspect of the environment a given label relates to. Without biases or principles, how could children's word learning progress as it does? On the other hand, with lexical principles, "children would not need to formulate a long list of potential meanings and painstakingly assess the evidence in support of each. Rather, they could quickly zoom in on some hypotheses that they are predisposed to prefer" (Markman, 1994, p.200).

Empirical support for the lexical principles approach has come mostly from research with young children, rather than infants. As such, most of this evidence is for later principles, such as N3C.

In *fast mapping* research (e.g. Carey and Bartlett, 1978; Golinkoff et al, 1994; Markman, 1994, Mervis and Bertrand, 1994), for example, 2- to 3-year-old children are presented with a familiar object for which they already know a label, such as a ball, and an unfamiliar object for which they do not know a label. The child is asked, for example, "Where's the dax?" Most children select the unfamiliar object in this situation. This prompts constraints researchers to conclude that children's learning is constrained by a principle of mutual exclusivity or N3C, whereby they assume that an object has only one name, or that an unnamed object must have a name, and therefore apply the novel name to the novel object, rather than to the familiar object for which they already have a label. With younger children and infants, this fast mapping between a novel label and a novel object is not found, which suggests that N3C does not emerge until late in the second year of life. Mervis and Bertrand (1994) found evidence of fast mapping in only half of a group of 16- to 20-month-old infants.

Markman (1994) presents evidence for the taxonomic assumption in older children's word learning. In her research, 18- to 25-month-olds showed a thematic bias in categorising objects together, but when the sample object was provided with a label, they showed a taxonomic bias in their categorising. For example, when they were presented with a picture of a sitting baby, children were more likely to select a picture of a stroller than a picture of a lying baby when the experimenter said, "Can you find another one?" But when the experimenter instruction changed to include a label (i.e., "This is a sud. Can you find another sud?), the children selected the picture of the lying baby more often than the stroller.

But these studies provide support for the operation of lexical principles in children's word learning well after the vocabulary spurt. In the papers discussed thus far, theorists do not suggest that mutual exclusivity and taxonomic assumptions are responsible for *initiating* listener learning in young infants. Rather, according to Golinkoff et al. (1994) at least, it is the more basic principles of reference, extendibility, and object scope that enable infants to comprehend and produce their first words. Some evidence is presented for these principles. Mervis (1984) found that 10-month-old infants presented with a particular spoken word selected objects that were similar but non-identical to those that featured in the relation first trained—this is taken as evidence for the principle of extendibility. Further, there is circumstantial evidence for the principle of object scope—infants' first words are usually names for objects (Gentner, 1988, cited in Pan and Berko Gleason, 1997), and names for object parts are rare at this age (Fenson et al., 1994; Mervis, 1991).

Constraints accounts can be criticised. There are several problems with Golinkoff et al.'s (1994) assertion that lexical principles are responsible for launching infants' word learning. There are further problems with lexical principles approaches to the emergence of verbal behaviour in general.

First, there is only limited evidence to support the existence of early word learning principles; this applies most to the basic principle of reference—infants' assumption that words and objects and events in the world go together. That pre-vocabulary spurt infants can learn listener and speaker relations at all can be seen as evidence for an immature principle of reference, and for object scope and extendibility. But research with non-humans demonstrates that they too, can learn novel listener relations (Herman, Richards and Wolz, 1984; Premack, 1990; Savage-Rumbaugh, 1986; Schusterman and Gisiner, 1988). It is unlikely that chimpanzees, dolphins, and sea lions were guided by language-specific principles in their learning, yet they still learned relations between spoken labels and objects or events in the world, they still learned labels for whole objects rather than for object parts or attributes, and they still extended (or generalised) new labels to perceptually similar stimuli (Herman et al., 1984).

Non-humans have also shown evidence of fast mapping—a behaviour that Golinkoff et al. (1994) attribute to the sophisticated, second-tier N3C principle in young children. In one study (Schusterman and Krieger, 1984), sea lions were taught relations between gestural signals and objects, through a process of response shaping and differential reinforcement. When new objects were introduced alongside familiar objects, the animals quickly learned the novel gesture-object relation, without the need for extended reinforcement training. If, as Golinkoff et al. suggest, infants' fast mapping performance arises from language-specific word learning constraints, it is difficult to see how it is possible for sea lions to perform equivalently.

Second, because alternative theories propose mechanisms other than lexical principles by which infants learn new words, it is important to present evidence that provides a direct test of early lexical principles. But it is difficult to see how lexical principles *can* be tested. This is, in part, because researchers fail to specify the mechanisms by which principles or constraints develop. The focus, in constraints research, is on identifying behaviour consistent with the principle in operation, and pinpointing when each becomes available to infants and young children. There is little attention devoted to *how* such principles arise. L. Bloom and Tinker (2001) criticise constraints accounts on just such grounds:

> When causality in language acquisition is assigned to factors...such as maturation, innate knowledge, or genetics, then we stop looking for the processes of developmental change. The result is description only of what *is*, what children can and cannot do, and correlations between behaviours and chronological age, or between behaviours and anatomy. (p.4)

This leads to a more general point on the nature of lexical principles. Infants learn relations between labels and whole objects, rather than between labels and object parts or properties. How might we explain such a phenomenon? The answer proposed by constraints accounts is that infants possess lexical principles—specific word learning preferences—in this case, the *whole object assumption*. But does such an account add anything to the original observation of infants' behaviour? Does it *explain* anything about infants' verbal behaviour? The answer is no. The whole object assumption is a simple re-description of observable events. Behaviour analysts have long criticised cognitivist explanations on such grounds (Ryle, 1984; Skinner, 1969).

Researchers need to look elsewhere for explanations of infants' early verbal learning preferences. P. Bloom (2001, see *social pragmatic accounts,* next section) suggests that principles such as mutual exclusivity arise from infants' sensitivity to social factors in word learning.

Social Pragmatic Accounts

> How do children make the connection between words and what they refer to?...they do so through their understanding of the referential intentions of others...children use their *naïve psychology* or *theory of mind* to figure out what people are referring to when they use words. (P. Bloom, 2000, pp.60-61)

Social pragmatic accounts (Baldwin, 1995, P. Bloom, 2000; Bruner, 1983; Snow, 1999; Tomasello, 1995) of the origins of word learning take a very different approach to that of constraints accounts. Individual social pragmatic theories differ from one another in various respects, but two points are held in common (to a greater or lesser extent) by most.

First, social pragmatic accounts emphasise the richness of the infant's social environment in providing cues to word learning. Caregivers monitor infants' focus of attention, and provide labels most often for objects that infants are already focussed on. Caregivers *scaffold* (Bruner, 1975; Ninio and Bruner, 1976) their infants' word learning by pointing or gazing at the object that they are labelling; they structure the infant's linguistic environment in such a way that the problem of knowing which object a new label applies to can be solved.

Second, many social pragmatic accounts suggest that infants, early on in life, develop an understanding of other people as "intentional agents" (Tomasello, 1995). This understanding is variously termed *intersubjectivity* (Snow, 1999; Trevarthen and Hubley, 1978), *social understanding* (Baldwin and Moses, 2001), *theory of mind* (P. Bloom, 2000; 2001), and *social cognition* (Tomasello, 2001; Tomasello and Camaioni, 1997). From around 9 to 12 months, infants assume that the minds of other people are like their own. This social understanding is a domain-general ability—it is not specific to language. But it is said to launch infants' word learning, because infants with a theory of mind understand the referential intent of caregivers when they label objects.

Infants, according to social pragmatic accounts, do not need language-specific principles to guide them in deciphering the problem of reference. Instead, they use their understanding of other people's minds to follow eye gaze or pointing gestures when they hear labels for objects. Thus verbal development is boosted by the infant's precocious social development. In addition, adults provide social and pragmatic cues to make both spoken label and referent clear for the infant.

It is social understanding, rather than constraints on word learning, that explains why children make few errors when they map labels to objects or events (P. Bloom, 2000). They understand that adults look towards objects they are referring to, so that when they hear a label, they check the caregiver's line of gaze and body posture to identify the appropriate referent.

If infants were equipped with such sophisticated social understanding from birth, presumably they would begin to comprehend words earlier than they do. Several theorists propose that social understanding, or theory of mind, is either wholly (P. Bloom, 2000, 2001; Trevarthen and Hubley, 1978) or partly (Baldwin and Moses, 2001) innate, but that the infant becomes more adept at interpreting social cues as she matures. Other theorists (Tomasello, 1995) believe that theory of mind develops through a variety of learning factors.

In Tomasello's (1995; and see Akhtar and Tomasello, 2000) learning formulation of the origins of theory of mind, or social cognition, he suggests that children come to understand the intentions of others by being treated intentionally themselves. In the first nine months of their lives, infants spend much time in interaction with caregivers and others.

Because, during this period, caregivers treat infants as if they are intentional, they begin to have "goals in mind", which direct their behaviour. At around 12 to 14 months, this learning consolidates, according to Tomasello. Infants realise that others, like themselves, are trying to accomplish goals.

Whether social understanding is innate or learned, most researchers view the development of *joint attention*—the ability to share attention with other human beings, which emerges at around nine to 12 months—as a crucial development in theory of mind that also leads to the onset of word learning. Tomasello (2001) goes so far as to suggest that word learning is simply one instance of a joint attentional skill.

Joint attentional skills include the infant's ability to follow another's eye gaze, to imitate a caregiver's actions on objects, and to direct a caregiver's attention to objects and events, through gestures such as pointing, showing, and offering. Acredolo and Goodwyn (1997) assert that the specific development of pointing, at around 9 to 13 months, indicates a fundamental change in infants' understanding of others as intentional beings which, in turn, launches them into word learning.

Verbal developments such as the vocabulary spurt are explained by social pragmatic theorists (P. Bloom, 2000; 2001) as reflecting, not the onset of new principles that give infants a qualitatively different understanding of the way language works, but rather general improvements in infants' ability to follow and use social cues. Indeed, P. Bloom argues against the existence of the vocabulary spurt at all, asserting instead that infants' rate of word learning simply undergoes a gradual increase from its start, at around 12 months, through to late childhood.

Social-pragmatic approaches to infants' early word learning are supported by various sources of evidence. Caregivers, at least in Western societies, do provide multiple social cues in their interactions with young infants. Child-directed speech (CDS), for example, is higher in tone, shorter and simpler in structure, more repetitive, has more exaggerated prosody, greater redundancy, more questions and demands, and greater reference to objects in the here and now, than speech directed at adults (Snow, 1986; Snow and Ferguson, 1977); it is suggested that these elements make it easier for infants to pick out the key content words in the speech stream (Jusczyk et al., 1989).

Caregivers adjust their speech as infants grow older—evidence that CDS is fine-tuned to infants' own verbal skills. With three-month-olds, caregivers use simple, redundant speech which has little syntactic structure and semantic content (Papousek, Papousek and Haekel, 1987), but with two-year-olds, caregivers talk in intelligible, fluent utterances (Newport, Gleitman and Gleitman, 1977).

Caregivers simplify the kinds of labels they provide for children. For example, they are more likely to use basic-level labels—such as *money* and *dog*—with children, but to use more specific, subordinate-level labels—such as *nickel* and *collie*—with other adults (Anglin, 1977, 1978). They even, sometimes, provide incorrect labels for objects when such labels can provide cues to the function of the object, and to appropriate conventional behaviours (Mervis and Mervis, 1982), for example, when a caregiver labels a toy truck a *car*.

Caregivers' nonverbal behaviours disambiguate the function of words for infants and toddlers. They *embody* the relation between a word and its referent, for example by putting an infant through an action whilst speaking its label (e.g. helping a child to clap whilst saying "clap!"); they *show* objects of reference, by moving them into infants' line of sight; they *point* towards objects of reference; and they *look* towards them (Zukow-Goldring, 1996). They also tend to label objects that infants are already looking at (Tomasello and Todd, 1983).

There is evidence that caregivers' social cues affect infants' word learning. When given the choice between infant-directed and adult-directed speech samples, four-month-olds are more likely to listen to infant-directed speech (Fernald, 1985). CDS heightens infants' sensitivity to language-relevant cues (Jusczyk, 1986). Maternal responsiveness (defined as "mothers responding promptly, contingently, and appropriately in either a physical or verbal manner", p.286) to 13-month-old infants' vocalisation and exploration activities is positively correlated with infants' language comprehension (Bornstein and Tamis-LeMonda, 1997); and mothers of infants who are learning language at a normal rate make more references to objects that infants are already focussed on than mothers of infants who are learning language at a slower-than-normal rate (Harris, Jones, Brookes and Grant, 1986). Tomasello and Farrar (1986) also found that infants are more likely to comprehend a new label if the mother labels what the infant is already focussed on.

Young infants' social behaviour has been interpreted as early evidence of intention-processing skills, or the beginnings of a theory of mind (Baldwin and Moses, 2001; Snow, 1999). There is no doubt that infants are socially responsive from an early age. They prefer human faces from birth (Goren, Sarty and Wu, 1975; Slater and Kirby, 1998), and, at as young as three months, they reduce their smiling and increase their gazing away from mothers when mothers show a still face (Toda and Fogel, 1993), and they respond to positive attention and mutual gaze with smiles and pre-speech (Reddy, 1999).

But what evidence is there for infants' deeper understanding of caregivers' referential intent in the word learning situation? Experimental research with older infants and children points to the advanced use of social stimuli in word learning. In a study by Tomasello and Barton (1994), 24-month-olds heard a novel label, and were then presented with three objects in turn. In the *without-search* condition, the experimenter said, "Where's the toma? Let's find the toma!", then opened one of three buckets in front of her. She pulled out the object, said "Ah!", gasped, and gave the toy to the child. In the *with-search* condition, the experimenter said "Where's the toma? Let's find the toma!" then opened each of three buckets in turn, saying, "Let's see what's in *here*?" When she opened the first two buckets, the experimenter pulled out the object inside, frowned, and then replaced the object. When she opened the third bucket, the experiment pulled out the object, said "Ah!", gasped, and gave the toy to the child. In the comprehension test, 10 of 15 children in the without-search condition, and 6 of 15 children in the with-search condition chose the correct object when asked for the *toma:* statistically there was no difference between conditions. Tomasello and Barton interpret their results as showing that children "clearly monitor the actions of E, discriminate accidental from intentional actions, and learn the new word for the intended object only." (p. 646)

In another study, Akhtar, Carpenter, and Tomasello (1996) presented 24-month-olds with three novel objects. The children played with two of the novel objects while two experimenters were present. Then the first two novel objects were removed, the second experimenter left the room, and children played with a third novel object in the presence only of the first experimenter. When the second experimenter returned, all three objects were presented, and she said, "Look! I see a gazzer! A gazzer! I see a gazzer in there!" but did not direct her gaze to any one of the three objects in particular. In comprehension tests, it was found that children reliably selected the object that they had played with in the presence of only the first experimenter when presented with the label *gazzer*. Akhtar, Carpenter, and Tomasello concluded from their findings that children showed a sophisticated social understanding: they assumed that the label *gazzer* referred to the third object because this was the object that the second experimenter had not previously seen.

Baldwin, Markman, Bill, Desjardin, and Irwin (1996) conducted similar research with 18- to 20-month-olds. They too found that infants did not learn labels to objects when there was no evidence of referential intent on the part of the speaker. When infants were presented with a novel object that was labelled by an in-view experimenter (who looked towards the novel object as she labelled it), they showed listener learning of the novel label-object relation in test trials. But when infants were presented with a novel object that was labelled by an out-of-view experimenter who was hidden behind a screen, infants did not learn the novel label-object relation. Baldwin and Moses (2001) interpret such behaviour as showing that "infants require evidence that the speaker is intending to talk about the object at issue" (p. 311).

Social-pragmatic accounts of early word learning can be criticised on several grounds. Their first assertion, that caregivers provide contextual cues that function to increase the salience of the referent for any given label, and to enable the infant to discriminate the label from other verbalisations in the speech stream, is well-supported. But alone, these social cues are not enough to lead to listener learning; they do not supply the *mechanism* by which an infant learns to perform a specific conventional behaviour when she hears a particular label.

This is why such accounts assign theory of mind, or social understanding, to human infants. With theory of mind comes the realisation that other people are intentional beings. When a caregiver looks or points towards an object and produces the label *dog*, the infant understands that the caregiver intends the spoken label to refer to the dog. This is how specific label-object relations are learned.

But theory of mind is problematic. There is, first, the issue of how it arises. Several theorists suggest that it is innate; others claim that it arises through a combination of ontogenetic and learning factors (Tomasello, 1995; Tomasello and Camaioni, 1997)—but they fail to specify how theory of mind could come about through learning. Tomasello (1995) admits that the basis for theory of mind is unclear, "but one possibility is that from individual acts of interacting with others as intentional...infants construct a generalized concept of persons as intentional agents" (p.123). But this explanation is incomplete because it does not detail how, in their interactions with others, infants come to such a realisation.

Second, evidence for infants' use of complex social cues in listener learning tasks (Baldwin et al., 1996; Tomasello and Barton, 1994) is limited to infants of 18 months and older, some six to eight months after they learn their first listener relations. These studies thus provide little support for the assertion that theory of mind *initiates* word learning. By the age of eighteen months, infants may have learned to discriminate and respond to social cues in listener and speaker learning, but entirely different processes may have led to the learning of their first label-object relations.

Third, theory of mind lacks parsimony as an explanation of early word learning. Infants are sensitive to social cues, and from a very young age. They show joint attentional skills at around 9 to 12 months, the period when listener learning begins. But, in order to explain these behaviours, it is not necessary to invoke 12-month-olds' sophisticated understanding of others' referential intent: infants may be able to attend and respond to social cues without having to understand their full referential implications—"attention to social information in the environment need not imply social intent" (Hirsh-Pasek et al., 2001, p.1109).

Simple *classical* and *operant conditioning* processes could explain infants' sensitivity to social cues. In classical conditioning, when one stimulus reliably precedes a second stimulus, the first stimulus comes to evoke a similar response to the second. In operant conditioning, behaviour change is dependent on its consequences. For example, a caregiver's points may reliably predict the presentation of new stimuli; further, they may signal a period of social attention or play. When an infant orients in the direction of a caregiver's point, this orienting behaviour is reinforced first by the infant's encounter with a new, potentially interesting object or event, and second by initiating or prolonging a period of caregiver attention to the infant.

Corkum and Moore (1995) used similar conditioning processes to elicit gaze-following behaviour in infants. In their experiment, 8- to 11-month-old infants were trained to follow a caregiver's gaze to one of two objects when that caregiver's gaze predicted the activation of a reinforcing toy (and see *associative learning accounts,* next section)

Behaviour Analytic Perspectives

Below the age of 18 months, infants can produce few spoken words. Yet, when they respond to a caregiver's vocalisation with an appropriate conventional behaviour (for example, by picking up a ball when the caregiver says "Fetch your ball!"), many developmental psycholinguistic theorists infer that the infant "understands" or "comprehends" the word's meaning, or "possesses" the word receptively (see Berko Gleason, 1997; P. Bloom, 2000).

The use of this sort of terminology implies that the experience of the preverbal infant in responding to the word *ball* is the same in quality as the verbal adult's experience on hearing the word *ball*. Yet there is little evidence for this interpretation of infants' behaviour.

As discussed, non-humans such as dolphins, chimps, and sea lions can be taught a conventional relation between a signed label and a set of behaviours (Herman et al., 1984; Premack, 1990; Schusterman and Krieger, 1984). Few people would attribute such *understanding of meaning* to these animals; researchers and lay people alike are more likely to suggest that the animals learned to respond to a visual stimulus by orienting or by performing a particular target behaviour.

Unless we find strong evidence to the contrary, there is no solid reason to differentiate between the performance of preverbal infants and non-human animals in such word comprehension tasks. This is why behaviour analysts (Horne and Lowe, 1996, 1997, 2000; Skinner, 1957; Stemmer, 1990, 1992, 1996, 2002) use the expression *listener behaviour* to describe an organism's nonverbal responding to verbal stimuli, rather than less precise terms such as *comprehension, receptive language*, and *understanding of meaning*. This definition makes no claims to verbal understanding on the part of the preverbal infant. The developmental behaviour analytic accounts that follow make a clear distinction between an infant's listener and speaker learning.

Associative Learning Accounts

> Most object names are learned in so-called ostensive processes. In these processes...the child is exposed to the pairing of a vocal stimulus with another (salient) stimulus. Such events are frequently sufficient to establish correct listener responses to the vocal stimulus. (Stemmer, 1996, p.247)

According to associative learning accounts of infants' listener learning, infants do not need to possess a set of language-specific principles or an understanding of others as intentional beings to guide the establishment of their first listener relations. Instead, simple learning mechanisms enable infants to form specific associations between labels and their referents. Labels are not symbolic at the start of listener learning; rather, through the consistent pairings between labels and objects or events, infants learn to emit specific listener responses when they hear spoken labels.

Several researchers in the developmental psycholinguistic tradition point to associative learning mechanisms as responsible for early listener and speaker learning. For example, Markman (1992, 1994) asserts that, prior to the vocabulary spurt, infants' label-learning is non-symbolic and associative in nature. It is only with the onset of specific word-learning constraints at around 18 months that infants come to use words to refer to or symbolise objects and events.

Other researchers, from behaviour-analytic and, more recently, connectionist traditions, assert that associative learning can account for listener learning up to and including the vocabulary spurt (Plunkett, 1997; Plunkett, Sinha, Moller and Strandsby, 1992; Samuelson and Smith, 1998; Schafer, 2001; Smith, 1995, 1999, 2000a; Stemmer, 1990, 1992, 1996, 2002). According to these accounts, there is no need to posit anything other than general associative learning processes in order to explain infants' verbal behaviour.

How does associative learning of listener relations arise? Building on Skinner's (1957) introduction to listener behaviour, Stemmer (2002) puts forward *ostensive learning*—or "learning by exposure to Pavlovian correlations" (p. 38)—as the means by which infants learn new listener relations.

In his account, Stemmer identifies three steps by which listener learning becomes established in infancy.

First, through differential reinforcement, infants learn listener responses to *action names*, such as "give me shoe" or "drop sock". Here, he contends, infants' responses are not to the specific label *sock* or *shoe*, but to the action name as a whole.

Second, more complex behaviours emerge from these initial action names such that infants come to respond to divisions and recombinations of their individual elements. For example, an infant who has learned, through operant conditioning, to respond appropriately to "drop sock" and "give me shoe", will now also respond correctly to "drop shoe" and "give me sock". Stemmer refers to elements such as "drop *x*" or "give me *x*" as *action frames,* and specific labels, such as "shoe" or "sock" as *modifiers.* Specific action frames determine the nature of the infants' listener responding, such as giving and pointing.

Third, according to Stemmer (2002), Pavlovian correlations between new spoken labels and objects "establish additional verbal stimuli as direct or indirect modifiers of action frames" (p. 45). For example, the caregiver might hold a cup and say, "This is a cup". After several such pairings, when the caregiver says, "Give me the cup" (where "give me" is a known action frame), the infant responds by selecting the appropriate object. Thus action frames are learned through operant conditioning, but novel label-object relations, or modifiers, are learned through ostensive processes.

Classical conditioning (see Rescorla and Wagner, 1972), according to Stemmer and others (Whitehurst and DeBaryshe, 1989) can best account for ostensive listener learning. A basic example of classical conditioning is as follows: an unconditioned stimulus (US), such as a puff of air to the eye, elicits an unconditioned response (UR), such as an eye blink. When a neutral stimulus (NS), such as a buzzer, is consistently paired with the US, eventually it becomes a conditioned stimulus (CS), such that it, on its own, elicits the conditioned response (CR); in this example, the buzzer comes to elicit an eye blink even when there is no longer a puff of air to the eye.

In the case of listener learning, the US could be the presentation of a new object, and the UR, the infants' automatic response of looking towards that object. When a label (the NS) is consistently paired with the presentation of the object, it becomes a CS for the CR of looking towards that specific object (Dugdale, 1996).

How do infants know what aspect of their environment a new label refers to? According to associative learning theorists, infants learn relations between labels and referents that are, for one reason or another, most *salient* to them in the learning context. The infant does not have to understand the referential intent of caregivers when they label an object or event; instead, caregiver behaviours function to increase the salience of the labelled object or event (Samuelson and Smith, 1998).

Associative learning of this kind can explain the vocabulary spurt, again without recourse to concepts such as constraints on word learning or theory of mind (Stemmer, 1996, 2002; Plunkett et al., 1992). Stemmer suggests that, through ostensive listener learning, the infant may learn to respond as a listener to many new label-object relations within a short space of time. It is this explosion in listener behaviour that makes possible the following explosion in speaker behaviour.

Whitehurst and DeBaryshe (1989) argue that a classical conditioning approach to early listener learning is upheld because features known to influence classical conditioning are also important to the learning of novel listener relations. When factors known to affect classical conditioning are manipulated in receptive learning tasks—such as the *informativeness* (Egger and Miller, 1962, 1963) of the label in predicting the occurrence of its associated object; the *temporal contiguity* between the presentation of the label and its associated object; and the *value* to the child of the object being labelled—they change the effectiveness of listener learning in two-year-old children.

In one study (Whitehurst, Kedesdy and White, 1982), when there was a perfect contingency between the presentation of an object and an object-label, two-year-olds showed good receptive learning. But when there were extra presentations of a label in the absence of its object, or extra presentations of the object in the absence of its label, then children's learning of the novel listener relation declined. Thus when the informativeness of the US in predicting the CS declined, so did children's listener learning.

Samuelson and Smith (1998) conducted research, also with two-year-olds, that showed that children of this age do not need an understanding of social cues in order to learn a novel label-object relation. They criticised earlier work by Akhtar, Carpenter, and Tomasello (1996, see *social pragmatic accounts*, previous section) in which it was argued that children's understanding of complex social cues enables them to respond to the spoken label *gazzer* by selecting one of three novel objects. Samuelson and Smith argued that, in Akhtar et al.'s research, the experimental procedure increased the *salience* of the target object at the expense of the other two. For example, children played with the target object last, and in the presence of only one experimenter; the children played with the two alternative objects in the presence of both experimenters. Thus, according to Samuelson and Smith (1998) children in this experiment did not need complex social understanding to learn the target label-object relation. Instead, they learned the listener response to the object that had been made most salient in the experimental context.

Samuelson and Smith (1998) supported their critique with the findings of their own experiment, which was based largely on Akhtar et al.'s design. In this study, children played with two objects, and then encountered a third. This object was in a new location—on a table draped with a glittery blue tablecloth. Then, all three objects were presented together, and the experimenter said, "Look, there is a gazzer." In subsequent comprehension tests, children selected the object that had been made most salient in response to the question, "Where's the gazzer?" Samuelson and Smith equate the findings of their experiment with those of Akhtar et al. (1996), and suggest that children in both studies learn the target label-object relation through "simple attentional mechanisms".

Recent findings from connectionist modelling of various learning situations are cited in further support of associative theories of early word learning (Plunkett, 1997; Plunkett, Sinha, Moller, and Strandsby, 1992).

Connectionist models are based loosely on the architecture of the brain; theorists reason that, although single neurons are limited in function, their rich connections to thousands of other neurons enable very complex functions to be performed (Ellis and Humphreys, 1999). Connectionism uses abstract computer models of the functioning of connected units in a network to explain how complex learning can arise through exposure to an environment, without the necessity for domain-specific, inbuilt structures.

A connectionist network "consists of a set of simple, but richly connected, processing units" (Ellis and Humphreys, 1999, p.14). There are input units and output units, and between, a number of hidden units. Units can be on and off, and can be weighted differently. Overall patterns of activation (and thus, the network's output) are determined by the weightings on the different connections between units. Changes in weighting are determined by exposure to a learning environment.

In Plunkett et al.'s (1992) research, the task of a simple network was to learn to associate images with labels. Images were sets of dot patterns that clustered into perceptually similar categories; the experiment was set up so that one label applied to each cluster of images. The network had *retinal input units*, through which images were presented to the hidden network of units, and *label input units*, through which labels were presented to the network. Over many hundreds of trials, labels were consistently paired with a specific set of images. The task of the network was simply to reproduce in the output the specific label-object relations presented in the input.

At the start of training, the weightings of the connections between hidden units were randomised; this means that there were no inbuilt preferences in the network. Thus in the first training trials, images and labels were presented to the retinal and label units, and activity was propagated through the network of randomly weighted hidden units to the output units. Initially, this output was extremely unlikely to produce a correct association between label and image. An *error signal* was produced, which estimated the amount of discrepancy between the initial label-image input, and the output of the network. Using this error signal, the network adjusted the weightings of the hidden units. When further training trials were run, the network analysed the new error signal, and either increased or decreased weightings each time, with the aim of reducing to zero the discrepancy between input and output.

Throughout training, the network's performance was evaluated in order to establish the developmental pattern by which it came to learn appropriate label-object relations. Both comprehension measures and production measures were taken. The comprehension measure tested the capacity of the network to select an appropriate image when presented with a label, and the production measure tested the capacity of the network to activate the appropriate label when presented with an image.

Plunkett et al.'s network showed patterns of learning that were surprisingly similar to those observed in infants and young children. First, for example, the network showed a dissociation between comprehension and production (or listener and speaker) learning. The network demonstrated appropriate listener responding well before appropriate speaker responding.

Second, the network demonstrated spurts in both comprehension and production. The comprehension spurt occurred quickly, after only a few training epochs, but the production spurt required a period of more prolonged training (this fits well with Stemmer's assertion that a listener spurt precedes a speaker spurt; see Chapter 7 for further discussion of the comprehension spurt).

Third, the network showed evidence of *generalisation* – when it was presented with novel images that were perceptually similar to images presented in training, it was able to extend the appropriate label to these new images. This contradicts Golinkoff et al.'s proposal that a specific lexical principle (extendibility) underlies such behaviour in infants.

Schafer (2001; Schafer and Mareschal, 2001) identifies such networks as associative in nature. In the network, learning results from small incremental changes that strengthen the connections between a label and an image; these small changes together elicit large changes, such as the vocabulary spurt. If this model can be applied to infants' listener learning, there is no need to posit the emergence of specific lexical principles or social understanding to explain the course of listener and speaker learning. Instead these developments can be explained as the results of "gradual experience-driven learning processes" (Plunkett and Schafer, 1999, p.67).

Nonetheless, evidence for the importance of associative learning in establishing infants' listener relations can be questioned. Whitehurst, Kedesdy, and White (1992) and Samuelson and Smith (1998) showed that factors known to affect classical conditioning also affect children's listener learning. But both sets of researchers conducted their experimental research with two-year-old children. Compared to 12-month-olds, two-year-olds are word learning experts. They have already gone through the vocabulary spurt; they produce many more spoken labels than do 12-month-olds, who may produce none. How two-year-olds learn to respond as listeners to novel label-object relations may not reflect how infants learn their *first* listener relations. These studies tell us little of how infants first become listeners.

A second problem with these studies is that the factors the authors show to affect children's listener learning—*contiguity* and value (or *salience*)—are as important in the establishment of operant conditioning as they are to classical conditioning. If operant conditioning were to account for listener learning, there would have to be a contiguous relationship between the presentation of a label and the presentation of an object, so that hearing the label could become discriminative for the infant's listener response of orienting towards the appropriate object or event. Further, if the object or event were to hold no value for the infant, or were not to be salient, it is difficult to see how she would learn through operant conditioning to respond as a listener to it. Thus these findings do not discriminate between associative and operant learning approaches to listener behaviour.

The third aspect of classical conditioning that was relevant to listener learning in Whitehurst, Kedesdy and White's (1992) research was *informativeness*—the better the label predicted its referent, the more likely it was that children would learn the label-object relation. But, in the real world, infants often see objects without hearing them labelled; there is not a perfectly contingent relationship between label and object. If children were learning novel listener relations through classical conditioning alone, their learning would be very slow, and its effects would be weak, even at two years of age (Baldwin, 1995).

In a classic paper, Rescorla (1988) reports research with rats in which a tone (NS) was paired with an electric shock (US), which produced an avoidance response (UR). In the standard paradigm, the tone always predicted the occurrence of a shock, and shocks did not occur without a tone to precede them. The tone quickly became a conditioned stimulus for the rat's avoidance response. But when the baseline rate of the US (the shocks) was increased, such that hearing a tone always predicted a shock but shocks also occurred without a tone, there was little conditioning. If listener behaviour is a product of classical conditioning then, for such learning to arise, every time an infant sees an object a label would have to accompany it. Baldwin (1995) makes just this point:

> Covariation information in adults' speech to children remains fairly noisy even when infants realize that words should be related to external objects...Adults do not make a practice of talking about everything in sight on every occasion, so things are often in infants' view without mention of their corresponding labels. When adults do comment on the things that are in the immediate context, such comments may or may not include a label for the particular object or objects involved. (p.141)

Stemmer (1992) is aware of the problems in assigning classical conditioning as the cause of listener learning in young infants. He states that ostensive learning is similar to classical conditioning, because it involves the pairing of a verbal stimulus with a non-verbal stimulus, such that the verbal stimulus comes to elicit a response which, prior to the pairing, it did not. But he also points to differences between the two processes. For example, a CS should normally precede a US for successful classical conditioning, but in ostensive learning, verbal and nonverbal stimuli can occur at around the same time, and "if one precedes the other, it does not matter which precedes which" (p.74). But Stemmer does not reject classical conditioning as the basis of his ostensive learning; nor does he explain how ostensive listener learning can arise if not through processes of classical conditioning. An associative account of listener learning that does not explain *how* label-object associations are formed is of little experimental value.

Smith (2000b) supports an associative account of word learning, but rejects classical conditioning as the mechanism. In her account (Smith, 1995; Smith, 2000a; Smith, 2000b), Smith identifies *attentional learning* as the basis for infants' word learning, "whenever one perceptual cue is regularly associated with another, the presence of the first will automatically increase attention to the second" (2000a, p.54). But it is difficult to see how such learning could come about without classical conditioning; Smith's account is therefore open to the same criticisms levelled at Stemmer's approach (1992).

Plunkett et al. (1992) used connectionist modelling to provide an alternative source of support for an associative account of early listener and speaker learning. Their network learned through "simple associative mechanisms" (Schafer, 2001), yet its performance on listener and speaker tasks closely mirrored the development of such skills in many infants and young children. But, first, Plunkett et al. did not build into their model the complexity and noise of the infants' word learning environment. In their set-up, an image was always presented with its to-be-associated label, and a label was always presented with one of its set of to-be-associated images. As discussed earlier, infants frequently see objects without hearing their labels. On top of this, infants must (at minimum) be able to discriminate a label from the caregiver's speech stream, and determine which object or event in the world is the referent for the caregiver's label. These factors are not represented in Plunkett et al.'s network. Might it have had more difficulty if they were?

Second, it could be argued that, in the type of connectionist network used by Plunkett et al. (1992), the network's learning did not reflect classical conditioning (or associative learning processes), but instead, operant learning. In Plunkett et al.'s *back propagation* model (as in many others, see Gasser and Smith, 1991; Mareschal, Plunkett and Harris; 1999), one of the few inbuilt parameters of the model is error-avoidance. The network comes successively closer to the desired response by changing the weightings of its hidden units (and thereby changing its output), dependent on the size of an error signal. This process matches the operant shaping of a new behaviour through differential negative reinforcement more closely than it matches classical conditioning. Particular weightings in the network are strengthened (reinforced) when error is reduced from one trial to the next.

In a typical negative reinforcement procedure, an animal is trained to avoid a shock by pressing a lever—this strengthens the desired lever-pressing response. In Plunkett et al.'s model, through a process of successive approximation, the network is trained to avoid error by correctly linking a label and an object in its output (or response). Under such conditions, according to supporters of an operant account, it is not surprising that the network learns novel listener relations. Operant learning provides the crucial selection mechanism through which such learning arises.

The next section considers theories of operant listener learning in more detail.

Operant Learning Accounts

> Reinforcement of some kind, even if not always explicit, may nevertheless be a crucially important determinant of every form of early language development, including listener behaviour, echoic responding, and naming. (Lowe and Horne, 1996, p.319)

Horne and Lowe (1996, 1997, 2000; Lowe and Horne, 1996; Lowe et al., 2002) propose a functional account of infants' listener learning that includes a role for classical conditioning, but that asserts the primacy of operant processes. In this account they, like Stemmer (1992, 1996, 2002), draw on Skinner's (1957) early thoughts on the establishment of listener relations. Unlike Stemmer, they recognise that Skinner included both classical *and* operant conditioning processes in his approach to listener behaviour. According to Skinner (1957), the verbal stimuli to which listeners respond first "evoke responses of glands and smooth muscles, mediated by the autonomic nervous system, especially emotional reactions. These exemplify classical conditioned reflexes…"; second, they "control much of the complex skeletal behaviour with which the individual operates on his environment. " (p.34)

But Skinner (1957) gives little consideration to listener behaviour in its own right; his *Verbal Behavior* refers to it, in the majority of instances, only under circumstances in which an adult speaker also acts as a listener. Horne and Lowe (1996), on the other hand, consider listener behaviour a "crucial precursor to the development of linguistic behaviour" (p.192); as such, it is worthy of detailed analysis.

Horne and Lowe (1996) define listener behaviour as a varied class of nonverbal responses to verbal stimulation from a member of the same linguistic community; listener behaviour arises when the verbal community "establishes a correspondence between a vocal or other conventional stimulus produced by a speaker and behavior evoked in the listener" (p.192).

In Horne and Lowe's (1996) account, the verbal community establishes such a correspondence primarily through selective reinforcement, such that a caregiver's verbal stimulus becomes discriminative for infants' conventional listener behaviour. Horne and Lowe put forward a number of steps that account for infants' learning of their first listener relations.

First, Horne and Lowe (1996) highlight the course of infants' early learning in preparing them for becoming listeners. As discussed, by the age of 9 to 12 months—when infants learn their first listener relations—they are already responsive to speech, especially child-directed speech, they can follow a caregiver's gaze; and they can point to and offer objects to a caregiver.

Caregivers scaffold infants' social and object-related behaviour further, through the use of simple, child-directed speech and nonverbal cues that increase the salience of target objects—they point towards objects of interest, and bring them into the infant's line of sight; they model objects' functions; and they "put through" or manually direct infants' conventional object-related behaviour (e.g. they might guide an infant's hands to throw and catch a ball). Caregivers provide social reinforcement for such conventional object-related behaviours.

Because of the above, infants respond to caregivers in their interactions with objects before they learn to respond as listeners to verbal stimuli. In this context, caregivers also produce labels for objects. For example, a caregiver might say, "Where's the ball?" while at the same time looking and pointing towards the appropriate object. The infant responds to the caregiver's nonverbal cues and, in turn, orients towards or picks up the ball. The caregiver reinforces such a response, by saying "Good girl!" and initiating play with the ball, for example. In this way, and after many repetitions, the caregiver's verbal stimulus *ball* becomes discriminative for the infant's object-related behaviour. During the time that the infant comes to reliably fetch the ball in response to the caregiver's verbal stimulus, the caregiver fades out pointing and modelling behaviours, but continues to reinforce the infant's listener response. Eventually, when the caregiver says, "Where's the ball?", because "ball" has become a discriminative stimulus for object-related behaviour with a ball, the infant can fetch a ball from an array of other objects, and her behaviour is reinforced. She has learned listener behaviour.

An important aspect to this theory is that, when an infant learns to respond as a listener to a verbal stimulus such as *ball,* she does not simply learn a relation between a label and a single object, but instead, between a label and a class of objects. A caregiver reinforces an infant's behaviour when the infant orients towards balls of many different colours and sizes in response to the verbal stimulus *ball.* Listener behaviour entails the infant learning the relation between a verbal stimulus, a class of objects, and a set of conventional behaviours, "...the infant learns when she hears */shoe/* to orient not just to a particular shoe...but to a class of objects...., membership of the class being established by her caregivers who name each of the different exemplars "shoe." (Horne and Lowe, 1996, p.195)

Further, after many reinforced pairings between the caregiver's label, "ball", and the infant's listener response, the label may come to elicit the infant's classically conditioned "seeing" or visualisation of the ball, and a range of other classically conditioned responses.

Infants' conventional listener responses to verbal stimuli are reinforced through a variety of means, according to Horne and Lowe (1996). For example, when a caregiver asks, "Where's the cat?", and the infant responds by orienting towards the cat, her behaviour may be reinforced by the caregiver saying, "Clever girl! There it is!", but it may also be intrinsically reinforced when she strokes and plays with the cat as a result of her orienting behaviour.

Horne and Lowe's (1996) predominantly operant theory of listener behaviour does not assign any linguistic or symbolic "understanding" to the infant at the start of listener learning; nor does it require the infant to understand the speaker's referential intent. The account given above explains the establishment of early listener relations, but it does not elucidate later developments in infants' verbal behaviour, such as the vocabulary spurt and findings that young children appear to *fast map* the relation between a novel label and a novel object.

According to Horne and Lowe (1996), such developments arise from the qualitatively new *name relation;* this can become established only when infants learn to speak as well as to listen. In brief, Horne and Lowe claim that the name relation arises through the following:

1. Through a process of operant reinforcement, infants learn to respond to classes of objects or events in response to caregivers'

verbal stimuli. For example, they learn to select multiple balls when the caregiver asks, "Where's the ball?"

2. Infants learn to *echo* caregivers' verbal stimuli in the presence of objects. For example, the caregiver might point to a ball and say, "This is a ball. Can you say ball?" Infants' echoic vocalisations are shaped, again through a process of reinforcement.
3. The shaping of infants' echoic behaviour usually occurs in the presence of the relevant object. For this reason, the sight of an object eventually becomes discriminative for a specific verbal response. The infant learns, on seeing a ball, to say "ball". This *tacting*, or speaker behaviour, is again reinforced.
4. The object alone evokes the infant's labelling response. Now, because of previously established listener behaviour, the infant responds as a listener to her own labelling, and re-orients to the object. Further, because the infant has learned listener behaviour to *classes* of objects, her speaker behaviour now comes to encompass those classes. When an infant sees one ball, she says "ball", listens to her own verbalisation, and thereby re-orients towards that ball or any other. When an infant learns both listener and speaker relations to classes of objects in this way, she has learned a *name relation*. Name relations, according to this theory, are the basis for symbolic behaviour.

The vocabulary spurt—the rapid increase in the rate of spoken word learning that, according to several researchers, occurs at around 18 months—relies on the establishment of an echoic repertoire, according to Horne and Lowe's (1996) theory. During the time that infants learn to produce more and more distinct speech sounds, the combinatorial possibilities of these sounds increases exponentially; this enables a rapid increase in spoken word learning.

A further explanation for the rapid increase in word learning observed in many infants at around 18 months, and for the observation (Carey and Bartlett, 1978; Golinkoff et al, 1992; Markman, 1994; Whitehurst and DeBaryshe, 1989) that listener behaviour in two-year-old children can be established quickly without extended explicit reinforcement, comes from long-established research on *learning sets* (Harlow, 1949).

In Harlow's (1949) classic research, monkeys were presented with two different objects, over repeated trials. Food was hidden under only one of the objects; through these means, the monkey's behaviour of picking up an object was differentially reinforced. In this way, over a number of trials, the monkeys learned to pick up one of the objects in a pair, rather than the other. Once monkeys had learned the discrimination with the first pair of objects, a new object-pair was presented. Again, food was hidden under only one of the objects and, over a number of trials, the monkeys learned to pick up only that object. This procedure was repeated with many new object pairs.

Over this training, Harlow (1949) found that, at first, monkeys required many training trials to learn each new discrimination. But as training continued, monkeys came to respond with 100% accuracy to the object with the food hidden under it on the second trial with a new object-pair.

Why did monkeys learn new discriminations so quickly in later trials?

> When the early problems are presented, the monkey must learn not only the particular stimulus correlated with reinforcement within each problem, but also many other aspects of the procedure (e.g., that food is correlated with one of the two stimuli rather than with position or some other feature of the setting; that this correlation does not change within problems; that reaching simultaneously for both stimuli will not be reinforced; and so on). During the early blocks of problems...the monkey is learning many things; only later, when these other aspects of this situation are learned, does the monkey have to learn only which of the two stimuli is correlated with food in a given problem. (Catania, 1984, pp.148-149)

This *learning-to-learn* phenomenon is one explanation of the behaviour of young children in fast mapping experiments. Because two-year-olds have already learned hundreds of listener relations; their appropriate orienting or selection response on the presentation of a novel label may require only one reinforcement for a novel listener relation to become established. This reinforcement does not have to be explicit - some element of the experimental situation may reinforce a child's appropriate listener response.

Thus fast mapping or ostensive learning need not, according to Horne and Lowe (1996; and see Lowe et al., 2002), arise from the onset of language-specific principles or classical conditioning processes. Neither does the fast mapping performance of infants above the age of 18 months reflect the roots of listener behaviour in operant learning processes.

Bell (1999; and see Horne and Lowe, 2000) presents evidence that the establishment of listener behaviour in young infants does, indeed, depend on reinforcement. In one of her studies, 9- to 16-month-old infants were exposed 27 times to a novel label in the presence of a novel object. After this exposure training, infants were tested for their comprehension of the novel label-object relations, through a preferential reaching test in which infants were presented with several objects and asked, "Where's the gek?", for example. Infants showed no evidence of having learned the novel listener relations after exposure training. Then, reinforced training trials were introduced, in which the experimenter presented several objects, asked "Where's the gek?", and reinforced infants' appropriate selection responses. Only when such reinforced training trials commenced did infants start to show evidence of listener learning.

Further, Rome-Flanders, Cronk and Gourde (1995) found that caregivers *do* reinforce object-related behaviours in their "natural" play with infants, and that there was a significant positive correlation between the amount of caregiver's reinforcement in a peek-a-boo game and verbal development in 6- and 9-month-old infants. In their research, caregiver and infant were observed playing a three-minute game (either a throw and catch ball game, or a peek-a-boo game), every three months from 6 months to 24 months. Although the amount of caregivers' modelling and instructing behaviours varied between the two games and over time, reinforcement was constant, both in frequency and in change over time, in both games. From 9 to 24 months, caregivers' reinforced their infants' game-related behaviour an average of around eight times in each three minute session.

Research with non-humans, including chimps, sea lions, and dolphins, also shows that listener behaviour can be established through operant training paradigms (Herman et al., 1984; Savage-Rumbaugh, 1986[3]; Schusterman and Kastak, 1994). For example, in Herman et al.'s (1984)

---

[3] Savage-Rumbaugh et al. (1993) have made more recent claims for the "spontaneous" learning of novel symbols in Kanzi, a chimp whose mother participated in their language-training programme. The authors claim that Kanzi received no special operant training; his treatment by experimenters in the word learning context was similar to that of a young child. But, given evidence that caregivers reinforce infants' and young children's vocal and listener responses in the "natural" word learning context (see p. 57), Savage-Rumbaugh et al.'s findings do not contradict an operant approach to verbal learning.

research, two dolphins were trained to respond as listeners to two-word spoken or gestural signals emitted by the experimenters. Through cueing and operant shaping, dolphins were successfully taught to respond to verbal stimuli such as "Ball fetch". These findings strengthen the hypothesis that listener behaviour in humans and non-humans alike results from general learning mechanisms, rather than from specific lexical principles or insights into the referential intent of others.

There is little other behavioural research on infants' early listener learning. But there are strong findings of the effects of reinforcement on children's learning of new *speaker* relations. For example, Bell (1999) used positive reinforcement to shape new echoics in infants, and Lowe et al. (2002) established new tacts in two- to four-year-old children through an operant procedure in which a novel object was presented and the experimenter said, "This is a zag. Can you tell me what it is?" If the infant produced an appropriate verbal response, the experimenter responded, "Yes! Clever girl! It's a zag". Children learned two novel speaker relations after an average of 55 trials.

Whitehurst and Valdez-Menchaca (1988) conducted a study in which 2- and 3-year-olds gained attractive toys to play with only if they requested them in a foreign language. Their use of the foreign labels increased over the learning period. In a control group, children could request the toys in either language in order to play with them—their use of the foreign language labels was low.

Operant conditioning has an effect on young infants' vocal behaviour. Routh (1969) used reinforcers such as smiling and "tsk" sounds to condition 3- to 7-month-old infants to produce vowel-sounds rather than consonant sounds. Smith, Michael, and Sundberg (2001) trained an 11-month-old and a 14-month-old infant to echo target phonemes; infants learned to echo the target phoneme when the experimenter modelled *and* reinforced infants' appropriate productions with tickles and bubbles, but not in a modelling-only condition.

Operant training has also been shown to improve the verbal behaviour of language-delayed and autistic children (Sachs, Bard, and Johnson, 1981; Sundberg, Michael, Partington, and Sundberg, 1996; Sundberg and Michael, 2001). Sachs et al. (1981) report the case study of a boy raised by deaf parents who heard speech via the television and at nursery school. His speech was below age level and idiosyncratic (e.g. "Where the wheels plane?" "It do down?"). Only through an operant intervention did his speech reach normality.

Many authors (specifically in the developmental psycholinguistic field) criticise operant accounts of verbal behaviour because, they claim, caregivers do not explicitly teach new listener and speaker relations. For example, P. Bloom (2000) argues that words can be acquired by human infants "without any training, or feedback; children can grasp much of a word's meaning after hearing it in the course of a passing conversation" (p. 1095).

The prevalence of this viewpoint in the developmental psycholinguistic field arises, in no small part, from early research by Brown and colleagues (Brown, 1973; Brown and Hanlon, 1970), who transcribed much of the early productive language of three young children, and analysed the relations between mothers' behaviours and children's language. Did mothers provide differential reinforcement for appropriate utterances? They concluded that "there is not a shred of evidence that approval and disapproval are contingent on syntactic correctness" (Brown and Hanlon, 1970, p.70).

But behaviour-analytic authors have rejected Brown's findings because of his limited view on reinforcement, "It was Brown's restrictive definition of reinforcement as the contrived and programmed delivery of a specific item following a targeted response, that led him to reject reinforcement as a significant cause of language acquisition" (Smith et al., 2001,p. 40).

Many authors suggest that caregivers do not always provide explicit reinforcement for their infants' appropriate verbal behaviour (Smith et al., 2001; Moerk, 1990, 1996; Horne and Lowe, 1996; Donahoe and Palmer, 1994). Nevertheless, they claim, there are multiple sources of reinforcement available to infants and young children in the process of verbal learning.

Reinforcement does not have to be of the "clever girl" variety. It can take non-verbal forms such as smiling, tickling, or play; it can be an automatic consequence of infants' correct listener or speaker behaviours (an infant's appropriate response to "find milk" is automatically reinforced by the milk itself); with more sophisticated speaker behaviour, it can take the form of caregivers' corrections, expansions, and recasts of children's own utterances.

> Only a very small proportion of the contingencies of reinforcement in human affairs is explicit, and verbal contingencies are no exception, as Moerk's analysis reminds us. When a child speaks, adults usually orient to the child and almost invariably respond appropriately in some way. Verbal behaviour provides children with tremendous power, which they learn to wield more and more effectively as their repertoire develops. Virtually every instance of verbal behaviour is changed with reinforcement of some sort, and very little of it is explicitly arranged. (Donahoe and Palmer, 1994, p.317)

Moerk's (1990, 1996) re-analysis of Brown's data found much evidence for caregivers' provision of corrective feedback for children's utterances, and that such feedback correlated with children's language improvement. Many other researchers support this viewpoint. For example, Poulson and Kymissis (1996) present evidence that caregivers model and reinforce conventional speaker behaviours in their interactions with young children; Demetras, Post and Snow (1986; and see Bohannon, Snow, and MacWhinney, 1990) showed that mothers responded differently to their two-year-old children's well-formed and ill-formed utterances with explicit and implicit feedback; and Otomo (2001) observed Japanese mothers' responses to infants aged 12 to 21 months, and found that mothers repeat only infants' word-like utterances, not their non-word-like utterances.

A second criticism of any approach that relies on caregivers' support for infants' early word learning is that, while middle-class western caregivers support their children's word learning through the use of child-directed speech and extensive, verbally-directed play, caregivers in other cultures do not provide such support. Indeed, in some cultures, adults do not talk to their children at all; instead, it is claimed, children are simply exposed to adult conversations (Berko Gleason, 1997; P. Bloom, 2000, 2001). Yet such children still learn to speak.

But recent research (see Lieven, 1994, for review) suggests that there are very few cultures in which adults do not talk to their children. Taylor (1990) reviews the use of child-directed speech in many communities, and records that it is prevalent in Europe (Papousek et al., 1987), the U.S., Australia (Cross, 1978), the Middle East (Zeidner, 1978), Central and

South America (Pye, 1986; Solberg, 1976) and Asia (Clancy, 1985). Further, although lower class mothers tend to talk to their children less than middle class mothers, they do adjust their speech to children in similar ways to middle class mothers; they use fewer function words and multi-clause sentences than they do in adult-directed speech (Ringler, 1978); thus, when lower class mothers do talk to their infants, they use child-directed speech.

Further, although adults in certain cultures may speak very little to their children, it is possible that older children play a role in reinforcing infants' listener and speaker behaviours. Finally, Lieven (1994) reports that it is not unusual, in cultures where children are spoken to very little, for children to start speaking only at the age of three. This does not conflict with an operant account; it suggests that the less the caregiver supports infants' word learning, the more likely it is to be delayed.

* * *

Horne and Lowe (1996) provide an operant account of how infants learn listener behaviour—the conventional relation between a heard word and a referent object or event—that, in their view, removes the need for recourse to rich, mentalistic explanations of the source of such behaviour.

This account is supported by several studies on operant listener learning in infants (e.g. Bell, 1999) and non-humans (e.g. Herman et al., 1984; Schusterman and Krieger, 1984). Further, recent evidence that shows effects of reinforcement on speaker behaviour in young children and special populations, and on vocal conditioning in infants (e.g. Moerk, 1990; Otomo, 2001), challenges the view that operant conditioning can play no role in the learning of speaker behaviour; this opens the possibility that infants' listener learning, too, is governed by operant processes.

Until recently, there has been little direct focus on infants' listener behaviour in experimental research. But recent developmental studies have turned to listener behaviour, or word comprehension, in order to test their own theories of the roots of word learning. Chapter 2 reviews this recent *rapid word learning* research; this challenges an operant account of the source of listener learning.

INTRODUCTION TO RAPID WORD LEARNING RESEARCH

Of the theoretical approaches to infants' word learning reviewed in Chapter 1, an operant approach to listener behaviour was identified as providing a functional, parsimonious account of infants' early listener learning. According to this account, various reinforcing consequences are provided when an infant produces a range of conventional behaviours in response to a caregiver's verbal utterance. These reinforcing consequences strengthen the relationship between the caregiver's verbal utterance and the infant's behaviour: the verbal utterance becomes discriminative for the infant's production of conventional behaviours on future occasions.

Chapter 1 presented support for an operant account of listener learning, including single-subject research (Bell, 1999; and see Horne and Lowe, 2000), in which infants from 9 to 16 months failed to learn novel listener relations after each object had been presented with its label on 27 separate occasions; but learned novel listener relations after extended reinforced training (see Chapter 1 for more detail of this research).

Recent research on *rapid word learning* calls into question this behaviour-analytic viewpoint on listener learning in infants below 18 months. A growing body of large-group, developmental studies report that new listener behaviours can be learned by infants as young as 12 months, after as few as five exposures to a new label-object relation.

According to an operant account, reinforcement is necessary for infants with little listener experience to learn a new label-object relation. It is only when infants become more experienced in listener learning that their performance is likely to show features of a learning set phenomenon (Harlow, 1949), such that listener behaviour may be learned through brief exposure to the new label-object relation. The findings of rapid word learning studies suggest that even early listener relations may be learned in the absence of contingent reinforcement; reinforcement may not be necessary in human infant listener behaviour learning.

This chapter reviews the methodology and findings of rapid word learning studies with infants below the age of 18 months. It examines the theoretical interpretations of this research (in terms of one or other of the theories discussed in Chapter 1), and it presents a detailed critique of rapid word learning studies, along with alternative interpretations of infant word learning data. This critique provides a rationale for the research carried out and reported in Chapters 4, 5, and 6 of this thesis.

Rapid Word Learning Studies

Preferential Reaching as a Test for Listener Learning

Woodward, Markman, and Fitzsimmons (1994) performed the earliest studies of rapid word learning in infants below the age of 18 months. Their research was informed by earlier studies by Oviatt (1980) and Lucariello (1987), who had conducted interesting but poorly controlled experiments on infants' learning of new words when they were below the age of 18 months—before the productive naming explosion.

Woodward et al. (1994) noted the sudden jump in infants' rate of learning to produce words at around 18 months—known as the vocabulary spurt—and asked whether there was a simultaneous jump in infants' rate of learning to understand words (or learning listener relations). To investigate this, the researchers compared pre-vocabulary spurt and post-vocabulary spurt infants' rate of learning a single new listener relation. In training, 13- and 18-month-old infants were exposed nine times to a new label in the presence of an unfamiliar object. In testing, infants were given a forced-choice reaching task, in which they were presented with the new label and a choice of two objects: the object that had been labelled during training (the target object) and an alternative object that had not been labelled by the experimenter during training (the distracter object).

Over several studies, Woodward et al. (1994) present evidence that, in test trials, 13- and 18-month-old infants selected the previously labelled target object more often than the unlabelled distracter object; this suggests that both groups of infants had learned the new label-object relation after only nine exposures.

Details of the methodology and findings of the four studies conducted by Woodward et al. (1994) follow.

In Study 1, 13- and 18-month-olds were presented with a plastic strainer and a large plastic paper clip. In training, one of the objects was labelled, and the other had attention drawn to it by the experimenter. To the labelled object, the experimenter said, "Look, that's a toma. See, it's a toma. Look, it's a toma" and repeated this sequence twice within five minutes. To the other object, the experimenter said, "Oo, look at that. Yeah, see it? Wow, look at that."

There were nine test trials. They fell into three trial types: *familiar label, new label, and preference control.* All test trials were play-like, and involved the infant placing test objects in a box, or sliding them down a chute, for example. In the three familiar label trials, infants were presented with a pair of objects—which each caregiver had previously confirmed that her infant knew. The infants were asked, "Can you put the dog in there? " for example. In the three new label trials, infants were presented with the strainer and the paper clip and asked, "Can you put the toma in there?" In the three preference control trials, the infants were presented again with the plastic strainer and the paper clip, and asked, "Can you put one in there?" The three trial types were randomly interspersed.

Results of this first study revealed that infants in both age groups reached more often towards familiar target objects when they were labelled than would be expected by chance (13-month-olds' mean score was 68% and 18-month-olds' mean score was 76% correct reaching on this task), and that, in preference control trials, infants in neither age group showed significant preferences for one object over the other. But only 18-month-olds reached at greater than chance levels towards the novel target object when it was labelled (they scored 76%). Thirteen-month-old infants showed a chance performance of 49%.

These results show label-object learning after limited exposure by 18-month-olds; their rapid learning may have arisen from a learning-to-learn phenomenon (see Chapter 1, p. 53). For this reason, these findings do not conflict with an operant learning perspective.

The three additional studies reported by Woodward et al. (1994) led them to different conclusions regarding 13-month-old infants' ability to learn new listener relations. In Study 2, test trials were simplified so as to prevent younger infants' "confusion". There were four new label trials and four familiar label trials, but preference control trials were excluded. Test trials were blocked by type, rather than interspersed at random, so that all trials of the same type were conducted together. After these changes, 13-month-old infants showed learning of the new label-object relation; on new label trials, when these infants were asked to select the *toma*, mean correct selection of the target object was 65%.

Study 3 also demonstrated that 13-month-olds could learn the new label. In this study, both 13- and 18-month-olds were tested, and preference control trials were included to further validate the results of Study 2 (but in this study the different trial types were tested between-subjects, rather than within-subjects: for each age group, one group of infants was tested on familiar label trials, one group on new label trials, and one group on preference control trials). Again, 13-month-old infants showed above-chance reaching towards the object that had been labelled *toma* during training (at 63%). But 18-month-old infants this time did not show significant above-chance reaching to target (their mean score was 59%). The authors suggest that—because the task had been simplified to make it appropriate for younger infants—older infants' poor performance arose from "boredom".

In Study 4, 13- and 18-month-old infants were trained in the same way as in the earlier studies, but tested for word comprehension after a 24-hour delay. Familiar and new label test trials were included (within-subjects) and blocked as in Study 2. Results revealed that both groups of infants showed learning of the new object-label after a day's delay (the mean score for the 13-month-olds was 67%, and the mean score for the 18-month-olds was 77%).

Woodward et al. (1994) generalised over the results of all four studies to conclude that "...when the measure of learning is comprehension, children who have approximately 6 months to go before the naming spurt are nevertheless able to map a new object label to its referent after only limited exposure" (p.565).

Woodward et al.'s (1994) results have been supported by further research. Woodward and Hoyne (1999) conducted a study with 64 13-month-olds, in which infants also showed significant preferential reaching towards a novel target object after nine labellings; when asked to select the labelled object, infants' mean reaching to the target object was 65%. And in research by Namy (2001), 17-month-old infants learned the relation between a novel label and a familiar category of objects after only ten labellings; on average, infants reached towards a target category member (as opposed to a distracter non-category member) at 66%.

Tests other than preferential reaching have been implemented to measure word learning in young infants. Over the last 15 years, the preferential looking paradigm (Golinkoff, Hirsh-Pasek, Cauley, and Gordon, 1987;

Reznick, 1990) has been developed. This too has indicated rapid word learning in pre-naming explosion infants.

Preferential Looking as a Test for Listener Learning

Research with infants and young children is difficult. Young participants may not respond appropriately to experimenter instructions for a number of reasons: they may become distracted, or they may not have learned how to respond appropriately, for example. These factors may mask the effects of infants' learning in an experimental setting. Golinkoff et al. (1987) suggest that "most language comprehension methods tend to assess young children's spirit of cooperation as well as their linguistic sophistication" (p.24).

For this reason, Golinkoff et al. (1987) developed a paradigm that aimed to test young participants' language comprehension skills, but required only a minimal response. In the *preferential looking* paradigm, two objects are presented to an infant, for example a cup and a shoe. The experimenter asks, "Where's the cup?" If the infant looks longer towards the cup than towards the shoe over a pre-defined time period, then it can be concluded that she has learned the listener behaviour to the word *cup*. Preferential looking as a measure of language comprehension has been validated over a series of studies (Golinkoff et al., 1987; Hirsh-Pasek and Golinkoff, 1993, 1996a, 1996b; Hollich, Hirsh-Pasek and Golinkoff, 2000).

Schafer and Plunkett (1998) used preferential looking to test for rapid word learning in 15-month-old infants. In this study, two novel images were presented on television monitors, one to the infant's left and one to the infant's right. In the training blocks, both images were labelled, one as *sarl* and the other as *bard*. One image was presented in each trial; after 1 second its auditory label was also presented (provided by a pre-recorded voice). Over two training blocks, each novel image was labelled 12 times.

In the testing blocks, a third label (*geek*) was introduced, which had not been presented with either image in training trials. In all test trials, both images were presented, along with one of the three labels: *bard, sarl,* or *geek.* The label was presented three times within a 7-second period. There were three trial types. In the first type, the label matched the image on the left. In the second type, the label matched the image on the right, and in the third type, the label matched neither image.

The duration of infants' looks to the left and to the right in each trial were coded in milliseconds, using videotapes of each experimental session. For each trial type, two *looking time difference* measures were derived—the first by subtracting the duration of total looks to the left from total looks to the right in each trial, and the second by subtracting the duration of the single longest look to the left from the single longest look to the right in each trial.

If infants had learned the new labels, on trials where the label matched the image on the left, infants would look more towards the left, and the value of the looking time difference would be negative; on trials where the label matched the image on the right, infants would look more towards the right, and the value of the looking time difference would be positive; and on trials where the label matched neither image, infants would not look more towards the left or the right, and the value of the looking time difference would therefore be around zero.

This pattern of results was indeed found by Schafer and Plunkett (1998), particularly for the looking time difference measure that compared infants' longest look to the right to their longest look to the left on each trial. This indicated that the 12- to 17-month-old infants in the sample had learned at least one of the novel label-image relations, "...even when the preferential looking task is made difficult by teaching two novel words in the same experiment young children are nevertheless capable of rapid word learning" (p.317).

Further research has supported Schafer and Plunkett's (1998) claim that infants under 18 months can show rapid word learning. Hollich, Hirsh-Pasek and Golinkoff (2000) conducted a series of experiments using the preferential looking paradigm. They adapted the traditional procedure to develop the interactive *intermodal preferential looking paradigm* (IPLP). The interactive IPLP aimed to improve the ecological validity of the preferential looking paradigm, and to enable experimenters to manipulate real-world word learning cues.

In the interactive IPLP (see Figure 2.1), the child sits on the blindfolded parent's lap. A display board in front of the child shows real objects, attached to the board by Velcro. The experimenter stands behind the board in order to issue prompts, and a mirror behind the parent and child allows the experimenter to check the positioning of objects on the board. A hidden camera behind the experimenter focuses on the child's face. The child's eye movements throughout the experimental session are recorded, and then coded offline.

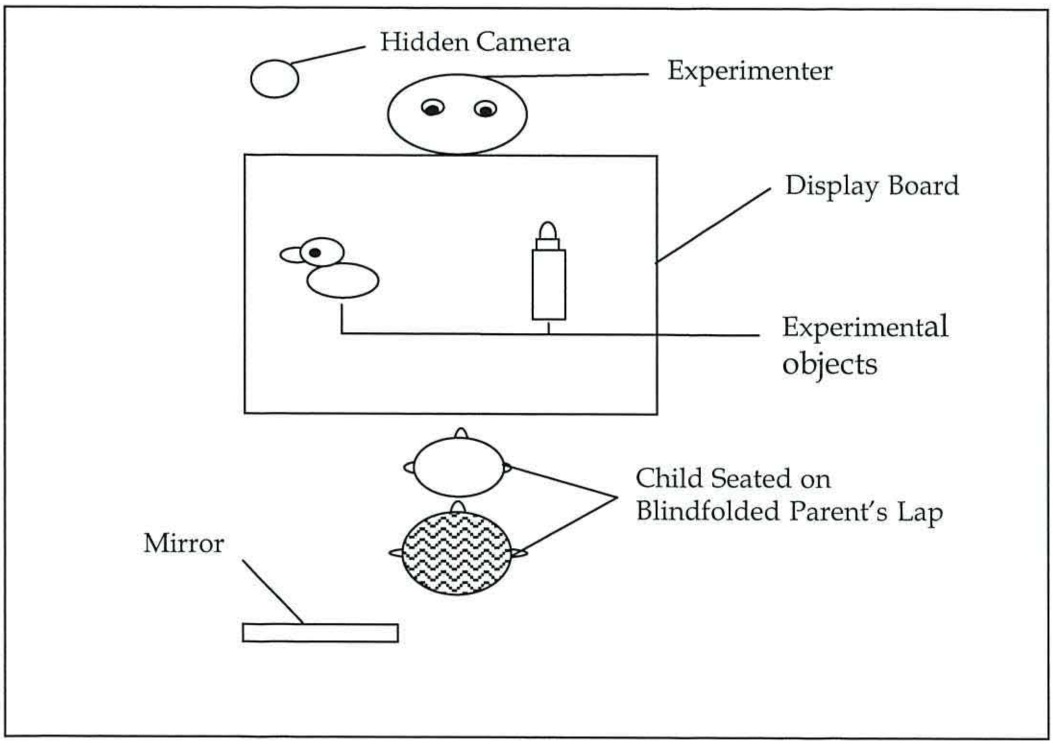

Figure 2.1. The interactive intermodal preferential looking paradigm. Figure adapted from Hollich et al. (2000).

In their relevant experiments, Hollich et al. (2000) manipulated cues, such as object salience and experimenter eye gaze, to discover which most affect infants' and young children's learning of a novel label-object relation. They tested three age groups: 12-month-olds, 19-month-olds, and 25-month-olds. In all of their experiments, a similar procedure was followed.

First, two familiar objects (either a book and a set of keys, or a block and a ball) were used to validate the measures, and to provide the opportunity for children to become familiarised with the task. Children were presented with each object in turn, and could handle each for 26 seconds. Then, both objects were placed on the display board and the experimenter asked, "Where's the [book/ball/keys/block]?"

Then two novel objects were presented. In Experiments 1-3, the objects were of unequal perceptual salience (a blue and silver sparkly wand and a white cabinet latch, or an orange and pink party clacker and a beige bottle opener), and in Experiments 4-9, objects were of roughly equal perceptual salience (a corn butterer and a tea leaf strainer, or a white garlic press and a green lint remover).

In the *exploration phase*, children were allowed to handle each novel object in turn. In the *salience phase*, both objects were placed on the display board, and the experimenter asked the children to "Look up here!" This provided a check for the comparative salience of the two novel objects prior to labelling. In the *training phase,* both novel objects were presented on the display board, and one was labelled (either *dawnoo* or *modi*). Either five or ten labels were presented, dependent on the experiment (e.g. Look! It's a modi, a modi!).

Further experimenter cues as to which object was being labelled, such as eye gaze and pointing, were provided in the training phase, dependent on the experiment. Finally, in the *testing phase,* both novel objects were presented on the display board, and the experimenter asked, "Do you see the [dawnoo/modi]?" The experimenter then hid behind the display board so as not to cue children's responses. Within a six-second period, she said, "Do you see the [dawnoo/modi]? Look at the [dawnoo/modi]." There were two test trials per testing phase.

Once this procedure had been completed with the first pair of familiar and novel objects, it was repeated with the second set of objects. It should be noted that, for each novel object pair, only one novel object was labelled.

The procedure outlined above was followed in all experiments conducted by Hollich et al. (2000), apart from in Experiment 3, in which the objects in each pair were of unequal salience. Here, for purposes of control, two additional test trial phases were included in the procedure after the test phase. In the *new phase*, both novel objects were presented, along with a novel label that had not been previously presented with the target object (if the target had been labelled *modi*, for example, then the experimenter prompt in this phase was, "Do you see the dawnoo?"). In the *recovery phase*, both objects and the label that had been provided during training were again presented–this phase was thus identical to the test phase.

The addition of these phases allowed the authors, in this experiment, to determine whether infants had learned the novel label-object relation, as opposed to simply preferring to look at the interesting object in each pair. If infants had learned a specific listener relation, then they should show greater preferential looking towards the target object during the test and recovery phases than in the new phase. If they simply preferred the interesting object, and had not learned the target listener relation, then they would show preferential looking towards the target object at the same levels in the test, new, and recovery phases.

Throughout all experiments, for all phases apart from the exploration phase, children's looks—towards the target object, the distracter object, the experimenter, and elsewhere—were coded to 1/100th of a second. A proportional total looking measure was derived from this coding, by dividing the total duration of looks towards the target object in each trial by the total duration of looks towards the target object and the distracter object.

Twelve-month-olds showed significant preferential looking towards familiar target objects (at a mean level of 54.2% across all studies), and preferential looking towards the novel target object during training phases (at between 57 and 82%), as long as the experimenter cues to the appropriate object involved more than direction of eye gaze alone. This validated preferential looking as a measure, and demonstrated that participants could follow experimenter cues to correctly identify the object being labelled in the training phase.

In three of the nine relevant experiments conducted by Hollich et al. (2000), 12-month-olds showed clear evidence of infants' preferential looking towards novel target objects during test trials.

In Experiment 3, objects within each pair were of unequal perceptual salience. When the experimenter labelled the more salient object during the training phase, 12-month-olds showed evidence of having learned the novel listener relation. After only five labellings, infants looked more towards the target object in test and recovery phases than in the new phase. Infants did not learn the label-object relation when the experimenter labelled the less salient object of the pair during the training phase; these results were interpreted as indicating that object salience is a powerful cue for early listener learning.

In Experiment 7, the experimenter looked at the target object, picked it up and turned it around as she labelled it; she also labelled the target object ten times. In Experiment 9, the same cues were provided to direct the infant's attention to the object being labelled, and five labels were presented—but spaced over the same time period as in Experiment 7. In both experiments, infants exhibited preferential looking to the novel target object as opposed to the distracter object during testing (at a mean of 56.1% in Experiment 7, and a mean of 55.3% in Experiment 9), indicating that at least some of the 12-month-old participants had begun to learn the novel listener relation.

In four of the six remaining experiments (Experiments 4-6 and 8), fewer cues to the target object were presented in training (for example, the experimenter only looked towards the target, or looked towards and touched the target object), or only five labellings of the novel object were presented. In none of these experiments did 12-month-old infants show preferential looking towards the novel target object during test phases.

These findings contrast with those of Experiments 1 and 2, in which novel objects within each pair were of unequal perceptual salience, and 12-month-olds *did* look preferentially towards the target object during test trials. In this case, however, the authors considered it possible that infants' successful performance arose because they preferred the target object, not because they had learned a specific label-object relation.

From their results, Hollich et al. (2000) conclude that 12- to 13-month-olds can learn novel object labels after relatively few exposures, but that "early word learning seems to start out as a fragile process that is dependent on the convergence of many factors" (p.83).

Habituation-Novelty as a Test for Listener Learning

Another widely-used methodology in developmental research with infants is the habituation-novelty paradigm (e.g. Cohen 1992; Younger and Cohen, 1986). In the habituation phase, infants are repeatedly presented with a particular type of stimulus (images of birds for example) until their looking towards it decreases to a pre-defined level. In the novelty phase, a further stimulus is presented (an image of a car, for example). If the infant looks longer (or *dishabituates*) towards this new stimulus than towards another example of the original category, then it is concluded that she can discriminate between the two categories.

This methodology has been put to use in the investigation of novel listener learning in infants even younger than 12 months. Werker, Cohen, Lloyd, Casasola, and Stager (1998) used the technique to compare comprehension learning of a novel word in 8- , 10-, 12-, and 14-month-old infants, over a series of six experiments.

In these experiments, infants sat on a blindfolded parent's lap, in front of a television monitor. All stimuli were presented as images on the monitor, accompanied simultaneously by a pre-recorded voice, which labelled the stimuli in single-word utterances.

In the habituation phase, infants were exposed to the relation between two objects (a toy dog and a toy truck) and two labels (*neem* and *lif*). Label-object pairings were presented alternately from a minimum of 16 to a maximum of 20 trials (or 10 trials per label-object pairing). Infants had to show habituation, or a reduction in looking to 65% of their original looking time, in order for their data to be included in the experiments' results.

In testing, two trials were presented: one *same* trial, and one *switch* trial. In the *same* trial, an identical label-object pairing to that used in the habituation phase was presented, and the duration of infants' looking time was measured. In the *switch* trial, a different label-object pairing was presented—both label and object were identical to those presented in the habituation phase, but a new pairing was formed. (For example, during habituation Label A had been presented with Object A, and Label B with Object B. In the switch trial, Label A was presented with Object B, or Label B with Object A.) Again, infants' duration of looking towards the video monitor was measured.

If infants had learned the specific relation between label and object, they would have looked longer towards an object when it was accompanied by a label with which it had *not* been paired on previous occasions (i.e. on the switch trial) than when it was accompanied by a label with which it had been paired during the habituation phase (i.e. on the same trial).

In Werker et al.'s (1998) research, 14-month-old infants showed this pattern of results in test trials, but only when objects were presented as moving stimuli (as in Experiment 4, and for the female infants that had habituated to the novel label-object pairings in Experiment 1). In Experiment 2, where objects were presented as stationary images, 14-month-olds showed no evidence of having learned the novel listener relations.

Infants aged 8, 10, and 12 months did not learn the specific label-object relations presented in these experiments.

The result of 14-month-olds in this series of experiments was interpreted by Werker et al. (1998) as challenging "any claims that infants cannot rapidly learn word-object associations on their own" (p.1303). The authors go on to suggest that infants undergo a comprehension "spurt" at around 14 months, which lends them a significant advantage in later productive language-learning.

Theoretical Interpretations of Rapid Word Learning Research

Taken together, the results of rapid word learning studies in the developmental literature support the hypothesis that infants, well before the productive vocabulary spurt, can learn a novel label-object relation after very few exposures. How do major theoretical approaches to early word learning (discussed in Chapter 1) account for these findings?

Constraints/Principles Accounts

In response to rapid word learning findings, constraints or principles approaches have refined their perspective to assign more sophisticated biases to infants at the very start of word learning. The early onset of specific principles or constraints on language acquisition, according to several researchers, can lead to the behaviour exhibited by infants in rapid word learning studies.

In the light of rapid word learning studies, Woodward and Markman (1998; Woodward, 2000) advance the view that three constraints are available to infants at the start of word learning: the whole object assumption, whereby infants assume that words refer to whole objects, rather than to object parts or objects in context; the taxonomic assumption, whereby infants assume that words refer to classes or categories of objects; and mutual exclusivity, whereby infants assume that objects have only one label—such that they apply a new label to a new object, rather than to an object that already has a label. Together, these early principles enable young infants' rapid learning of a new label-object relation.

Woodward and Markman present evidence that infants below the age of 18 months possess a "set of default assumptions about what words are likely to mean" (p.410). For example, Echols (1991), in a visual habituation paradigm, showed that, when a verbal label was presented alongside visual depictions of objects or actions, infants as young as 13 months looked longer at novel objects than at novel actions; this was seen as evidence for the early development of the whole object assumption. Waxman and Markow (1995), again in a habituation paradigm, repeatedly presented 9- to 20-month-olds with objects from one superordinate class (e.g. animals) until their time spent in play with members of that class of objects decreased. Then, infants were presented with a new item, either from the same class (e.g. a new animal) or from a different class (e.g. a new vehicle). Infants played longer with the item from a different class only when the objects presented during the habituation phase had been labelled by the experimenter. This was interpreted as evidence for the early development of the taxonomic assumption. Littschwager and Markman (1994) attempted to teach 16-month-olds new labels for objects that already had labels, and for objects that did not. They were successful only in teaching new labels for objects that had not previously been labelled; this finding was interpreted as evidence for the early development of the mutual exclusivity assumption.

In an alternative formulation, Hollich et al. (2000; and see Hirsh-Pasek, Golinkoff and Hollich, 2000) propose that what infants possess at 12 months is an "immature principle of reference" (p.113)—the assumption that words "symbolize, or stand for, objects, actions, or events" (p.4). In Hollich et al.'s model of early word learning, principles are emergent; they move from an immature to a mature state. At the start of word learning, reference is limited, such that infants assume that words apply to objects and events that they are focussing on. Infants are less sensitive to social cues, such as eye gaze and pointing, in forming label-object relations. Later, infants begin to use more specific social cues to read the speaker's intent, and to understand the symbolic nature of words. Nevertheless, "By the time infants are learning their first words, the principle of reference is already available. Even 12-month-olds, at some level, assume that words refer" (pp. 5-6). It is this principle of reference that leads to 12-month-old infants' successful performance in rapid word learning studies, according to Hollich et al.

But (as discussed in Chapter 1), constraints formulations of early word learning suffer from the circularity problem long observed by behaviour-analysts (e.g. Ryle, 1984; Skinner, 1969). That infants more readily learn labels for whole objects than for object parts may be a valid observation, but to suggest that word learning occurs *because* of this preference is tautologous: it is using a description of infant behaviour as an explanation for that very same behaviour.

It is more likely that the learning preferences exhibited by young infants, such as their readiness to learn a label for a whole object, or for an object that has not previously been labelled, reflect infants' learning history with objects and object labels. For example, caregivers do not, at the start of infants' listener learning, attempt to teach multiple labels to a single object; instead they provide basic-level words to label objects and events in the world (they are, in the presence of a dog for example, more likely to say "dog" than to say "animal" or "greyhound" – Anglin, 1977, 1978). It follows that infants who have already learned several listener relations might come to expect that a novel label applies to a novel object. But this is not a "principle" possessed by the infant, nor is it responsible for initiating infants' word learning.

Further, the assertion that 12-month-old infants possess an immature principle of reference, such that they understand that a word symbolises an object (Hollich et al., 2000) has not been tested by any rapid word learning study. Infants, in these studies, learn to look longer at an object when they hear a label that has previously accompanied that object. How is it that the label stands for or symbolises the object? Hollich et al.

provide a rich interpretation of infants' performance, which is unsupported by their data.

Associative Learning Accounts

Several researchers reject claims that lexical principles are instrumental in kick-starting word learning, and thus are responsible for rapid word learning. As discussed in Chapter 1, authors such as Stemmer (1996), Smith (1999), and Whitehurst (1996) believe that associative processes enable infants to learn novel listener relations.

Most authors of rapid word learning studies do not reject the possibility that their results could be the product of associative learning. Werker et al. (1998) and Woodward et al. (1994), in particular, reflect that highly effective associative learning mechanisms could account for infants' success in rapid word learning studies. Indeed, Werker et al. suggest that what infants learn in rapid word learning studies is "recognitory comprehension" (p.1289). Infants learn that a novel object and a novel label "go together", not that the novel label "stands for" the novel object.

Hollich et al. (2000) provide evidence for associative learning playing a role in infants' early listener learning. In their studies, 12-month-olds learned a novel listener relation after limited exposure when the target object was perceptually salient, but not when it was indicated by the social cue of experimenter eye gaze.

Other studies support an associative learning perspective. Schafer and Plunkett (1998) showed that 12- to 17-month-olds learned novel label-object relations in the absence of social cues. Likewise, Werker et al. (1998) found that 14-month-olds succeeded in learning novel label-object relations when there were no social cues to such learning. In their experiments, infants were presented with an image of an object, and a recorded voice that labels it. In their view, it is the contiguity between label and object that leads to rapid listener learning.

Nevertheless, researchers who claim that associative learning may play a role in rapid word learning fail to specify how this associative learning could have arisen in their studies.

One model of associative learning is classical, or Pavlovian, conditioning. Might classical conditioning account for rapid word learning? When an object is presented, it elicits an unconditioned looking response. The object label is, at the start of the exposure period, a neutral stimulus. But with repeated pairing, the neutral stimulus can become conditioned, such that hearing the label can elicit the conditioned response of looking towards the object.

The problem with the above account is that rapid word learning studies violate the rules by which classical conditioning generally becomes established. A neutral stimulus should precede an unconditioned stimulus in order for the organism to learn that the neutral stimulus predicts the unconditioned stimulus (Egger and Miller, 1963; Rescorla 1988) In the case of rapid word learning studies, this means that the novel label should precede presentation of the novel object. But in all rapid word learning studies, the object was presented first, followed by a spoken label. For example, in Schafer and Plunkett's (1998) research, a novel image appeared on the screen for one second before its label was given in training trials. The neutral stimulus did not, therefore, reliably predict the unconditioned stimulus.

It is possible that developmental researchers envisage another means by which listener learning could be established via associative learning in rapid word learning studies. But, if so, they don't specify the learning mechanism. This weakens their account.

Social Pragmatic Accounts

P. Bloom (2000) suggests that the strongest factor in determining early word learning is infants' developing theory of mind. Infants become sensitive to social cues from an early age. For example, Morales, Mundy, and Rojas (1998) found that infants as young as six months can follow their mother's gaze, and that this behaviour is positively correlated with receptive vocabulary size at 12 months. Bloom interprets gaze following behaviour as "a precursor to the ability to appreciate a speaker's referential intent... such a finding is consistent with the idea that the emergence of theory of mind abilities is related to the onset of word learning." (p. 23).

Rapid word learning studies present problems for such social pragmatic accounts of the origins of listener learning, because it appears that 12-month-old infants do not need social cues to learn novel label-object relations. Schafer and Plunkett (1998) and Werker et al. (1998) found rapid word learning in young infants in the absence of social cues. Further, Hollich et al. (2000) found that when 12-month-olds were presented with two objects—one designated "interesting" and the other "boring"—accompanied by a verbal label, infants looked longer towards the interesting object in test trials, even when the experimenter had *looked* towards the boring target object during label training trials. In Hollich et al.'s later experiments, it was only when multiple social cues were provided that 12-month-olds learned a novel label-object relation.

These results question the causative role of social-pragmatic factors in initiating young infants' listener learning.

Alternative Interpretations of Rapid Word Learning Research

Constraints and associative learning accounts of early listener learning are weakened further by the problems associated with rapid word learning research. For example, there is research that conflicts with the finding of rapid word learning in young infants, and there are flaws in rapid word learning studies. Together, these difficulties damage the interpretation that infants' behaviour demonstrates listener learning after limited exposure. The following section details such issues surrounding the rapid word learning literature.

Conflicting Evidence

Although the majority of published experiments in the developmental field present evidence for young infants' rapid word learning via exposure alone, several studies have failed to show such successful performance.

As reported in Chapter 1, Bell (1999) conducted longitudinal research with infants aged between 9 and 16 months. Despite 27 repeated exposures to a novel label linked with a novel object, infants failed to learn the new listener behaviour until positive reinforcement was introduced. It is possible that these null results could have arisen from differences in methodology between Bell's research and that of rapid word learning experiments; for example, Bell used a preferential reaching task in order to test for the establishment of listener relations which, it is claimed (Golinkoff et al., 1987; Hollich et al., 2000), is less sensitive to the beginnings of word learning than the more widely used looking measures.

Further, because of the single subject design employed in Bell's research, a binomial criterion of eight correct responses over nine trials was required as evidence of each infant's listener learning. In large group designs, less stringent statistical criteria are used to provide evidence of group learning. It is possible that the strict testing procedures employed in Bell's research concealed the fragile effects of young infants' early listener learning.

Rapid word learning effects tend to be small, as do the number of trials included in rapid word learning studies. If a binomial criterion is applied to each participant's performance in such studies, it is unlikely that it will reach significance (Bates, 1993). For example, if six comprehension test trials were conducted, each infant would have to succeed on all trials in order to show significance on the binomial test. But each infant may show success on around four out of six trials, and if this result is replicated over a large number of participants, it should be possible to conclude that they show some evidence of word learning.

Note that Bell's research did not aim to provide a systematic test of rapid word learning via exposure. Instead, it intended to teach a new *name relation* (see Horne and Lowe's naming theory, 1996) to young infants, and listener learning was just one step in this process. For Bell, it was essential that each infant could be shown to have learned a novel listener relation in order to be able to progress to the next stage of the procedure. The small learning effects shown in rapid word learning studies would thus have been of no practical use in her research.

Several large-group studies in the developmental field also fail to show rapid word learning in infants below 18 months. Baldwin, Markman, Bill, Desjardins, and Irwin (1996), for example, conducted a study with 15- to 17-month-olds, and 18- to 20-month-olds. Their aim was to discover whether infants followed "cues regarding the speaker's referential intent" (p. 3135) to learn a novel listener relation.

Baldwin et al. (1996) used a repeated measures design, in which two conditions were implemented. In the *decoupled condition,* the first experimenter took one object from a bucket, said, "Hey, what do we have here?" and allowed each infant to play with it for a minute. Then a second object was pulled from the bucket, and a second experimenter, hidden behind a screen (and therefore out of the infant's sight), produced a label three times (e.g. "A peri!").

In the *coupled condition*, the same procedure was followed with two different novel objects and a second novel label. This time, the first experimenter (who was in the infant's sight, and gazing at the novel object) labelled the target object three times (e.g. "A toma!").

In a preferential reaching test task, the experimenter asked each infant to point towards the labelled object on four separate trials (e.g. "Can you point to the peri?"). There were also four trials with familiar object-labels—these provided a check that infants could respond appropriately on a preferential reaching task.

In the decoupled condition, despite showing above-chance pointing to familiar target objects, infants in neither age group responded appropriately to the novel target object. But in the coupled condition, 18- to 20-month-olds pointed towards the novel target object at a mean of 63%, indicating that they had started to learn the novel label-object relation after only three exposures. Infants aged 15 to 17 months failed to show such learning in the coupled condition; for this group, the mean pointing towards the novel target object was at a chance level of 49%.

These results are interpreted as providing evidence for a social pragmatic account, and against an associative account. Older infants were unable to learn a novel listener relation on the basis of temporal contiguity between presentation of a novel label and a novel object alone. They required evidence that the speaker was referring to the novel object when she produced the novel label. But this explanation holds only for 18- to 20-

month-olds, who are already experienced in language learning, and beyond the point of the vocabulary spurt. The less experienced 15- to 17-month-olds, after only three exposures, "seem not to have been able to establish a stable mapping between the novel label and the target toy" (Baldwin et al., 1996, p. 3145).

Nazzi and Gopnik (2001) also performed large-group research, which attempted to make use of the rapid word learning phenomenon in pre-vocabulary spurt infants, to test for the effects of learning a novel label on infants' categorisation abilities. In training, 16- and 20-month-old infants were presented with six novel labellings of each of three perceptually dissimilar novel objects. In a naturalistic play setting, two of the objects were labelled *tib*, and the third was labelled *dap*. In testing, the experimenter held one of the novel objects that had previously been labelled *tib*, and asked the infant to give him, "the object that goes with this one." There were three test trials.

Results revealed that, although 20-month-olds selected the correct comparison object significantly more often than chance, 16-month-olds failed to do so. Nazzi and Gopnik (2001) draw the tenuous conclusion that 16-month-olds are unable to put object-labels to use in categorising. But they also consider the possibility that 16-month-olds simply do not learn the relation between novel labels and objects, "The 16-month-olds might have had difficulties remembering the new words, and the pairings between the words and the three objects, and maybe they would have succeeded if presented with more repetitions of the label" (p. B18).

In the research of both Baldwin et al. (1996) and Nazzi and Gopnik (2001), it is difficult to conclude with any certainty that pre-vocabulary spurt infants were unable to learn novel label-object relations after limited exposure. Baldwin et al. used only three labellings of each novel object in their research; most other rapid word learning studies use at least five labellings. Nazzi and Gopnik conducted no direct test of rapid word learning—it is possible that 16-month-olds' failure on the categorisation task arose from their inability to use a label to categorise, or from the relative complexity of the task, rather than from a failure to learn the novel label-object relations. Nevertheless, the results of these experiments cast doubt on the speed of listener learning in infants prior to the vocabulary spurt.

Potential Experimental Confounds

There are a number of problems with one or other of the rapid word learning studies; these flaws weaken their conclusions that pre-vocabulary spurt infants can learn a novel listener relation after limited exposure. Each of these flaws is discussed in turn, with reference to specific studies.

Preference for Labelled Objects

In the training phase of several rapid word learning studies, the experimenter presented two novel objects to each infant, but labelled only one of them. For example, Woodward, Markman, and Fitzsimmons (1994) presented two objects, labelled one a *toma,* and drew attention to the other one. In testing, the experimenter asked for the toma. Baldwin et al. (1996), Hollich et al. (2000), Namy (2001), and Woodward and Hoyne (1999) used a similar methodology.

The difficulty with labelling only one of the two objects is that it is possible that, by labelling an object, its salience is increased. In adult speech, labels are used to pick out objects and events for special attention. For infants, the effect of labelling may be to increase the salience of an object, such that infants prefer a labelled object to an unlabelled object. Baldwin and Markman (1989) performed research with 10- to 14-month-old and 17- to 20-month-old infants. Both age groups looked longer at an object they were playing with when the experimenter labelled the object, "…infants of only 10-14 months attend more to objects when a labeling phrase accompanies their presentation"(p.397).

Although these rapid word learning studies attempt to control for the increased salience of the labelled object by also drawing attention to the distracter object (e.g. by saying, "Look at this! Wow!"), there may be a specific effect of a label on infant behaviour. Shi and Werker (2001) demonstrated that infants aged six months show a preference for lexical words, as opposed to grammatical words. In a habituation-novelty procedure, infants who were habituated to a list of grammatical words (such as *in, a, you, its* or *the*) dishabituated when they heard a lexical word (such as *hide* or *chair*). But infants who were habituated to lexical words did not dishabituate to a grammatical word. In the rapid word learning studies mentioned earlier, the spoken phrase accompanying the labelled object contains more lexical content than the phrase accompanying the unlabelled object (e.g. "Look at this *blicket*!" compared to "Look at this!", as used in Namy, 2001), because the object-label is a lexical word. It is possible that this lexical preference leads infants to look longer at objects that accompany lexical labels.

The result of this visual-based preference for a labelled object is that infants may select the appropriate target object during test trials, not because they have learned a specific novel label-object relation, but because they have learned to attend more to an object that has been labelled than to one that has not.

Several of the studies in which only one object in each pair was labelled attempted to provide some extra control for infants' possible preference for a labelled object. Woodward, Markman, and Fitzsimmons (1994) and Woodward and Hoyne (1999), included *preference control trials* in their research, in which infants were presented with both labelled and unlabelled objects and were asked, "Can you get one?". Infants did not select the previously labelled object more often than the unlabelled object in these trials, leading the authors to conclude that preference for a labelled object did not affect their results.

But, in studies where infants showed listener learning, these preference control trials were conducted between-subjects rather than within-subjects. Schafer and Plunkett (1998) suggest, first, that a between-subjects control of this variable is inherently inferior to a within-subjects control, and, second, that the lack of a preference for a labelled object found by Woodward et al. (1994)

> ...constitutes a replication failure of the previous finding of Baldwin and Markman (1989) that naming an object increases its subsequent salience. It seems sensible, then, to evaluate word learning in an experimental design that controls for the naming effect but does not rely on a failure to observe that very effect." (p.311)

Several rapid word learning studies included good control for the possible effects of preference for a labelled object. Schafer and Plunkett (1998), for example, overcame the problem by labelling both objects used in their research. They used two novel images, and labelled one *bard* and the other *sarl*. Because both images had been labelled, infants' attention could not be drawn to one over the other. Nazzi and Gopnik (2001), and Werker et al. (1998) also employed this control.

No Learning of Specific Label-Object Relations

A second problem is created when only one of two novel objects is labelled. This problem persists even when preference control trials—in which both objects are presented, and the experimenter asks, for example, "Can you get one?"—are included. In test trials, infants are presented with the labelled target object and the unlabelled distracter object, and asked, "Where's the toma?", for example. They may reach or look towards the target object in test trials, but show no preference for the target object in preference control trials. In many studies, this has been interpreted as clear evidence that infants have learned the novel label-object relation.

But an alternative interpretation is possible. Infants may not have learned a specific relation between label and object. Instead, they may have learned to look or reach towards the novel target object when they were presented with any unfamiliar label. In the latter instance, infants who had heard the label *toma* during training would look or reach towards the novel target object when asked for the *toma;* but they would also look when asked for the *blicket*, or the *dax*. A specific label-object relation has not been learned.

Woodward, Markman, and Fitzsimmons (1994), Woodward and Hoyne (1999), Hollich et al. (2000, in all but one of their studies) failed to control for this problem. The use of a different label for each novel object, included in the research of Schafer and Plunkett (1998), and Werker et al. (1998), eliminates this problem. If, as in Schafer and Plunkett's study, one object is labelled *bard* in training and the other *sarl*, any preferential looking or reaching in test trials would be the result of the learning of a specific label-object relation.

Hollich et al. (2000) also controlled for this problem in one of their studies. In Experiment 3, they labelled only one novel object during training, but added a *new phase* after test trials in which a second novel label—which had accompanied neither novel object during training—was presented. The label *dawnoo*, for example, had been presented with one of the novel objects during training. In testing, each infant was asked, "Where's the dawnoo?" Then, in the new phase, each infant was asked, "Where's the modi?" Finally, in the *recovery phase*, each infant was asked, "Where's the dawnoo?" once more. Assuming that other controls are in place, if infants show greater preferential looking towards the target object during test and recovery phases than during the new phase, then it is clear that they have learned a specific relation between label and object.

Object or Side Preferences

Without proper control, it is possible that infants' preferences for one of the novel objects presented, or for one side of presentation, might interfere with their learning of the novel label-object relations. For example, if the labelled object is presented on the right throughout training and test trials, then an infant might look or reach towards the target object in test trials, not because she has learned the listener relation, but because she has a preference for the right side of presentation (Mount, Reznick, Kagan, Hill and Szpak, 1989, report a growing preference for the right between 13 and 20 months), or because she has learned to look towards the right in the experimental setting.

Most rapid word learning research controlled for the possible effects of infants' visual-based preference for a specific object or side of object presentation, by counterbalancing the number of times an object appeared on the left and on the right in both training and test phases. But Hollich et al. (2000) did not maintain this control throughout all their experiments.

In one of only three experiments in which 12-month-olds exhibited preferential looking towards novel target objects during test trials, Hollich et al. (2000) maintained the same positions for both novel objects throughout training and test phases. In Experiment 3, they used two pairs of novel objects. In the first part of the experiment, one object of the first novel pair was labelled, and infants were tested for their visual preference for this object. Then the second novel pair was presented; again, one object was labelled, and infants were tested for their visual preference for this object. Several counterbalancing measures were used. For half of the infants, the target object was on the left in training and test trials, and for the other half, the target object was on the right. Further, if the target object was presented on the right for the first object pair, it was presented on the left for the second object pair for each infant. But, if the target object was labelled on the right, in test trials it was on the right. This fails to control for the possibility that infants might learn to associate the experimenter label with a particular side of presentation, rather than with the target object.

That counterbalancing of side of presentation was not implemented in this experiment is unfortunate, because Experiment 3 was the only experiment conducted by Hollich et al. (2000) that included proper control of infants' potential preference for a labelled object, and for the possibility that infants' had not learned a specific label-object relation when they showed a visual preference for the novel target object in test trials.

Inadvertent Reinforcement and Cueing

In most large group developmental studies of infant learning, infants' parents are present throughout the experimental session. This helps to reduce their distress on encountering the unfamiliar experimenter and experimental setting. But, without proper control, it is possible that parents cue infants' responses; in this situation the research gains a measure not of how much infants have learned throughout the experiment, but of how sensitive they are to parental cues.

Hollich et al. (2000), Schafer and Plunkett (1998), and Werker et al. (1998) provided good control for parental cueing. In these studies, parents listened to music via headphones, and therefore did not hear experimenter labellings, or they wore a blindfold, opaque glasses, or a baseball cap with the visor pulled down over the eyes; in the latter case parents could hear experimenter labellings, but they were not aware of which label had been presented with which object.

But control of the potential effects of parental cueing was poor in several other studies. In Woodward, Markman, and Fitzsimmons' (1994) research, parents were instructed to act as observers as much as possible, but were not blind to the procedure. Similar instructions were provided for parents in Baldwin et al.'s (1996) and Nazzi and Gopnik's (2001) research. It is likely that throughout the course of these experiments, parents would learn the novel label-object relations; this makes it possible that infants gained cues from their parents during testing—from eye gaze, for example. It is also possible that parents inadvertently provided reinforcement (for example, by smiling) for infants' appropriate responses during training and testing, and that infants learned novel label-object relations this way–not simply via exposure, but via exposure and parental reinforcement.

Unintended experimenter effects were also possible in play-based studies of rapid word learning (Baldwin et al., 1996; Nazzi and Gopnik, 2001; Woodward and Hoyne, 1999; Woodward et al., 1994). In this research, the experimenter and the infant spent time in free play with the experimental objects in the training period. There is no report, in these studies, of how experimenters responded to infant vocalisations or other behaviours relating to the novel experimental objects; it is possible that the experimenter may have inadvertently reinforced infants' looking or reaching towards the target object on presentation of its label.

In highly structured research (Schafer and Plunkett, 1998; Werker et al., 1998), this experimenter effect was not possible because infants were not free to play with novel objects, and labellings were presented via a pre-recorded voice, rather than through interaction with an experimenter. In Hollich et al.'s (2000) research too, experimenter responses were specified throughout the procedure, and there was limited opportunity for free play; these measures minimised the probability of the experimenter inadvertently reinforcing infants' looking responses.

Failure to Learn How to Respond in the Experimental Session

In several studies, some groups of infants failed the test for listener learning with novel target objects. For example, Werker et al. (1998) reported significant learning only in a sub-group of female 14-month-olds in their first experiment, and no learning at all in 8-, 10-, and 12-month-olds in Experiments 5 and 6.

In these cases, it is difficult to determine whether infants simply failed to learn novel label-object relations, or whether they failed to learn how to respond to experimenter instructions in the experimental task.

Many studies provide a control for this problem. In their experiments, Baldwin et al. (1996), Hollich et al. (2000), and Woodward et al. (1998) included test trials with familiar target objects. If infants respond appropriately on familiar test trials, by looking or reaching more towards a cup than a shoe when asked, "Where's the cup?", for example, then it is clear that they can respond to experimenter instructions, and the test measure is validated. Without such familiar trials, it is difficult to come to a conclusion regarding infants' failure to respond appropriately on test trials with novel target objects.

Use of Familiar "Novel" Objects

It is important to use novel objects and labels in word learning experiments in order to control for infants' history of exposure to those objects and labels.

In Werker et al.'s (1998) research, novel labels were applied to familiar objects: a toy dog and a toy tow truck. It is likely that many of the 14-

month-old infants in their sample had already learned listener or speaker relations for these objects. Indeed, these object-labels are included in the MacArthur Communicative Development Inventory (Fenson et al., 1994) for infants aged 8 to 16 months.

In several of the other studies, everyday objects were used as novel stimuli. These objects included doorknobs and shapes made of play-doh (Nazzi and Gopnik, 2001), paper clips (Woodward et al., 1994), tea strainers, garlic presses, and bottle openers (Hollich et al., 2000). Because these items are common in most households, it is impossible to be certain that some infants had not had prior experience—including prior labelling experience—with them.

In their research, Schafer and Plunkett (1998) generated complex computer images to act as novel stimuli. Baldwin et al. (1996) used unusually-shaped plastic objects. With these objects, infant performance during the experimental session is unlikely to be confounded by the effects of prior learning.

Methodological Differences

Rapid word learning studies differ from one another in several key respects. They use different measures to test for label comprehension, they test different age groups below the age of 18 months, and they present different numbers of exposures to each novel label-object relation. But the authors of rapid word learning research interpret each study's results as comparable, regardless of the possibility that different methodologies may test different aspects of infant behaviour.

Different measures of label comprehension. Preferential reaching, preferential looking, and habituation-novelty measures, all of which test for infants' learning of novel label-object relations, were described earlier in this chapter. Each of these measures is assumed to "tap into" infants' learning of a novel label-object relation. But in the literature reviewed, no study tested this assumption by comparing learning effects across looking and reaching measures in rapid word learning studies.

*Different age groups.*Rapid word learning studies often compare learning of a novel listener relation in infants above and below the age of 18 months. But often infants between the ages of 12 and 17 months are considered a single, indistinguishable group. Rapid word learning studies variously consider the learning of 12-month-olds (Hollich et al., 2000), 13-month-olds (Woodward et al., 1994), 16-month-olds (Nazzi and Gopnik, 2001), 15- to 17-month-olds (Baldwin, 1996), 17-month-olds (Namy, 2001), and 12- to 17-month-olds (Schafer and Plunkett, 1998). No distinctions are drawn between these groups.

From 12 to 17 months infants gain five months' word learning experience. By 17 months, British infants comprehend many more words, than by 12 months, according to parental report (Hamilton, Plunkett and Schafer, 2000). Even if there is some qualitative change in word learning that occurs with the vocabulary spurt at around 18 months, it is possible that older pre-vocabulary spurt infants—by virtue of their greater verbal experience—may learn novel listener relations more quickly than younger pre-vocabulary spurt infants (this relates to the earlier discussed literature on *learning sets*, Harlow, 1949).

Werker et al. (1998) compared different age groups prior to the age of 18 months. In their research, rapid word learning was examined in 8-, 10-, 12-, and 14-month-old infants. The authors found differences between age groups; in their procedure infants at 8, 10 and 12 months did not learn novel label-object listener relations, but 14-month-olds did. This highlights the possibility that infants learn novel label-object relations more rapidly as they grow older, even prior to the productive vocabulary spurt.

This issue presents a particular problem for Schafer and Plunkett's (1998) research. In their study, infants aged 12- to 17-months were tested as a single group. The group results showed preferential looking towards target objects in test trials. But individual results were not reported. It is possible that a few older infants learned the novel label-object relations and skewed the group results; this may have led to a misleading significant group effect.

Different numbers of exposures to label-object relations. By definition, rapid word learning must occur after very few exposures to a novel label-object relation. For this reason, infants in most successful studies have been presented with between only 5 and 12 exposures to a novel label accompanied by a novel object (Hollich et al., 2000; Namy, 2001; Schafer and Plunkett, 1998; Woodward and Hoyne, 1999; Woodward, Markman, and Fitzsimmons, 1994).

But in Werker et al.'s (1998) research, some infants may have received many more than 12 exposures to the novel label-object relations. In their training procedure, between 16 and 20 training trials were presented to each infant (8-10 trials per label-object relation). But in each training trial, infants heard up to seven repetitions of the novel label. Each trial was timed according to the amount of time each infant spent looking towards the novel object. The trial started then, while the infant continued to look at the novel object, its label was repeated up to a maximum of seven times. When the infant looked away from the novel object, the trial ended.

Infants had to *habituate*, or reduce their looking towards novel objects during training, in order for their test results to be included in the final analyses. So infants who habituated were not exposed to the full 70 repetitions of each novel label-object relation, but they may have heard around 40 to 50 repetitions of each label while looking at the novel object.

Although Werker et al. claim that their results provide evidence for "rapid" word learning in 14-month-olds, the large number of exposures available to infants in their experiments suggests that their findings should be interpreted with caution.

Poor Reporting of Individual Performance

In the developmental literature, it is relatively uncommon to find reports of individual participants' performance within a group study. This pattern is reflected in rapid word learning studies.

Woodward and Hoyne (1999) conducted six test trials, and reported the number of infants who scored less than or more than three. This gave a measure of how representative the group score was of individuals' performance. In Woodward et al.'s (1994) research, individual results were not reported because only three test trials were conducted per infant.

But in the majority of rapid word learning studies, there were at least four counterbalanced test trials, or a looking measure was used (Hollich et al., 2000; Schafer and Plunkett, 1998; Werker et al., 1998), yet there was no report of individual results. This leaves such studies open to the possibility that a small number of high-performing infants biased the results of the whole group, and that the rapid word learning effects found are not representative of young word learners in general.

High Attrition

High attrition is a problem because it makes the study sample less representative. It is possible, for example, that a self-selection process comes into play, whereby the least verbally-able infants become most distracted in the task, and are dropped from the study. This, in effect, can mean that the study criteria select for infants who are likely to succeed on the task, and exclude those who are likely to fail.

The rate of attrition in rapid word learning studies varies from only 3% to over 50%. In general, play-based or interactive procedures, which were high in ecological validity, had lower attrition than more artificial procedures. For example, Woodward et al.'s (1994) research, which was interactive, used play-like tasks, and involved interaction with a live experimenter, had attrition rates ranging from 3 to 21%. Hollich et al. (2000) also made efforts to make their tasks interactive and rewarding for their infant participants—and their attrition rates ranged from 16 to 28%, but were mostly below 25%. Attrition in non-interactive, video-based procedures was higher. Schafer and Plunkett's (1994) study lasted only five minutes - but there was still a drop-out rate of 24%. And Werker et al. (1998) had attrition of between 24 and 52%—because their task required that infants habituate to novel label-object relations, non-habituators had to be excluded from the final sample.

* * *

It is clear that evidence of rapid word learning in pre-vocabulary spurt infants is weakened by conflicting evidence and methodological flaws. But a critique of rapid word learning research, on its own, does not deny the possibility that infants can learn novel listener relations after limited exposure. Nor does this critique give support to an operant account of early listener learning.

An operant account of listener learning in pre-vocabulary spurt infants is strengthened if, in a methodology that eliminates the problems of previous rapid word learning studies,

1. Pre-vocabulary spurt infants do not learn novel listener relations after limited exposure to each object accompanied by a label, and
2. Pre-vocabulary spurt infants do learn novel listener relations after limited positive reinforcement for their appropriate responses to each object accompanied by a label.

This research reported in this thesis aimed to assess each of the above predictions.

Three experiments are presented in this thesis. Experiments 1 and 2 reassess the effects of exposure on listener learning, using tight control for the potential confounds described earlier in this chapter. Experiment 3 compares listener learning via exposure to listener learning via positive reinforcement. It provides a first step towards an analysis of the effect of limited positive reinforcement on young infants' listener learning.

The following chapter (Chapter 3) introduces the general methodology employed in the three experiments reported in this thesis.

INTRODUCTION TO EXPERIMENTAL METHODOLOGY

The research presented in this thesis used a basic methodology, which was adapted to suit the needs of each experiment. This chapter presents this methodology in full.

Design

All studies used a cross-sectional design, in which two groups of infants were tested: those at a mean age of 13 months, and those at a mean age of 17 months. Trial order, side of object presentation, and types of object-label relation were counterbalanced within and between subjects throughout all studies. Further control measures, such as test trials with familiar objects and preference control trials, were employed within-subjects.

Potential confounds to experimental investigations of infant comprehension were discussed in the previous chapter. The present studies employed a standard set of controls in order to improve the reliability and validity of our measures. I take each potential confound in turn below, and discuss the controls implemented to minimise them.

Preference for Labelled Objects

In a number of previous studies, the experimenter presented two novel objects to the infant, but labelled only one (e.g. Hollich et al., 2000;

Woodward, Markman and Fitzsimmons, 1994). This made it possible that infants had not learned a specific association between label and object, but rather looked more frequently at the object that had been labelled. Comprehension tests following this training procedure cannot distinguish between these two interpretations of the infants' looking patterns. The present studies avoided this problem by presenting two objects to each infant, and labelling both of them. Because both objects were labelled, the infant's attention was not drawn by labelling differences to one over the other.

No Learning of Specific Word-Object Relations

Some studies employed a "no-label control" test (e.g. Hollich et al., 2000; Woodward and Hoyne, 1999; Woodward et al., 1994) in which both objects are presented, but no label is given. This control is an alternative to labelling both objects; it was implemented in order to overcome the problem of infants' preference for a labelled object. Infants in these studies show no apparent visual preference for a previously labelled object; instead, they look at labelled and unlabelled objects for equal durations. It is therefore claimed that when infants go on, in the comprehension test, to look at or select the target (the labelled object) at a higher rate than the distracter (the unlabelled object), their performance must have arisen from label-learning.

But these studies failed to control for the further possibility that infants learn to look at any previously named object when they hear any unfamiliar label, rather than learning a specific relation between the object and the label. This problem is controlled for by providing two labels—one for each object—as in the present studies.

Object or Side Preferences

The present studies ensured that each object was presented an equal number of times to the left and to the right of each infant during training and testing for the establishment of listener relations. This countered the effects of any individual infant's visual-based preference for one object over the other, or for one side of presentation over the other. For example, an infant might have learned neither object-label but have preferred to look at Object 1. In the latter event, with the counterbalancing implemented, she would do well on half of the trials, but poorly on the other half, bringing her total average performance to around 50%. But if that same infant had also learned at least one of the labels, then she would continue to show a bias towards Object 1, but would perform better overall, bringing her total mean performance to above 50%.

For example, the infant's preference for Object 1 might lead her to look towards Object 1 for 60% of a trial and Object 2 for 40% of a trial before any learning of listener relations. Her mean score would be 50%. After training trials, the infant might have started to learn the listener relation to Object 2. Now, on test trials where Object 1 is the target, she looks (as before) towards Object 1 for 60% of trial time. But her looking towards Object 2, on test trials where Object 2 is the target, increases to 50% of trial time. When the mean of Object 1 and Object 2 test trials is calculated, the infant shows 55% preferential looking to target—slightly above chance.

There were two types of preference control trials in the present studies. In the first type, the infant was presented with both experimental objects and asked to select one in response to a third label, one that had not been paired with either object in the training trials. In the second type, the infant was presented with both experimental objects, and a general experimenter instruction to "Look at these". No specific object-label was presented. This provided a check for any systematic effects of object preference over all infants.

Several recent studies have included these control measures for object and side preferences with success (e.g. Nazzi and Gopnik, 2001; Schafer and Plunkett, 1998).

Inadvertent Reinforcement and Cueing

With few exceptions (see Schafer and Plunkett, 1998), rapid word learning studies are flawed in their control of the potential reinforcing and cueing effects of parent on the infant's behaviour. In most studies, parents were not blind to the procedure and so were likely to learn the word-object relations under investigation. Even when parents were instructed not to influence the proceedings or to talk, it is possible that they could "help" their children by smiling or nodding at appropriate moments.

Control of experimenter cueing is more effective in rapid word learning studies. For example, experimenters in Hollich et al.'s (2000) research, so as not to provide inadvertent cues for target behaviour, were required to hide from infants during comprehension test trials. Other studies used one experimenter in training phases, and a second, blind, experimenter during testing phases, again as a control against experimenter cueing (see Woodward et al., 1994).

However, in play-based procedures (such as those of Nazzi and Gopnik, 2001; Woodward and Hoyne, 1999; and Woodward et al., 1994) there is no report of experimenter responses to infant vocalisations or other object-related behaviours during training. In these studies, it is possible that experimenters inadvertently reinforced infants' looking towards target objects on hearing the label. It is possible that infants learned novel listener relations through operant conditioning, implemented by parents, rather than through exposure alone in these studies.

The present studies ensured that parents were blind to the experimental label-object relations; the studies did this by requiring each parent to wear a baseball cap pulled down over her eyes. This ensured that, although parents could hear all experimenter-produced labels, they could not see the object to which a particular label referred[1].

The experimenter looked only towards the infant at the start of each test trial, and withdrew behind a screen so that she was hidden from the infant during the trial; these measures minimised experimenter cueing. After each session, video recordings of experimenter behaviour were inspected; these confirmed that she had looked only towards the infant at the start of each test trial.

Extra measures were taken in the training of label-object relations to prevent the experimenter's inadvertent reinforcement of infant object-related behaviours. Details of the measures are given in Chapters 4, 5, and 6; the measures were specific to each experiment.

---

[1] In pilot testing, parents listened to loud music over headphones as an alternative means of blinding. However, some parents reported being able to hear the experimenter's voice over the music. Also, at several points in the final procedure, parents were required to hear and follow experimenter instructions, rendering this method impractical.

Failure to Learn How to Respond in the Experimental Session

In some previous studies, groups of infants have failed the comprehension test (e.g. Nazzi and Gopnik, 2001; Werker et al., 1998). In these cases, it is difficult to know what caused their failure. It might have been that the number of exposures to the object-label was too few to lead to learning, especially in younger infants, or it might have been that infants failed to learn how to respond to the task instructions. The present studies controlled for the latter possibility by introducing test trials with familiar objects; these trials mirrored those with novel objects. This increased the explanatory power of our comprehension tests: if infants could respond appropriately in the comprehension test but had not yet learned the new relations between word and object, they should succeed on the familiar objects tests but fail on the novel objects tests. If they could not respond appropriately on the comprehension test, they should fail on both familiar and novel objects tests.

Use of Familiar "Novel" Objects

A number of different objects have served as "novel" over the range of rapid word learning studies reviewed in Chapter 2. These include coasters, door knobs, strainers, garlic presses, and bottle openers. Some studies excluded the use of novel objects altogether; they instead applied novel labels to objects known to be familiar to infants from an early age (e.g. dog and truck). Infants may have experienced many of these objects in their homes, and may have already produced either conventional or idiosyncratic labels for them.

Because infants' previous experience with objects may have affected their learning in the experimental setting, the novel objects used in the present studies were asymmetrical abstract shapes; they were created specifically for experimental purposes.

Methodological Differences

Different Measures of Label Comprehension

Previous studies have used three different paradigms to test for infant comprehension of novel labels. These are

- *Preferential looking*, here, when the target label is presented, the infant demonstrates comprehension by looking longer at a target object than at a distracter object.
- *Preferential reaching*, here the infant demonstrates comprehension of the target label by reaching more often towards a target object than towards a distracter object.
- *Habituation-novelty*, here infants are exposed to the relation between object and label many times, until they become habituated—until they look progressively less at the object on hearing the label. Tests for comprehension of that label-object relation involve presenting the same object with a different label or the same label with a different

object. Infants demonstrate comprehension by looking longer towards an object when it is accompanied by a label with which it has not been paired on previous occasions.

To date, no study has used more than one of these techniques to investigate rapid word learning. The present studies used preferential looking and reaching measures together to assess infant learning of novel listener relations. This allowed the assessment of the different measures within a consistent methodology. Habituation-novelty was not used—this because it is suitable only for younger age groups (Hollich et al., 2000).

Different Age Groups

In most previous rapid word learning experiments, different age groups of infants prior to 18 months (the proposed age of the vocabulary spurt) were not directly compared; this prevented the analysis of potential effects of infants' age or verbal experience on listener learning. The present studies—in order to parallel rapid word learning studies—tested infants in the 12- to 18-month age range; further, they compared two separate age groups within this age range—one with a mean age of 13 months (ranging from 12 to 14 months), and the other with a mean age of 17 months (ranging from 16 to 18 months).

The use of separate age groups was aimed to prevent the possibility that a subset of older infants could skew the whole-group results, and to investigate the possibility that older infants (prior to the vocabulary spurt), by virtue of their greater listener experience, could learn novel listener relations more rapidly than younger infants.

Different Numbers of Exposures to Label-Object Relations

Studies that have investigated "rapid word learning" to date have variously presented infants with as few as 3 and perhaps as many as 50 exposures to novel label-object relations. But, when three exposures were presented (Baldwin et al., 1996), 15- to 17-month-olds did not learn novel label-object relations. And when as many as 50 exposures were presented (Werker et al., 1998) it is doubtful whether many researchers would qualify infants' learning as "rapid". The present studies followed Schafer and Plunkett's (1998) example, to provide 12 exposures to each novel label-object relation.

Poor Reporting of Individual Performance

Individual data are not reported in many studies of rapid word learning; this is often because only two or three test trials were conducted with each infant. This makes it difficult to discern whether statistical effects for group data were reflected in the majority of infants' performances. In the present studies, four or more test trials were conducted with each infant, and trials were counterbalanced within participants; this was in order that individual data could be reported.

High Attrition

Large-group studies in the developmental field often have high rates of participant attrition (25% or greater); this is because infants are easily distracted. One means to deal with this is to run a tightly-controlled procedure that takes as little time as possible; this can ensure that infants do not become fatigued during training and testing (this is the approach taken by Schafer and Plunkett, 1998).

Other studies simply accept high attrition as a cost of working with an infant population. For example, Werker et al (1998) report attrition rates of up to 51%; they used a habituation paradigm, and a large proportion of infants tested did not habituate to novel stimuli within their criterion number of exposures. An unfortunate side-effect of losing this many participants is that it opens up the possibility that the study criteria select for infants who are likely to succeed on the task and eliminates those who will fail; this reduces the external validity of the findings.

The potential for participant attrition was also high in the present studies. The inclusion of the extra control measures highlighted above—familiar objects trials, more trials for reporting on individual performance, and testing of both reaching and looking measures—lengthened the procedure and thereby increased the risk that infants could would fail to attend to experimenter instructions. To offset this, a procedure was adopted which was high in ecological validity. It used real objects, rather than computer-generated images, included interaction with an experimenter—who used infant-directed speech throughout—and introduced an element of play into all the tasks. Several play-breaks were taken, and new trials were presented only when infants were attentive. This led to a high level of infant compliance in the procedure, and reduced attrition, across studies, to 10%.

No Assessment of Infant Vocalisations

There is great variation in the development of verbal behaviour, even amongst individuals within the same age-group (Reznick and Goldfield, 1992). Some infants use many more tacts and echoics than do others of the same age.

Most developmental studies of rapid word learning have taken a parental measure of infant productive vocabulary; only a few have used this measure as a correlate with infant performance on the word learning task (Hollich et al., 2000; Woodward et al., 1994; see Schafer and Plunkett, 1998, for a correlational approach). In addition, parental report of infant verbal behaviour may suffer from bias. The present studies take a closer look at the relationship between infants' speaker behaviour and their performance on the listener behaviour task by coding all infant vocalisations in relation to the experimental objects in object handling, training and test trials. Parental report measures of the number of words each infant could produce and comprehend at the time of testing were taken where possible. To measure vocabulary, in Experiments 1 and 2, the MacArthur Communicative Development Inventory (MCDI) was used; in Experiment 3, the draft form of the bilingual Bangor Communicative Developmental Inventory (BCDI) was used.

Participants

Infants were recruited via advertising in local newspapers, public locations (e.g. supermarkets, libraries), and nurseries within approximately 20 miles of the University of Wales, Bangor. Infants fell into one of two age groups; in the younger group, the mean age was 13 months (ranging from 12 to 14 months); in the older group, the mean age was 17 months (ranging from 16 to 18 months). No participant was born more than four weeks prematurely. Prior to experimental sessions, caregivers were requested to complete either MCDI or BCDI questionnaires (dependent on experiment: see *No Assessment of Infant Vocalisations* above); these assessed their infants' speaker and listener skills. Caregivers received £10.00 per session in payment and "infant scientist" certificates for their infants' participation.

Setting and Apparatus

Experimental Set-up

All experiments were conducted in a small room measuring 400cm in length, 190cm in width, and 250cm in height; it was featureless apart from the experimental apparatus.

Throughout, the infant was seated on the caregiver's lap on a height-adjustable swivel chair 80cm away from the presentation board (see Figure 3.1) on which experimental objects were displayed. The experimenter stood immediately behind and central to the presentation board, with her head and shoulders visible. A mirror (90cm height x 45 cm width), placed behind infant and caregiver, was angled such that the experimenter could see the front of the presentation board and, if necessary, correct problems with object positioning during training and test trials.

For coding purposes, an LTD CC-9000AF colour camera, mounted on a tripod at a height of 100cm, was placed in the right-hand corner of the room behind infant and caregiver, and focussed on the presentation board and the experimenter. This recorded infant responses in the preferential reaching test; it also allowed coders to check for experimenter cueing at the start of each trial.

Presentation Board

The matt black presentation board (100cm width x 125cm height) contained two rectangular presentation slots, measuring 20cm width x 24cm height, placed 36cm apart centre to centre,[2] and at a height of 105cm at their central point (see Figure 3.1). The infant's eye level was in line with the centre of the presentation slots.

Figure 3.1. The presentation board and experimental set-up. The infant was seated on the parent's lap, and three cameras recorded the infant's looking towards the objects on the presentation board.

Experimental objects were attached by velcro to a wooden flap, which hinged back from each rectangular slot, so that the objects could be hidden from sight and replaced between trials. A fixation light placed

[2] Pilot testing with five infants aged between 12 and 18 months showed that all could reach for objects placed this distance apart.

mid-way between the two presentation slots (at a height of 107cm) could be flashed to draw the infant's attention back to the board.

A camera was positioned, unobtrusively, at the rear of the presentation board, 3cm above each of the two rectangular object presentation slots; this was to record infants' looking to objects placed at each of these locations. A third camera was placed above and to the rear of the central fixation point to further aid coding of infants' looking responses. A small Realistic microphone (frequency response: 20 -18000Hz, impedance: 600 ohms, sensitivity: -74 dB) was attached to the front of the presentation board, in a central position 4cm down from the top; this was to record infant and experimenter vocalisations.

A wire basket (30cm across, 14cm down, and 15 cm deep) was positioned centrally on the front of the presentation board 30cm below the object presentation slots. This could be hinged backwards by the experimenter so that she could remove objects placed within it during the preferential reaching phase.

Recording Equipment

Recording and coding equipment was concealed by a large grey screen (160cm height x 165cm width) at the back of the room. This consisted of a JVC BR-S605EB video recorder; a Computa QS-C11 split-screen unit; an IMP time code reader/generator, accurate to $1/25^{th}$ second; and an 18-

inch Hitachi television monitor. The monitor showed four separate images simultaneously; these were from video cameras on the left, right and centre of the object presentation board, and from the fourth camera (this was situated behind and to the right of the seated infant and parent).

Stimuli

Two novel objects were adapted from those used by Erjavec (2002). These three-dimensional soft fabric objects differed in shape and colour, and were 20 x 24cm in size, with a depth of 4cm (see Figure 3.2). Throughout this thesis, the pink, white, and red object is referred to as Object 1, and the yellow, blue, and green object is referred to as Object 2.

Figure 3.2. Novel experimental objects.

Five familiar toy objects were used across experiments: a banana, a bottle, a cup, a cow, and a shoe (see Figure 3.3). These objects were used because their labels are amongst those learned earliest by infants in the course of development (Baldwin, 1989). The familiar objects were a similar size to the novel objects.

Figure 3.3. Familiar experimental objects.

A further assortment of non-experimental play objects was used in the course of familiarisation and during play-breaks. This included a soft ball, trucks, trains and cars, teddy bears, and toy bricks.

Procedure

Infants participated in one or two experimental sessions (dependent on experiment), each of which lasted between 30 and 45 minutes. Each experimental session comprised a training period, and a number of test trials for listener learning and for word production. Although procedural detail varied according to the aim of each experiment, a general framework was used across experiments for purposes of comparison. This general procedure is described here.

Prior to entering the experimental room, the caregiver, the experimenter and the infant spent around ten minutes together. During this time, the experimenter familiarised with the infant through play with non-experimental toys, and informed the caregiver of the general aims and procedure of the research. The experimenter and the parent also discussed, when necessary, problems in filling out the infant language questionnaire.

Phase 1: The Preferential Looking Task

In this phase, each of two novel objects was paired with its respective label, and the infant's learning of these label-object relations was assessed in preferential looking test trials for listener behaviour.

On entering the experimental room, the caregiver was asked to wear a baseball cap pulled down over her eyes so that she could not see the objects that were attached to the presentation board. The caregiver was instructed to remain quiet and to hold her infant facing forwards in a central position on her lap throughout. These measures were designed to minimise the possibility that the caregiver might cue the infant's response.

The experimenter spent a few minutes familiarising the infant with the room and set-up, generally through play with a non-experimental toy.

When the infant appeared attentive and relaxed, the preferential looking phase began.

This phase comprised the familiar and novel objects stages. Familiar objects test trials were included as a control to check that infants in both age groups could meet the demands of all tasks used in this research. The format of familiar objects tasks thus mirrored that of novel objects tasks throughout, with the exception that no familiar objects training trials were presented. Dependent on experiment (see Chapters 4, 5, and 6) infants were either assumed to have learned the conventional label-object relations for the familiar objects during interaction with their caregivers, or caregivers chose two familiar objects, from a range of five—these related to labels they were confident their infant understood.

Stage 1.1 Familiar Objects Exploration

The baby handled each of the two familiar objects for approximately 20 seconds. The experimenter encouraged the infant to look at the object she presented by saying, "Ooh, look at that!", "Isn't that nice?", and so on, but did not label either of the objects.

Stage 1.2 Familiar Objects Test for Listener Behaviour

Hidden from view, the experimenter placed the two familiar objects in their pre-determined positions, one on the left, the other on the right of the hinged presentation flap. She stood up behind the board, flashed the central fixation light, and said, "[Name], look over here! Can you see the light?" On gaining the infant's attention, the experimenter asked, "[Name], can you see the X[3]?" and set the stopwatch for a timed period. She then moved the flap upwards such that the objects came into view, and hid from the infant's view behind the presentation board. Within the remaining timed period, the experimenter once again asked, "Can you see the X? Where's the X?" When the timed period had elapsed, the experimenter let the hinged flap down such that the objects disappeared from view, and stood up again.

Stage 1.3 Novel Objects Exploration

The infant now handled each novel object in turn for approximately 20 seconds. This was aimed both to encourage infant interest in the novel objects, and to display the objects to the child from all angles. Again, the experimenter used encouraging phrases such as, "Ooh, look at that!" and, "Isn't that nice?", but did not label either object.

Stage 1.4 Novel Objects Training

During this stage, the experimenter presented the relation between each object and its label. Training methods varied across experiments, but in

---

[3] Where X is one of the familiar object labels, e.g. "cup".

all cases the experimenter presented novel objects and object-labels in every trial. Over the course of the training period, each novel object was presented with its spoken label several times.

Stage 1.5 Novel Objects Test for Listener Behaviour

These trials determined whether infants had learned the association between each novel object and its label. As in familiar objects test trials for listener behaviour, the experimenter presented both novel objects and asked the infant to look towards the target object on three separate occasions within a pre-set timed period. Experimenter cueing of infant gaze direction during test trials was prevented by her (a) following a strict procedure of looking only towards the infant during the first probe at trial start (the video camera directed towards the experimenter provided a codeable record of this), and (b) hiding behind the board immediately after presenting the first probe, so that she was not visible to the infant whilst the objects were in view.

Preference control trials were also included in this stage; in these, infants were presented with both novel objects, and either a third label—one that had not been previously associated with experimental objects—or no label at all.

Repetition of Phase 1

Phase 1 was now repeated in full. The aim of this alternating train-test-train-test pattern was to reduce the rate of participant attrition by allowing the presentation of relatively few similar trials within one block, and to improve the reliability of the test measure by increasing the number of trials presented overall.

Phase 2: The Preferential Reaching Task

In this phase, infants were tested for their comprehension of label-object relations through preferential reaching test trials for listener behaviour. The infant was introduced to a game in which she could pull objects from the presentation board and put them into the attached basket. The experimenter then pulled the hinged flap backwards so that the basket disappeared from the infant's view; then she retrieved the object.

Stage 2.1: Task Familiarisation

Prior to commencing experimental test trials, infants were familiarised with the requirements of the preferential reaching task with non-experimental objects. The experimenter presented several non-experimental familiar objects on the board (e.g. a duck, a boat), one at a time, and on either the left or the right. These objects varied in colour and texture but were roughly the same size as the experimental objects.

The experimenter encouraged the infant to take the object from the board and place it in the basket by pointing to it and using the prompt, "[Name], can you put this in the basket?" The caregiver was then asked to move her chair forwards in order that the infant could pull the object from the board.

When the infant placed the object in the basket, the experimenter said, "Thank you!"[4] and levered the basket backwards such that the object disappeared from view. Caregivers were asked to move their chair backwards so that the infant was no longer within reach of the board.

If the infant did not initially respond, the experimenter came to the front of the board and modelled the desired action. Only when the infant had responded on two separate trials to the prompt without modelling did the experiment continue to the next stage.

Stage 2.2 Familiar Objects Test for Listener Behaviour

While both experimenter and objects were hidden from view, the experimenter positioned both familiar objects on the presentation board. She stood, and asked, "[Name], can you put the X in the basket, can you put the X in, the X?" The objects were pulled into view of the infant, and the caregiver was asked to move forwards in order that the baby could

---

[4] There was thus no specific reinforcement for performing correctly on these trials.

reach the objects. The experimenter hid behind the presentation board while the infant responded.

When an object was placed in the basket, the caregiver was asked to move out of reach of the board, and the experimenter said, "Thank you!" and opened the flap so that the basket could be pulled backwards and the object retrieved for a new trial. The experimenter responded in the same way regardless of whether the infant retrieved the correct object. When an infant did not respond on a trial after repeated prompting, that trial was repeated.

Stage 2.3 Novel Objects Test for Listener Behaviour

Trials followed the same format as Stage 2.2, except that novel objects were used as target objects.

Phase 3: The Word Production Task

The final phase tested the infant's ability to produce the familiar and novel labels used throughout the experiments.

The experimenter took each experimental object in turn, and held it centrally in front of the infant. She waited for the infant to look towards the object, and then asked, "What's this?" The caregiver was asked to prompt the infant in the same way twice more, leaving about 10- to 15-

seconds' gap between prompts. The experimenter did not respond to infants' vocalisations following each prompt, and she instructed the caregiver to do likewise.

Coding

All data were coded offline by the experimenter following each experimental session. The same coding procedure was used across all experiments, as follows.

Preferential Looking Trials

Test Trials

On all test trials, each infant look was coded as towards the target object, towards the distracter object, or elsewhere. The coding period for each trial started immediately after the experimenter's first probe utterance, "Where's the X?", and ended when the trial duration had elapsed.

Looks were coded frame-by-frame to 1/25th of a second. A look started on the frame in which an infant's eyes showed a change in direction. A look ended when there was a further change in direction of eye movement (thus the end of one look was also the start of a new look). The experimenter noted down the start and the end time of each look, along with its direction. From this, the duration of each look was calculated. On test trials, the experimenter identified each look as towards the target object, towards the distracter object, or elsewhere.

In a small number of test trials (2% over all experiments), infants looked at target and distracter objects for less than a second. These trials were not included in the final analyses.

From this initial coding, two proportional looking measures were calculated for the target object on each trial. These were,

- *Percentage Total Looking to target (TL).* This gave a measure of the proportion of time that the infant spent looking at the target object as opposed to the distracter in total over the whole trial. In this measure, the duration of all looks to the target object was summed. TL was then calculated using the following formula:

$$\frac{\textit{Total duration of looking to target}}{\textit{(Total duration looking to target + total duration looking to distracter)}} \times 100 \tag{1}$$

- *Percentage Longest Look to Target (LL).* This gave a proportional measure of the amount of time that the infant spent looking at the target rather than the distracter object taken from the infant's single longest look towards target and distracter within each trial. It was calculated as follows:

$$\frac{\textit{Duration of longest look to target}}{\textit{(Duration longest look to target + duration longest look to distracter)}} \times 100 \qquad (2)$$

TL was the primary looking measure employed across the present studies; this was because it is the measure employed by most rapid word learning studies. LL was a subsidiary measure of looking; it was used in the present studies because Schafer and Plunkett (1998) suggested that it is a more representative measure of infants' learning.

Mean TL and LL scores across all trials (for novel and familiar objects respectively) were calculated for each child. A mean score of greater than 50% indicated some learning of at least one of the label-object relations; a score of 50% or below indicated no label-learning.

Proportional looking measures, in which infants' time spent looking towards the target and the distracter were compared, and infants' time spent looking elsewhere was factored out, were used in order to control for potential effects of increasing infant distraction over repeated test trials. In test trial one, an infant might spend five seconds looking towards target and distracter objects, and one second looking elsewhere. By test trial four, an infant might spend only three seconds looking towards target and distracter objects, and three seconds looking elsewhere. With the formula used, time spent looking elsewhere is ignored, but the ratio of time spent looking towards the target as opposed to the distracter is preserved.

In preference control trials, in which neither object was the target, looking towards Object 1 was coded and analysed in all trials. Because looking towards Objects 1 and 2 was related in these trials, such that looking towards Object 1 60% of the time by necessity meant that Object 2 was looked at 40% of the time, the decision to code and analyse results for Object 1 made no difference to the findings.

Training Trials

On all training trials, looks were coded as towards the target object, towards the experimenter, towards the distracter object (Experiment 3 only), or elsewhere. Calculation of total looking to target objects during training trials varied across experiments, because in Experiment 3, but not in Experiment 1 and 2, there was a distracter object in training trials. For all experiments, two total looking measures were used. Thus:

- *Percentage total looking to target (TL).* This was a proportional measure of the total training trial time spent looking towards the target object as opposed to anywhere else in the room (in Experiments 1 and 2), or as opposed to the distracter object (in Experiment 3). It was calculated as follows:

For Experiments 1 and 2

$$\frac{\textit{Total duration of looking to target}}{\textit{(Total duration looking to target + total duration looking elsewhere)}} \times 100 \qquad (3)$$

For Experiment 3

$$\frac{\textit{Total duration of looking to target}}{\textit{(Total duration looking to target + total duration looking to distracter)}} \times 100 \qquad (4)$$

- *Percentage total looking to target and experimenter*. This was the proportion of total trial time that infants spent looking towards the target object and the experimenter, as opposed to anywhere else in the room. It was calculated as follows:

$$\frac{\textit{Total looking to target object and experimenter}}{\textit{Total looking to target object and experimenter + total looking elsewhere}} \times 100 \qquad (5)$$

Preferential Reaching

On each trial, infants' *first reach*, with either hand, towards either the target or the distracter object was coded. Reaches were coded as either correct (reaching to target) or incorrect (reaching to distracter, or reaching to both objects at once), and a tallied score was produced for each infant. Because there were four trials for each object-type in all experiments, a score of two or below indicated no comprehension learning, and scores above two indicated some learning of at least one of the labels.

Word Production

1. Test Sessions

All trials were coded for infant production of recognisable approximations to the familiar and novel object labels in training, testing, and word production test phases. For each approximation, the test phase (training, testing or word production) and preceding stimulus or stimuli were identified (e.g. the presentation of an object, or an experimenter vocalisation).

2. Parent Questionnaires

The number of words produced and comprehended by each infant, as reported by parents, was tallied.

Second Coding

A second coder, blind to target object and trial type, coded 20% of looking and reaching test trials. On each looking trial, the second coder was instructed to note the time that each look started and ended, and to note the direction of that look as towards the left, towards the right, or elsewhere. The coding of the experimenter and the second coder was said to agree for a look when:

1. The start and end times of the look were the same, to within 1/5th of a second,
2. The direction of the look was the same.

On each reaching trial, the second coder was instructed to note down the direction of an infant's first reach, as well as the object towards which she reached. This second coding yielded an inter-observer reliability rating of 90.89% over all three experiments (90.97% in Experiments 1 and 2, 90.8% in Experiment 3).

* * *

The general methodology described in this chapter was put to use to investigate:

1. Whether 13- and 17-month-old infants could learn two novel listener relations after between 6 and 12 exposures (Experiment 1);
2. Whether 13- and 17-month-old infants could learn two novel listener relations after between 18 and 24 exposures (Experiment 2); and
3. Whether 13- and 17-month-olds could learn two novel listener relations after between 5 and 10 reinforced training trials or between 5 and 10 exposures (Experiment 3).

The chapters that follow (Chapters 4, 5 and 6) describe and discuss these experiments in full.

EXPERIMENT 1: CAN 13- AND 17-MONTH-OLD INFANTS LEARN TO COMPREHEND NOVEL OBJECT LABELS AFTER UP TO 12 EXPOSURES?

The aim of this experiment was to establish whether infants aged 13 and 17 months can learn novel label-object relations after up to 12 exposures to each label in the presence of the corresponding object.

As discussed in earlier chapters, experimental studies in the developmental field have reported that infants as young as 12 months can learn at least one novel object-label after as few as five exposures to the label-object relation. Researchers have labelled this phenomenon *rapid word learning*, and have attributed it to a number of causes, including social bootstrapping, lexical principles, and associative learning.

It was argued in Chapter 2 that many of these studies failed to control for a number of different confounds that could have resulted in infants' successful performance on the label comprehension task, and that findings of single-subject design studies in the behaviour-analytic field do not report evidence of such rapid learning of listener behaviour without reinforcement.

The present study aimed to test for rapid word learning within an experimental paradigm that implemented tight control, yet retained ecological validity. This study incorporated key elements from the research of Hollich et al. (2000), Schafer and Plunkett (1999), and Woodward et al. (1994), with changes designed to exclude design flaws identified in one or other of these studies.

A group design—as opposed to a single-subject design—was used; this was in order that the results of this study were directly comparable to others in the developmental field.

The discussion of related literature in earlier chapters led to several predictions for the results of this study. First, it was expected that infants in both age groups would respond to familiar object labels with appropriate listener behaviour—by showing above-chance preferential looking and reaching towards the corresponding familiar targets during listener behaviour test trials. This result is vital: if infants do not respond to the familiar spoken label by looking and reaching towards the appropriate object, then the test validity of the looking and reaching measures is cast into doubt; it becomes difficult to interpret a poor result on the later test trials for listener behaviour with novel objects.

Second, infants in both age groups were expected to attend to each novel label-object relation during training trials, by spending the majority of the time during training periods looking to the novel target object presented with the label. Because, in this experiment, only one target object was presented in each training trial, infants simply had to look more towards the novel target (which the experimenter looked and pointed at) than towards anything else in the experimental room in order to meet this expectation. If infants did not show preferential looking towards novel targets during training, a poor result on the later test for listener behaviour with novel target objects could have arisen from a failure to follow experimenter cues in training, rather than to the limited number of exposures to each label-object relation presented in the experiment.

Third, it was predicted that infants in both age groups would fail to learn the novel label-object relations, and show only chance looking and reaching towards novel target objects on listener behaviour test trials.

Finally, it is possible that, regardless of age group, other factors influenced task success. The number of words an infant can produce (as measured by the MacArthur Communicative Development Inventory), might increase the likelihood of her learning new listener relations; similarly, if infants produce novel labels during the experimental session (for example, by echoing), their listener performance might be improved (see Chapter 1 for discussion of related literature).

A second possibility is that the amount of time spent looking to target during training trials predicts success on the listener test with novel objects—an infant who spends three-quarters of the training period looking at the target object may be more likely to succeed on the listener test than an infant who spends only half this time looking towards the target. Each of these alternative factors is considered in the Results section.

Method

Participants

Forty-four infants participated, but 3 were rejected because of fussiness (2 infants) and experimenter error (1 infant). There were 21 infants in the 13-month-old age group (mean age 13.0 months, range 12.2 to 14.9 months) and 20 infants in the 17-month-old age group (mean age 17.2 months, range 16.2 to 18.9 months). As far as possible, a balance of sexes was maintained across both age groups: in the younger age group there were 11 females and 10 males; in the older age group there were 8 females and 12 males. All infants were from families in which the first language of both parents was English.

Prior to arrival for the experimental session, caregivers were asked to read a short information letter, and to give written consent to their infant's participation (see Appendix A). They were also asked to complete the McArthur Communicative Development Inventory (Fenson, Dale, Reznick, Bates, Thal, and Pethick, 1994) (MCDI), for their infant. There are two versions of the MCDI: the first (*Words and Gestures*), for infants aged 8 to 16 months, gives a parental estimate of the number of words an infant can understand and produce. The second (*Words and Sentences*), for infants aged 16 to 30 months, gives a parental estimate only of the number of words an infant can produce.

Three questionnaires were not returned by caregivers. Mean productive vocabulary scores for the 38 remaining infants showed that the 13-month-olds produced a mean of 9 words (ranging from 0 to 37 words), while the 17-month-olds produced a mean of 51words (ranging from 8 to 76 words). This difference was confirmed with an independent-samples t test ($t(19.5)=-3.34$, $p<.05$), demonstrating that, despite some overlap, the two age-groups represented distinct groupings in terms of productive vocabulary.

Infants in the younger age group understood a mean of 109 words (ranging from 4 to 238 words): this pattern of understanding many more words than can be produced is common in this age group (Fenson et al., 1994).

Infants participated in a single experimental session. At the end of the session, caregivers received £10.00, an "infant scientist degree certificate" for their infants' participation, and a short, written debriefing on the aims of the study. Further debriefing was made available to parents when the results of the study had been collated (see Appendix B for copies of the debriefing information).

Stimuli

Novel Labels and Objects

Three labels were chosen. The choice of labels was based on their novelty in English (*pab, gek* and *dut*), and because they have been used extensively in previous research (Bell, 1999; Horne and Lowe, 2000). These words take the consonant-vowel-consonant form; research shows infants learn to understand and use this form earliest (Charles-Luce and Luce, 1990). The vowel in the label *pab* was pronounced as in the word *cat,* the vowel in the label *gek* was pronounced as in the word *bed,* and the vowel in the label *dut* was pronounced as in the word *lute.*

Pab and *gek* were used as experimental labels, while the third label, *dut,* was used as an alternative label in preference control trials. Experimental object labels were counterbalanced, such that half the participants heard the label *pab* to Object 1 and *gek* to Object 2; this order was reversed for the remaining infants.

The two colourful fabric objects presented in Chapter 3 (see Figure 3.2, p. 131) served as novel objects in this experiment.

Familiar Labels and Objects

Two familiar object-labels (*cup* and *shoe*) were chosen because they are among those learned first by young infants (Baldwin, 1989). The corresponding objects used were similar in size, and intended to be of equal perceptual salience. These objects are presented in Chapter 3 (see Figure 3.3, p.132). For one infant, an alternative object (a toy cow) was used; this was because the parent indicated that the infant did not understand the label *cup*. For three more infants, the label *drink* was used; this was because parents indicated that this was the label best known by their infants for a cup.

Procedure

The procedure followed the general outline described in Chapter 3. It lasted between 30 and 45 minutes; short play-breaks were taken in between phases, and a ten-minute break was taken outside the experimental room between preferential looking and preferential reaching tasks. All experimenter and infant behaviours in training and test trials were video-recorded. Figure 4.1 (see p. 157) shows a summary of the procedure in pictorial form.

In *Phase 1: The Preferential Looking Task,* infants were presented first with one and then the other of the familiar objects, and allowed to handle each for approximately 20 seconds. The experimenter then presented two test trials for listener behaviour, in which she said, "[Name], where's the X[1]? Can you see the X? Look at the X!", within a six-second period.

In the same manner as for the familiar objects, infants then handled each novel object in a predetermined, counterbalanced order.

Novel Objects Training went as follows:

Hidden from view, one object was placed in its predetermined position on the presentation board by the experimenter, who was also out of sight. The experimenter appeared behind the presentation board, facing the infant, and flashed the central fixation light as she said, "Ooh! What's going to come up?" She then raised the novel stimulus on the presentation board. The experimenter pointed at the object, and labelled it six times, saying: "Look [Name]! This is an X[2]! It's an X, an X. Look! This is an X! It's an X, an X!". This labelling took approximately nine seconds to complete. If the infant looked away from the novel object or the experimenter within this period, the experimenter directed her attention back to the object (for example by calling out his or her name), and then continued with the labelling sequence. The experimenter looked

---

[1]Where X was either *cup* or *shoe*.

[2] X was *pab* or *gek* dependent on the counterbalanced order of presentation.

down towards the object during labelling, occasionally glancing up at the infant to check that she was looking at the target object.

When the object had been labelled six times, the experimenter said, "Bye-bye!" and lowered the presentation flap so that the object disappeared. She then hid behind the presentation board and removed the first novel object. The process was repeated with the second novel object and alternative label, so that this also was labelled six times.

In the *Novel Objects Test for Listener Behaviour,* the experimenter placed both objects on the board in their predetermined positions, while hidden from the infant's view. She stood up behind the board, flashed the central fixation light, and said, "[Name], look over here! Can you see the light?" On gaining the infant's attention, the experimenter asked, "[Name], can you see the X?", and set the timer for six seconds. She then moved the flap upwards such that the objects came into view, and hid behind the board. Within the remaining timed period, the experimenter said, "Can you see the X? Look at the X!" When the timed period had elapsed, the experimenter let the hinged flap down such that the objects disappeared from view. There were two such test trials for listener behaviour: one with each novel object-label.

One preference control trial was also conducted in this period. This followed the same pattern as listener test trials described above, but during presentation of the two novel objects, the experimenter said, "Can you see the dut? Where's the dut? Look at the dut!" within the six second period. The label *dut* had not been linked with either novel object, in these trials, the infant was expected to look at the object or side that she preferred.

Phase 1 was then repeated in full so that, by its end, infants had been exposed 12 times to each novel label-object relation, and had encountered 4 novel objects test trials, 2 preference control trials, and 4 familiar objects test trials.

In *Phase 2: The Preferential Reaching Task*, the infant learned how to respond appropriately to the experimenter's instructions in the experimental setting by placing non-experimental objects in the basket on the presentation board at the experimenter's request. There followed two test trials for listener behaviour to familiar object labels, two test trials for listener behaviour to novel object labels, and a preference control trial.

In all trials, the experimenter placed two objects on the board and asked, "[Name]! Can you put the X[3] in the basket, can you put the X in, the X?" before the parent moved the infant close to the board so that she could

---

[3] Where X was either *cup*, *shoe*, *pab*, or *gek*, dependent on stage.

select an object. When the infant had selected an object, the experimenter said, "Thank you!" regardless of whether the selection was correct.

Test trials in *Phase 2* were then repeated, so that a total of four trials for familiar objects, four trials for novel objects, and two preference trials had been completed by its end. Trials were counterbalanced so that each object had been presented an equal number of times to each infant's left and right.

In *Phase 3: The Word Production Task,* each infant's ability to produce the familiar and novel labels used throughout the experiment was tested; each infant was presented with each experimental object in turn, and asked (three times), "What's this?"

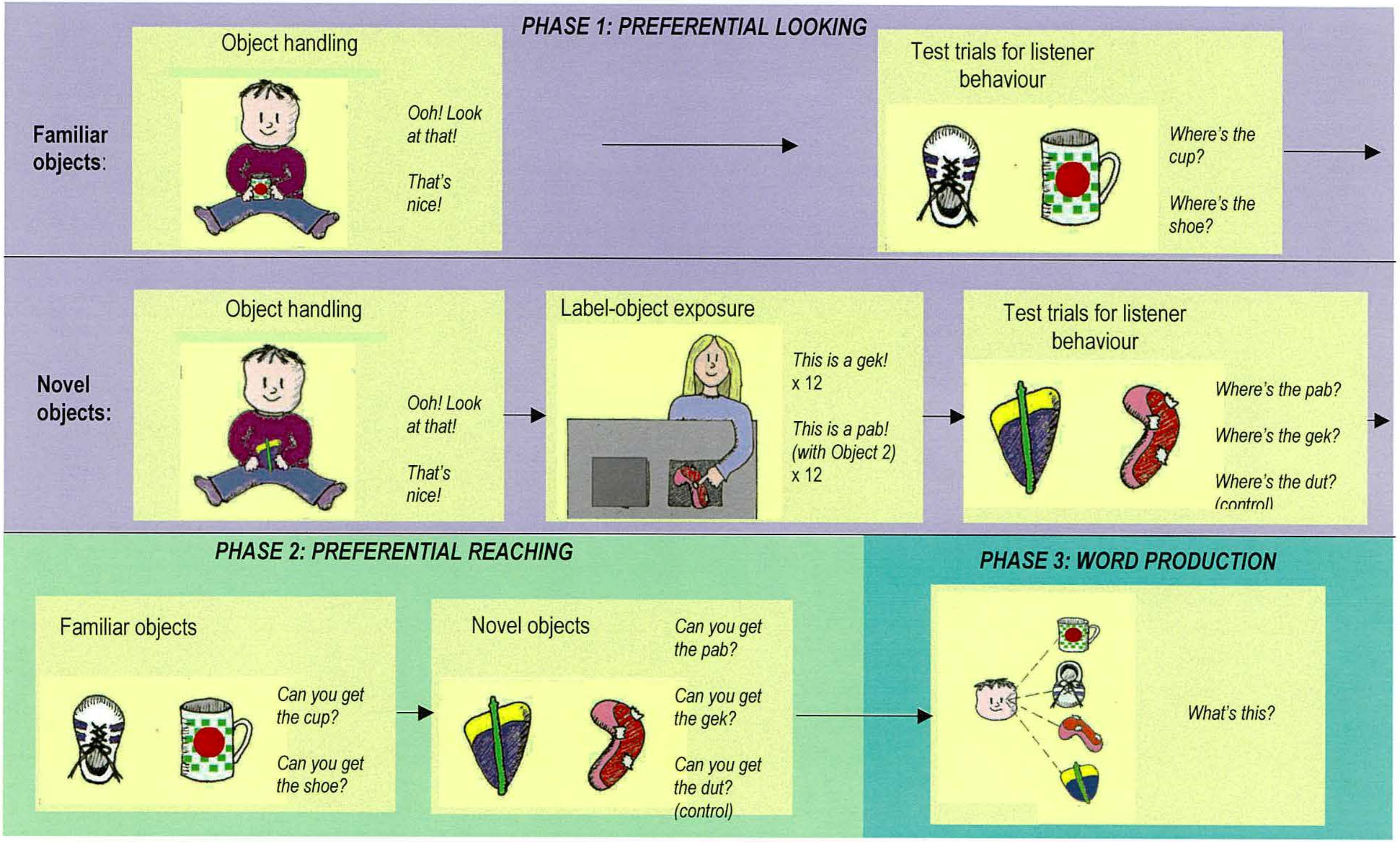

Figure 4.1. Summary of the main stages in the procedure of Experiment 1.

Results

The following section considers, first, whether infants' behaviour differed across age groups; second, whether infants in both age groups responded appropriately on familiar objects tests for listener behaviour (to establish the test validity of the measures used); third, whether infants attended to target objects during novel objects training (to establish that infants were able to follow experimenter cues by looking to target); and fourth, whether infants in both age groups learned novel label-object relations after up to 12 exposures. The final section considers whether there is a relationship between word production and learning of novel label-object relations, or between time spent looking to target during training trials and learning of novel label-object relations. An alpha level of .05 was used throughout the statistical analyses of this experiment, and those following in later chapters.

Were there Differences in the Performance of 13- and 17-Month-Old Infants?

For the *preferential looking measure*, a 3 x 2 ANOVA—with a within-subjects factor of trial type (familiar, training and novel trials), and a between-subjects factor of age (13- and 17-month-olds)—was conducted for the primary total looking measure. There was no significant main effect of age [$F(1,39)=.01$, $p>.05$], indicating that 13- and 17-month-olds did not differ on familiar objects test trials for listener behaviour, looking to target in novel objects training trials, or novel objects test trials for listener behaviour; there was also no significant interaction effect [$F(1, 39)=.002$ $p>.05$]. There was a significant main effect of trial type [$F(2,39)=14.09$, $p<.05$].

For the *preferential reaching measure*, a 2 x 2 analysis of deviance[4]—with a within-subjects factor of trial type (familiar and novel trials), and a between-subjects factor of age (13- and 17-month-olds)—was conducted. There was, again, no significant main effect of age [chi-square(1)=.9, $p>.05$] and no significant interaction between age and trial type [chi-square(1)=.01, $p>.05$] There was a significant main effect of trial type [chi-square(1)=13.82, $p<.05$]; infants' performance in each trial type is considered in the sections that follow.

These results show that 13- and 17-month-olds did not differ in their performance in looking and reaching comprehension tests.

Did Infants Respond Appropriately to Task Instructions? Familiar Objects Tests for Listener Behaviour

Preferential Looking Trials

Proportional looking to target was calculated for familiar objects and compared to a chance level of 50% for total looking (TL) and longest look

---

[4] An analysis of deviance was more appropriate than an analysis of variance for the preferential reaching measure.

(LL) measures. Group means for each age group are presented in Table 4.1.

Table 4.1. Percentage group means and standard deviations for infants' preferential looking towards familiar target objects at 13 and 17 months. Means marked with a * are statistically significant at $p<.05$.

	13 months $n=21$	*17 months* $n=20$
	Mean *(SD)*	Mean *(SD)*
% Total looking	56.91* *(10.80)*	61.56* *(7.64)*
% Longest look	55.92* *(10.96)*	58.93* *(8.65)*

One-sample *t* tests compared scores in familiar objects trials to a chance level of 50%, yielding significant results for both 13- and 17-month-olds, regardless of the looking measure used. [At 13 months, TL $t(20)=2.93$, $p<.05$, and LL $t(20)=2.48$, $p<.05$; at 17 months, TL $t(19)=6.77$, $p<.05$, LL $t(19)=4.62$, $p<.05$.]

Individual results supported the group finding. Infants who looked towards familiar target objects for more than 50% of the time were in the majority in both age groups (see Appendix C for individual results). In the younger age group, 16/21 infants (76%) spent more than 50% of the total trial time looking towards the target object as opposed to the distracter (the total looking measure), as did 15/21 infants (71%) on the longest look measure. In the older age group, 18/20 infants (90%) showed the same pattern on the total looking measure, as did 17/20 infants (85%) on the longest look measure.

It is clear from these results that infants in both age groups responded appropriately to the preferential looking task used in this experiment; they looked significantly longer at the familiar target objects that corresponded with the familiar labels presented.

Preferential Reaching Trials

Group means for infants' preferential reaching to familiar target objects are presented in Table 4.2, below.

Table 4.2. Group means and standard deviations for infants' preferential reaching towards familiar target objects at 13 and 17 months, expressed in tallied score, and as a percentage. Means marked with a * are statistically significant at $p<.05$.

	13 months *n=21*	***17 months*** *n=20*
Mean score / 4	2.86*(*0.56*)	2.65*(*0.88*)
Mean as a %	71.50	66.25

Two one-sample *t* tests compared reaching towards familiar target objects to a chance level of two correct over four trials for each age group. Both were significant [at 13 months, $t(20)=6.85$, $p<.05$; at 17 months, $t(19)=3.32$, $p<.05$]; this suggests that these infants had learned to select cup and shoe when they were labelled by their caregiver(s), and that this behaviour had generalised to the experimental setting.

Because only four reaching trials were conducted—too small a number for a normal approximation to the binomial distribution to be made without checking—further tests were carried out using the generalised linear model with binomially distributed errors. The results of these tests confirmed the findings of the initial *t* tests [at 13 months, $t(20)=3.79$, $p<.05$, and at 17 months, $t(19)=2.85$, $p<.05$].

Again, individual results supported the group statistic. Figure 4.2 shows the number of infants in each age group who scored 0, 1, 2, 3, or 4 out of 4. In both groups, the majority of infants scored 3 (or 75%).

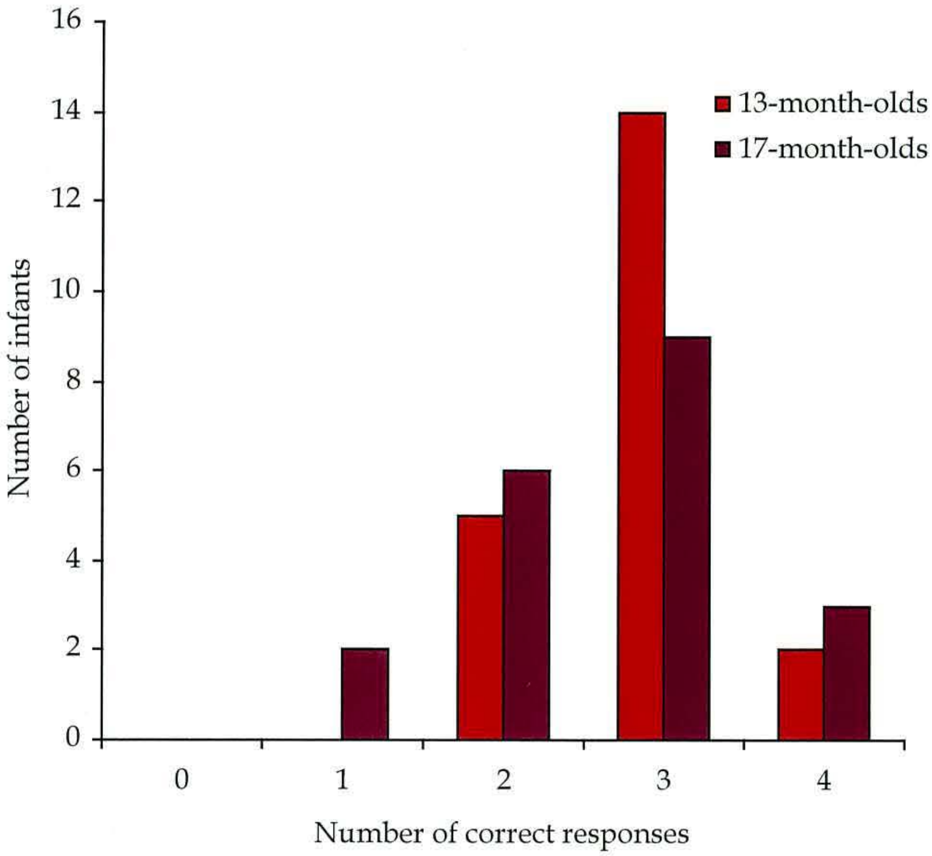

Figure 4.2. The number of infants at 13 and 17 months who scored 0, 1, 2, 3, or 4 out of 4 on the preferential reaching task with familiar target objects. N.B. $n=21$ for 13-month-olds, and $n=20$ for 17-month-olds.

Overall, results with the familiar objects validate the preferential looking and reaching tasks used in Experiment 1, by demonstrating infants' clear preference for these target objects.

Did Infants Attend to Novel Target Objects During Exposure Training?

Formula 3, presented in Chapter 3 (p. 143), was used to calculate infants' proportional looking to target during training trials; this proportion was high.

Infants in the 13-month-old age group spent an average of 66.89% (*SD*=12.28) of training trial time looking at the target object, and infants in the 17-month-old group spent an average of 65.52% (*SD*=13.49) of this time looking at the target object. Individual scores for this measure are presented in Appendix C.

Individual results supported the finding that infants in both age groups spent substantial periods looking towards novel target objects, with 19/21 and 18/20 infants in the younger and older groups respectively looking towards the target object for more than 50% of the time (see Figure 4.3).

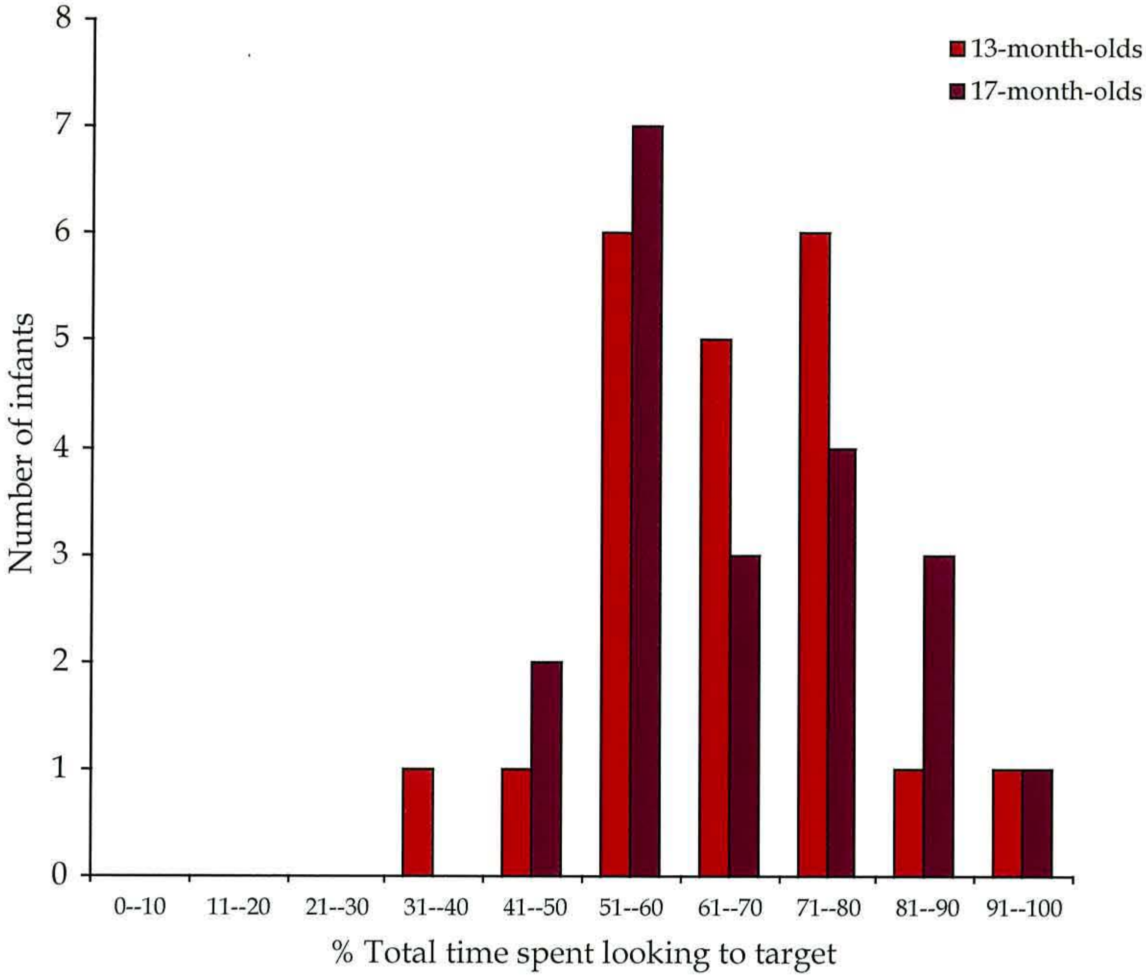

Figure 4.3. The number of infants at 13 and 17 months who showed total looking towards the target object between 0 and 100% of training trial time. N.B. n=21 for 13-month-olds, n=20 for 17-month-olds.

These results demonstrate that infants in both age groups attended—through looking—to the novel experimental objects during training trials.

Although infants spent the majority of training trials looking towards the novel target object, their mean scores of between 65 and 67% looking to target during this time seems low, considering that only one object was presented during training trials, and that the experimenter pointed and looked towards the object throughout training. This raised the question of whether the infants were distracted for approximately one-third of training trials.

Further analysis of training trials showed that infants were not distracted for this proportion of training trials. When infants' looks towards the experimenter were added to their looks towards the target object in training trials (see formula 5, p. 144), it was clear that they spent the vast majority of trial time attending to the experimental task.

There was a clear pattern of behaviour, in these infants, of alternating looks between the target object and the experimenter, who was labelling the object. Infants in both age groups spent over 85% of trial time looking either towards the experimenter or towards the target object (at 13 months, M=85.12%, SD=11.3; at 17 months, M=92.57%, SD=8.49). The difference in means between age groups was significant [$t(39)=2.17$, $p<.05$], demonstrating that older infants spent more time looking towards the experimenter than did younger infants.

Individual scores (see Appendix C) supported the group means for infants' proportional total looking towards the target and experimenter. All 41 infants spent more than 61% of training trial time looking either towards the experimenter or towards the target object. Figure 4.4 shows the distribution of individual scores.

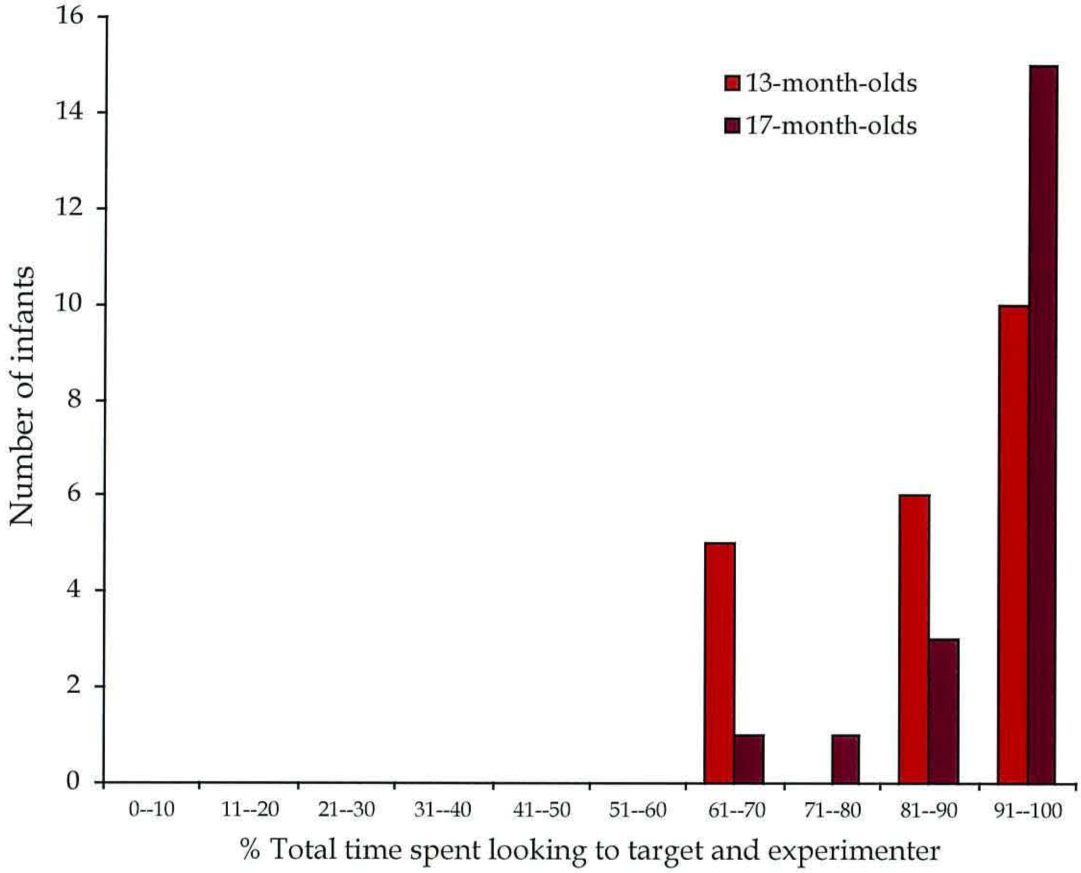

Figure 4.4. The number of infants at 13 and 17 months who showed total looking towards the target object between 0 and 100% of training trial time. N.B. n=21 for 13-month-olds, n=20 for 17-month-olds.

Did Infants Learn Novel Object Labels after up to 12 Exposures?

Preferential Looking Test Trials

The proportion of time infants spent looking to target was calculated for novel objects trials as described in Chapter 3; it was compared to a chance level of 50% for total looking and longest look measures. Group means for each age group are presented in Table 4.3.

Table 4.3. Group means for infants' preferential looking towards novel target objects at 13 and 17 months. Means marked with a* are statistically significant at $p<.05$.

	13 months $n=21$	*17 months* $n=20$
	Mean *(SD)*	Mean *(SD)*
% Total looking	53.90 *(10.51)*	51.17 *(9.45)*
% Longest look	53.10 *(11.20)*	49.72 *(9.33)*

One-sample t tests compared scores in each phase to a chance level of 50% looking to target. Infants in neither age group looked significantly longer-than-chance towards novel targets after 6-12 exposures—at 13 months: TL $t(20)=1.70$, $p>.05$, LL $t(20)=1.27$, $p>.05$; at 17 months: TL $t(19)=.55$, $p>.05$, LL $t(19)=-.14$, $p>.05$. Infants did not show listener behaviour—via preferential looking—to novel object labels after the 12 exposures to each novel label-object relation presented in this experiment.

It is possible that infants who scored poorly on familiar or training trials may not have learned to follow experimental cues and, as a result, they may have performed poorly on the listener test with novel targets. Perhaps these infants' scores skewed the results of the whole sample.

But when the results of infants who scored 50% or less on familiar and training trials were excluded from the analysis of the primary total looking measure, ($n=5$ in the 13-month-old group, and $n=3$ in the 17-month-old group), the results of one-sample t tests were still not significant—at 13 months, M=51.12, SD=12.21, $t(15)$=.45, p=.672; and at 17 months, M=50.45, SD=11.08 , $t(16)$=.18, p=.856.

Individual results supported this finding (see Appendix C for individual scores). Only 12/21 younger infants and 11/20 older infants scored above 50% on the TL measure. On the LL measure, individuals showed even lower performance: only 11/21 younger infants and 8/20 older infants scored above 50% for preferential looking to novel targets.

Novel Objects Preference Control Trials with the Looking Measure

In preference control trials, infants were instructed to "Look at the dut" when the label *dut* had been applied to neither object during training. Infants' looking in these trials should reflect preferences for one object over the other, or for one side of object presentation over the other. Because only two preference control trials were performed with each infant, an analysis of each individual's preferences was not conducted; the following analyses detected only preferences shared by infants within each age group.

Several infants were distracted during one of the preference control trials (n=5); their results were excluded from the following analyses.

Object preferences. In order to analyse potential object preferences, the total amount of time that infants spent looking to Object 1—as opposed to

Object 2—was calculated. Both groups looked towards Object 1 for less than 50% of the time, suggesting a general preference for Object 2 (13-month-olds: M=43.72, SD=16.61; 17-month-olds: M=45.33, SD=16.72). But when one-sample t tests were used to compare looking to Object 1 to a chance level of 50% for each age group, neither proved significant—13-month-olds t(17)=-1.56, p>.05; 17-month-olds t(17)=-1.19, p>.05. Preference control trials revealed no significant group preference for Object 2 over Object 1.

Side preferences. Potential side preferences were analysed by taking infants' TL scores for looks to the right side of object presentation—as opposed to the left—in each preference trial.

Thirteen-month-olds looked towards the right for slightly less than 50% of the time (*M*= 45.54, *SD*=13.45), and 17-month-olds looked towards the right for slightly more than 50% of the time (*M*=56.97, *SD*=17.11). The results of neither age group differed significantly from chance—at 13 months, $t(17)=-1.41$, $p>.05$, at 17 months, $t(17)=1.73$, $p>.05$—but an independent samples *t* test revealed a significant difference between age groups—$t(34)=-2.23$, $p<.05$—confirming the older infants' increased looking towards the right side of presentation.

Although there were no clear visual preferences for one object over the other, or for one side of presentation over the other, the non-significant trends apparent in infants' looking patterns highlight the importance of using trials counterbalanced for side of object presentation in this experiment.

Preferential Reaching Test Trials

Group means for infants' preferential reaching to novel target objects are presented in Table 4.4.

Table 4.4. Group means and standard deviations for infants' preferential reaching towards novel target objects at 13 and 17 months, expressed as tallied scores and as percentages. Means marked with a* are statistically significant at p<.05. N.B. Reaching at chance would give an overall score of 2.

	13 months n=21	*17 months* n=20
Mean score / 4	2.05 *(0.87)*	1.85 *(0.88)*
Mean % correct	51.25	46.25

Two one-sample t tests compared reaching towards novel targets to a chance level of two correct over four trials for both age groups, neither of which proved significant at p<.05—at 13 months, $t(20)$=0.25, and at 17 months $t(19)$=-0.77. Tests using the generalised linear model with binomially distributed errors gave similar—non-significant—results [at 13 months, $t(20)$=0.22, and at 17 months, $t(19)$=0.67]. After 12 label-object exposures, when infants were presented with a label and both novel objects, they did not select the object that had matched that label during training at greater-than-chance levels.

Individual results were also poor for novel target objects. Figure 4.5 shows the distribution of individual infants' scores on the reaching test. In both age groups, the modal score was 2—equal to a chance performance of 50%.

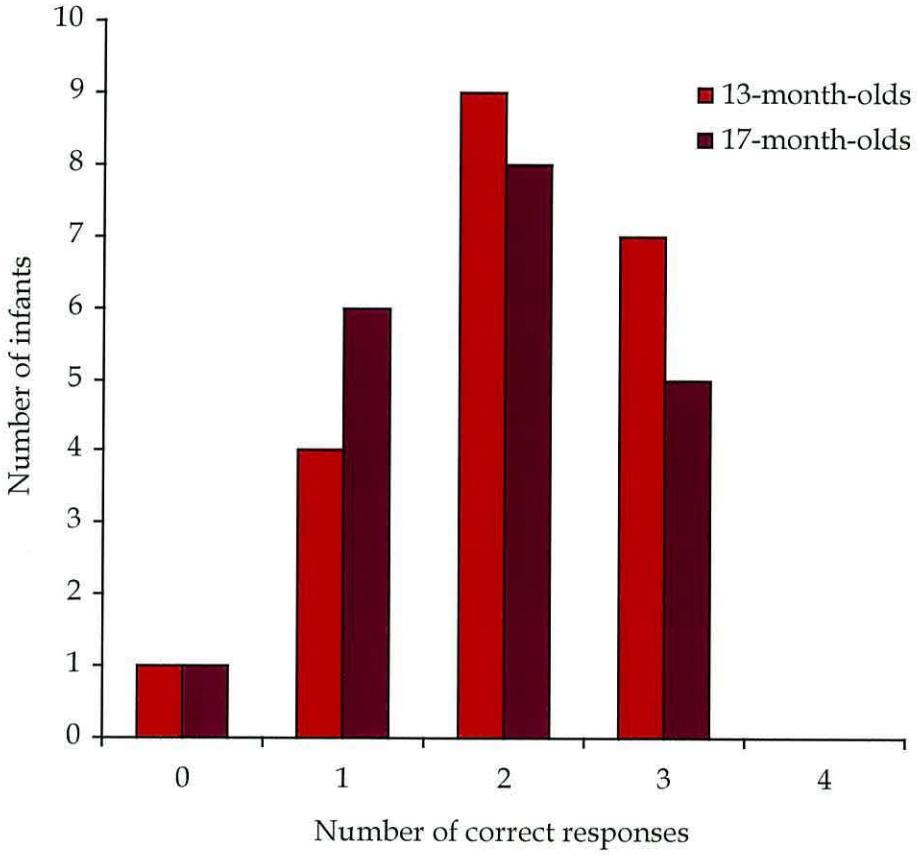

Figure 4.5. The number of infants at 13 and 17 months who scored 0, 1, 2, 3, or 4 on the preferential reaching task with novel target objects. N.B. n=21 for 13-month-olds, and n=20 for 17-month-olds.

Novel Objects Preference Control Trials with the Reaching Measure

In preference control trials, infants were presented with both novel objects and asked, "Can you get the dut?" Two trials were conducted; each novel object was presented once on the left and once on the right.

Three infants failed to respond on one of these trials; their results are excluded from the data that follow. Because only two reaching preference control trials were conducted per infant, no statistical analyses were performed—the data that follow are descriptive.

Object preferences. Table 4.5 shows the total tally of reaches to Object 1 and to Object 2 in novel objects preference trials for both age groups.

Table 4.5. Total tally of infants' reaches towards Object 1 and Object 2 in novel objects preference trials. N.B. trials in which infants reached towards both objects simultaneously are excluded from these tallies.

	13 months $n = 20$		*17 months* $n = 18$	
	Object 1	Object 2	Object 1	Object 2
Total reaches	13	22	12	19

Table 4.5 shows results similar to preference trials with the looking measure. A preference towards Object 2 is apparent in the number of reaches towards each object: 62.86% of the number of reaches for 13-month-olds, and 61.29% for 17-month-olds, was towards Object 2.

Side preferences. Table 4.6 shows the tally of reaches to the right and to the left in novel objects preference trials for both age groups. Similar to preference trials with the looking measure, there was a small age difference in the number of reaches to the right as opposed to the left. Younger infants reached more towards the left than towards the right (44.12% of the reaches was to the right), and older infants reached more towards the right than towards the left (55.17% of the reaches was to the right).

Table 4.6. Total tally of infants' reaches towards the right side of presentation and the left side of presentation in novel objects preference trials.

	13 months n= 20		*17 months* n=18	
	Right	Left	Right	Left
Total reaches	15	19	16	13

Again, the small fluctuations apparent in infants' reaching preferences make clear the usefulness of the counterbalancing measures employed in this experiment.

Is there a Relationship between Infants' Verbal Repertoire and their Label Learning?

MCDI Scores

Pearson's product-moment correlations were performed to determine whether there was a relationship between productive MCDI scores for both age groups combined and performance on the familiar and novel preferential looking tasks. For familiar targets, no significant correlation between productive vocabulary and task performance was found (TL r=.03, n=38, p>.05, LL r=.09, n=38, p>.05). After the removal of one outlier, no significant correlations were found between MCDI production scores and success in the novel objects preferential looking tasks (TL r = .07, n=38, p>.05, LL r=.01, n=38, p>.05).

For 13-month-olds, the MCDI measured receptive as well as productive vocabulary. There was no correlation between performance on the receptive vocabulary measure and performance on the novel objects preferential looking task (TL r=.19, n=20, p>.05).

Within-session Label Production

A measure of infant vocal approximations to novel labels was drawn together from three areas: spontaneous vocalisations during object handling periods, echoic vocalisations during training and test trials, and prompted vocalisations during the word production test. For each infant, the number of approximations to a novel object label was tallied to produce a total production score.

Infants who produced one or more correct approximations to novel object-labels during the session were classified as *producers,* and those who produced no approximations to novel labels within-session were classified as *non-producers*.

The occurrence of infant vocal approximations to novel object labels was rare in Experiment 1. Only 4 infants could be classified as producers (3 17-month-olds, and 1 13-month-old), with a mean score on the novel objects test for listener behaviour of 49.45%. The low number of producers made it impossible to perform any valid analysis of the effects of novel label production on label learning.

Is there a Relationship between Looking to Target during Training and Label Learning?

The proportion of time spent looking to target during training trials. It may affect infants' results. It might be expected that the proportion of looking to target during the period when each novel object is paired with its label would be predictive of success on listener test trials, regardless of age group. Infants who look longer to target might learn labels more quickly.

Pearson's product-moment correlations were performed on the data. This aimed, first, to find a relationship between total looking to target during training and total looking to target during listener test trials with novel objects; and, second, to find a relationship between total looking to the target object and the experimenter during training, and total looking to target during listener test trials with novel objects. No significant correlations were found (for total looking to target during training, $r=-.20$, $n=41$, $p>.05$, and for total looking to target and experimenter during training, $r=.009$, $n=38$, $p>.05$).

Discussion

The results of the present study confirmed the expectation that infants would not show learning of two novel label-object relations when extra controls were introduced, despite (a) having learned to respond to experimental instructions by selecting the appropriate familiar object when presented with its label, and (b) looking appropriately towards the cued target objects during training.

In neither looking nor reaching trials did infants show evidence of having learned the two novel listener relations, even when those infants who had performed poorly on familiar objects test trials for listener behaviour and training trials were excluded from the analyses.

These results relate to recent behaviour analytic findings, which suggest that many more than 6-12 exposures are necessary in order to teach new listener relations to infants below the age of 18 months. In a study by Bell (1999; also reported in Horne and Lowe, 2000), 27 exposures to novel label-object relations were presented to infants under 18 months, in a single subject design. No infant showed learning of listener relations by reaching preferentially towards the appropriate novel object when presented with its corresponding label.

As discussed in Chapter 2, the procedure and criteria for success in Bell's behaviour-analytic study differed from those of large-group rapid word learning studies, which often use more sensitive preferential looking measures, and which focus on the beginnings of word learning; these looking measures do not require the learning of both labels or large statistical effects.

Nonetheless, the difference in the results of studies from behaviour-analytic and developmental research paradigms is still large. Experiment 1 shows that rapid word learning does not occur as quickly as had previously been suggested.

The inclusion of control measures, such as providing two labels for two objects and ensuring that parents were blind to label-object pairings, as expected, reduced the success rate of infants in the novel objects test for listener behaviour. It is likely that the poor control and high attrition of many earlier studies provided a false view of the rate of listener learning in infants below the age of 18 months.

Looking and Reaching Measures

In the present study, the results of looking and reaching trials were similar. Infants in both age groups succeeded on familiar objects test trials for listener behaviour for both looking and reaching measures. This suggests that, for object-labels already in the infants' listener repertoires, reaching is as effective a measure as looking. Because there was no learning of novel label-object relations in either measure, the comparative sensitivity of looking and reaching paradigms has not yet been tested.

Effects of Age, Verbal Repertoire, and Looking to Target during Training

This experiment, contrary to predictions, showed no relation between the productive verbal repertoire of infants, and the learning of novel label-object relations. There are several potential reasons for this. It is possible that the parental report measure of infants' productive verbal repertoire, which was used as a correlate with listener task success, was biased and unrepresentative of infants' true productive skills. Because few words were produced within-session by participants, the MCDI questionnaire was the primary measure of verbal ability in this experiment. Because it is a lengthy questionnaire, the MCDI may be open to social desirability and boredom effects; these could bias results. Indeed, Hollich et al. (2000) report a similar poor correlation between the MCDI measure and success on their task.

An alternative explanation of the poor correlation between infants' productive verbal repertoires and listener task success is that 12 exposures to a novel label-object relation might be simply too few for even the most verbally-experienced 17-month-old to gain a learning advantage.

There may be similar reasons for the lack of age effects on listener relation learning, and for the lack of a relation between looking to target during training trials and success on the listener tasks with novel objects. The number of exposures to novel label-object relations may have been so few as to create a floor effect, such that there was so little learning of the novel label-object relations that any potential differences between age groups were concealed. Chapter 7 presents a more detailed discussion of these issues.

* * *

The present experiment showed that 13- and 17-month-old infants were unsuccessful in learning two new listener relations after up to 12 exposures to label-object pairings. It leaves unanswered the question of how quickly 13- and 17-month-old infants can learn new object-labels through exposure alone. Experiment 2 was designed to answer this question, by presenting a further 12 exposures to each novel label-object relation, and by repeating the test for listener behaviour learning.

EXPERIMENT 2: CAN 13- AND 17-MONTH-OLD INFANTS LEARN TO COMPREHEND NOVEL OBJECT LABELS AFTER UP TO 24 EXPOSURES?

The aim of this experiment was to establish whether infants aged 13 and 17 months can learn novel object-label relations after up to 24 exposures to each label in the presence of the corresponding object. The infants who took part in Experiment 2 were a subgroup of the infants who had participated in Experiment 1; infants in this subgroup were exposed a further 12 times to the two novel label-object relations within 24 hours of their initial experimental session.

As in Experiment 1, it was expected that infants in both age groups would show preferential looking and reaching to target in the familiar objects test for listener behaviour; this establishes the test validity of the measures used. Infants' preferential looking to target during training trials was also important to the validation of the research methodology—if infants did not look towards the target object during training trials, there would be no reason to expect them to learn the novel label-object relations.

In Experiment 1, 13- and 17-month-olds failed to learn novel listener relations after up to 12 exposures to two novel objects, accompanied by their corresponding labels. In this experiment, it was asked whether infants would learn such labels after a further 12 exposures to the novel objects, along with their corresponding labels. Because there is no requirement that infants learn both labels in order to achieve above-chance performance on listener test trials, the measures used in this experiment are more sensitive to the beginnings of listener relation learning than those in the field of behaviour analysis employed to date.

Because only half of the participants in Experiment 1 also took part in Experiment 2, it was important to ensure that no self-selection process came into play, whereby a subgroup of high scorers in Experiment 1 formed the majority of participants in Experiment 2.

If infants were to show above-chance looking to novel target objects in Experiment 2, but those particular infants also performed well in Experiment 1, then the results of Experiment 2 would be meaningless. Against this, if the infant participants who went on to take part in Experiment 2 are shown to have performed on a par with the rest of the group in Experiment 1, then it is likely that the possible novel object task success in Experiment 2 arises from learning rather than from self-selection.

As in Experiment 1, possible correlations between infants' verbal repertoire and listener task success, and the proportion of looking to target during training and listener task success, were analysed regardless of age group; this was because these factors may be of equal or greater importance than age in predicting infants' success in learning the novel listener relations.

Method

Participants

Of the 41 infants participating in Experiment 1, 22 took part in Experiment 2. Two infants were rejected because they became distracted; this left a total of 10 infants in the 13- month-old age group (mean age 13.0 months, range 12.2 to 14.9 months), and 10 in the 17-month-old age group (mean age 17.4 months, range 16.2 to 18.8 months). These groups were formed from all those infants available to participate in a second session within 24 hours of the first. Since all available infants were tested, it was difficult to maintain a balance of sexes across both age groups: so, at 13 months, there were equal numbers of male and female infants but, at 17 months, there were fewer females (n=3) than males (n=7).

Mean productive vocabulary scores for each age group showed that 13-month-olds produced a mean of 8 words (ranging from 0 to 37 words), and 17-month-olds, 49 words (ranging from 8 to 84 words). An independent-samples t test showed that these means were significantly different ($t(11.38)=-4.11$, $p<.05$); this demonstrates that, despite some overlap, the two age groups represented distinct vocabulary groupings.

According to parental report, 13-month-olds comprehended a mean of 92 words (ranging from 27 to 238 words). As in Experiment 1, this supported Fenson et al.'s (1994) findings that infants understand many more words than they produce at this age.

Design and Procedure

Design and procedure were identical to that of Experiment 1. All infants had taken part in Experiment 1, in which 12 novel label-object exposures were presented for each of two novel objects. This procedure was repeated in Experiment 2 such that, within the space of 24 hours, infants had received a total of 24 exposures to each of the novel label-object relations.

Results

Was there Self-Selection of Participants in Experiment 2?

The check against self-selection of participants took all infants in the current experiment and compared their results in Experiment 1 to the rest of the infants' results in Experiment 1.

Table 5.1 shows the mean scores of infants who took part in Experiment 1 only, compared to those of infants who participated in Experiments 1 and 2.

Table 5.1. Percentage group mean scores and standard deviations (in parentheses) in preferential looking tasks for infants who took part in Experiment 1 only, and infants who participated in Experiments 1 and 2. These scores are for data obtained in Experiment 1.

13 months	***E1 only infants*** n=*11*	***E1 & E2 infants*** n=*10*
Familiar objects test	57.91 *(7.08)*	55.81 *(14.18)*
Novel objects test	52.73 *(10.07)*	53.81 *(11.53)*
17 months	**E1 only infants** *n*=10	**E1 & E2 infants** *n*=10
Familiar objects test	60.56 *(6.73)*	62.57 *(8.7)*
Novel objects test	49.81 *(12.33)*	52.53 *(5.67)*

The scores of infants who took part only in Experiment 1 were compared to those of infants who took part in both experiments, using independent-samples t tests, with the result that there were no significant differences in Experiment 1 performance between these groups. On the familiar objects test for listener behaviour, 13-month-olds: $t(19)=.44$, $p>.05$, and 17-month-olds: $t(18)=.58$, $p>.05$. On the novel objects test for listener behaviour, 13-month-olds: $t(19)= .04$, $p>.05$, and 17-month-olds: $t(18)=-.63$, $p>.05$.

These results suggest that there was no selection of the high scoring participants from Experiment 1 to go on to take part in Experiment 2.

Were there Differences in the Performance of 13- and 17-Month-Old Infants?

For the *preferential looking measure,* a 3 x 2 (trial type x age) ANOVA was conducted for the primary total looking measure. There was no significant main effect of age [$F(1,18)=1.8$, $p>.05$]; this indicated that age groups did not differ on any of the three trial types (listener test trials with familiar objects, novel label-object training trials, and listener test trials with novel objects). There was no significant interaction effect [$F(1,18)=.08$, $p>.05$] There was a significant main effect of trial type [$F(2, 18)=15.56$, $p<.05$]; infants' performance in each trial type is analysed in the sections that follow.

For the *preferential reaching measure,* a 2 x 2 (trial type x age) analysis of deviance was conducted. There was no significant main effect of age [chi-square(1)=2.57, $p>.05$], nor was there a significant effect of trial type [chi-square(1)=0.94, $p>.05$], or an interaction effect [chi-square(1)=0.37, $p>.05$].

These results show that 13- and 17-month-olds did not differ in their performance in looking and reaching comprehension tests.

Did Infants Respond Appropriately to Task Instructions? Familiar Objects Tests for Listener Behaviour

Preferential Looking Trials

Total looking and longest look measures for preferential looking to familiar target objects were calculated, and the group results were compared to a chance level of 50%. Means for these measures are presented in Table 5.2 below.

Table 5.2. Percentage group means and standard deviations for infants' preferential looking towards familiar target objects at 13 and 17 months. Means marked with a * are statistically significant at $p<.05$.

	13 months n=*10*	*17 months* n=*10*
	Mean *(SD)*	Mean *(SD)*
% Total looking	59.96* *(7.86)*	61.71* *(9.29)*
% Longest look	58.64* *(8.59)*	62.55* *(9.94)*

One-sample *t* tests compared scores in familiar objects trials to a chance level of 50%. At both 13 and 17 months, infants showed significant preferential looking to familiar targets, regardless of the looking measure used [at 13 months TL $t(9)=4.01$, $p<.05$, LL $t(9)=3.18$, $p<.05$; and at 17 months TL $t(9)=3.99$, $p<.05$, LL $t(9)=3.99$, $p<.05$].

Further, 9/10 of the 13-month-old infants scored above 50% on both looking measures with familiar target objects; 9/10 of the 17-month-olds scored above 50% on the longest look measure, and 8/10 of the 17-

month-olds scored above 50% on the total looking measure (see Appendix D for individual results).

These results show that, as in Experiment 1, 13- and 17-month-old infants responded appropriately in the preferential looking task; they looked significantly longer at familiar target objects when presented with the corresponding familiar object labels.

Preferential Reaching Trials

Each infant's first reach was coded as either correct or incorrect on reaching trials with familiar objects; there were four reaching trials, so each infant could score a maximum of four on the reaching task. Group means of these scores are presented in Table 5.3.

Table 5.3. Group means and standard deviations (in parentheses) for infants' preferential reaching towards familiar target objects at 13 and 17 months, expressed as a tallied score, and as a percentage. Means marked with a ∞ are marginally significant at $p<.10$.

	13 months n=*10*	*17 months* n=*10*
Mean score / 4	**2.5** *(0.85)*∞	**2.6** *(0.84)*∞
Mean as a %	62.5	65

Infants in both age groups reached towards familiar objects at marginally significant levels [at 13 months, $t(9)=1.86$, $p=.096$, and at 17 months, $t(9)=2.25$, $p=.051$]. When these results were checked with further tests using the generalised linear model with binomially distributed errors, only the results of the older age group were marginally significant [$t(9)=1.87$, $p=.094$]—the younger group's results became non-significant [$t(9)=1.56$, $p=.152$].

Individual results showed a trend towards correct responding on the familiar objects task. Figure 5.1 shows the number of infants in each age group who scored 0, 1, 2, or 3 out of 4. Over both age groups, the majority of infants scored 3.

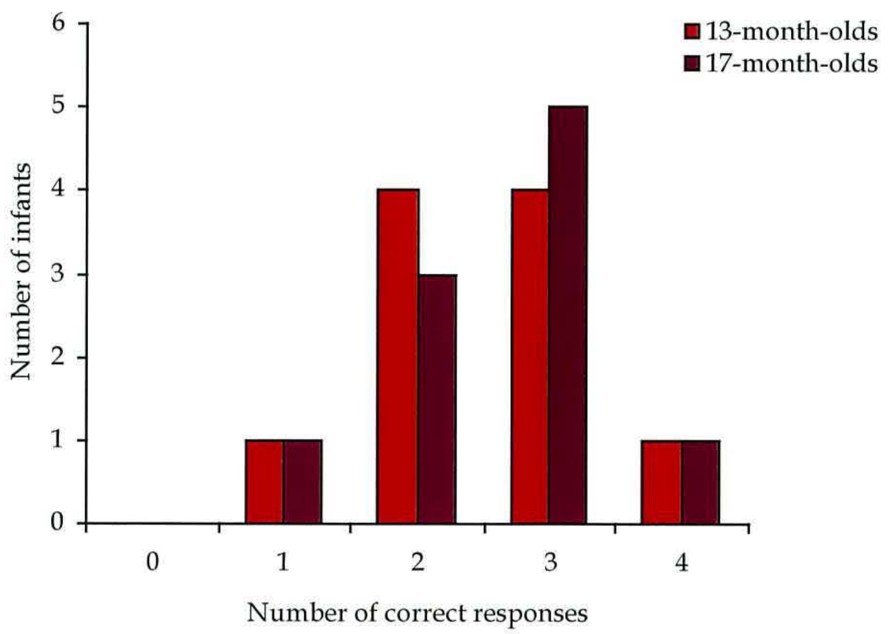

Figure 5.1. The number of infants at 13 and 17 months who scored 0, 1, 2, 3 or 4 on the preferential reaching task with familiar target objects. N.B. $n=10$ in each age group.

Overall, results with familiar objects in the preferential reaching task show a trend towards correct performance, but only marginally significant results.

Did Infants Attend to Target Objects During Exposure Training?

Infants spent a substantial proportion of training trials looking towards the target object as opposed to anywhere else. At 13 months, the mean looking to target was 72.38% (*SD*=12.82). At 17 months, the mean looking to target was 66.01% (*SD*=11.4).

Individual results (see Appendix D) supported this finding, with 9/10, and 10/10 of the infants in the younger and older groups respectively looking towards the target object for more than 50% of training trial time. Figure 5.2 shows individual performance in this phase.

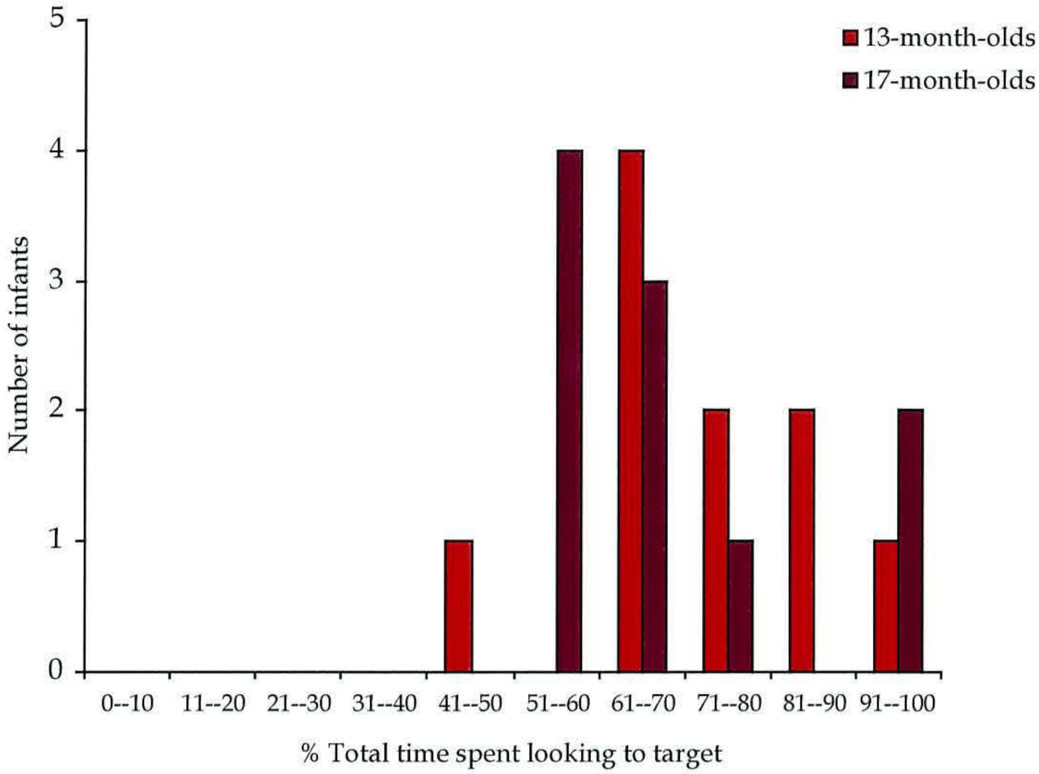

Figure 5.2. The number of infants at 13 and 17 months who showed total looking towards the target object between 0 and 100% of training trial time. N. B. n=10 in each age group.

These results demonstrate that infants in both age groups responded to the demands of the training phase by attending to novel targets.

As in Experiment 1, infants in both age groups showed a pattern of looking alternately at the experimenter and at the target object. At 13 months, infants looked towards the experimenter and the target for a mean of 86.92% (SD=15.23) of total trial time, and at 17 months, infants showed this pattern of looking for a mean of 95.5% (SD=3.92) of trial time. This difference in means between age groups showed marginal statistical significance at $p<.10$ ($t(10.19)= -1.91$, $p=.085$).

Did Infants Learn Novel Object Labels after up to 24 Exposures?

Preferential Looking Trials

Total looking and longest look measures were calculated for infants in both age groups as described in Chapter 3. Means for these measures are presented in Table 5.4.

Table 5.4. Group means for infants' preferential looking towards novel target objects at 13 and 17 months. Means marked with a* are statistically significant at $p<.05$.

	13 months n=*10*	*17 months* n=*10*
	Mean *(SD)*	Mean *(SD)*
% Total looking	62.0* *(10.79)*	58.36* *(8.73)*
% Longest look	60.46* *(10.38)*	56.79∞ *(9.54)*

One-sample *t* tests compared preferential looking scores to a chance level of 50%. Thirteen-month-olds looked significantly longer towards novel targets than towards novel distracter objects after up to 24 exposures, on both looking measures [TL $t(9)=3.52$, $p<.05$; LL $t(9)=3.19$, $p<.05$]. Seventeen-month-olds showed above-chance looking towards novel targets on the total looking measure [$t(9)=3.03$, $p<.05$], and marginally above-chance looking on the longest look measure [$t(9)=2.25$, $p=.051$]. Overall, these results suggest that infants in both age groups had learned at least one of the two novel listener relations presented by the experimenter.

Inspection of individual infants' scores in each age group supports the group results further. Of the younger infants, 9/10 scored above 50% on both looking measures; of the older infants, 9/10 scored above 50% on the total looking measure, and 8/10 scored above 50% on the longest look measure.

Novel Objects Preference Control Trials with the Looking Measure

In the preference control trials, infants were instructed to "Look at the dut" when the label *dut* had been applied to neither object during training. Infants' looking in these trials should reflect preferences for one object over the other, or for one side of object presentation over the other. Because only two preference control trials were performed with each infant, an analysis of each individual's preferences could not be conducted; the following analyses detected only preferences shared by infants within each age group.

Several infants were distracted during one of the preference control trials (n=2); their results were excluded from the following analyses.

Object preferences. In order to analyse potential object preferences, the total amount of time that infants spent looking to Object 1—as opposed to Object 2—was calculated. Infants in the younger age group looked towards Object 1 for slightly less than 50% of the time (M=45.37, SD=15.1), and older infants looked towards Object 1 for slightly more than 50% of the time (M=56.01, SD=15.16). Neither group of infants, however, showed significant object preferences [at 13 months, $t(8)=-1.12$, $p>.05$, at 17 months, $t(8)=1.25$, $p>.05$].

Side preferences. Potential side preferences were analysed by taking infants' TL scores for looks to the right side of object presentation—as opposed to the left—in each preference trial.

Thirteen-month-olds looked towards the right for slightly more than 50% of the time (M=53.94, SD=10.9), and 17-month-olds looked towards the right for slightly less than 50% of the time (M=45.35, SD=18.18). The results of neither age group differed significantly from chance [13-month-olds $t(8)=1.09$, $p>.05$, 17-month-olds $t(8)=-.77$, $p>.05$]. Further, there was no significant difference between age groups in their side preferences [$t(16)=1.22$, $p>.05$]. These results run counter to Experiment 1, in which 17-month-olds looked significantly more towards the right than did 13-month-olds.

Although, in this experiment, there were no clear preferences for one object over the other, or for one side of presentation over the other, the non-significant trends apparent in infants' looking patterns highlight the importance of using trials counterbalanced for side of object presentation in this experiment.

Preferential Reaching Trials

Infants' success on the preferential looking task was not reflected in preferential reaching trials. Table 5.5 displays mean reaching scores for each age group.

Table 5.5. Group means and standard deviations (in parentheses) for infants' preferential reaching towards novel target objects at 13and 17 months. N.B. Reaching at chance would give a value of 2.

	13 months n=*10*	*17 months* n=*10*
Mean score / 4	**1.8** ***(0.78)***	**2.3** ***(0.82)***
Mean as a %	45	57.5

One-sample *t* tests showed that infants in both age groups reached at chance levels towards novel targets. [At 13 months, $t(9)=-.8$, $p>.05$; at 17 months, the trend in the mean towards preferential reaching to target was not significant $t(9)=1.15$, $p>.05$]. These results were supported by tests using the generalised linear model with binomially distributed errors [at 13 months, $t(9)=-.63$, $p>.05$; and at 17 months, $t(9)=.95$, $p>.05$].

Individual results (see Appendix D) with novel target objects showed a different pattern for the two age groups, with many younger infants reaching to target twice or less over the four test trials, while more of the older infants reached to target more than twice. Figure 5.3 shows the number of infants in each age group who scored 0, 1, 2, or 3 or 4 out of 4 on the reaching test.

Overall, infants in neither age group showed clear evidence of having learned novel listener relations on the preferential reaching task.

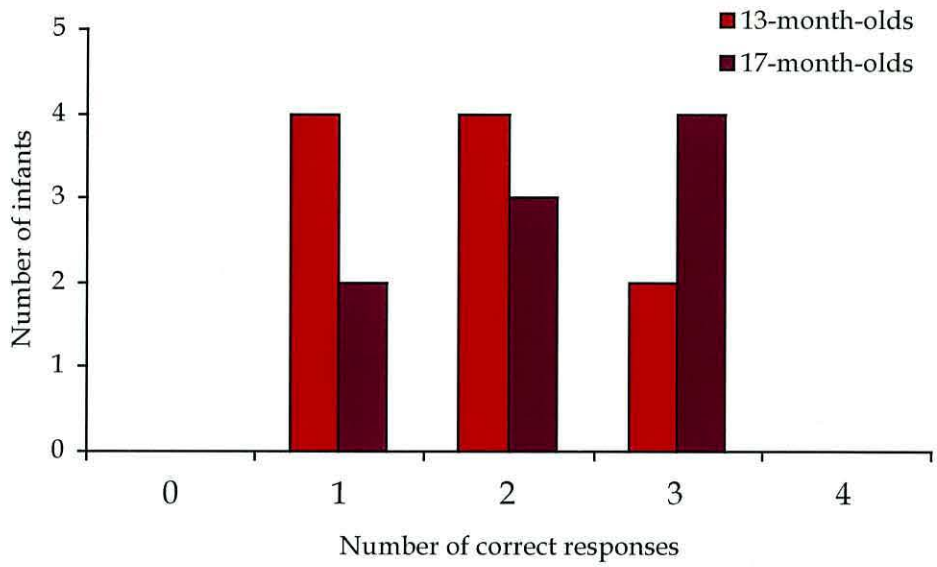

Figure 5.3. The number of infants at 13 and 17 months who scored 0,1, 2, 3 or 4 on the preferential reaching task with novel target objects.

Novel Objects Preference Control Trials with the Reaching Measure

In preference control trials, infants were presented with both novel objects and asked, "Can you get the dut?" Two trials were conducted in order that each novel object was presented once on the left and once on the right. Only one infant failed to respond on these trials; this infant's results were excluded from the data that follow. Because only two reaching preference control trials were conducted per infant, no statistical analyses were performed; the data that follow are descriptive.

Object preferences. Table 5.6 shows the tally of reaches to Object 1 and to Object 2 in novel objects preference control trials for both age groups.

Table 5.6. Tally of infants' reaches towards Object 1 and Object 2 in novel objects preference control trials. N.B. trials in which infants reached towards both objects simultaneously are excluded from these tallies.

	13 months $n = 10$		***17 months*** $n = 9$	
	Object 1	Object 2	Object 1	Object 2
Total reaches	8	7	4	8

Infants' performance in preference control trials with the reaching measure was dissimilar to their performance in preference control trials with the looking measure. The 13-month-olds showed no preference for one object over the other, but 17-month-olds tended to reach towards Object 2 in preference to Object 1. In the looking trials, 17-month-olds showed a non-significant tendency to look, instead, to Object 1.

Side preferences. Table 5.7 shows the tally of reaches to the right and to the left in novel objects preference control trials for both age groups. Younger infants reached about equally towards the left and towards the right, and older infants reached slightly more towards the right than towards the left.

Table 5.7. Tally of infants' reaches towards the right side of presentation and the left side of presentation in novel objects preference control trials.

	13 months n= 10		***17 months*** n=9	
	Right	Left	Right	Left
Total reaches	8	7	8	5

Again, the small fluctuations apparent in infants' reaching preferences make clear the usefulness of the counterbalancing measures employed in this experiment.

Is there a Relationship between Infants' Verbal Repertoire and their Label Learning?

MCDI Scores

A series of Pearson's product moment correlations was used to look for a relationship between productive MCDI scores of infants in both age groups combined, and their total looking performance on familiar and novel preferential looking tasks. There were no significant correlations between the number of words spoken by infants and task performance (novel objects r=-.08, n=20, p>.05; familiar objects r=.07, n=20, p>.05).

For 13-month-olds, the MCDI measured receptive as well as productive vocabulary. There was no significant correlation between performance on the novel objects task and the number of words in receptive vocabulary

(r=.23, n=10, p>.05), or between performance on the familiar objects task and the number of words in receptive vocabulary (r=.428, n=10, p>.05), despite the trends in the results towards a correlation.

Within-session Label Production

Producers and *non-producers* were identified in the same way as in Experiment 1, by tallying the number of approximations each infant made to novel object labels during object handling periods, novel objects training and test trials, and the word production test. Again, the occurrence of infant vocal approximations to novel object labels was rare. Only 3 infants could be classified as *producers* (all from the older age group). The mean total looking score for these infants on the novel objects test for listener behaviour was 55.54%, but the number of producers was too low for any valid statistical analysis to be performed.

Is There a Relationship Between Infants' Looking to Target during Training and their Label Learning?

As in Experiment 1, a Pearson's product-moment correlation was performed; this aimed to discover whether there was a relationship between infants' total looking to target during training and their total looking to target during listener test trials with novel objects, regardless of age group. No significant correlation was found (r=-.30, n=20, p>.05).

A second correlation was conducted to determine whether there was a relationship between, on the one hand, infants' total looking towards the target object and the experimenter and, on the other hand, their total looking towards novel target objects in test trials. Again, there was no significant relationship between these two variables ($r=-.14$, $n=20$, $p>.05$).

Discussion

Looking and Reaching Measures

The results of this study show different effects for preferential looking and reaching measures. On the looking measure, both age groups show significant above-chance looking to novel target objects, at approximately 60%. This suggests that 24 exposures to each novel label-object relation are sufficient for listener relation learning by infants under the age of 18 months.

On the reaching measure, such successful performance by infants in both age groups was not replicated, although the results of 17-month-olds showed a non-significant trend towards correct reaching. These results are difficult to interpret, because infants in both age groups reached at only marginally significant levels towards familiar objects tests for listener behaviour. It is possible that infants in the present experiment had not learned to respond appropriately to the experimental instructions on the reaching task, and that this adversely affected their performance on the listener task with novel objects.

It is more likely, however, that the reaching measure is simply less sensitive to the beginnings of listener learning than is the looking measure, particularly as infants in the 13-month-old age group performed at above-chance levels on the familiar objects task in Experiment 1 [13-month-olds, $t(9)=4$, $p<.05$], and 17-month-olds again performed at marginally significant levels in Experiment 1 [$t(9)=1.96$, $p=.081$]; these results support the assumption that infants could respond appropriately to the experimental instructions in the preferential reaching task. As discussed in Chapter 7, the reaching task requires a categorical response in which, in each trial, it is possible only to be either 100% correct (by selecting the target object) or 100% incorrect (by selecting the distracter object). The looking task allows for a more sophisticated, graded response, so that an infant can score anywhere between 0 and 100% in each trial.

The differing results given by preferential looking and reaching measures in the present experiment may shed some light on the poor performance of infants in Bell's (1999) study, in which 27 label-object exposures were presented to each infant, with no resulting evidence of listener relation learning. In Bell's study, only a reaching measure was used. It may be that infants had begun to learn the novel listener relations, but that the preferential reaching measure was not sufficiently sensitive to reveal this learning.

How did infants learn the novel label-object relations in the current experiment? One possibility is that the multiple pairings between the novel objects and their corresponding labels led to associative listener learning, through a process similar to classical conditioning; another is that infants' looking behaviour was automatically reinforced by some aspect of the experimental procedure, and that their resultant listener learning was an example of operant behaviour. This issue is discussed in detail in Chapter 7.

Effects of Age, Verbal Repertoire, and Looking to Target during Training

In the present experiment, there was no difference between age groups on listener behaviour test trials.

These results are surprising: it was expected that older infants, with more word learning experience, would be able to put this experience to use in learning novel labels. It might be the case, however, that 12 to 18-month-old infants learn new listener relations at similar rates, and that a "spurt" in listener learning occurs before most infants reach the age of 12 months. This is the view advocated by Woodward et al. (1994).

An alternative explanation (discussed in Chapter 2) is that it is possible that other factors are as important as age in determining which infants are more or less successful on the listener behaviour task with novel objects. This is why, in Experiments 1 and 2, MCDI and within-session measures of infants' verbal repertoires were taken.

Individual variation in the acquisition of a verbal repertoire is high in young children (Goldfield and Reznick, 1992). This may mean that an infant's age, between the relatively narrow range of 12 and 18 months, may not be representative of her word learning experience; an older infant may not necessarily be a more experienced word learner.

Against this, when infants' verbal repertoires—measured by the MCDI—were correlated with their performance on familiar and novel objects test trials, no relation was found. Infants who could produce more words did not perform better on the listener learning task and, within the younger age group, infants who could understand more words did not perform better on the listener learning task.

The MCDI measure of verbal repertoire taken in this study may be flawed. Questionnaire responses are open to bias from social desirability effects. In their research, which used a similar paradigm, Hollich et al. (2000) also found no relation between the MCDI measure of productive verbal repertoire and infants' listener learning.

Further, the MCDI does not take a measure of the number of words an infant can comprehend past the age of 16 months. This meant that, in Experiments 1 and 2, an analysis of the relationship between receptive vocabulary and task performance could not be conducted for the whole of the participant sample. It is possible that—regardless of age group—the more words an infant understands, the more likely she is to succeed on the listener learning task (and the trend towards a significant correlation between receptive vocabulary and task performance in 13-month-olds adds weight to this expectation); unfortunately, because of the limitations of the MCDI, this prediction could not be tested.

Because of potential problems in the MCDI, an alternative measure of productive verbal repertoire was planned: within-session label production by infant participants. However, because so few infants produced novel labels during sessions (either as tacts or echoics), no analyses could be performed with this measure.

So it remains possible that infants' receptive and productive verbal repertoires (rather than age) do affect their listener relation learning, but that Experiments 1 and 2 took no reliable measures of these verbal skills.

It was also suggested that the amount of time each infant spent looking towards the novel target object during training trials might predict her success on listener test trials with novel objects. Why was such a relationship not found?

In training trials, the lowest proportion of looking to the target object was 47.96%. Even this proportion is large: there was only one target during these trials, and thus no ambiguity about which object was being labelled by the experimenter. After each infant had looked once at the target object, there was no need for her to look again in order to determine which object was being labelled. In this situation, infants could look for relatively small amounts of time towards the target object, but by listening to the experimenter's labelling, still learn the novel label-object relations—this after a sufficient number of exposures to the label. This may explain the lack of a relation between looking to target during training trials, and listener task success.

* * *

Experiments 1 and 2 showed that using exposure to teach novel listener relations to infants below the age of 18 months is less effective than other researchers in the developmental field suggest.

Experiment 3 was designed to test the effectiveness of positive reinforcement as an alternative means for teaching novel listener relations.

Studies in the field of behaviour analysis (e.g. Bell, 1999; Hughes, 2001; Randle, 1999) have used positive reinforcement to teach novel listener and speaker relations to infants and young children, but there has been no direct assessment of the effects of positive reinforcement on infants' learning of novel listener relations within the rapid word learning research paradigm.

Experiment 3 used the methodology established in Experiments 1 and 2 to compare the effects of positive reinforcement and exposure on listener relation learning in groups of 13- and 17-month-old infants.

EXPERIMENT 3: CAN 13- AND 17-MONTH-OLD INFANTS LEARN TO COMPREHEND NOVEL OBJECT LABELS AFTER A) UP TO 10 REINFORCEMENT TRIALS, AND B) UP TO 10 EXPOSURE TRIALS?

The aim of this experiment was to compare infants' novel listener relation learning when their correct looking to novel targets was reinforced, to their novel listener relation learning when they were exposed to the relation between novel label and object.

Experiments 1 and 2 showed that listener relation learning via exposure alone is less effective than previous research in the developmental field has suggested. In Experiment 2, 18-24 exposures to label-object relations were required before infants showed above-chance looking to novel target objects.

The role of feedback in the development of more sophisticated language learning is well-documented in the psycholinguistic literature. For example, Demetras, Post, and Snow (1986), and Gallaway and Richards (1994) showed that feedback by a caregiver is important in older children's productive language learning (see Chapter 1). Although feedback is not directly equated with positive reinforcement in this literature, positive feedback is often identified as the caregiver saying "Yes!", or repeating the child's utterance, and thus reinforcing her appropriate speaker behaviour through increased social attention.

Applied behaviour analytic research makes use of positive reinforcement in listener and speaker behaviour training tasks with special needs populations (Sachs et al., 1981; Sundberg et al., 1996; Sundberg and Michael, 2001) and with animals (Herman et al., 1981, 1984; Savage-Rumbaugh, 1986; Schusterman and Krieger, 1984; and see Chapter 1). Despite positive reinforcement being acknowledged as a powerful tool in the training of verbal behaviour, the speed of acquisition when reinforcement is employed to teach novel listener relations has not been fully investigated in normally developing infants.

If positive reinforcement is an effective means of establishing listener relations, it must produce learning in at least the same number of trials as are required for learning via exposure. Accordingly, this experiment aimed to establish whether infants aged 13 and 17 months can learn novel label-object relations after up to 10 training trials in which their correct looking towards the novel target object was reinforced.

Changes to the basic experimental framework used in Experiments 1 and 2 had to be made in order to use positive reinforcement as a means of teaching new listener relations. This meant that the results of the current study could not be directly compared to those of earlier experiments reported in this thesis. For this reason, an Exposure Condition was included in the current experiment, which employed the same independent and dependent variables as the Reinforcement Condition, except that in the Reinforcement Condition positive reinforcement contingent upon the infant's appropriate looking to a novel target object was presented; in the Exposure Condition such positive reinforcement was presented non-contingently.

In the Reinforcement Condition, infants were presented with both novel objects, and asked, "Where's the X?", where X was either of the two novel labels. Only when the infant responded appropriately—by looking towards the target object—was positive reinforcement, in the form of verbal praise, clapping and music, presented. After the reinforcement period had ended, a new training trial began. This, by necessity, meant that the infant was presented with individual, spaced, training trials; this differed from the short exposure period of earlier experiments, in which infants were presented with six labels for each novel object within a period of around nine seconds. Hollich et al. (2000) claim that infants show improved performance on listener relation learning via exposure when trials are spaced, rather than massed together, and many studies in the fields of adult and infant learning suggest that this distributed learning is more effective than massed learning (e.g. Crowder, 1976; Merriman, Rovee-Collier and Wilk, 1997; Vander, Linde, Morongiello, and Rovee-Collier, 1985). This made the Exposure Condition in the current study vital; it allowed the experimenter to present distributed exposure trials that provided a direct comparison to the distributed reinforcement trials.

The Exposure Condition was matched to the Reinforcement Condition in several other ways. In earlier experiments, the experimenter pointed and looked towards the novel target object and said, "This is an X!" during exposure training. Because, in the current experiment, training trials in the Reinforcement Condition required the experimenter to ask, "Where's the X?", the same prompt was also used in the Exposure Condition. This was to control for the possibility that the verbal frame, "Where's the..." might be a more effective means of establishing word learning than the frame, "This is the..."

The amount of reinforcement presented in both conditions was also constant; this was to control for the possibility that greater access to reinforcers might increase infants' compliance in the Reinforcement Condition, and thereby lead them to attend more to the label-learning task. So, in the Exposure Condition, positive reinforcement was presented for infants' appropriate looking towards the experimenter outside of the label-learning task.

Additional improvements were made to the current experiment; these were based on the outcome of Experiments 1 and 2, and on pilot testing. First, a larger range of familiar objects was used, and caregivers were asked to select the two object-labels with which each infant was most familiar. In Experiments 1 and 2, mean preferential looking to target objects was between 56% and 63%; this was significant in all cases, but low in terms of the mean score. The current experiment aimed to strengthen the validity of the comprehension measures by increasing preferential looking and reaching to familiar target objects.

Second, the reliability of the preferential looking measure was improved—this by doubling the number of test trials for both familiar and novel objects: from four in Experiments 1 and 2, to eight in the current experiment. Pilot testing showed that infants became distracted more quickly during preferential reaching trials, so the number of trials used for this measure was kept constant, at four.

Third, the preference control trials, in which infants in Experiments 1 and 2 were presented with both novel objects and asked, "Where's the dut?", were modified in the current experiment. Many of the excluded trials in earlier experiments were the "dut" preference control trials, during which infants did not look towards either experimental object for more than one second (see p. 140). It is possible that the use of this third label in the presence of two previously-labelled objects confused the infants. In the current experiment, infants were instead asked, "Can you look at these?" when presented with both novel objects in preference trials. As in Experiments 1 and 2, there were two preference control trials with novel objects in the current experiment. In addition, two preference control trials were introduced with familiar objects.

Fourth, in the current experiment, both novel objects were presented during training trials (as opposed to a single object in Experiments 1 and 2). Because some infants—especially younger infants—may have difficulty following the experimenter cues of eye gaze and pointing in order to identify the target object in each trial, a further disambiguating cue was introduced. A set of red LED lights was placed around each slot on the presentation board; these could be activated by the experimenter to appear around the target object, and increase its salience, in any given trial. These LED lights were used in the Exposure Condition along with pointing and eye gaze, and in the Reinforcement Condition immediately after the infant had looked appropriately to the target object.

Further, in pilot testing, it was found that infants responded best on training trials (by increased attention to novel objects and to experimenter instructions) when each novel object was labelled at the start of the period. In the current experiment, the experimenter presented an initial labelling of each novel object at the start of each training period in both Exposure and Reinforcement Conditions. So, by the end of the Reinforcement Condition, infants had been presented with two initial labellings of each novel object, and ten reinforced training trials per object; by the end of the Exposure Condition, infants had received two initial labellings of each novel object, and a further ten exposures to each label-object relation. Because there has been no study in which infants of 13 and 17 months have shown rapid word learning of novel listener relations after only two exposures (15- to 17-month-old infants in Baldwin's et al.'s research, 1996, did not learn novel labels after three exposures), any learning in the Reinforcement Condition can be attributed to effects of the reinforced training trials, rather than to these initial labellings.

Finally, in order to increase participant recruitment, both Welsh- and English-hearing infants were included in this experiment, and additional analyses were conducted to test for differences between the two groups. Because the labels used in Experiments 1 and 2 (*pab* and *gek)* are similar to real words in Welsh, two alternative labels *(zag* and *vek*) were used in this experiment; these were novel in both languages.

As in Experiments 1 and 2, it was expected that infants in all age groups and conditions would succeed on the familiar objects test for listener behaviour by showing above-chance looking towards familiar target objects, thus validating both preferential looking and reaching measures. It was also expected that all infants would show significant looking towards novel target objects during training trials; this would show that they followed experimenter cues and could discriminate the target from the distracter during training.

Infants should differ according to condition in their performance on the novel objects test for listener behaviour. In the Exposure Condition, it was predicted that infants would fail to learn novel label-object relations, as in Experiment 1. In the Reinforcement Condition, it was expected that infants would succeed in learning novel label-object relations. It was also predicted that older infants, because they are more experienced word learners, would show greater success on the listener learning task in the Reinforcement Condition.

In Experiment 2, the preferential looking measure was more sensitive to the beginnings of word learning than the reaching measure. It was expected that this pattern would be replicated in the current experiment, with success on the novel objects test for listener behaviour most likely on the preferential looking measure.

As in Experiments 1 and 2, possible correlations between infants' verbal repertoire and listener task success, and the proportion of looking to target during training and listener task success, were analysed regardless of age group; these factors may be of equal or greater importance than age in predicting infants' success in learning the novel listener relations.

Method

Participants

A total of 47 infants participated, but 5 were rejected due to fussiness, leaving a total of 22 infants in the 13-month-old age group (mean age 13.8

months, range 12.1 to 14.9 months) and 20 infants in the 17-month-old age group (mean age 17.6 months, range 16.1 to 18.9 months). Infants in each age group were assigned randomly as they became available to either the Reinforcement or the Exposure Condition, but due to procedural issues (see *Extra spoken labels in the Exposure Condition*, p. 224), infants in the Reinforcement Condition were tested prior to infants in the Exposure Condition. For 13-month-olds, there were 11 infants per condition and, for 17-month-olds, there were 10 infants per condition.

As far as possible, a balance of sexes was maintained across age groups and within conditions: for 13-month-olds there were 6 females and 5 males in the Reinforcement Condition, and 7 females and 4 males in the Exposure Condition; for 17-month-olds, there were 4 females and 6 males in the Reinforcement Condition, and 4 females and 6 males in the Exposure Condition.

Within the Bangor community, infants may hear either English or Welsh predominantly in their home environment, and infants were drawn from both language groups. Caregivers were asked to indicate before the session the language to which their infant was most exposed, and experimental sessions were conducted in the dominant language. As far as possible, a balance of languages was maintained, but fewer Welsh-hearing participants were recruited; overall, there were 26 English-hearing infants and 16 Welsh-hearing infants.

Prior to arrival for the experimental sessions, caregivers were asked to read a short information letter and to give written consent to their infants' participation (see Appendix A). They were also asked to complete the draft form of the bilingual Bangor Communicative Development Inventory (BCDI) for their infant; this gives a measure of the number of words that an infant can both understand and produce; the BCDI is suitable for infants from 8 to 30 months.

BCDI questionnaires were not returned for five infants. Mean productive and receptive vocabulary scores for the rest of the infants in each age group, taken from the BCDI, are displayed in Table 6.1.

Table 6.1. Mean number of words produced and understood by 13- and 17-month-old infants in Reinforcement and Exposure conditions. Ranges for these figures are displayed in brackets.

	13 months Reinforcement n=9 Exposure n=10		17 months Reinforcement n=9 Exposure n=9	
	Produced (range)	Understood (range)	Produced (range)	Understood (range)
Reinforcement Condition	9 (0-48)	94 (25-202)	31 (0-102)	179 (68-327)
Exposure Condition	9 (0-44)	120 (56-373)	19 (5-80)	199 (69-410)

For each measure of verbal repertoire, infants' scores were compared using a 2 x 2 (age group x condition) ANOVA. For both production and comprehension measures, there was a significant effect of age [for the production measure, $F(1, 33)=4.44$, $p<.05$; for the comprehension measure, $F(1, 33)=6.4$, $p<.05$], but no effect of condition [for the production measure

$F(1, 33) = .71$, $p > .05$, and for the comprehension measure, $F(1, 33) = .059$, $p > .05$]. There were no significant interactions between factors [production $F(1, 33) = .51$, comprehension $F(1, 33) = .05$, $p > .05$]. So, in both conditions, 17-month-olds showed significantly larger production and comprehension repertoires than did 13-month-olds.

The majority of infants participated in two experimental sessions, the second within 24 hours of the first. Each session lasted approximately 45 minutes. A minority of infants (four in the Reinforcement Condition, and five in the Exposure Condition) completed the experiment in a single session of about one hour. After completing the experiment, caregivers received £10.00 per session, an "infant scientist degree certificate", and a short, written debriefing on the aims of the study (see Appendix E for debriefing information).

Stimuli

Novel Labels and Objects

Two labels were selected based on their novelty in both English and Welsh. The chosen labels —*zag* and *vek* —have been used extensively in previous research (Horne and Lowe, 2000; Hughes, 2000; Lowe et al., 2002; Randle, 1999), and follow the consonant-vowel-consonant form that infants learn to understand and use earliest (Charles-Luce and Luce, 1990). The central vowel of each novel label was pronounced as in the *pab* and *gek* labels used in Experiments 1 and 2: the vowel in *zag* was pronounced as in the word *cat*, and the vowel in *vek* was pronounced as in the word *bed*.

The two colourful fabric objects described in Chapter 3 (see Figure 3.2, p. 131), and used in Experiments 1 and 2; served as novel objects in this experiment. For ease of reference, the pink, red, and white object is referred to as Object 1, and the yellow, blue and green object as Object 2, throughout this chapter.

Familiar Labels and Objects

Five familiar object-labels (*banana, bottle, cow, cup*, and *shoe*) were chosen because they are among those learned first by infants (Baldwin, 1989). The toy objects corresponding to these labels were similar in size, and intended to be of equal perceptual salience. Photographs of these objects are presented in Chapter 3 (see Figure 3.3, p. 132).

Prior to the start of the experimental session, each caregiver was asked to estimate which two of these labels their infant understood best, and the corresponding pair of objects was selected for use in familiar object trials for that infant throughout the experiment. For four English-hearing infants, the alternative label *drink* was used, and for five Welsh-hearing infants, the alternative label *diod* was used—this because the caregivers indicated that this was the label best known by their infants for a cup. To prevent confusion, the bottle and the cup were never presented to infants as a pair.

Experimental Set-up

The set-up for this experiment was the same as that described in Chapter 3 and used in Experiments 1 and 2, but with two additional elements.

First, two black frames were constructed for the presentation board, one around each presentation slot. Within each frame, a series of 48 red LED lights was embedded, each light placed 1.5 cm apart. The lights were activated by a switch concealed behind the board to come on either in the left or the right frame; the lights came on in sequence, in a clockwise direction. When an object was presented in one of the slots, these lights had the effect of drawing infants' attention to that part of the board. The black frames were designed to be unobtrusive when the lights were not on. Figure 6.1 shows a lit frame around one of the presentation slots.

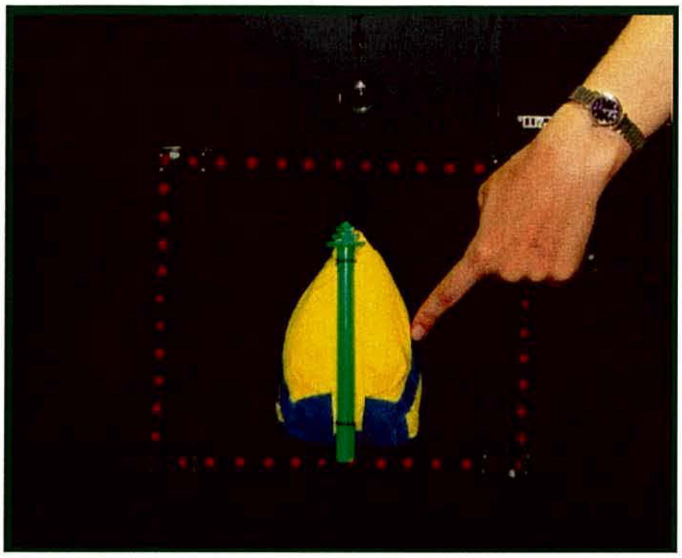

Figure 6.1. Object 2 on the presentation board, with LED lights activated around the presentation slot.

Second, a tape-player, set up to play a 15-second nursery melody (the tune to *Pop Goes the Weasel*) when activated by the experimenter, was obscured from participants' view behind the presentation board. This was used during training trials in both conditions.

Procedure

The procedure followed that described in Chapter 3. It took up to an hour and a half to complete, including free play periods and breaks. Most infants (n=33) completed the procedure over two sessions on consecutive days; a minority (n=9) completed the procedure within one hour-long session. In order to gain maximal performance from each infant, the timing of individual sessions was, to some extent, determined by the amount of time that each infant maintained attention to the experimental stimuli without becoming distracted. But the same general pattern of testing was followed for all infants: a ten minute play-break outside of the experimental room was taken in every session; shorter breaks, involving play with non-experimental toys, were taken between stages of the experiment.

This procedure was conducted in Welsh for many infants. A Welsh transcript of all experimenter instructions can be seen in Appendix F.

In Phase I: The Preferential Looking Task, infants were presented first with one and then the other of the familiar objects, and allowed to handle each for approximately 20 seconds. The experimenter then presented four test trials for listener behaviour, in which she said, "[Name], where's the X[1]? Can you see the X? Look at the X!", within a six-second period. There was also one preference control trial in this period, in which both familiar objects were presented, and the experimenter asked, "[Name], can you look at these? Look over here! Look at these!", again within a six-second period.

In the same manner as for the familiar objects, infants then handled each novel object in a predetermined, counterbalanced order.

---

[1] Where X was *banana, bottle, cow, cup or shoe,* depending on which two objects had been pre-selected by each caregiver as familiar to their infant.

Novel Objects Training

Infants in each age group participated in one or the other of the Reinforcement or Exposure Conditions. Novel Objects Training differed according to condition as follows.

Initial labelling of novel objects. In both conditions, the experimenter presented both novel objects on the board, in predetermined counterbalanced positions, and labelled each one. She pointed and looked towards the first object, and said, "Look, this is an X[2]!" She then directed the infant's attention in the same way towards the second object, saying, "And this is an X!" This initial labelling drew the infant's attention to the unfamiliar objects.

Reinforcement Condition. Training trials in this condition lasted 20-30 seconds, and went as follows:

Hidden from view, both objects were placed in their predetermined positions on the presentation board by the experimenter, who was out of sight. The experimenter then appeared behind the presentation board, facing the infant, and said, "Ooh! What's going to come up?", and raised the novel stimuli on the presentation board.

---

[2] Where X was *zag* or *vek*, dependent on counterbalancing.

Looking directly at the infant, the experimenter flashed the central fixation light, and said, "Look!" Then, when the infant looked towards the presentation board or towards the experimenter, she asked, "Where's the X?" The experimenter was careful to stand in a central position between the two novel objects behind the board, and to look only at the infant. If the infant failed to respond appropriately, the experimenter pointed towards both objects, and said, "Is it one of these? The X!" still looking only towards the infant. This prompt was repeated up to two more times. If the infant still failed to look appropriately (by turning her eyes towards the target object), the objects were lowered from view, and the trial was repeated (see Table 6.2 for a summary procedure of each training trial in the Reinforcement Condition).

When the infant looked towards the appropriate object, the experimenter said, "Yes! There it is! Good girl!", started the 15-second tune, and clapped. While the tune was playing, the experimenter activated the LED lights to appear around the presentation slot of the target object (see Figure 6.1, p. 219), and pointed towards the target object. Halfway through the musical sequence, the experimenter said, "Bye bye!" to the infant, and asked the caregiver to spin her chair slowly around, such that the infant could no longer see the presentation board, and then return it to its central position. During this period, the experimenter lowered the novel objects and repositioned them for the next trial. There were approximately 5 to 10 seconds between trials.

There were 10 reinforcement training trials, 5 with each novel object-label.

Exposure Condition. As in the Reinforcement Condition, training trials lasted 20-30 seconds, and went as follows:

Hidden from view, both objects were placed in their predetermined positions on the presentation board by the experimenter, who was out of sight. The experimenter then appeared behind the presentation board, and said, "Ooh! What's going to come up?" as she raised the novel stimuli into view.

The experimenter then flashed the central fixation light as she said, "Look at me!" When the infant looked towards the experimenter, she said, "Yes! Good girl!", activated the first half of the 15-second tune, and clapped.

When the tune was over, the experimenter flashed the LED lights around the target object and then pointed and looked towards it, saying, "Where's the X[3]?"

---

[3] Where X was *zag* or *vek*, dependent on counterbalanced order.

After this labelling, the experimenter lowered the presentation flap such that the novel objects disappeared from sight. She said, "Bye bye!" to the infant, and asked the caregiver to move her chair slowly around and return it to its central position while the second half of the tune was played. During this period, the experimenter repositioned the novel objects for the following trial.

There were 10 exposure training trials, 5 with each novel object-label.

Extra spoken labels in the Exposure Condition. In the Reinforcement Condition, it was sometimes necessary for the experimenter to ask, "Where's the X?" more than once in order to evoke appropriate looking towards the target object. This did not occur in the Exposure Condition; here the experimenter checked that infants were looking towards the target object before she labelled it. The Reinforcement Condition was conducted prior to the Exposure Condition of the current experiment; this was in order that the number of extra novel spoken labels presented to infants could be calculated and used in the same quantity for infants in the Exposure Condition.

On average, each infant in the Reinforcement Condition heard 26 novel spoken labels. In the Exposure Condition, without intervention, each infant would hear only 20 novel spoken labels (10 per novel object). Although, in the Reinforcement Condition, the extra labels were presented before each infant looked towards the target object, it is possible that this extra exposure to the label alone might lead to increased listener relation learning in infants in the Reinforcement Condition.

In order to keep the number of times infants heard each novel spoken label constant over conditions, the experimenter presented six extra spoken labels in the Exposure Condition—three per novel object label. The extra labels were spaced over the total training period, such that in 6 of the total of 20 training trials, 1 extra label was presented.

Extra spoken labels were presented immediately after each exposure training trial, but before the novel objects had been removed from view. The experimenter looked directly at the infant and asked, "Where's the X?" She did not point or look towards the target object; this replicated the manner of presenting extra labels in the Reinforcement Condition. When the extra spoken label had been presented, both novel objects were lowered from the infant's view as normal.

Reinforcement and Exposure Conditions. It should be noted that all the elements of novel objects training trials in the Reinforcement Condition were duplicated in the Exposure Condition, but the sequence of the procedure was changed in order that infants in the Exposure Condition did not receive positive reinforcement contingent upon looking towards the appropriate novel object on hearing it labelled.

Nonetheless, for control purposes, the Exposure Condition did contain positive reinforcement—contingent upon infants' looking towards the experimenter in the first part of each trial. The Exposure Condition of this experiment, unlike Experiments 1 and 2, can therefore be characterised as a second reinforcement procedure in which a response other than that of appropriate looking to a target object, given a specific spoken label, is reinforced.

Table 6.2 shows the sequence of events in each condition.

Table 6.2. Procedure of novel objects training trials in Exposure and Reinforcement Conditions. All elements of the Reinforcement condition are duplicated in the Exposure condition.

Exposure Condition	Reinforcement Condition
Novel stimuli presented	Novel stimuli presented
"Look at me!"	"Look!"
[Infant looks appropriately]	**"Where's the X?"**
Sr+: Verbal praise, clapping, and first half of tune	[Infant looks appropriately]
Salience lights around target, and pointing	Sr+: Verbal praise, clapping, and tune starts
"Where's the X?"	Salience lights around target, and pointing [tune continues]
Novel stimuli removed	Chair spun around [tune continues]
Chair spun around, and second half of tune	Novel stimuli removed

In the *Novel Objects Test for Listener Behaviour,* which was the same for both conditions, the experimenter, while hidden from the infant's view, placed both objects on the board in their predetermined positions. She stood up behind the board, flashed the central fixation light, and said, "[Name], look over here! Can you see the light?" On gaining the infant's attention, the experimenter asked, "[Name], can you see the X?", and set the timer for six seconds. She then moved the presentation flap upwards so that the objects came into view, and hid behind the board. Within the remaining timed period, the experimenter asked, "Can you see the X? Look at the X!" When the timed period had elapsed, the experimenter let the presentation flap down so that the objects disappeared from view. There were four such trials for listener behaviour, two with each novel object-label.

One novel objects preference control trial was conducted in this period. This followed the same pattern as that of the listener test trials, described above save that, during presentation of the two novel objects, the experimenter asked, "Can you look at these? Look over here! Look at these!" within the six second period. In these preference control trials, the infant was expected to look towards the object or side of presentation that she preferred.

The procedure of *Phase 1: The Preferential Looking Task,* was then repeated in full such that, by its end, infants in both conditions had been presented with four familiar objects listener test trials, two familiar objects preference control trials, and two initial labels for each novel object. In addition, infants in the Reinforcement Condition had received 10 reinforcement training trials with each novel object, and infants in the Exposure Condition had received 10 exposure training trials with each novel object. All infants had then received eight novel objects listener test trials, and two novel objects preference control trials.

In *Phase 2: The Preferential Reaching Task,* infants first learned how to respond appropriately to the experimenter's instructions in the experimental setting by placing non-experimental toys (e.g. a duck) in the basket on the presentation board at the experimenter's request. There followed four familiar objects test trials for listener behaviour, and two familiar objects preference control trials; these were followed by four novel objects test trials for listener behaviour, and two novel objects preference control trials. Trials were counterbalanced in order that each object was presented an equal number of times to the infant's left and right.

In all trials, the experimenter placed two objects on the board and asked, "[Name]! Can you put the X[4] in the basket, can you put the X in, the X?" The parent then moved the infant close to the board so that she could

[4] Where X was either of the infant's selected familiar objects, *zag,* or *vek,* depending on stage of the procedure and counterbalancing measures.

select an object. When the infant had chosen an object, the experimenter said "Thank you!" regardless of whether the infant's selection was correct.

In *Phase 3: The Word Production Task,* the infant's ability to produce the familiar and novel object-labels used throughout the experiment was tested. Each experimental object was presented in turn, and the experimenter asked the infant, "What's this?" three times.

Results

The following section considers, first, whether infants in each age group and condition responded appropriately in familiar objects tests for listener behaviour (to establish the test validity of the measures used); second, whether infants in each age group and condition attended to target objects during novel objects training (to establish that infants were able to follow experimenter cues by looking to target); third, whether infants in each age group and condition learned novel label-object relations; and fourth, whether there is a relationship between infants' verbal repertoires and their learning of novel label-object relations in each condition; or between infants' time spent looking to target during training and their learning of novel label-object relations in each condition.

Did Infants Respond Appropriately to Task Instructions? Familiar Objects Tests for Listener Behaviour

Preferential Looking Trials

Proportional looking to target was calculated for familiar objects and compared to a chance level of 50% for total looking (TL) and longest look (LL) measures. Group means for each age group and condition are presented in Table 6.3.

Table 6.3. Percentage group means and standard deviations for 13- and 17-month-old infants' preferential looking towards familiar target in Reinforcement and Exposure Conditions. Means marked with a * are statistically significant at $p<.05$.

	13 months $n=22$	*17 months* $n=20$
	Mean *(SD)*	Mean *(SD)*
Reinforcement		
% TL	62.46* *(8.82)*	69.57* *(7.54)*
% LL	61.74**(8.94)*	68.94* *(7.72)*
Exposure		
% TL	63.49* *(8.6)*	61.24* *(8.53)*
% LL	63.32**(7.79)*	60.07* *(9.35)*

A set of one-sample *t* tests was performed for each looking measure; this compared infants' scores in each age group and condition to a chance level of 50%. Infants in all age groups and conditions performed at significantly above-chance levels on these familiar test trials: for the TL measure in the Reinforcement Condition, 13-month-olds' $t(10)=4.68$, $p<.05$, and 17-month-olds' $t(9)=8.21$, $p<.05$; in the Exposure Condition, 13-month-olds' $t(10)=5.21$, $p<.05$, and 17-month-olds' $t(9)=4.17$, $p<.05$. On the

LL measure in the Reinforcement Condition, 13-month-olds' $t(10)=5.74$, $p<.05$, and 17-month-olds' $t(9)=7.76$, $p<.05$; and in the Exposure Condition, 13-month-olds' $t(10)=4.35$, $p<.05$, and 17-month-olds' $t(9)=5.74$, $p<.05$.

A 2 x 2 (condition x age) ANOVA compared results from the familiar objects test trials for listener behaviour for the primary total looking measure. There was no main effect of condition [$F(1, 38) = 1.97$, $p>.05$], or of age group [$F(1, 38)=.87$, $p>.05$], although there was a marginally significant interaction between the two factors [$F(1, 38)=3.25$, $p=.079$].

Individual results supported the group finding of above-chance looking to familiar target objects in all conditions (and see individual scores in Appendix G). Infants who looked towards familiar target objects for 55% or more of the time were in the majority in both age groups and conditions. In the Reinforcement Condition, 10/11 of the younger infants and 10/10 of the older infants spent more than 55% of the trial time looking towards the target as opposed to the distracter object, as did 11/11 of the younger infants and 8/10 of the older infants in the Exposure Condition.

It is clear from these results that infants in both age groups and both conditions responded appropriately to the preferential looking task used in this experiment by looking significantly longer at the familiar target objects that corresponded with the familiar labels presented.

Familiar Objects Preference Control Trials with the Looking Measure.

Preference control trials for familiar objects determined whether infants in each group and condition showed systematic object or side preferences in their total looking patterns.

Object preferences. Trials testing for familiar object preferences were not analysed statistically. This was because the familiar object pairing used varied from infant to infant; in addition, infants were easily distracted in these trials, especially younger infants. Eight infants were excluded from the analysis of preferential looking trials because they did not look towards either object for more than a second on one of the trials.

Table 6.4 shows mean proportional total looking towards the first object in each of the presented list of pairs, as opposed to the second. In all groups, the majority of infants were tested with the shoe-cup pairing.

Table 6.4. Mean percentage total looking towards the first, as opposed to the second, object in each pairing during preference trials in Reinforcement and Exposure Conditions, and at 13 and 17 months.

	13 months	*17 months*
	Mean % TL (n)	Mean % TL (n)
Reinforcement		
Shoe-cup	**50.58** (n=4)	**51.58** (n=9)
Banana-cup	65.88 (n=1)	_
Shoe-bottle	44.18 (n=3)	_
Exposure		
Shoe-cup	**51.93** (n=5)	**56.16** (n=7)
Shoe-banana	63.34 (n=2)	79.61 (n=2)
Shoe-bottle	83.83 (n=1)	_

Although looking to the shoe in the shoe-cup pairing appears to be close to chance levels, the above data show variable preferences towards familiar objects in some of the other pairings in both age groups and both conditions. This validates the use of counterbalanced test trials in the current experiment, in which objects were presented to each infant an equal number of times to the left and to the right in order that any preferences for specific objects could be taken into account.

Side preferences. Proportional looking to the right, as opposed to the left, in preference control trials was calculated using the following formula:

$$\frac{\textit{Total duration of looking to right}}{\textit{(Total duration looking to right + total duration looking to left)}} \times 100$$

If infants preferred to look to the right, their TL scores should have been above 50%. Table 6.5 shows proportional total looking to the right in each age group and condition.

Table 6.5. Percentage group means and standard deviations for 13- and 17-month-old infants' preferential looking towards the right in Reinforcement and Exposure Conditions.

	13 months	*17 months*
	Mean *(SD)*	Mean *(SD)*
Reinforcement	*n*=8	*n*=9
% TL	55.66 *(15.79)*	47.83 *(11.46)*
Exposure	*n*=8	*n*=9
% TL	47.17 *(16.57)*	64.18 *(20.81)*

There was, again, variable performance in looking towards the right in familiar objects preference control trials, with two of the four groups showing mean scores above the 50%, and the other two groups showing mean scores of just below 50%. One-sample *t* tests showed that total looking towards the right side of presentation did not differ significantly from chance levels of 50% for any group [in the Reinforcement Condition, 13-month-olds' $t(7)=.95$, $p>.05$, and 17-month-olds' $t(8)=-.569$, $p>.05$; and in the Exposure Condition, 13-month-olds' $t(7)=.483$, $p>.05$, and 17-month-olds' $t(8)=2.04$, $p>.05$], although the scores of 17-month-olds in the Exposure Condition were marginally significant [$p=.075$].

Overall, variable object and side preferences support the use, in the current experiment, of counterbalancing measures—these ensured that each novel object was presented to the infant an equal number of times to the left and to the right.

Preferential Reaching Trials

Table 6.6 presents group means for infants' preferential reaching to familiar target objects.

Table 6.6. Group means for 13- and 17-month-old infants' preferential reaching towards familiar target objects in Reinforcement and Exposure Conditions. Means are expressed as tallied scores, and as percentages. Means marked with a * are significant at $p<.05$.

	13 months $n=22$	*17 months* $n=20$
	Mean *(SD)*	Mean *(SD)*
Reinforcement		
Mean score/4	2.64* *(0.92)*	3.0* *(0.82)*
Mean as a %	66	75
Exposure		
Mean score /4	2.0 *(1.04)*	2.7* *(0.82)*
Mean as a %	50	67.5

One-sample *t* tests compared reaching towards familiar target objects to a chance level of two correct over four trials for each age group and condition. Scores were significant for both age groups in the Reinforcement Condition [at 13 months $t(10)=2.28$, $p<.05$; at 17 months $t(9)=3.87$, $p<.05$], but only for the older age group in the Exposure Condition [at 13 months, $t(10)=.00$, $p>.05$; at 17 months, $t(9)=2.69$, $p<.05$].

Additional tests were carried out using the generalised linear model with binomially distributed errors. The results of these tests confirmed those of the earlier t tests [Reinforcement Condition: 13 months $t(10)=2.07$, $p<.05$; 17 months $t(9)=3.01$, $p<.05$; Exposure Condition: 13 months $t(10)=.00$, $p>.05$; 17 months $t(9)=2.17$, $p<.05$].

A 2 x 2 (condition x age) analysis of deviance with binomial errors was conducted to check for differences between conditions and age groups in test trials with familiar target objects. There was no effect of age [chi-square(1)=3.25, $p>.05$], or condition [chi-square(1)=2.65, $p>.05$], nor was there an interaction effect [chi-square(1)=.20, $p>.05$].

Individual reaching results with familiar target objects reflected the group results. Figure 6.1 shows the number of infants in each age group and condition who scored 0, 1, 2, 3, or 4 out of 4.

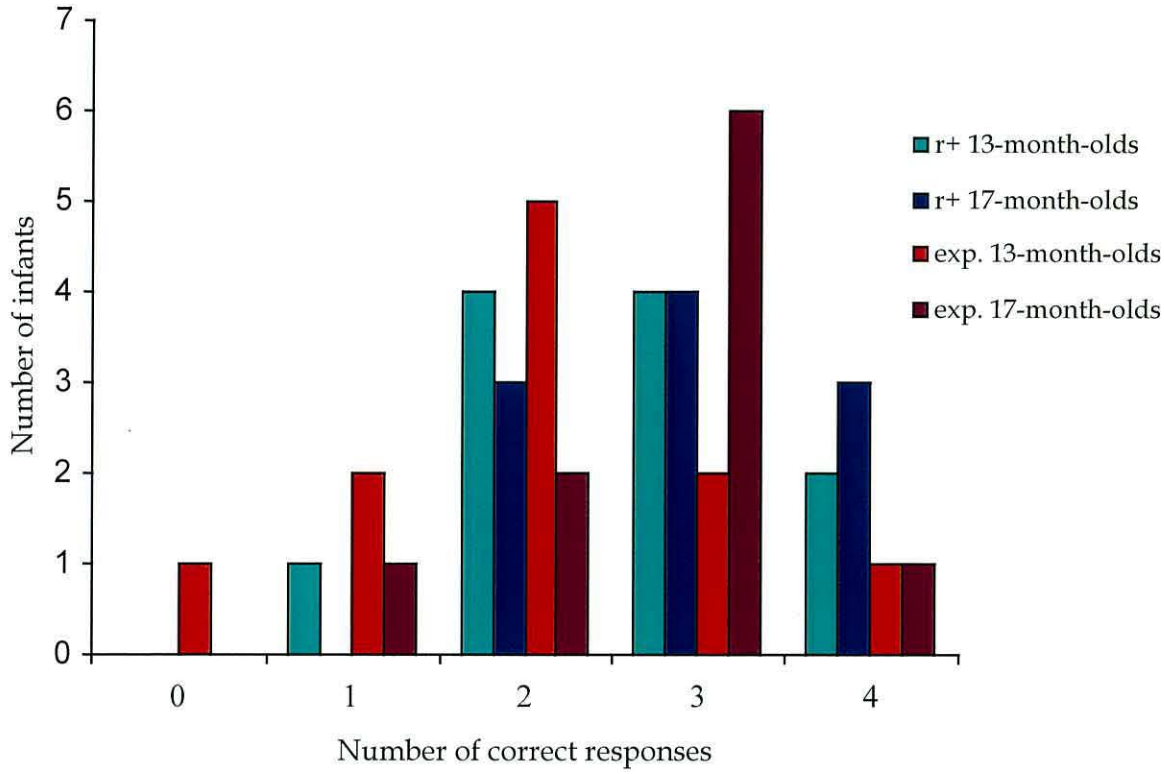

Figure 6.1. The number of infants at 13 and 17 months in Reinforcement (r+) and Exposure (exp.) Conditions who scored 0, 1, 2, 3, or 4 on the preferential reaching task with familiar target objects. N.B. n=11 in each condition for 13-month-olds, and n=10 in each condition for 17-month-olds.

Overall, preferential reaching results with familiar target objects validate the measure with all groups apart from the 13-month-olds in the Exposure Condition, who performed at only a chance level.

Familiar Objects Preference Control Trials with the Reaching Measure

In preference control trials, infants were presented with both familiar objects and asked, "Can you get one?" Two trials were conducted, so that each familiar object was presented once on the left and once on the right. Three infants failed to respond on one of these trials: their results were excluded from the data that follow. Because numbers of trials were low in reaching preference trials, no statistical analyses were performed; the data that follow are descriptive.

Object preferences. Because, in these trials, familiar object pairs varied from infant to infant (so that one infant could have been presented with the shoe-cup pairing, and another with the banana-shoe pairing), reaching to each object was tallied for each of the familiar object pairs used. Table 6.7 shows total reaching tallies for each familiar object pair used. In all groups, the shoe-cup pair was most frequently used; these tallies are presented in bold.

Table 6.7. Tallied reaching in preference control trials towards first and second object in each familiar object pair used: *n* indicates the number of infants in each group for whom this pair was used. N.B. trials in which infants reached towards both objects simultaneously are excluded from these tallies.

	13 months			*17 months*		
	Tally 1st object in pair	Tally 2nd object in pair		Tally 1st object in pair	Tally 2nd object in pair	
Reinforcement						
Shoe-cup	**3**	**7**	**(*n*=5)**	**7**	**7**	**(*n*=9)**
Banana-cup	1	0	(*n*=1)	–	–	
Shoe-bottle	3	4	(*n*=3)	–	–	
Banana-bottle	1	1	(*n*=1)	–	–	
Exposure						
Shoe-cup	**5**	**6**	**(*n*=7)**	**6**	**8**	**(*n*=7)**
Shoe-banana	0	4	(*n*=2)	0	4	(*n*=2)
Shoe-bottle	0	2	(*n*=1)	–	–	
Banana-bottle	0	2	(*n*=1)	–	–	

The above tallied scores show some variability in infants' object preferences. Apart from the 13-month-olds in the Reinforcement Condition, infants reached towards shoe and cup at close to equal rates;

but the number of infants assigned to each familiar object pair was too low for a statistical analysis to be performed.

Side preferences. Reaching to the left or the right was tallied for all infants in preference trials, with the totals presented in Table 6.8

Table 6.8. Total number of reaches to left and right for all age groups and conditions in familiar objects preference trials with the reaching measure. N.B. trials in which infants reached towards both objects simultaneously are excluded from these tallies.

	13 months			*17 months*		
	Total reaches to right	Total reaches to left		Total reaches to right	Total reaches to left	
Reinforcement condition	10	10	(*n*=10)	9	4	(*n*=9)
Exposure condition	10	7	(*n*=11)	11	7	(*n*=9)

These results show that, in three out of four groups, there is a trend towards reaching to the right as opposed to the left in familiar objects preference trials. Over all four groups, 40/68 reaches (or 58.82% of reaches) were to the right in these trials.

Overall, the results of familiar objects preference trials with the reaching measure show a trend towards a right-side preference, and variability in object preferences. This supports the usefulness of the counterbalancing measures employed in the current experiment, which compensate for infants' potential object- and side-preferences.

Did Infants Attend to Novel Target Objects During Training?

The proportion of time that infants spent looking at the novel target objects during training trials was high. In this experiment (unlike in Experiments 1 and 2), both novel objects were presented to the infant in training trials. A proportional total looking measure (TL) was calculated; this compared the amount of time spent looking to the target object as opposed to the distracter object. It used formula 3 described in Chapter 3 (p. 143).

Table 6.9 shows percentage TL to novel target objects during training trials in each age group and condition.

Table 6.9. Percentage group means and standard deviations for 13- and 17-month-old infants total looking to novel target objects during training trials in Reinforcement and Exposure Conditions..

	13 months n=22	*17 months* n=20
Reinforcement	95.49* *(3.35)*	96.65* *(1.51)*
Exposure	95.59* *(3.26)*	91.56* *(6.13)*

One-sample t tests compared total looking to target to a chance level of 50%, and confirmed that infants in all groups looked appropriately towards the target object in training trials [in the Reinforcement Condition at 13 months $t(10) = 45.05, p<.05$, and at 17 months $t(9) = 97.12$,

$p<.05$; in the Exposure Condition at 13 months $t(10)=46.44$, $p<.05$, and at 17 months $t(9) = 21.44$, $p<.05$].

Within each condition, 13- and 17-month-old infants' looking to target during training trials was compared. Age groups showed no significant difference in the Reinforcement Condition: $t(14.23)=.008$, $p>.05$, and a marginally significant difference in the Exposure Condition $t(13.41)=-1.86$, $p=.086$, with younger infants showing a trend towards longer looking than older infants.

Inspection of individual data shows that variability in infants' looking to novel target objects during training trials was low: all infants showed mean proportional total looking scores of between 81% and 100% on these trials (see Appendix G for individual scores).

These results demonstrate that infants in all age groups and conditions attended to novel target objects during training trials.

Did Infants Learn Novel Object Labels after Reinforcement or Exposure Training?

Preferential Looking Trials

Proportional looking to target was calculated for novel objects trials as described in Chapter 3, and compared to a chance level of 50% for total looking and longest look measures. Group means for each age group and condition are presented in Table 6.9, below.

Table 6.9. Percentage group means and standard deviations for 13- and 17-month-old infants' preferential looking towards novel target objects in Reinforcement and Exposure Conditions. Means marked with a * are statistically significant at $p<.05$.

	13 months n=22	*17 months* n=20
	Mean *(SD)*	Mean *(SD)*
Reinforcement		
% TL	61.77* *(10.55)*	59.98* *(5.34)*
% LL	59.61* *(10.64)*	58.34* *(6.93)*
Exposure		
% TL	50.04 *(13.55)*	50.74 *(11.92)*
% LL	50.15 *(13.35)*	50.12 *(12.00)*

One-sample t tests for the Reinforcement Condition showed significant results for both age groups [for the TL measure at 13 months, $t(10)=3.71$, $p<.05$, and at 17 months, $t(9)=5.91$, $p<.05$; for the LL measure at 13 months, $t(10)=3.00$, $p<.05$; and at 17 months, $t(10)=3.8$, $p<.05$], indicating that these infants showed listener behaviour, via preferential looking, to novel object labels after the 10 reinforcement trials presented in this experiment.

In the Exposure Condition, neither age group performed at above-chance levels [for the TL measure at 13 months, $t(10)=.363$. $p>.05$, and at 17 months, $t(9)=.557$, $p>.05$; for the LL measure at 13 months, $t(10)=.04$, $p>.05$; and at 17 months $t(9)=.04$, $p>.05$], demonstrating that infants in this condition did not learn listener behaviour to novel label-object relations.

A 2 x 2 (age x condition) ANOVA compared TL results on the novel objects test for listener behaviour in different age groups and conditions. There was no interaction between factors, $F(1, 38)=.43$, $p>.05$, and no effect of age on performance, $F(1, 38)=.028$, $p>.05$. There was a significant effect of condition, $F(1, 38)=9.78$, $p<.05$. *Post hoc* independent samples *t* tests showed that Reinforcement and Exposure Conditions differed for both age groups [at 17 months, $t(18)=2.23$, $p<.05$; and at 13 months, $t(20)=2.72$, $p<.05$].

Overall, these results suggest that infants in the Reinforcement Condition —but not the Exposure Condition—had learned at least one of the two novel listener relations presented in this experiment.

It is possible that infants who scored poorly on familiar or training trials did not learn to follow experimental cues, with the result that they performed poorly on the listener test with novel targets. These infants' scores might have skewed the results of the Exposure Condition. Therefore, infants' scores on novel objects tests for listener behaviour were excluded from the analysis where they had scored less than 50% on the familiar objects test for listener behaviour, but this applied to only one infant in the Exposure Condition (in the 17-month-old group), and when a one-sample *t* test was performed again for this group, results still failed to reach significance [$M=52.1$, $SD=11.81$, $t(8)=.533$, $p>.05$].

One 13-month-old infant in the Exposure Condition looked towards novel target objects in test trials at only 15.4% (see Appendix G, table G4); this score was a great deal below the scores of other infants in this condition. It is possible that this infant's results skewed the group mean away from significance. For this reason, a further *t* test was conducted for novel objects test trials, in which this infant's score was excluded. Although the group mean increased when this infant's score was removed (M=53.51, SD=7.57), the group's results did not reach significance [$t(9)$=1.46, p=.177).

Again, inspection of individual data reflected the group results (see Appendix G for individual scores). In the Reinforcement condition, 9/11 of the 13-month-olds and 7/10 of the 17-month-olds scored at least 55% on the total looking measure, whereas in the Exposure Condition, only 4/11 of the 13-month-olds and 5/10 of the 17-month-olds scored at least 55% on the same measure.

Novel Objects Preference Control Trials with the Looking Measure

Two possible preferences were examined: for one object over the other, and for one side over the other. There were only two preference control trials, and eleven infants failed to respond on one of them. These infants' results were dropped from the following analyses (the number of infants remaining in each condition is given in Table 6.10).

Object preferences. In order to analyse potential object preferences, the total amount of time that infants spent looking to Object 1, as opposed to Object 2, was calculated. This proportional total looking measure was compared to a chance score of 50% for each age group and condition. Table 6.10 shows group means for looking towards Object 1 during preference trials.

Table 6.10. Percentage group means and standard deviations for 13- and 17-month-old infants' preferential looking towards Object 1 in Reinforcement and Exposure Conditions.

	13 months	*17 months*
	Mean *(SD)*	Mean *(SD)*
Reinforcement	*n*=7	*n*=8
% TL	48.82 *(15.48)*	54.68 *(9.55)*
Exposure	*n*=8	*n*=8
% TL	40.39 *(14.91)*	46.29 *(14.59)*

Infants' looking to Object 1 during preference trials was compared to a chance level of 50%. No group looked significantly longer than chance towards Object 1, although the results of 13-month-olds in the Exposure Condition were marginally significant [In the Reinforcement Condition, 13-month-olds $t(7)=-.22$, $p>.05$, and 17-month-olds $t(7)=1.39$, $p>.05$; in the Exposure Condition, $t(8)=-1.93$, $p=.089$, and 17-month-olds $t(7)=-.72$, $p>.05$].

Side preferences. Potential side preferences were analysed by taking infants' TL scores for looks to the right (as opposed to the left) in each preference trial. These scores were compared to a chance level of 50% for each of the four groups. Table 6.11 shows group means for infant's right-side preference.

Table 6.11. Percentage group means and standard deviations for 13- and 17-month-old infants' preferential looking towards the right in Reinforcement and Exposure Conditions.

	13 months	*17 months*
	Mean *(SD)*	Mean *(SD)*
Reinforcement	*n*=7	*n*=8
% TL	51.69 *(14.12)*	53.29 *(14.32)*
Exposure	*n*=8	*n*=8
% TL	53.99 *(17.18)*	72.61 *(21.44)*

Each of the four groups showed a trend towards a right side-preference, but the scores within each group were variable; neither of the groups showed significant above-chance performance in the Reinforcement Condition [at 13 months, $t(6)=.32$, $p>.05$, and at 17 months, $t(7)=.65$, $p>.05$]. In the Exposure Condition, infants' biased looking towards the right side of presentation was significantly above-chance for 17-month-olds [$t(7)=2.08$, $p<.05$], but not for 13-month-olds [$t(7)=.63$, $p>.05$].

Overall, the majority of the groups showed no significant object or side preferences with novel objects, but the right-side preference of one of the groups validates the use of counterbalancing measures in this experiment.

Preferential Reaching Trials

In preferential reaching trials with novel objects, mean scores for all groups were close to a chance performance of two correct reaches over four trials, except for 17-month-olds in the Reinforcement Condition, whose mean reaching to target reached 60%. Group means for infants' preferential reaching to novel target objects are presented in Table 6.12.

Table 6.12. Group means for 13- and 17-month-old infants' preferential reaching towards novel target objects in Reinforcement and Exposure Conditions. Means are expressed as tallied scores, and as percentages.

	13 months n=22	*17 months* n=20
	Mean *(SD)*	Mean *(SD)*
Reinforcement		
Mean score/4	1.91 *(0.83)*	2.4 *(0.97)*
Mean as a %	47.75	60
Exposure		
Mean score /4	2.09 *(0.79)*	2.1 *(0.56)*
Mean as a %	52.25	52.5

One-sample t tests compared reaching towards novel targets to a chance level of two correct over four trials for both age groups and conditions, none of which proved significant. [in the Reinforcement Condition at 13 months, $t(10)$ =.363, p>.05, and at 17 months, $t(9)$=1.31, p>.05; in the Exposure Condition at 13 months, $t(10)$=.557, p>.05, and at 17 months, $t(9)$=.363, p>.05]. These results were supported by tests using the generalised linear model with binomially distributed errors [in the Reinforcement Condition at 13 months, $t(10)=.302$, $p>.05$, and at 17 months, $t(9)=1.26$, $p>.05$; in the Exposure Condition at 13 months, $t(10)=.30$, $p>.05$, and at 17 months, $t(9)=.317$, $p>.05$].

A 2 x 2 (age x condition) analysis of deviance with binomial errors revealed no significant differences between age groups or conditions. There was no main effect of age [chi-square(1)=.66, $p>.05$], or of condition [chi-square(1)=.02, $p>.05$], and no interaction between age and condition [chi-square(1)=.62, $p>.05$].

Individual results were poor for preferential reaching to novel targets, as presented in Figure 6.2. For all four groups, the modal score was 2 — equal to a chance performance of 50%.

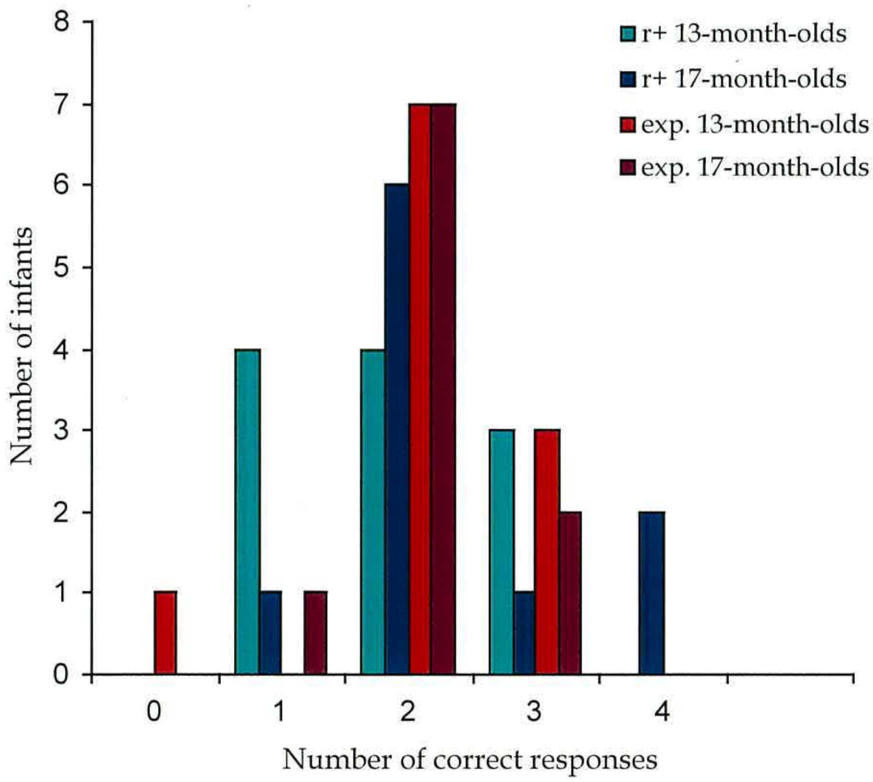

Figure 6.2. The number of 13- and 17-month-old infants in Reinforcement (r+) and Exposure (exp.) Conditions, who scored 0, 1, 2, 3, or 4 on the preferential reaching task with novel target objects. N.B. n=11 for 13-month-olds, and n=10 for 17-month-olds.

Overall, infants in none of the four groups showed evidence of having learned novel listener relations on the preferential reaching task.

It is possible that infants who scored poorly on familiar trials did not learn to follow experimental cues, and therefore performed poorly on the listener test with novel targets. These infants' scores may have skewed the results for all four groups on the reaching task, leading to the poor results.

In order to investigate this possibility, where infants scored two or less on the reaching task with familiar objects, their scores on the novel objects reaching task were removed. Because many infants' scores were excluded in some groups, statistical analysis was not performed on these revised data. The following results are descriptive.

The resulting mean scores for reaching to novel targets differed only slightly from the whole group means reported in Table 6.12. For 13-month-olds in the Reinforcement Condition, five infants' scores were excluded, leaving a total of six, with a mean score of 2.17 (SD = 0.75); this slightly higher than the whole group mean of 1.9. Three 17-month-olds' scores were excluded in the Reinforcement Condition, leaving seven infants; their mean score was 2.29 (*SD*=0.95); this is lower than the whole group mean. In the Exposure Condition, eight 13-month-olds had to be excluded from the analysis because their scores in the familiar objects reaching task were two or below. The mean score of the three remaining infants was 2.33 (*SD*=0.58); this is slightly higher than the original group mean. For 17-month-olds in the Exposure Condition, three infants' scores were excluded. The mean of the remaining seven infants' scores on the novel reaching task was 2.14 (*SD*=0.69); again this is almost identical to the whole group's original mean performance. It is therefore unlikely that the poor results on the novel reaching task arose only from the infants' inability to respond appropriately to task instructions: because those infants who did well on the familiar objects test did poorly on the novel objects test.

Novel Objects Preference Control Trials with the Reaching Measure

In preference control trials, infants were presented with both novel objects and asked, "Can you get one?" Two trials were conducted, such that each novel object was presented once on the left and once on the right. Five infants failed to respond on one of these trials: they are excluded from the data that follow. Because only two reaching preference trials were conducted per infant, no statistical analyses were performed; the data that follow are descriptive only.

Object preferences. Table 6.13 shows the total tally of reaches to Object 1 and to Object 2 in novel objects preference control trials for all age groups and conditions. There was a trend in biased reaching towards Object 1 in three out of the four groups: overall, 38/65 (58.46%) of reaches were to this novel object.

Table 6.12. Total number of reaches to Object 1 and Object 2 for all age groups and conditions in novel objects preference trials with the reaching measure. N.B. trials in which infants reached towards both objects simultaneously are excluded from these tallies.

	13 months		*17 months*	
	Total reaches to Object 1	Total reaches to Object 2	Total reaches to Object 1	Total reaches to Object 2
Reinforcement condition	11	8 (*n*=10)	8	4 (*n*=8)
Exposure condition	10	10 (*n*=11)	9	5 (*n*=8)

Side preferences. Table 6.14 shows the tally of reaches to the right and to the left in novel objects preference control trials for all age groups and conditions. Overall, reaching is balanced between the right and the left: 33/66 (or 50%) of reaches were towards the right.

Table 6.13. Total number of reaches to the right and the left for all age groups and conditions in novel objects preference trials with the reaching measure. N.B. trials in which infants reached towards both objects simultaneously are excluded from these tallies.

	13 months			*17 months*		
	Total reaches to right	Total reaches to left		Total reaches to right	Total reaches to left	
Reinforcement condition	10	9	(n=10)	8	4	(n=8)
Exposure Condition	8	10	(n=11)	7	7	(n=8)

In general, novel objects preference control trials with the reaching measure showed balanced side preferences, but possible bias in object preferences. This, again, supports the use of counterbalanced sets of test trials in the current experiment, in which both objects were presented an equal number of times to the left and right of the infant.

Is there a Relationship between Infants' Verbal Repertoire and their Label Learning?

BCDI Scores

In each condition, infants' scores on the BCDI were correlated with total looking to novel target objects; this was to determine whether there was a relationship between verbal repertoire for both age groups combined, and label-learning performance. Two Pearson's product-moment correlations were performed in each condition, one using the BCDI measure of the number of words understood by each infant, and the second using the BCDI measure of the number of words produced by each infant. Four BCDI questionnaires were not returned by parents; these infants' scores were omitted from analyses.

No significant correlation was found, in either condition, between BCDI comprehension and production measures and total looking to novel target objects. [In the Reinforcement Condition using the production measure, r=.08, n=18, p>.05, and using the comprehension measure, r=.07, n=18, p>.05. In the Exposure Condition using the production measure, r=.23, n=19, p>.05, and using the comprehension measure, r=.0005, n=19, p>.05].

Within-session Label Production

Producers and *non-producers* were identified in the same way as in Experiments 1 and 2, by tallying the number of approximations each infant made to novel object labels during object handling periods, novel objects training and test trials, and the word production test. Again, the occurrence of infant vocal approximations to novel object labels was rare. Only 7 infants could be classified as *producers* (3 infants in the Reinforcement Condition, all from the older age group, and 4 infants in the Exposure Condition, 1 from the older age group, and 3 from the younger age group). The mean total looking score for infants in the Reinforcement Condition on the novel objects test for listener behaviour was 62.6%, similar to overall group mean for infants in the Reinforcement

Condition. The mean total looking score for infants in the Exposure Condition on the novel objects test for listener behaviour was 52.31%, again, similar to the overall group mean for infants in the Exposure Condition. The number of producers was too low for any meaningful statistical analysis to be performed.

Is there a Relationship between Infants' Looking to Target during Training and their Label Learning?

The proportion of looking to target during the period when each novel object is paired with its label might be predictive of success on listener test trials, regardless of age group. Infants who look longer to target might learn labels more quickly.

The use of Pearson's product-moment correlations aimed to find a relationship between total looking to target during training and total looking to target during listener test trials with novel objects in each condition. No significant correlations were found [In the Reinforcement Condition, r=.05, n=21, p>.05, and in the Exposure Condition, r=.24, n=21 p>.05].

Were there Differences between English- and Welsh-hearing Infants?

In the current experiment, data from preferential looking and reaching measures suggest that the performance of English- and Welsh-hearing infants did not differ.

Preferential Looking

Table 6.14 shows mean proportional total looking to target for English and Welsh-hearing infants in each condition.

Table 6.14. Percentage group means for English and Welsh-hearing infants' proportional total looking to target in Familiar, Training and Novel objects phases.

Trial type	*Language*	Reinforcement Condition *English n=14* *Welsh n=7*	Exposure condition *English n=12* *Welsh n=9*
% TL Familiar	English	64.73 *(9.38)*	61.94 *(10.2)*
	Welsh	67.3 *(7.75)*	62.79 *(5.87)*
% TL Training	English	94.43 *(2.65)*	92.44 *(5.78).*
	Welsh	97.71 *(2.58)*	94.72 *(4.29)*
% TL Novel	English	62.07 *(8.92)*	49.33 *(9.58)*
	Welsh	58.60 *(7.12)*	51.77 *(16.1)*

English- and Welsh-hearing infants' scores were similar in all phases of the experiment for the preferential looking measure. For each condition, a 2 x 3 (language group x trial type) ANOVA was performed, to compare the scores of English- and Welsh-hearing participants on the primary familiar, training, and novel total looking measures.

In both Reinforcement and Exposure Conditions, there was no significant effect of language group [Reinforcement: $F(1, 37)=0.48$, $p>.05$, Exposure:

$F(1, 37)=0.31$, $p>.05$]. There was, as expected, a significant difference between trial types [Reinforcement: $F(2, 37)=132.87$, $p<.05$, Exposure: $F(2, 37)=116.52$, $p<.05$]; the effects of each trial type have been explored in earlier sections. There was no significant interaction between language group and trial type [Reinforcement: $F(2, 37)=1.11$, $p>.05$, Exposure: $F(2, 37)=.10$, $p>.05$].

Preferential Reaching

Table 6.15. Group means and standard deviations for English- and Welsh-hearing infants' reaching to familiar and novel target objects in Reinforcement and Exposure Conditions.

Trial type	Language	Reinforcement Condition *English n=14* *Welsh n=7*	Exposure Condition *English n=12* *Welsh n=9*
Familiar	English	2.64 *(0.84)*	2.17 *(1.11)*
	Welsh	3.14 *(0.90)*	2.78 *(0.88)*
Novel	English	2.14 *(0.86)*	2.08 *(0.79)*
	Welsh	1.86 *(1.06)*	2.11 *(0.60)*

English- and Welsh-hearing infants' scores were also similar in preferential reaching tests with familiar and novel target objects, although on familiar objects trials in the Exposure Condition, the scores of English-hearing infants are close to a chance level of 2.

The effects of language group on reaching scores in novel and familiar objects test trials were analysed using two 2 x 2 (language group x trial type) analyses of deviance, one for each condition.

In the Reinforcement Condition, there was no effect of language group [chi-square(1)=0.64, *p*>.05], a significant effect of trial type [chi-square(1)=4.98, *p*>.05], and no interaction between age group and trial type [chi-square(1)=0.82, *p*>.05]. In the Exposure Condition there was, again, no effect of language group [chi-square(1)=0.60, *p*>.05], but nor was there a significant effect of trial type [chi-square (1)=0.45, *p*>.05]; this can be explained through the lack of above-chance performance by the younger infants in the Exposure Condition in familiar objects test trials for listener behaviour. Again, there was no significant interaction between language group and trial type [chi-square (1)=0.35, *p*>.05]

Discussion

Looking and Reaching Measures

Preferential Looking

In this experiment, infants in the Reinforcement and Exposure Conditions showed above-chance preferential looking to familiar target objects. Preferential looking to familiar target objects, as expected, increased in the current experiment. In Experiments 1 and 2, the cup and the shoe were used as familiar objects with all but one of the infants, and mean performance was between 55% and 63%; this was above-chance in all cases, but the effect size was small. In the current experiment, parents selected the two objects, from a set of five, whose labels their infants understood best; performance on the familiar objects test for listener behaviour was between 66% and 75% over all age groups and conditions. This showed that, for object-labels with which they had a learning history, infants responded to instructions in the preferential looking task—this by looking proportionally more towards a target object, when it was labelled by the experimenter, than towards a distracter object.

Infants in all four groups also showed above-chance preferential looking to novel target objects during training. Performance, for all infants, ranged between 81% and 100% proportional looking towards the target object as opposed to the distracter object. This showed that all infants followed the multiple cues of eye gaze, pointing, and salience lights to look towards the target object during training trials.

Despite success in the familiar objects test trials and novel objects training trials, only infants in the Reinforcement Condition showed above-chance preferential looking towards novel target objects in test trials, indicating that they had learned listener behaviour to at least one of the novel object-labels.

In this experiment, there were eight testing trials for each infant with the preferential looking measure, so the reliability of the obtained data was high. The 13- and 17-month-olds in the Reinforcement Condition showed preferential looking to novel target objects at levels of around 60%, whereas, in the Exposure Condition, this score was close to a chance level of 50% for infants in both age groups.

These results suggest that reinforcement contingent upon appropriate looking towards a target object given its spoken label is more effective than exposure to the label-object relation in training listener relations to normally developing infants below the age of 18 months. The results are in line with behaviour-analytic and psycholinguistic research on the role of reinforcement and feedback in the development of verbal behaviour (see Chapter 1).

Infants failed to learn novel listener relations in the Exposure Condition despite the switch, in this experiment, from a massed style of presenting novel object labels as used in Experiments 1 and 2 (in which infants were presented with six spoken labels for a single novel object within the space of ten seconds), to a distributed schedule of presentation (in which infants were presented with one label for a novel object per trial, with around 10 seconds between labelling trials). If, as research suggests, distributed learning is more rapid than massed learning, in this experiment the number of exposures was still not enough to enable novel listener relation learning in infants below the age of 18 months.

Preferential Reaching

The preferential reaching measure showed a different pattern of results from preferential looking.

In three out of the four groups, infants exhibited above-chance reaching to familiar target objects, indicating that they could respond appropriately to the demands of the reaching task. It was less clear, for the reaching measure, whether infants' performance was improved by asking parents to select the two familiar objects whose labels they thought their infant knew best. In Experiment 1, both age groups showed successful performance on the familiar objects reaching task, at 66-72%. In Experiment 2, both age groups showed only marginally significant reaching to familiar targets. In the current study, three of the four groups showed significant reaching towards familiar target objects, at between 66% and 75% (slightly better than in Experiments 1 and 2), but 13-month-olds showed only a chance mean performance of 50% reaching to target: most infants in this group selected two correct target objects over four trials.

Because the failure of 13-month-old infants in the Exposure Condition to reach to familiar target objects might mean that they did not learn to respond appropriately to the task instructions, their failure to also reach to novel target objects may not have arisen from a lack of novel listener relation learning; it may have arisen instead from a failure to learn appropriate responding in the reaching task. In the three other groups, however, infants succeeded in reaching towards familiar target objects at above-chance levels, yet none of them showed above-chance performance on preferential reaching listener test trials with novel target objects.

One explanation for the disparity between looking and reaching results, as suggested in Chapter 5, is that the reaching measure is less sensitive to the beginnings of listener relation learning than the looking measure. The looking task allows for a graded response on each trial; on the reaching task, by contrast, it is possible for the direction of the infant's reach to be only correct or incorrect in each trial. Further discussion of this difference between looking and reaching measures is in the General Discussion (Chapter 7).

In the behaviour-analytic literature, most studies that used reinforcement to teach novel listener relations to infants (e.g. Bell, 1999) used a preferential reaching measure (or matching-to-sample) to test for the development of listener relations, in which participants had to point to or pick up the object that corresponded to a spoken label in order for reinforcers to be presented. These studies demonstrate the effectiveness of reinforcement in training novel listener relations. They do not show rapid listener relation learning, as exhibited in the current study, in which infants below the age of 18 months learn novel listener relations after up to 10 training trials.

This difference between earlier behaviour-analytic research and the current study is probably caused by two factors. First, earlier research used a reaching measure rather than the more sensitive looking measure; second, earlier research required for its completion that infants learn each of two or more object labels. In the current study, infants need not have learned both labels to show above-chance responding on the preferential looking task; instead, some learning of at least one label is all that was required.

Preference Control Trials

Contrary to predictions, more infants failed to respond in the preference control trials of the current experiment (in which presentation of the novel objects was accompanied by a general verbal instruction from the experimenter to "look at these"), than in those of Experiments 1 and 2 (in which both novel objects were presented, accompanied by the label *dut*; this label had not been presented with either object in training trials). One explanation for these results is founded in Baldwin and Markman's (1989) finding that presenting infants with verbal labels increases their attention to objects in that context. Perhaps in preference control trials without labels (in the current experiment) infants' attention to the novel objects decreased; this may have led to many more trials being excluded from the analyses.

Effects of Age, Verbal Repertoire, and Looking to Target during Training

In the present experiment, as in Experiments 1 and 2, there was, again, no difference between age groups on listener behaviour test trials, and no relation between productive and receptive verbal repertoire or the proportion of time spent looking towards the target object during training trials, and scores on novel objects tests for listener behaviour.

These results go against expectations that older infants, who have greater word learning experience, are able to put this experience to use in learning novel labels—this expected age effect has been found in none of the experiments in this thesis. One explanation for this is that 12- to 18-month-old infants learn new listener relations at similar rates, and that a

"spurt" in listener learning occurs before most infants reach the age of 12 months. This is the view advocated by Woodward et al. (1994).
An alternative explanation, as discussed in Chapter 2, is that other factors, such as verbal repertoire, or the proportion of time spent looking to the novel target object during training trials, is of equal importance to age in determining which infants are more successful or less successful in the listener behaviour task with novel objects.

Nonetheless, the current experiment, like Experiment 2, showed no relation between measures of verbal repertoire and listener relation learning, or between the proportion of time infants spent looking to target during training trials and listener relation learning.

It is possible that the BCDI does not present an accurate picture of infants' verbal abilities. It is a lengthy questionnaire, and it is possible that parents who devoted greater time and attention to completing it might have produced a longer list of words comprehended and spoken by their infants, than did those who devoted less energy to this task. Therefore the primary measure of infant verbal skill used in this experiment may not have provided a good correlate with task performance.

It was unfortunate that, as in Experiments 1 and 2, few infants produced vocal approximations to the novel object-labels within the experimental

sessions. This made it impossible to carry out planned analyses on the effects of infants' label production on their label comprehension.
In training trials, all infants spent a high proportion of trial time looking towards the target object (all infants scored between 80 and 100% proportional total looking to target). Perhaps individual variation here was too low to have any correlation with task performance.

Another perspective on the lack of an effect of age on task performance is that the preferential looking measure used in the current experiment detects the very earliest stages in infants' learning of novel listener relations. It is possible that older and younger infants diverge in the later stages of learning a novel listener relation: for example, older infants might be quicker to put their learning to use in pointing to or picking up an object when it is labelled by a caregiver. Tenuous support for this possibility is provided by the non-significant trend in the results of only the older infants in the Reinforcement Condition to show preferential reaching towards novel target objects. This issue is discussed further in the following chapter.

* * *

The results of the current experiment provide preliminary evidence that infants below the age of 18 months can learn novel listener relations within 10 reinforced training trials. The results also suggest that reinforcement is more effective than exposure in 13- and 17-month-old infants' learning of novel listener relations.

GENERAL DISCUSSION

How do infants learn novel listener relations before they can speak? The research reported in this thesis aims to elucidate this issue. The recent results of rapid word learning studies have been interpreted as demonstrating that infants, well before the vocabulary spurt, can learn novel listener relations after only a few exposures to a novel object accompanied by a verbal label. Researchers have put forward a number of theories to account for such learning, such as infants' early understanding of the ways words work, their understanding of others' referential intent, or the effectiveness of simple associative learning mechanisms.

But first, many rapid word learning studies were flawed—for example, in several studies (e.g. Woodward, Markman, and Fitzsimmons, 1994), the experimenter labelled only one of the two novel objects presented; in doing so, these researchers failed to account properly for the previous finding that infants preferentially select labelled objects over unlabelled objects (Baldwin and Markman, 1989). It is possible that infants' behaviour in these rapid word learning studies may have arisen from a learned preference for a labelled object, rather than from listener learning. On these grounds, Experiments 1 and 2 of this thesis were conducted to reassess under carefully controlled conditions the effects of label-object exposure on infants' learning of novel listener relations. Second, no rapid word learning study has tested the function of positive reinforcement in establishing young infants' conventional listener behaviour towards novel objects, despite the long history of support for the role of positive reinforcement in the learning of a wide range of novel behaviours in humans and animals (Skinner, 1938). Experiment 3 of this thesis aimed to test the effectiveness of this alternative learning mechanism. Together, these analyses of infants' listener learning via exposure and positive reinforcement constitute the main aims of this thesis.

Rapid word learning studies failed to consider several other issues important to a complete understanding of infants' listener learning. Many studies did not consider the effects of age or infants' existing receptive and productive verbal repertoires on their listener learning under the age of eighteen months. And, despite the use, across rapid word learning studies, of preferential looking and reaching measures as tests of label comprehension, no study has compared the effectiveness of both types of comprehension test within one experimental design. These secondary issues are also considered in this thesis, and are discussed in the sections that follow.

Reassessing the Role of Exposure in Establishing Listener Relations

Experiments 1 and 2 of this thesis considered the role of exposure to two novel label-object relations in establishing the corresponding listener behaviours. In contrast to the findings of previous research 13- and 17-month-old infants in Experiment 1 did not learn novel label-object relations after up to 12 exposures to each object accompanied by its experimentally-defined verbal label; insufficient infants looked towards the correct target object on test trials for more than 50% of the time. In Hollich et al.'s (2000) research, 12-month-olds looked to target on average 55% of the time after 10 exposures to a novel label-object pairing—significantly above what would be expected by chance.

Only in Experiment 2, after a further 12 exposures to each of the two label-object pairings, did infants show evidence of listener learning in the preferential looking task—13-month-olds looked towards the novel target on hearing its label 62% of the time, and 17-month-olds 58% of the time, on average.

Hollich et al. (2000) suggest that a distributed training schedule, rather than a massed training schedule, improves infants' listener learning. In their research, when five object-labels were presented over the same period of time that it had previously taken to present 10 labels, infants learned novel listener relations as well as when 10 object-labels had been presented. Schafer and Plunkett (1998) also used a distributed training procedure; in their research, 12 object-labels were presented, each one in a separate trial lasting 2.5 seconds.

Of the research reported in this thesis, massed training was used in Experiments 1 and 2, such that 12 labellings of each novel object were presented in two blocks, each of around 10 seconds' duration. But in the Exposure Condition of Experiment 3, a distributed training schedule was used to present 12 pairings of each label and its object and, again, the 13- and 17-month-old infants did not learn the novel listener relations in the Exposure Condition—in test trials, they looked towards novel target objects at chance levels—at a mean of around 50%.

The findings reported in this thesis diverge further from previous studies on the preferential reaching test for comprehension. Although, in most cases, infants reached more often than chance to familiar target objects on hearing them labelled, they failed to reach more often than chance to novel target objects throughout. Even in Experiment 2, in which infants in both age groups looked preferentially to novel targets, 13-month-olds reached to novel targets, on average, at only 45%, and 17-month-olds, on average, at a non-significant 58%. In Woodward et al.'s (1994) research, 13- and 18-month-olds reached at around 65% on average to novel target objects after only nine exposures to the novel label-object relation, and this level was replicated in later research (Namy, 2001; Woodward and Hoyne, 1998;).

Why did Infants Fail to Learn Novel Label-object Listener Relations after 12 Exposures?

If infants had failed to learn to respond appropriately in preferential looking and reaching tasks, it could be argued that their failure to learn novel listener relations arose, not because they had not learned the new relations, but because the looking and reaching measures used failed to provide an adequate test of such learning.

But across all experiments, infants' behaviour in familiar label-object test trials and in novel label-object training trials validated the looking measure used. When presented with familiar objects, the 13-month-olds looked at the target object as opposed to the distracter object for an average of 62% of the time, and the 17-month-olds looked at the target object as opposed to the distracter object for an average of 63% of the time, across all three experiments. These results compare well with those of Hollich et al. (2000)—in their research, 12-month-olds looked towards familiar target objects for 54% of the time across all experiments, and 19-month-olds looked towards familiar target objects 65% of the time. There is good evidence, therefore, that the infants could respond appropriately to the main task instruction, "Where's the [object name]?"

There was also evidence that infants responded appropriately to experimenter cues to target objects during training trials. In Experiments 1 and 2, infants were exposed to only one object in each training trial.

Here, 13-month-olds looked towards this target object, as opposed to anywhere else, for 70% of trial time, and 17-month-olds looked towards the training object for 66% of trial time, on average. In Experiment 3, in which both objects were presented during training trials, looking to target was calculated as a proportion of the time that infants spent looking either towards the target object or the distracter. In this experiment, 13-month-olds in the exposure condition looked towards the target object for 96% of the time, and 17-month-olds for 92% of the time. These results compare favourably to Hollich et al.'s (2000) findings that infants looked to the target, as opposed to the distracter, during exposure trials for an average of 74% of the time in experiments in which they also showed preferential looking to target in comprehension test trials with novel objects.

That looking to target occurred at greater than 90% in the training trials employed in the present studies suggests that conditions for learning each label-object relation were at least as good as in previous studies. For this reason, it is unlikely that the infants' failure, in Experiment 1, to respond at above-chance levels in the looking test trials arose from inadequate exposure to the relation between each object and its label or from infants' incomplete understanding of the verbal instruction employed in the test.

On the reaching measure, infants, overall, also showed successful performance in familiar objects test trials, but this performance was generally lower than that of infants in Woodward et al.'s (1994) similar reaching test with familiar objects. In the experiments reported in this thesis, 13-month-olds reached towards familiar target objects, on average, 63% of the time, and 17-month-olds 68% of the time. In Woodward et al.'s research, 13-month-olds reached to the familiar target 69% of the time, and 18-month-olds 77% of the time, on average.

One possibility for the increased reaching to target of infants in Woodward et al.'s (1994) research is that only one familiar label was presented in test trials, such that infants did not need to discriminate between *two* familiar labels across trials (as in the present studies).

A further possibility is that the comparatively low performance of infants in the experiments reported in this thesis arose from the placing of the reaching test at the end of the procedure. Infants may have become more distracted than those in Woodward et al.'s research, in which the reaching measure was the only test of label-object comprehension. Following a series of looking test trials, the infants may have been more likely to reach towards the object they preferred than to select an object on the basis of how each had previously been labelled by the experimenter.

Nonetheless, there is good evidence that infants understood, or were able to respond appropriately to, the verbal instruction employed in the reaching task of the present studies. In Experiment 1, the infants failed to perform at above-chance levels on both the looking and the reaching measures of label-object comprehension. The failure on both measures precludes a comparison of the two measures in this case. In Experiment 2, however, the infants looked at above-chance levels to novel targets, but their success was not replicated in the reaching task. This suggests that the reaching measure may be a less sensitive measure of listener behaviour learning, at least when it follows a series of preferential looking trials. (For further discussion of the differences between looking and reaching measures, see Infants' Learning Measured by Preferential Looking and Preferential Reaching, p. 287).

Another potential explanation for infants' failure to learn the novel listener relations in Experiment 1 is that, as a control measure, all the experiments reported in this thesis involved the training of two novel label-object relations. In the majority of rapid word learning studies, only one object in the novel object pair was labelled; presentation of the second object in the exposure period was accompanied by a phrase such as, "Look at this one!" Because infants in the one-labelled-object studies could clearly discriminate between the instructions, "Look at this one!" versus "Look at the toma!" on the basis of prior learning, the task is simpler than that employed in Experiment 1, where the infants had to discriminate between the two experimental labels *and* a third label (*dut*) in order to respond appropriately. This requirement may have overstretched the learning ability of infants in Experiment 1.

Even in a task in which only one object in the pair was labelled in training, Woodward et al. (1994, Study 1) reported that 13-month-olds failed on the reaching task when test trials of different types (in their research, familiar, novel and preference control trials) were interspersed within one block. When familiar, novel and preference control trials were grouped separately, 13-month-olds in Woodward et al.'s research succeeded on the reaching task—when trials of one type are blocked in this way, the infant has less successive discriminations to make within a trial block.

But the interpretation that the task overstretched the learning ability of infants in Experiment 1 is doubtful because, in Schafer and Plunkett's (1998) research, infants were also presented with two labels for two objects. In test trials too, infants were presented with each of the two label-object relations and, in interspersed control trials, a third label that had not been presented with either object in exposure training. Still, as a group, the 12- to 17-month-olds responded at above-chance levels on the listener learning task; they looked significantly longer towards the object that had accompanied the label *bard* in training than towards the object that had accompanied the label *sarl* in training when *bard* was given as a verbal prompt in testing.

Unfortunately, Schafer and Plunkett's (1998) study was the only one that employed two-label training and a control label procedure comparable to Experiment 1 of the present research; in this study, data were combined from infants ranging in age from 12 to 17 months. Because older infants' successive discrimination learning may be better than that of younger infants, it is possible that the older infants performed successfully, skewing the group results towards a significant outcome in Schafer and Plunkett's study. Thus it is not clear that infants as young as 13 months could make the successive discriminations required of them to enable their successful performance in Experiment 1 of this thesis. However, it should be noted that even 17-month-old infants failed to learn novel listener relations in Experiment 1; this finding reduces the probability that older infants' success in making successive discriminations masked younger infants' failure to do so in Schafer and Plunkett's study.

An alternative interpretation of infants' failure, in the experiments reported in this thesis, to learn novel listener behaviour after only 12 exposures to the label-object relations is that previous research provided a biased account of such learning. As discussed in Chapter 2, many rapid word learning studies fail to consider that their results might be explained by infants' tendency to look or reach more readily to a labelled object, as opposed to an unlabelled object (Baldwin and Markman, 1989); or by a novelty mechanism whereby infants tend to orient towards any novel object upon hearing any unfamiliar label. It is possible that these previously learned behavioural preferences produced above-chance performance after as few as five exposures to a label-object relation, but that the infants had not learned a *specific* relation between the object and its spoken label

Schafer and Plunkett's (1998) research controlled for many of the confounds present in other rapid word learning studies, and their 12-to 17-month-old participants still showed above-chance preferential looking to novel target objects after 12 exposures to each of two new label-object relations. It was argued that Schafer and Plunkett's research suffered from different flaws; for example, the research tested 12- to 17-month-olds as a single age group and did not report individual results, failing to consider that the performance of a few older, more verbally experienced infants in the sample may have biased the group's statistical results.

This critique is less appropriate in the light of the lack of a difference between the group performances of 13- and 17-month-old infants in all three of the experiments reported in this thesis. Further, in Experiment 2 of this thesis, infants in both age groups showed similar preferential looking performances after 24 novel label-object exposures. What can account for this learning, which occurred in the absence of explicit reinforcement?

How did Infants Learn Novel Label-Object Listener Relations after 24 Exposures?

Classical Conditioning

One possibility is that classical conditioning may have led to the performance of infants in Experiment 2, and in Schafer and Plunkett's (1998) research. As described in Chapter 2, a novel object may be considered to be an unconditioned stimulus which elicits the unconditioned response of orienting towards that object. When a novel label is repeatedly paired with object presentation, presentation of the label alone may elicit orientation towards that object (the label becomes a conditioned stimulus for the conditioned orienting response).

In both of these studies, there was a strong correlation between the presentation of a novel stimulus and its corresponding label. In Schafer and Plunkett's (1998) training trials, this correlation was perfect—every time a novel image was presented, its label was presented. In Experiment 2 of this thesis, each novel object was presented without labelling during object handling phases, but, otherwise, in the training trials the object label was presented only while the object was in the infants's view.

In the classical conditioning literature, it is accepted that for optimal conditioning the CS should normally precede the US (Egger and Miller, 1962, 1963; Rescorla and Wagner, 1972). This was not the case in both Schafer and Plunkett's research and Experiment 2 of this thesis, where presentation of a novel object (the US) was followed by labelling (the CS). But in both studies, although the novel object was presented first, it remained present throughout labelling. It is possible that initial object presentation could serve as an orienting stimulus, drawing the infant's attention to the listener learning context. When the label was presented, it may have led to the infant's reorientation to the novel stimulus. This scenario was especially likely in Experiment 2, in which presentation of a novel object was followed by multiple presentations of its corresponding label. The infant could see the object, look at the experimenter while she spoke the label, and follow experimenter cues of pointing and gazing to relocate the object. In this way, the object label could eventually come to elicit the infant's orientation response. This scenario was less likely in Schafer and Plunkett's procedure, in which the novel image was presented for one second before the presentation of a single auditory stimulus (e.g. *bard*), after which the image disappeared from view. Because the novel image onsets before the auditory stimulus, the object may be conditioned as a CS for "hearing the spoken label", which is the converse of the relation to be established.

In the real word learning environment, label-object correlations are less perfect than in Schafer and Plunkett's research and in Experiment 2. In the experiments, the infant rarely saw a novel object without hearing it labelled. In real word-learning contexts, infants often see objects without hearing them labelled, and even hear labels without seeing the corresponding objects or events. Classical conditioning of listener behaviour may be relatively easy to establish in experiments in which there is a good correlation between object and label presentation. But the speed of such learning in experimental contexts may not reflect that of real word-learning contexts.

The infants in Schafer and Plunkett's research learned novel listener relations after only 12 exposures to the novel label-object pairings, but those in the experiments reported in this thesis learned only after 24 exposures. One possibility for this difference is that, during object handling periods, infants in Experiments 1 and 2 were exposed to novel objects several times without the accompaniment of novel labels. In Schafer and Plunkett's research, presentation of a novel stimulus was always followed by a novel label.

A related possibility is that the methodology employed in Schafer and Plunkett's (1998) research may have made it easier for young infants to learn label-object relations through associative processes. Recall that Schafer and Plunkett's training paradigm involved the presentation of a novel image on a computer screen, followed by the presentation of a single label (e.g. *bard*). There was no interaction with an experimenter; infants were seated on their blindfolded parents' laps throughout the procedure. In real-world listener learning contexts, many cues to the relation between a specific label and a specific object or event (such as pointing, eye gaze, and verbal framing) are provided by caregivers. The lack of such cues in Schafer and Plunkett's task has been interpreted by several researchers (Werker et al., 1998) as increasing the difficulty of the listener learning task.

But Schafer and Plunkett's methodology included none of the "noise" of the usual listener learning situation. As discussed earlier, there was a perfect correlation between the presentation of a novel image and its corresponding verbal label. Further, only one novel image was presented at a time in training trials, the experimenter ensured that infants were looking towards presentation screens before launching each labelling trial, and training trials were conducted in a darkened room; this may have served to increase the salience of the novel stimuli. There was no off-task play between phases of the procedure. It could be argued that, under such circumstances, social cues are unnecessary for the establishment of novel listener relations.

In Experiment 2 of this thesis (and in many other rapid word learning studies), social cues to the target object in each training trial, such as pointing and eye gaze, were included. A verbal frame was provided for each labelling phrase (e.g. "Look at the pab! It's a pab, a pab!"), and there were periods of off-task play with non-experimental toys. These periods often included further verbal comments and instructions.

Infants over 18 months respond well to such social cues. They do not show preferences for previously labelled objects when cues to the target object such as pointing and eye gaze are not provided (Baldwin et al., 1996; Tomasello and Barton, 1994). When they are presented with non-verbal labels for objects, 26-month-olds do not learn preferences for previously-labelled objects unless a verbal frame, such as "This is a...", is included in training trials. But younger infants respond less well to social cues. Infants as old as 18 months do not need a verbal frame to learn a preference for an object that has been accompanied by a novel gesture (Namy and Waxman, 1998). Hollich et al. (2000) demonstrated that only when experimenters presented multiple social cues did 12-month-olds show a preference for a previously labelled object, but they readily learned such a preference when the visual salience of the target object was increased.

If younger infants are relatively insensitive to many social cues, their inclusion in rapid word learning studies may increase the difficulty of the task by "cluttering" the listener learning context. For example, the inclusion of a verbal frame around an object-label means that infants have the extra task of discriminating the label from the experimenter's speech stream. Schafer and Plunkett's (1998) task, by eliminating such cues, may make it easier for classical conditioning of novel listener relations in young infants. This may be why infants learned novel listener relations faster in Schafer and Plunkett's experiment than in Experiment 2 of this thesis.

But as discussed earlier, real-world listener learning contexts are rarely as clear-cut as in Schafer and Plunkett's task. Often, there are multiple objects and events present, and the infant must learn to follow a caregiver's gaze or point in order to discriminate the target of the novel label. The caregiver may intersperse labelling of objects and events with other play activities. She may not always label an object when she presents it to the infant. Young infants must learn to discriminate and respond to social cues in order to learn appropriate listener behaviour to novel labels. Thus the speed of classical conditioning shown in Schafer and Plunkett's research may not reflect the speed of such learning in "natural" listener learning contexts.

Automatic Reinforcement

It is difficult to rule out the possibility that automatic reinforcement of some kind played a role in infants' learning in Experiment 2 of this thesis. Sundberg and Michael (2001) describe the role that automatic reinforcement may play in the development of early vocal behaviour:

> A two-stage conditioning history is involved in this process. In Stage 1, a neutral stimulus (e.g., a mother's voice) is paired with an existing form of conditioned or unconditioned reinforcement (food, warmth, removal of aversive stimuli). As a result, the previously neutral stimulus becomes a form of conditioned reinforcement (hearing mother's voice or any similar stimulus will now strengthen whatever behaviour precedes that stimulation). In Stage 2, a vocal response by the child (either as random muscle movement of the vocal cords or as reflexive behaviour) produces an auditory stimulus somewhat like the mother's voice (words, intonation, pitch), which then functions as reinforcement in automatically increasing the frequency of that type of vocal behaviour. The concept of automatic reinforcement may help to explain why a typical infant engages in such extensive babbling without the apparent delivery of reinforcement. (p.715)

Is there a role for automatic reinforcement in listener learning? In a typical listener learning context, a caregiver asks, "Where's the ball?" and looks towards it. When the infant successfully follows the caregiver's eye gaze to locate the ball, the caregiver reinforces her orienting behaviour, for example by saying, "Yes! Good girl! There it is!" Often, such verbal reinforcement may be accompanied by a point towards the ball. Pointing may initially be a neutral stimulus that accompanies already-established verbal reinforcement; but over multiple pairings with verbal reinforcement it may become a conditioned reinforcer for whatever behaviour precedes it.

In Experiments 1 and 2 of this thesis, in training trials, the experimenter first presented a novel object, looked towards it, and said, "Look [name]. This is a pab!" She accompanied this labelling with a point towards the target object. Thereafter, each time she said "pab", the experimenter pointed towards the target object.

If pointing is a conditioned reinforcer then, when infants orient towards the target object on being presented with its label, their orienting behaviour is automatically reinforced. Over multiple labelling occasions, it is possible that the verbal stimulus *pab,* for example, became discriminative for infants' orientation towards a specific novel object. Though testing occurred under extinction, because no joint regard or pointing cues were present, this operant learning may nevertheless have contributed to infants' appropriate behaviour during non-reinforced test trials.

Together, classical conditioning and automatic reinforcement may account for 13- and 17-month-olds' learning of novel listener relations after 24 exposures in Experiment 2.

The Role of Reinforcement in Establishing Listener Relations

Experiment 3 of this thesis compared the roles of positive reinforcement and exposure in establishing pre-vocabulary spurt infants' listener behaviour to two novel label-object relations. These results support an operant account of listener learning, such as that proposed by Horne and Lowe (1996).

Despite the extensive literature on the role of explicit reinforcement and feedback in verbal learning, the effect of positive reinforcement on young infants' listener learning had not been tested within a rapid word learning paradigm. The results of Experiment 3 demonstrate, not only that infants *can* learn novel listener relations through positive reinforcement, but also that positive reinforcement establishes listener relations faster than learning through exposure to novel label-object relations.

The 13- and 17-month-old infants in the Reinforcement Condition of Experiment 3 showed preferential looking towards novel target objects on listener test trials at an average of around 60%—after 10 training trials in which infants' looking towards novel target objects was reinforced. In the Exposure Condition of the same experiment, infants did not spend any longer looking to novel target objects than they did looking towards novel distracter objects in test trials after 10 exposures to the novel label-object relations. In an earlier experiment, it was only when infants were exposed 24 times to each of the two novel label-object relations that they looked to target in test trials at levels of around 60%, on average.

It is doubtful whether anything other than positive reinforcement could account for the learning shown by infants in the Reinforcement Condition of Experiment 3. For example, it is improbable that classical conditioning could have occurred in the Reinforcement Condition: infants were not *exposed* to the relation between label and object in training trials; instead, they were presented with both novel objects and asked, "Where's the vek?" (for example). When they looked appropriately towards the target object, their orienting response was reinforced.

There *was* one exposure to each novel label-object relation prior to each block of training trials in the Reinforcement Condition. In these initial labellings, the experimenter presented an object, and said, "This is a zag", for example. It is unlikely that these two exposures to each novel label-object relation could have resulted in classical conditioning—first, no rapid word learning study to date has shown listener learning after only two exposures; second, infants experienced the same two initial labellings in the Exposure Condition of Experiment 3, with no resultant listener learning.

Why have previous studies failed to consider the role of positive reinforcement in infants' listener learning? Perhaps because authors such as Chomsky (1959), and more recently Pinker (1994), and researchers such as Brown (Brown et al., 1969) have advocated the view that caregivers do not reinforce or provide feedback for infants' verbal behaviour. But a body of recent literature (see Chapter 1) suggests that caregivers do provide feedback and reinforcement for children's speaker behaviour and young infants' vocal behaviour; moreover, the rapid word learning task involves listener behaviour, not speaker behaviour—listener behaviour may be shaped by different factors from those that shape speaker behaviour.

The finding that positive reinforcement can lead to the establishment of listener relations in 13- and 17-month-old infants weakens alternative perspectives on young infants' listener learning. Constraints perspectives, social-pragmatic perspectives, and associative learning perspectives on the development of listener behaviour do not consider a role for positive reinforcement. Listener learning, in all these accounts, is said to be accomplished through exposure to the relation between a label and an object. The results of Experiment 3 present preliminary evidence that positive reinforcement is more effective than exposure in establishing new listener relations; other perspectives therefore fail to incorporate a key learning process in infants' listener learning.

Infants' Listener Learning Measured by Preferential Looking and Preferential Reaching Tasks

In none of the three experiments reported in this thesis did infants reach at above-chance levels towards a novel target object when presented with its label, despite showing evidence of label comprehension in the preferential looking task in Experiment 2, and in the Reinforcement Condition of Experiment 3.

It is possible that infants failed in the reaching test with novel objects because this task was presented at the end of the experimental procedure in all three studies. Infants may have become distracted and reached towards the objects that they preferred, rather than attending to the experimenter's label before selecting an object. But infants in both age groups did reach towards target objects on test trials with familiar objects; this test with familiar objects was also presented at the end of the procedure. Although the performance of infants in the reaching task with familiar objects was generally lower in the experiments reported in this thesis than that of infants in Woodward et al.'s (1994) familiar reaching task, it was, in most cases, significant, and similar to the performance of infants in the preferential looking task with familiar objects. Bell (1999) reported infants' similarly poor reaching to novel targets after 27 exposures to each novel label-object relation; in her research, 9- to 16-month-old infants required many reinforced training trials before they achieved reaching success. Thus distraction may not be a factor, in the current experiments, that led to infants' poor performance on the reaching task with novel objects.

An alternative interpretation is that the looking task is more sensitive to infants' early listener learning than the reaching task. One reason for this is that looking trials provide a more graded measure of infants' learning than reaching trials. Over four reaching trials an infant can score 0, 1, 2, 3, or 4 correct reaches to target. Over four looking trials, an infant's average score can be anywhere between 0 and 100%. In the experiments reported in this thesis, when infants showed significant looking to novel targets, the group score averaged at around 60%. If looking scores were reduced to the five levels of response available in the reaching task (i.e. 0, 1, 2, 3, or 4 correct responses), infants who looked to target 0-20% of the time would score 0, those who looked to target 21-40% of the time would score 1, those who looked to target 41-60% of the time would score 2, those who looked to target 61-80% of the time would score 3, and those who looked to target 81-100% of the time would score 4. With this level of data reduction, the small learning effect shown in the looking task would disappear, because looking at 60% would be equivalent to only two correct reaches (the criterion for chance responding). If the number of participants is held constant over looking and reaching measures, only when many more reaching trials are conducted will the reaching measure achieve the sensitivity of the looking measure.

A further reason for the failure of infants to respond appropriately in the reaching task with novel objects may be that there was greater potential for automatic reinforcement of infants' responses in the reaching test trials than in the looking test trials. In the reaching task, the infant was presented with two objects, and asked to get one, for example the *pab*.

When an infant reached towards one of the experimental objects, her reaching behaviour may have been reinforced by her consequent encounter and play with one of the toy-like experimental objects. Further, her reaching behaviour may have been more reinforced by one object in the pair than the other because, for each infant, one object may have been more salient than the other. The effect of multiple reaching trials with the same object pair may thus have been to increase each infant's reaching towards one object over the other. Because side of presentation was counterbalanced over reaching trials, the effect of this preference would be for infants to show chance responding on the reaching measure.

The effect of differential automatic reinforcement in reaching trials may have been greater on the test with novel target objects than with familiar target objects—this because infants have had a prior history of responding to caregivers' verbal requests for familiar objects. In this previous learning, infants' reaching behaviour was reinforced by caregivers only when they selected the labelled object. For example, the infant's reaching towards a shoe should be reinforced if the caregiver had asked for *shoe,* but not if she had asked for *cup*. This may explain why infants succeeded on the reaching test with familiar target objects, but not with novel target objects.

It is important that a sensitive reaching measure of infants' label comprehension is found, particularly because there may be a ceiling effect on infants' performance in the alternative looking measure (see *Is there a Ceiling Effect in Preferential Looking Test trials?* p. 294). The reaching test is potentially sensitive to the effects of age and vocabulary on infants' listener learning. Future research with a reaching measure of label comprehension can improve test sensitivity simply by increasing the number of test trials. One means of increasing the number of trials is to train and test infants in longitudinal, single subject research, such as that conducted by Bell (1999).

It is more difficult to reduce automatic reinforcement of infants' side or object biases in reaching, but one option is to vary the nature of the reaching task, so that infants' reaching behaviour is reinforced more by their participation in the task than by the handling of a specific experimental object. Woodward et al. (1994), for example, asked infants to slide objects down chutes and put them in boxes in reaching test trials.

The Effects of Age and Verbal Experience on Infants' Listener Learning

It was surprising that, in all three of the experiments reported in this thesis, there were no effects of age on listener learning. It was expected that pre-vocabulary spurt infants would show a learning-to-learn effect (Harlow, 1949), whereby a history of learning listener responses to caregivers' verbal stimuli should increase the speed by which novel words are learned in future. Because 17-month-olds have a longer history of learning listener relations than 13-month-olds, it was predicted that these older infants should learn novel listener relations more quickly.

Indeed, all of the experiments reported in this thesis showed differences between age groups on the vocabulary measure. Over all experiments, 13-month-olds comprehended an average of 107 words, whereas 17-month-olds comprehended an average of 189 words (the measure of receptive vocabulary was taken for older infants in Experiment 3 only).

Because there was some overlap between age groups on the vocabulary measures, a second set of analyses was performed to determine whether the number of words comprehended or the number of words spoken was correlated with infants' comprehension of novel label-object relations, regardless of age group. But neither vocabulary measure was correlated with infants' comprehension of novel object-labels.

Is there a Comprehension Spurt prior to 13 Months?

There are several possible reasons for these null findings. Woodward et al. (1994) and Werker et al. (1998) point to evidence that infants undergo a comprehension spurt at around 13 months. In Werker et al.'s research, infants aged eight, 10, and 12 months did not learn novel listener relations after up to 10 exposures to an object accompanied by multiple presentations of an object-label, but 14-month-olds did show listener learning under identical conditions. Werker et al. interpret their results as indicating an underlying improvement in infants' ability to comprehend novel words that occurs between the ages of 12 and 14 months.

Harris, Barlow-Brown and Chasin (1995) provided further evidence of a comprehension spurt. In their longitudinal study of infants' receptive and productive word learning, all six infants underwent a comprehension spurt—defined as "the age at which comprehension of 10 or more new words was acquired over a two week period…" (p.26)—between the ages of 12 and 14 months. Further, in Plunkett et al.'s (1992) connectionist model of receptive and productive learning of object-labels, the network exhibited a comprehension spurt well before a production spurt.

If there is a dramatic increase in the speed with which infants can learn novel listener relations at around 12 to 14 months, many of the 13-month-old infants in the experiments reported in this thesis may have already undergone such a spurt, putting their performance on a par with that of 17-month-olds in listener learning tasks.

Because 13-month-olds in these experiments, according to parental report, had already learned an average of over one hundred listener relations, it is possible that they were experienced enough that their listener responses already fell into a learning set. This learning-to-learn phenomenon may be the cause of an early comprehension spurt.

Is there a Ceiling Effect in Preferential Looking Test Trials?

An alternative interpretation of the lack of age or vocabulary effects on infants' listener learning is that the preferential looking measure (used as the primary correlate in these analyses) is insensitive to the difference between one infant's limited and another infant's extensive comprehension learning. In most experiments that make use of a preferential looking measure, infants must look longer at a target object than at a distracter object (within a period of around six seconds) in order to show evidence of label comprehension.

If the preferential looking test were sensitive to differences in how well infants comprehend a label, then infants would show greater looking towards familiar target objects, with which it is assumed they have a long learning history, than towards novel target objects, with which their learning history has extended only to 10 reinforced training trials. But in the experiments reported in this thesis, infants looked towards familiar target objects around 63% of the time, and towards novel target objects around 60% of the time, on average. Thus, even when presented with familiar object-labels, infants tended to look towards the (incorrect) distracter object for at least part of a test trial, even when the majority of their looks were towards the (correct) target object.

The effect of this looking pattern may be to put a ceiling on infants' looking during test trials such that, because infants are unlikely to spend

100% of a test trial looking towards the target object as opposed to the distracter object, looking scores may be under 70% even after extensive training. In the same way that this ceiling effect potentially concealed differences between looking to familiar and novel targets in test trials, it could conceal potential age differences in listener learning, and minimise a correlation between vocabulary size and comprehension test scores.

Problems with Parental Report Measures of Infants' Receptive and Productive Verbal Repertoires

Several researchers have reported the lack of a correlation between infants' reported verbal repertoires and their performance on comprehension tests (Hirsh-Pasek and Golinkoff, 1996a, 1996b; Hollich et al., 2000). Biases in parental reporting of infants' receptive and productive repertoires are one probable reason for these results. The MCDI and BCDI measures used in the experiments reported in this thesis take some time and concentration to complete accurately, and there is a particular problem in the reporting of words that infants comprehend because it is difficult to distinguish when an infant comprehends a word from when she has learned to respond to the context in which the word is often spoken by the caregiver (Reznick, 1990). Parental report may be a way to gain a picture of the overall trends in infants' verbal development, but too blunt a tool for use as a correlational measure with relatively small groups of infants. Future studies should make use of alternative measures of infants' verbal comprehension and production skills. Several researchers (e.g. Harris, Barlow-Brown and Chasin, 1995; Harris, Yeeles et al., 1995) have pointed to the greater reliability of observational measures of individual infants' responding to verbal stimuli in interaction with caregivers, for example.

Future Research

The experiments reported in this thesis broaden the accepted view that young infants learn to comprehend new words when they are exposed to a verbal label in the presence of an object or event. Although, in the current experiments, 24 exposures to a novel label-object relation eventually led to appropriate listener behaviour at above-chance levels, when selective positive reinforcement—in the absence of exposure—was presented for infants' appropriate looking response to a target object on hearing a specific label, 13- and 17-month-olds learned novel listener relations within 10 training trials.

These results provide evidence for positive reinforcement as a potent learning mechanism in pre-vocabulary spurt infants' listener learning. But many other questions regarding infants' early comprehension of object names have yet to be answered.

Can the Group Effects of Rapid Word Learning be Observed in Individual Infants?

The experiments reported in this thesis used a large-group methodology to assess the effects of exposure and reinforcement on infants' listener learning; this was in order to provide a direct comparison with rapid word learning research. But there are specific problems with a large-group approach to infants' listener learning. The statistical effects observed in many preferential looking studies are small. Perhaps, for specific reasons, some infants learned novel label-object relations in rapid word learning studies, and others did not; the results of these few infants may have skewed the overall group findings.

One way in which biased group results in rapid word learning studies could arise comes from factors specific to the preferential looking training paradigm. In training trials, infants are presented repeatedly with a verbal stimulus paired with a specific object. This training may be viewed as a habituation procedure study with a potential confound—there is a developmental shift from preference for familiar over unfamiliar stimuli to the converse (Hunter and Ames, 1988). If that shift occurs at different points for each infant in a sample, on test trials some infants will look preferentially towards an object previously paired with a sound (familiarity preference), while others will do the opposite—they will look towards an object that has not been previously paired with the presented sound (novelty preference). Hunter and Ames' (1988) research suggests that older infants make the shift more quickly from a familiarity preference to a novelty preference; this may mean that these infants look away from target objects in test trials, and thereby lower the group mean for preferential looking to target objects.

In order to analyse more fully the process of infants' listener learning, not only must the findings reported by Schafer and Plunkett (1998) and of the experiments reported in this thesis be replicated, but also longitudinal single subject research must be conducted.

How Robust are Listener Responses Learned through Exposure and Reinforcement?

Most rapid word learning studies (including those presented in this thesis) trained and tested infants' listener learning after training in which seeing an object was always correlated with presentation of a label. It was argued earlier that, in infants' listener learning outside of experimental contexts, an object is not always accompanied by a label, and that this would weaken the effects of listener learning through classical conditioning. This prediction can be tested by introducing into a standard rapid word learning paradigm extra occasions on which an object is presented in the absence of a label, and reassessing the effects of exposure and reinforcement on infants' speed of learning.

What are the Combined Effects of Reinforcement and Exposure on Infants' Listener Learning?

Outside of experimental contexts, caregivers expose infants to the relations between labels and objects, *and* reinforce their appropriate listener behaviours. For example, a caregiver might point and look towards a ball, whilst saying "Where's your ball?" (exposure), and then say "Yes! Good girl!" when the infant orients toward and fetches the ball (reinforcement). Might the combination of exposure and reinforcement lead to even faster establishment of listener relations in young infants? An empirical test of this expectation is provided by presenting the infant with cued exposure to a novel label-object relation (for example, by presenting two novel objects, asking, "Where's the zag?", and pointing and looking towards the target object) *and* with positive reinforcement contingent on the infant's appropriate orientation towards the target object.

Do Caregivers Reinforce Infants' Listener Behaviour?

Chapter 1 presented evidence that caregivers reinforce infants' early vocal and speaker behaviour, and some initial evidence that they reinforce conventional object-related behaviours in the presence of verbal stimuli too (Rome-Flanders, Cronk and Gourde, 1995). Further support for an operant account of listener learning may be gained from observational studies of caregiver-infant interactions in listener learning contexts. If various reinforcers are observed in such contexts, then the findings of Experiment 3 would gain ecological validity.

How do Infants under the Age of 13 Months Learn Novel Listener Relations?

The experiments reported in this thesis provide support for an operant account of rapid listener learning in infants aged 13 to 17 months. This age range was tested to provide a direct comparison with previous studies on rapid word learning via exposure. But in the current experiments, infants aged 13 months had already learned, on average, over one hundred listener relations. With this extensive learning history, even infants as young as 13 months may have already undergone a "comprehension spurt", or a rapid increase in the speed with which they learn novel listener relations, probably as a result of a learning-to-learn phenomenon. Thus the listener learning observed in the current studies may not reflect that of even younger infants who have learned only a few listener relations.

In the literature reviewed, no study used preferential looking or reaching paradigms to study listener learning of novel label-object relations in infants below the age of 12 months. Werker et al. (1998) employed a habituation-novelty technique to study 8- to 14-month-old infants, but this methodology is not ideal, first because many infants have to be excluded from the research when they fail to habituate to novel stimuli over a number of trials, and second because it would be difficult to incorporate reinforced training trials into such a paradigm. Future research should consider the possibility of extending the preferential looking paradigm for use with infants down to eight months of age—the point at which most infants start to learn novel listener relations (Fenson et al., 1994). If the preferential looking paradigm can be validated with infants below 12 months, then it will provide valuable data on the roots of listener learning in infancy.

What do Infants Learn when they Learn to Respond as Listeners to Verbal Stimuli?

In the developmental literature, it is often claimed that when infants learn to comprehend verbal labels they possess *verbal understanding*. That is, they understand that labels refer to or symbolise objects or events in the world (Hollich et al., 2000; Mervis and Bertrand, 1994; Woodward and Markman, 1997). Such researchers support this viewpoint with evidence that infants, without training, can "extend" an object-label to perceptually similar objects (e.g. When they are asked for "the ball", they can respond by fetching any number of balls, not just the ball to which they originally learned to respond as a listener).

But in earlier chapters, it was argued that to accredit young infants with verbal understanding is to provide a rich interpretation of the available data. Non-humans readily generalise labels to perceptually similar objects, and it is doubtful that we would ascribe their behaviour to verbal understanding. Several researchers (Gopnik and Meltzoff, 1993; Horne and Lowe, 1996, 1997; Lowe and Horne, 1996; Lowe et al., 2002) argue that a more stringent criterion of an infants' verbal understanding is met when, without training, she can categorise perceptually dissimilar objects together on the basis of her learning of a listener relation common to the objects. Adult humans and normally developing children succeed on such tests, but there has yet been no convincing evidence that non-humans do so (see Horne and Lowe, 1997). Further, research conducted by Randle (1999) showed that young children could not categorise objects together when they had learned a listener relation common to such stimuli—only when a common name relation (speaker *and* listener relations) had been established to the stimuli did infants succeed in the categorisation task.

Nazzi and Gopnik (2001) attempted to test whether 13- and 20-month-old infants who had learned a novel listener relation common to two perceptually dissimilar objects could categorise those objects together. Infants were exposed ten times to the label *tib* for two different objects, and ten times to the label *dap* for a third object. Then the experimenter presented one of the objects that had previously been labelled *tib* and asked, "Can you get the other one?" Twenty-month-olds selected the second object that had been labelled *tib* more often than chance, but 13-month-olds did not. These results appear to suggest that 13-month-olds cannot categorise perceptually dissimilar objects together on the basis of their learning of a common listener relation. But Nazzi and Gopnik's research was confounded because it did not first check that infants in both age groups had learned each of the three novel listener relations after only 10 exposures to each object accompanied by a verbal label. Future research should aim to provide a better test of infants' ability to categorise perceptually dissimilar objects together on the basis of their listener learning alone.

* * *

To understand how an infant becomes verbal, we must first understand how she learns to comprehend words. Theories in the developmental literature assert that preverbal infants possess complex language-specific or social abilities, and that these abilities spur their listener learning. But such viewpoints provide rich interpretations of infants' behaviour in response to verbal stimuli; further, they fail to provide testable predictions with regard to infants' listener behaviour.

Behaviour analytic accounts suggest that simple learning processes lead to the establishment of listener behaviour in infancy. The experiments reported in this thesis provide support for a behaviour-analytic account and, in particular, for the effectiveness of positive reinforcement as a means by which 13- and 17-month-old infants can be taught to comprehend novel object-labels after very few training trials. Further research must be conducted to test the implications and generalisability of these initial findings.

References

Acredolo. L., and Goodwyn. S. (1997). Furthering our understanding of what humans understand. *Human Development, 40(1),* 25-31.

Akhtar, N., Carpenter, M., and Tomasello, M. (1996). The role of discourse in early word learning. *Child Development, 67(2),* 635-645.

Akhtar, N. and Tomasello, M. (2000). The social nature of words and word learning. In R. M. Golinkoff et al. *Becoming a word learner: A debate on lexical acquisition* (pp. 115-135). Oxford: Oxford University Press

Aldridge, M. A., Braga, E. S., Walton, G. E. and Bower, T. G. R. (1999). The intermodal representation of speech in newborns. *Developmental Science* 2(1), 42-46.

Anglin, J. (1977). *Word, object and conceptual development.* New York: W. W. Norton.

Anglin, J. M. (1978). From reference to meaning. *Child Development, 49(4),* 969-976.

Augustine, St. (398/1961). The confessions of St. Augustine. New York: Random House.

Baldwin, D. A. (1995). Understanding the link between joint attention and language. In C. Moore and P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp.131-158). Hillsdale, NJ: Lawrence Erlbaum Associates.

Baldwin, D. A., and Markman, E. M. (1989). Establishing word-object relations: A first step. *Child Development, 60(2),* 381-398.

Baldwin, D. A., Markman, E. M., Bill, B., Desjardins, R. N., and Irwin, J. M. (1996). Infants' reliance on a social criterion for establishing word-object relations. *Child Development, 67(6),* 3135-3153.

Baldwin, D. A. and Moses, L. J. (2001). Links between social understanding and early word learning: Challenges to current accounts. *Social Development 10(3),* 309-329.

Bates, E. (1993). Comprehension and production in early language development. *Monographs of the Society for Research in Child Development, 58(3-4),* 222-242.

Bell, M. H. (1999). *The determinants of naming in human infants.* Unpublished doctoral dissertation, University of Wales, Bangor.

Benedict (1979). Early lexical development: Comprehension and production. *Journal of Child Language, 6(2),* 183-200.

Berko Gleason, J. (1997). *The development of language.* Boston: Allyn and Bacon.

Bloom, L. (1973). *One word a time: The use of single word utterances before syntax.* The Hague: Mouton.

Bloom, L. and Tinker, E. (2001). The intentionality model and language acquisition: Engagement, effort, and the essential tension in development. *Monographs of the Society for Research in Child Development, 66(4),* 1-89.

Bloom, P. (2000). *How children learn the meaning of words.* Cambridge, MA: The MIT Press.

Bloom, P. (2001) Precis of *How Children Learn the Meanings of Words. Behavioral and Brain Sciences, 24,* 1095-1103.

Bohannon, J. N., Snow, C., and MacWhinney, B. (1990). No negative evidence revisited: Beyond learnability or who has to prove what to whom. *Developmental Psychology, 26(2),* 221-226

Bornstein, M. H., and Tamis-LeMonda, C. S. (1997). Maternal responsiveness and infant mental abilities: Specific predictive relations. *Infant Behavior & Development, 20(3),* 283-296.

Brown, R. (1973). *A first language: The early stages.* Cambridge, MA: Harvard University Press.

Brown, R. and Hanlon, C. (1970). Derivational complexity and order of acquisition in child speech. In J. R. Hayes (Ed.), *Cognition and the development of language.* New York: Wiley.

Bruner, J. (1975). The ontogenesis of speech acts. *Journal of Child Language, 24,* 1-19.

Bruner, J. (1983). *Child's talk: Learning to use language.* New York: W. W. Norton.

Butterworth, G. (1991). The ontogeny and phylogeny of joint visual attention. In A. Whiten (Ed.), *Natural theories of mind: Evolution, development, and simulation of every-day mindreading.* Oxford: Blackwell.

Butterworth, G. and Jarrett, N. (1991). What minds have in common is space: Spatial mechanisms serving joint visual attention in infancy. *British Journal of Developmental Psychology, 9(1),* 55-72.

Carey, S., and Bartlett, E. (1978). Acquiring a single new word. *Papers and Reports on Child Language Development, 15,* 17-29.

Catania, A. C. (1984). *Learning* (2nd ed.). Englewood Cliffs, NJ: Prentice-Hall, Inc.

Charles-Luce, J., and Luce, P. A. (1990). Similarity neighbourhoods of words in young children's lexicons. *Journal of Child Language, 17(1),* 205-215.

Chomsky, N. (1959). Review of the book *Verbal Behaviour. Language, 35(1),* 26-58.

Clancy, P. M. (1985). The acquisition of Japanese. In D. I. Slobin (Ed.), *Cross-linguistic study of language acquisition.* Hillsdale, NJ: Erlbaum.

Clark, E. V. (1987). The principle of contrast: A constraint on language acquisition. In B. MacWhinney (Ed.), *Mechanisms of language acquisition* (pp.1-33). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohen, L. B. (1992, May). *The myth of differentiation.* Symposium paper presented at the International Conference on Infant Studies, Miami, FL.

Corkum, V. and Moore, C. (1995). Development of joint visual attention in infants. In C. Moore and P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 61-83). Hillsdale, NJ: Lawrence Erlbaum Associates.

Cross, T. G. (1977). Mothers' speech adjustments: The contributions of selected child listener variables. In C. E. Snow and C. Ferguson (Eds.), *Talking to children: Language input and acquisition.* Cambridge: Cambridge University Press.

Crowder, R. G. (1976). Principles of learning and memory. Oxford, England: Lawrence Erlbaum.

DeCasper, A. J. and Fifer, W. P. (1980). Of human bonding: Newborns prefer their mother's voices. *Science, 208(4448),* 1174-1176.

Demetras, M. J., Post, K. N., and Snow, C. E. (1986). Feedback to first language learners: The role of repetitions and clarification questions. *Journal of Child Language, 13(2),* 275-292.

Donahoe, J. W., and Palmer, D. C. (1994). *Learning and complex behaviour.* Needham heights, MA: Allyn & Bacon.

Dromi, E. (1987). *Early lexical development.* New York: Cambridge University Press.

Dugdale, N. (1996). Naming, stimulus equivalence, and conditioned hearing. *Journal of the Experimental Analysis of Behavior, 65(1),* 272-273.

Echols, C. (1991). *Infants' attention to objects and consistency in linguistic and nonOlinguistic contexts.* Paper presented at the biennial meetings of the Society for Research in Child Development, Seattle, WA.

Egger, M. D. and Miller, N. E.(1962). Secondary reinforcement in rats as a function of information value and reliability of the stimulus. *Journal of Experimental Psychology, 64,* 77-104.

Egger, M. D., and Miller, N. E. (1963). When is a reward reinforcing? An experimental study of the information hypothesis. *Journal of Comparative & Physiological Psychology, 56(1),* 132-137.

Eimas, P. D., Siqueland, E. R., Jusczyk, P., and Vigorito, J. (1971). Speech perception in infants. *Science, 171(3968),* 303-306.

Ellis, R. and Humphreys, G. (1999). *Connectionist psychology.* Hove: Psychology Press.

Erjavec, M. (2002). *Determinants of gestural imitation in young children.* Unpublished doctoral dissertation, University of Wales, Bangor.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D., and Pethick. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59(5),* v -173.

Fernald, A. (1985). Four-month-old infants prefer to listen to motherese. *Infant Behavior & Development, 8(2),* 181-195.

Gasser, M. and Smith, L. B. (1991). The development of a notion of sameness: A connectionist model. In *Proceedings of the 13th Annual Conference of the Cognitive Science Society* (pp. 719-723). Hillsdale, NJ: Lawrence Erlbaum Associates.

Goren, C. C., Sarty, M., and Wu, P. Y. K. (1975). Visual following and pattern discrimination of face-like stimuli by newborn infants. *Pediatrics, 56,* 544-549.

Golinkoff, R. M., Hirsh-Pasek, K., Bailey, L. M., and Wenger, N. R. (1992). Young children and adults use lexical principles to learn new nouns. *Developmental Psychology, 28(1),* 99-108.

Golinkoff, R. M., Hirsh-Pasek, K., Cauley, K. M., and Gordon, L. (1987). The eyes have it: Lexical and syntactic comprehension in a new paradigm. *Journal of Child Language, 14(1),* 23-45.

Golinkoff, R. M., Mervis, C. B., and Hirsh-Pasek, K. (1994). Early object label: The case for a developmental lexical principles framework. *Journal of Child Language, 21(1),* 125-155.

Gopnik, A., and Meltzoff, A. (1993). Words and thoughts in infancy: The specificity hypothesis and the development of categorization and naming. *Advances in Infancy Research, 8,* 217-249.

Hamilton, A., Plunkett, K., and Schafer. G. (2000). Infant vocabulary development assessed with a British communicative development inventory. *Journal of Child Language, 27(3),* 689-705.

Harlow, H. E. (1949). The formation of learning sets. *Psychological Review, 56,* 51-65.

Harris, F. D. A. (2002*). Naming, gesture and categorisation in young children.* Unpublished doctoral dissertation, University of Wales, Bangor.

Harris, M. (1997). Language and its pathology. In G. Bremner, A. Slater, and G. Butterworth (Eds.) *Infant development: Recent advances* (pp.311-329). Hove, East Sussex: Psychology Press.

Harris, M., Barlow-Brown, F., and Chasin, J. (1995). The emergence of referential understanding: Pointing and the comprehension of object names. *First Language, 15(43, Pt 1),* 19-34.

Harris, M., Jones. D., Brookes, S., and Grant, J. (1986). Relations between the non-verbal context of maternal speech and rate of language development. *British Journal of Developmental Psychology. Special Issue: Language cognition in early social interaction, 4(3),* 261-268.

Harris, M., Yeeles, C., Chasin, and Oakley, Y. (1995). Symmetries and asymmetries in early lexical comprehension and production. *Journal of Child Language, 22,* 1-18.

Herman, L. M., Richards, D. G., and Wolz, J. P. (1984). Comprehension of sentences by bottlenosed dolphins. *Cognition, 16(2),* 129-219.

Hirsh-Pasek, K., and Golinkoff, R. M. (1993). Skeletal supports for grammatical learning: What infants bring to the language learning task. *Advances in Infancy Research, 8,* 299-338.

Hirsh-Pasek, K., and Golinkoff, R. M. (1996a). *The origins of grammar: Evidence from early language comprehension.* Cambridge, MA: The MIT Press.

Hirsh-Pasek, K., and Golinkoff, R. M. (1996b), The intermodal preferential looking paradigm: A window onto emerging language comprehension. In D. McDaniel, C. McKee, et al. (Eds), *Methods for assessing children's syntax. Language, speech, and communication* (pp. 105-124). Cambridge, MA: The MIT Press.

Hirsh-Pasek, K., Golinkoff, R. M., and Reeves, L. (1994). Constructivist explanations for language acquisition may be insufficient: The case for language-specific principles. In W. F. Overton and D. S. Palermo (Eds.), *The nature and ontogenesis of meaning* (pp.237-254). Hillsdale, NJ: Lawrence Erlbaum Associates.

Hirsh-Pasek, K., Hennon, E., Golinkoff, R. M., Pence, K., Pulveman, R., Sootsman, J., Pruden, S., and Maguire, M. (2001). Social attention need not equal social intention: From attention to intention in early word learning. *Behavioral and Brain Sciences, 24*(6), 1108-1109.

Hirsh-Pasek, K, Golinkoff, R. M., and Hollich, G. (2000). An emergentist coalition model for word learning: Mapping words to objects is a product of the interaction of multiple cues. In R. M. Golinkoff et al., *Becoming a word learner: A debate on lexical acquisition* (pp.136-164). Oxford: Oxford University Press.

Hollich, G., Hirsh-Pasek, K., and Golinkoff, R. M. (2000). Breaking the language barrier: An emergentist coalition model for the origins of word learning. *Monographs of the Society for Research in Child Development, 65(3),* v-138.

Horne, P. J. and Lowe, C. F. (1996). On the origins of naming and other symbolic behaviour. *Journal of the Experimental Analysis of Behavior, 65(1),* 185-241.

Horne, P. J. and Lowe, C. F. (1997). Towards a theory of verbal behaviour. *Journal of the Experimental Analysis of Behavior, 68(2),* 271-296.

Horne, P. J. and Lowe, C. F. (2000). Putting the naming account to the test: Preview of an experimental program. In J. C. Leslie and D. Blackman (Eds.), *Experimental and applied analysis of human behaviour* (pp. 127-148). Reno, NV: Context Press.

Hughes, J. C. (2000). *Naming and generalisation of behaviour in infants.* Unpublished doctoral dissertation, University of Wales, Bangor.

Hunter, M. A., and Ames, E. W. (1988). In C. Rovee-Collier and L. P. Lipsilt (Eds.), *Advances in Infancy Research, Vol 5* (pp. 69-95). Norwood, NJ: Ablex Publishing Corporation.

Jusczyk , P. W. (1986). Toward a model of the development of speech perception. In J. S. Perkell and D. H. Klatt (Eds.) *Invariance and variability in speech processes* (pp. 1-35). Hillsdale, NJ: Lawrence Erlbaum associates.

Jusczyk, P. W., Rosner, B. S., Reed, M. A., and Kennedy, L. J. (1989). Could temporal order differences underlie 2-month-olds' discrimination of English voicing contrasts? *Journal of the Acoustical Society of America, 85(4)*, 1741-1749.

Kuhl, P. K. (1987). Perception of speech and sound in early infancy. In P. Salapatek and L. Cohen (Eds.), *Handbook of infant perception: Vol 2. From perception to cognition* (pp. 275-382). New York: Academic Press.

Kuhl, P. K. and Miller, J. D. (1975). Speech perception by the chinchilla: Voiced-voiceless distinction in alveolar plosive consonants. *Science, 190(4209)*, 69-72.

Lieven, E. V. M. (1994). Crosslinguistic and crosscultural aspects of language addressed to children. In C. Gallaway and B. J. Richards (Eds.), *Input and interaction in language acquisition* (pp.56-72).

Littschwager, J. C., and Markman, E. M. (1994). Sixteen- and 24-month-olds' use of mutual exclusivity as a default assumption in second-label learning. *Developmental Psychology, 30(6)*, 955-968.

Lowe, C. F. and Horne, P. J. (1996). Reflections on naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior, 65(1)*, 315-340.

Lowe, C. F., Horne, P. J., Harris, F. D. A., and Randle, V. R. L. (2002). Naming and categorization in young children: Vocal tact training. *Journal of the Experimental Analysis of Behavior, 78(3)*, 527-549.

Lock, J. (1980). *The guided reinvention of language.* London: Academic Press.

Lucariello, J. (1987). Concept formation and its relation to word learning and use in the second year. *Journal of Child Language, 14(2)*, 309-332.

Mareschal, D., Plunkett, K., and Harris, P. (1999). A computational and neuropsychological account of object-oriented behaviours in infancy. *Developmental Science, 2-3,* 306-317.

Markman, E. M. (1987). How children constrain the possible meanings of words. In U. Neisser (Ed.). *Concepts and conceptual development: Ecological and intellectual factors in categorization.* New York: Cambridge University Press.

Markman, E. M. and Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meaning of words. *Cognitive Psychology, 20,* 121-157.

Markman, E. M. (1989). *Categorization and naming in children: Problems of induction.* Cambridge, MA: The MIT Press.

Markman, E. M. (1991). The whole-object, taxonomic, and mutual exclusivity assumptions as initial constraints on word meanings. In S. A. Gelman and J. P. Byrnes (Eds.), *Perspectives on language and thought: Interrelations in development* (pp.72-106). New York: Cambridge University Press.

Markman, E. M. (1992). Constraints on word-learning: Speculations about their nature, origins, and domain specificity. In M. R. Gunnar and M. Maratsos (Eds.), *Modularity and constraints in language and cognition. The Minnesota symposia on child psychology: Vol. 25* (pp. x-242). Hillsdale, NJ: Lawrence Erlbaum Associates.

Markman, E. M. (1994). Constraints on word meaning in early language acquisition. *Lingua 92,* 199-227.

Markman, E. M. and Wachtel, G. F. (1988). Children's use of mutual exclusivity to constrain the meaning of words. *Cognitive Psychology, 20(2),* 121-157.

Merriman, J. Rovee-Collier, C., and Wilk, A. (1997). Exemplar spacing and infants' memory for category information. *Infant Behavior and Development. 20(2),* 219-232

Mervis, C. B. (1987). *Child-basic object categories and early lexical development.* In U. Neisser (Ed.), Concepts and conceptual development (pp. 25-262). Cambridge: Cambridge University Press.

Mervis, C. B. and Bertrand, J. (1993). Acquisition of early object labels: The roles of operating principles and input. In A. P. Kaiser and D. B. Gray (Eds.), *Enhancing children's communication: Research foundations for intervention* (pp. 286-316). Baltimore, MD: Paul H. Brookes Publishing.

Mervis, C. B. and Bertrand, J. (1994). Acquisition of the novel name nameless (N3C) principle. *Child Development, 65(6),* 1646-1662.

Mervis, C. B., and Mervis, C. A. (1982). Leopards are kitty-cats: Object labelling by mothers for their thirteen-month-olds. *Child Development, 53(1),* 267-273.

Moerk, E. L. (1990). Three-term contingency patterns in mother-child verbal relations during first-language acquisition. *Journal of the Experimental Analysis of Behavior, 54(3),* 293-305.

Moerk, E. (1996). Input and learning processes in first language acquisition. *Advances in Child Development, 26,* 181-228.

Molfese, D. L. (1977). Infant cerebral asymmetry. In S. J. Segalowitz andF. A. Gruber (Eds.), *Language development and neurological theory* (pp. 21-35). New York: Academic Press.

Mount, R., Reznick, J. S., Kagan, J., Hiatt, S., and Szpak, M. (1989). Direction of gaze and emergence of speech in the second year. *Brain and Language, 36(3),* 406-410.

Morales, M., Mundy, P., and Rojas, J. (1998). Following the direction of gaze and language development in six-month-olds. *Infant Behavior and Development, 21,* 373-377.

Namy, L. L. (2001). What's in a name when it isn't a word? 17-month-olds' mapping of nonverbal symbols to object categories. *Infancy, 2(1),* 73-86.

Namy, L. L., and Waxman, S. R. (1998). Words and gestures: Infants' interpretations of different forms of symbolic reference. *Child Development, 69(2),* 295-308.

Nazzi, T., and Gopnik, A. (2001). Linguistic and cognitive abilities in infancy: When does language become a tool for categorization? *Cognition, 80(3),* B22-B20.

Nelson, K. and Lucariello, J. (1985). The development of meaning in first words. In M.Barrett (Ed.), *Children's single-word speech* (pp.59-86). New York: Wiley.

Newport, E. L., Gleitman, H. R., and Gleitman, L. R. (1977). Mother I'd rather do it myself: Some effects and non-effects of maternal speech style. In C. E. Snow and C. A. Ferguson (Eds.), Talking to children: Language input and acquisition. Cambridge: Cambridge University Press.

Ninio, A., and Bruner, J. (1976). The achievement and antecedents of labelling. *Journal of Child Language, 5(1),* 1-15.

Otomo, K. (2001). Maternal responses to word approximations in Japanese children's transition language. *Journal of Child Language, 28(1),* 29-57.

Oviatt, S. L. (1980). The emerging ability to comprehend language: An experimental approach. *Child Development, 51(1),* 97-106.

Pan, B. A. and Berko Gleason, J. (1997). Semantic development:: Learning the meanings of words. In Berko Gleason, J. (Ed.), *The development of language.* Boston: Allyn and Bacon

Papousek, M., Papousek, H., and Haekel, M. (1987). Didactic adjustments in fathers' and mothers' speech to their 3-month-old infants. *Journal of Psycholinguistic Research, 16(5),* 491-516.

Perner, J. (1991). *Learning, development, and conceptual change.* Cambridge, MA: MIT Press.

Pinker, S. (1994).*The language instinct: The new science of language and mind.* London: Allen Lane.

Poulson, C. L, and Kymissis, E. (1996). The operant language-acquisition paradigm and its empirical support. In Bijou, S.W. and Ribes, E. (Eds.), *New directions in behavior development* (pp.73-90).

Plunkett, K. (1997). Theories of early language acquisition. *Trends in Cognitive Sciences, 1(4),* 146-153.

Plunkett, K. and Schafer, G. (1999). Early speech perception and word learning. In M. Barrett, (Ed.), The development of language. Studies in developmental psychology (pp.51-71). Philadelphia, US: Psychology Press.

Plunkett, K., Sinha, C., Moller, M. F., and Strandsby, O. (1992). Symbol grounding or the emergence of symbols? Vocabulary growth in children and a connectionist net. *Connection Science: Journal of Neural Computing, Artificial Intelligence & Cognitive Research. Special Issue: Philosophical issues in connectionist modelling, 4(3-4),* 293-312.

Premack, D. (1990). Words: What are they, and do animals have them? *Cognition, 37(3),* 297-212.

Pye, C. (1986). Quiche Mayan speech to children. *Journal of Child Language, 13(1),* 85-100.

Quine, W. V. O. (1960). *Word and object.* Cambridge, MA: MIT Press.

Randle, V. R. L. (1999). *Naming and categorisation in pre-school infants.* Unpublished doctoral dissertation. University of Wales, Bangor.

Reddy, V. (1999). Prelinguistic communication. In M. Barrett (Ed.), *The development of language: Studies in developmental psychology.* Hove: Psychology Press.

Rescorla, R. A. (1988). Pavlovian conditioning: It's not what you think it is. *American Psychologist, 43(3),* 151-160.

Rescorla, R. A. and Wagner, A. R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black and W. F. Prokasy (Eds.), *Classical conditioning II: Current research and theory* (pp. 64-99).

Reznick, J. S. (1990). Visual preference as a test of infant word comprehension. *Applied Psycholinguistics, 11(2),* 145-166.

Reznick, J. S. and Goldfield, B. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology, 28*(3), 406-413.

Ringler, N. (1978). A longitudinal study of mother's language. In N. Waterson and C. Snow (Eds.), *The development of communication.* New York: Wiley.

Rome-Flanders, T., Cronk, C., and Gourde, C. (1995). Maternal scaffolding in mother-infant games and its relationship to language development: A longitudinal study. *First Language, 15(3),* 339-355.

Routh, D. K. (1969). Conditioning of vocal response differentiation in infants. *Developmental Psychology, 1(3),* 219-226.

Ryle, G. (1984). *The concept of mind.* Chicago: University of Chicago Press.

Sachs, J., Bard, B., and Johnson, M. L. (1981). Language learning with restricted input: Case studies of two hearing children of deaf parents. *Applied Psycholinguistics, 2(1),* 33-54.

Samuelson, L. K., and Smith, L. B. (1998). Memory and attention make smart word learning: An alternative account of Akhtar, Carpenter and Tomasello. *Child Development, 69(1),* 94-104.

Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R. A., Brakke, K. E., Williams, S. L., and Rumbaugh, D. M. (1993). Language comprehension in ape and child. *Monographs of the Society for Research in Child Development, 58(3-4),* 1-256.

Savage-Rumbaugh, E. S. (1986). *Ape language: From conditioned response to symbol.* New York: Columbia University Press.

Scaife, M. and Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature, 253(5489),* 265-266.

Schafer, G. (2001). Intersensory origins of word comprehension: But what's the mechanism? *Developmental Science, 4(1),* 23-26.

Schafer, G., and Mareschal, D. (2001). Modeling infant speech sound discrimination using simple associative networks. *Infancy, 2(1),* 7-28.

Schafer, G., and Plunkett, K. (1998). Rapid word learning by fifteen-month-olds under tightly controlled conditions. *Child Development, 69(2),* 309-320.

Schusterman, R. J. and Gisiner, R. (1988). Artificial language comprehension in dolphins and sea lions. The essential cognitive skills. *Psychological Record, 38(3),* 311-348.

Schusterman, R. J. and Kastak, D. (1993). A California sea lion *(Zalophus californianus)* is capable of forming equivalence relations. The Psychological Record, 43, 823-839.

Schusterman, R. J. and Krieger, K. (1984). California sea lions are capable of semantic comprehension. *Psychological Record, 34(1),* 3-23.

Shi, R., and Werker, J. F. (2001). Six-month old infants' preference for lexical words. *Psychological Science, 12(10),* 70-75.

Skinner, B. F. (1938). *The behavior of organisms.* New York: Appleton-Century Company.

Skinner, B. F. (1957). *Verbal behavior.* New York: Appleton-Century-Crofts.

Skinner, B. F. (1969). Behaviorism at fifty. In *Contingencies of reinforcement* (pp. 221-268). New York: Appleton-Century-Crofts.

Slater, A. and Kirby, R. (1998). Innate and learned perceptual abilities in the newborn infant. *Experimental Brain Research, 123 (1-2),* 90-94.

Smith, L. B. (1995). Self-organizing processes in learning to learn words: Development is not induction. In C. A. Nelson (Ed.), *Basic and* *applied perspectives in learning, cognition, and development* (pp.1-32). Mahwah, NJ: Lawrence Erlbaum Associates.

Smith, L. B. (1999). Children's noun learning: How general learning processes make specialized learning mechanisms. In B. MacWhinney (Ed.), *The emergence of language* (pp.277-203). Mahwah, NJ: Lawrence Erlbaum Associates.

Smith, L. B. (2000a). Learning how to learn words: An associative crane. In R. M. Golinkoff et al. (Eds.), *Becoming a word learner: A debate on lexical acquisition* (pp. 51-80). Oxford: Oxford University Press.

Smith, L. B. (2000b). Avoiding associations when it's behaviorism you really hate. In R. M. Golinkoff et al. (Eds.), *Becoming a word learner: A debate on lexical acquisition* (pp. 169-174). Oxford: Oxford University Press

Smith, R., Michael, J., and Sundberg, M. L. (2001). Automatic reinforcement and automatic punishment in infant vocal behaviour. *The Analysis of Verbal Behavior, 13,* 39-48.

Snow, C. E. (1989). Understanding social interaction and language acquisition: Sentences are not enough. In M. Bornstein and J. Bruner (Eds.), *Interaction in human development* (pp. 80-103). Hillsdale, NJ: Lawrence Erlbaum Associates.

Snow, C. E. (1999). Social perspectives on the emergence of language. In B. MacWhinney (Ed.), *The emergence of language* (pp.257-304). Mahwah, NJ: Lawrence Erlbaum Associates.

Snow, C. E. and Ferguson, C. E. (1977). *Talking to children: Language input and acquisition.* Cambridge: Cambridge University Press.

Snyder, Bates and Bretherton (1981). Content and context in early lexical development. *Journal of Child Language 8,* 565-582.

Solberg, M. E. (1976). Constraint and structure contingent characteristics of the language array. In R. Campbell and P. T. Smith (Eds.), *Recent advances in the psychology of language.* New York: Plenum.

Sorce, J. F., Emde, R. N., Campos, J. J., Klinnert, M. D. (1985). Maternal emotional signalling: Its effect on the visual cliff behavior of 1-year-olds. *Developmental Psychology, 21(1),* 195-200.

Stemmer, N. (1990). Skinner's Verbal Behavior, Chomsky's review, and mentalism. *Journal of the Experimental Analysis of Behavior. Special Issue: The experimental analysis of human behavior, Vol 54(3),* 307-315.

Stemmer, N. (1992). The behaviour of the listener, generic extensions, and the communicative adequacy of verbal behaviour. *Analysis of Verbal Behavior, 10,* 69-80.

Stemmer, N. (1996). Listener behavior and ostensive learning. *Journal of the Experimental Analysis of Behavior, 65(1),* 247-249, 241-53.

Stemmer, N. (2002). Further steps towards an improved version of behavior analysis. *European Journal of Behavior Analysis, 1(1),* 37-48.

Sundberg, M. L, and Michael, J. (2001). The benefits of Skinner's analysis of verbal behaviour for children with autism. *Behavior Modification, 25(5),* 698-724.

Sundberg, M. L., Michael, J., Partington, J. W., and Sundberg, C. A. (1996). The role of automatic reinforcement in early language acquisition. *The Analysis of Verbal Behavior, 13,* 21-37.

Taylor, I. (1990). *Psycholinguistics: Learning and using language.* NJ: Prentice Hall

Toda, S. and Fogel, A. (1993). Infant response to the still-face situation at 3 and 6 months. *Developmental Psychology, 29(3),* 532-538.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore and P. J. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 103-130), Hillsdale, NJ: Lawrence Erlbaum Associates.

Tomasello, M. (2001). Could we please lose the mapping metaphor, please? *Behavioral and Brain Sciences, 24(6),* 1119-11120.

Tomasello, M. and Barton, M. (1994). Learning words in non-ostensive contexts. *Developmental Psychology, 30(5),* 639-650.

Tomasello, M., and Camaioni, L. (1997). A comparison of the gestural communication of apes and human infants. *Human Development, 40(1),* 7-24.

Tomasello, M., and Farrar, J. (1986). Joint attention and early language. *Child Development, 57,* 1454-1463.

Tomasello, M., and Todd, J. (1983). Joint attention and early lexical acquisition style. *First Language, 4,* 197-212.

Trevarthen, M. and Hubley, P. (1978). Secondary intersubjectivity: Confidence, confiding, and acts of meaning in the first year. In A. Lock (Ed.), *Action, gesture and symbol: The emergence of language (pp. 183-230).*

Vander Linde, E., Morongiello, B. A., and Rovee-Collier, C. (1985). Determinants of retention in 8-week-old infants. *Developmental Psychology, 21(4)*, 601-613.

Waxman, S. R., and Markow, D. B. (1995). Words as invitations to form categories: Evidence from 12- to 13-month-old infants. *Cognitive Psychology, 29(3)*, 257-302.

Werker, J. F., Cohen L. B., Lloyd, V. L., Casasola, M. S., and Stager. C. L. (1998). Acquisition of word-object associations by 14-month-old infants. *Developmental Psychology 34(6)*, 1289-1309.

Whitehurst, G. J. (1996). On the origins of misguided theories of naming and other symbolic behaviour. *Journal of the Experimental Analysis of Behavior, 65(1)*, 255-259, 341-53.

Whitehurst, G. J. and DeBaryshe, B. D. (1989). Observational learning and language acquisition: Principles of learning, systems, and tasks. In G.E. Speidel and K. E. Nelson (Eds.), *The many faces of imitation in language learning* (pp.251-276). New York: Springer-Verlag.

Whitehurst, G. J., Kedesdy, J., and White, T. G. (1982). A functional analysis of meaning. In S. A. Kuczaj (Ed.), *Language Development: Syntax and semantics* (pp.397-427). Hillsdale, NJ: Erlbaum.

Whitehurst, G. J., and Valdez-Menchaca, M. C. (1988). What is the role of reinforcement in early language acquisition? *Child Development, 59*, 430-440.

Wilkinson, K. M., Dube, W. V., and McIlvane, W. J. (1996). A crossdiciplinary perspective on studies of rapid word mapping in psycholinguistics and behaviour analysis. *Developmental Review, 16(2)*, 125-148.

Wilkinson, K. M., Dube, W. V., and McIlvane, W. J. (1998). Fast mapping and exclusion (emergent matching) in developmental language, behaviour analysis, and animal cognition research. *Psychological Record, 48(3)*, 407-422.

Wittgenstein, L. (1953). *Philosophical investigations*. New York: Macmillan.

Woodward, A. L. (2000) Constraining the problem space in early word learning. In R. M. Golinkoff et al. *Becoming a word learner: A debate on lexical acquisition* (pp. 81-114). Oxford: Oxford University Press.

Woodward, A. L., and Hoyne, K. L. (1999). Infants' learning about words and sounds in relation to objects. *Child Development, 80(1)*, 65-77.

Woodward, A. L., Markman, E. M., and Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology, 30(4),* 553-566.

Woodward, A. L., and Markman, E. M. (1998). Early word learning. In D. Kuhn and R. S. Siegler (Eds.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (pp. 371-420). New York: John Wiley and Sons.

Younger, B. A., and Cohen, L. B. (1986). Developmental change in infants' perception of correlations among attributes. *Child Development, 57(3),* 803-815.

Zeidner, M. (1978). Psycholinguistic aspects of the "baby talk" register in Hebrew. *Haifa University, Studies in Education, 20,* 105-120.

Zukow-Goldring, P. (1996). Sensitive caregiving fosters the comprehension of speech: When gestures speak louder than words. *Early Development and Parenting, 5(4),* 195-211.

APPENDIX A: SAMPLE CONSENT LETTER AND FORM

Dear Parent(s)

The language and learning research group at the School of Psychology, University of Wales Bangor, is conducting a new study on the early stages of language acquisition. We are investigating the steps involved in learning a first language, and particularly how the child comes to respond appropriately to words used by parents and other caregivers. Paula Gurteen is a postgraduate member of our team who will be conducting and organising this research with the additional involvement of undergraduate researchers.

We wish to conduct studies with infants between the ages of twelve and eighteen months because babies at this age cannot yet use a large number of words. We will assess how quickly infants learn a new name by showing your baby a variety of play and unfamiliar objects along with either familiar or unfamiliar names, and looking at how they respond.

The study will take up to an hour to complete, including a number of breaks and free-play periods. The session will be conducted at a specially equipped room in the School of Psychology. You, the parent, will be in the room with researcher and baby for the entirety of the session. We will videotape the session so that we can analyse responses afterwards, but we will not identify participants by name in any publication or report so that your baby's anonymity is retained.

When you consent to the study, we will also send you a questionnaire to complete at home prior to the session. This, the MacArthur Communicative Development Inventory (MCDI), assesses your baby's current language skills, and takes approximately half an hour to complete. If you are unsure about any of your answers, there will be an opportunity to discuss them with Paula at the session.

The session can be arranged at any time to suit your schedule, and we will reimburse you ten pounds in compensation for your time and travel expenses. We will also provide you with written details of the study and a certificate for your baby by way of thanks for your involvement.

Please let us know whether or not you are interested in this study by filling in the details on the attached consent form and sending it to: ..., as soon as possible. If you consent to the study, we will contact you to arrange a suitable time for the session at the earliest opportunity. If you would like more information before deciding, please telephone Paula Gurteen on ... or email.... Even after you have given your consent to the study, you are free to withdraw your baby at any time.

Thank you for your time,
Yours faithfully,

Professor C.F. Lowe

Consent form

Date: ______________

Parent's name: ____

Please tick one of the statements below:
I have read the information accompanying this form and -
I consent to the participation of my child in the language study [ ]
I do not consent to the participation of my child in the language study [ ]

Parent's signature:____

If you have consented to the study, please also fill in the following details so that we can arrange the experimental session:

Address:____
____
____

Telephone number and/or email address:_____________________________________

Baby's name:____

Baby's date of birth: ____

APPENDIX B: SAMPLE DEBRIEFING INFORMATION IN EXPERIMENTS 1 AND 2

Can infants learn to comprehend new words after only limited exposure?

Study information.

Overall, this study aims to test for the possibility that babies can learn new words for objects that are unfamiliar to them after only a few exposures to the link between the word and the object. In the room you saw a black board on which I placed one or two objects. Above the position of each object on the board were cameras, which we used to assess the direction of your baby's looking throughout the session.

The first part of the study exposed your baby to the link between a strange object (e.g. the blue and yellow triangular object) and a strange word (e.g. 'pab'). So, for example, I placed a single object on the board and said, "This is a pab!" Then, your baby was tested to see whether s/he looked longer at the blue and yellow object when we presented the word 'pab'. In these trials, I placed two objects on the board and asked, "Where's the pab?", for example. The video cameras in the board will allow us to code these trials for the direction of your baby's looks.

In the second part of the study, we investigated whether the baby would not only look longer, but reach towards, the blue and yellow object when we said 'pab'. We use this test because it more closely resembles a natural play situation, where the baby is encouraged to handle new objects and not only to look at them.

The final part of the study tested to see whether the baby could produce the strange words that I presented earlier in the session.

Unfortunately, I can't tell you exactly what your baby did throughout this session until we complete coding of the video-recordings. If you are interested in our results, however, please contact me and I will let you know when we have completed the study.

Thank you very much for taking part in this study!

Paula Gurteen

To contact me for further information or comment, please:
Email:
Telephone:
Write to:

APPENDIX C: RESULTS OF INDIVIDUAL INFANTS IN EXPERIMENT 1

Table C1. Mean individual looking scores for **13-month-old infants** on familiar test trials (TL and LL measures), training trials (Train 1 = % total looking to target objects, Train 2 = % total looking to target objects and experimenter), and novel test trials (TL and LL measures).

CHILD	FAM TL	FAM LL	TRAIN 1	TRAIN 2	NOV TL	NOV LL
1	58.12	54.29	65.72	97.4	57.63	54.95
2	68.21	65.52	58.86	66.61	56.42	48.88
3	58.94	60.1	60.88	86.76	39.26	41.75
4	50.1	50.85	79.69	88	56.1	55.07
5	52.68	60.35	60.3	68.95	59.69	55.47
6	54.88	54.18	76.97	94.1	28.29	30.47
7	60.29	55.51	76.7	85.98	72.37	67.52
8	57	54.18	85.59	93.16	53.6	52.09
9	46.27	46.68	59.43	93.62	74.44	74.96
10	62.13	61.75	69.73	93.21	45.7	42.43
11	73.9	68.11	59.21	92.71	36.92	35.78
12	51.22	50.89	46.28	68.22	59.83	62.87
13	46.64	45.49	73.4	86.15	49.7	49.29
14	75.09	75.91	91.35	95.96	53.26	51.81
15	44.93	34.53	59.03	87.09	54.97	56.13
16	62.83	62.29	68.6	93.59	51.85	60.38
17	50.73	46.73	75.79	94.34	68.47	59.42
18	56.42	55.26	39.54	67.61	62.34	64.92
19	52.85	55.59	59.02	63.8	46.6	50.76
20	65.93	64.76	71.07	83.43	47.71	50.26
21	37.32	32.32	67.5	96.19	63.56	65.84

Table C2. Mean individual looking scores for **17-month-old infants** on familiar test trials (TL and LL measures), training trials (Train 1 = % total looking to target objects, Train 2 = % total looking to target objects and experimenter), and novel test trials (TL and LL measures).

CHILD	FAM TL	FAM LL	TRAIN 1	TRAIN 2	NOV TL	NOV LL
1	66.97	63.55	81.71	100	44.78	47.29
2	69.01	56.45	64.36	92.57	55.14	54.85
3	48.29	45.92	76.03	100	59.68	55.09
4	64.95	64.26	85.12	95.18	39.87	37.42
5	67.41	59.18	60.83	100	56.3	55.92
6	66.42	69.33	76.37	87.62	54.82	47.26
7	53.85	49.64	76.46	95.56	28.99	29.57
8	54.96	50.65	82.53	96.36	58.49	60.7
9	74.64	71.25	58.54	68.49	46.42	42.12
10	72.81	74.43	51.1	96.7	51.27	44.92
11	65.46	55.32	70.61	99.1	57.21	53.91
12	60.85	60.08	64.34	90.88	36.34	39.17
13	63.94	64.45	50.69	87.9	51.21	57
14	54.34	53.05	49.4	92.37	52.64	51.12
15	68.25	49.33	50.37	95.81	52.86	48.94
16	73.63	72.44	51.26	95.39	68.91	67.29
17	56.92	56.94	56.92	82.73	56.03	49.17
18	64.44	67.32	57.87	98.58	74.65	78.74
19	56.38	58.14	91.79	97.18	57.18	53.18
20	57.7	60.45	54.04	74.87	48.59	40.93

APPENDIX D: RESULTS OF INDIVIDUAL INFANTS IN EXPERIMENT 2

Table D1. Mean individual looking scores for **13-month-old infants** on familiar test trials (TL and LL measures), training trials (Train 1 = % total looking to target objects, Train 2 = % total looking to target objects and experimenter), and novel test trials (TL and LL measures).

CHILD	FAM TL	FAM LL	TRAIN 1	TRAIN 2	NOV TL	NOV LL
1	58.55	56.36	71.22	78.07	40.84	48.8
2	54.39	56.44	72.34	93.18	65.82	66.14
3	59.74	62.2	67.02	96.54	57.33	57.72
4	50.61	50.78	81.91	94.84	39.46	38.39
5	68.79	69.05	47.96	70.1	68.6	66.07
6	54.81	55.08	63.56	93.85	67.99	58.13
7	55.82	49.44	86.42	96.55	75.33	72.79
8	76.83	76.12	70.04	100	66.76	66.93
9	64.95	64.06	69.25	85.15	62.28	60.84
10	54.45	54.41	94.12	51.93	66.53	59.21

Table D2. Mean individual looking scores for **17-month-old infants** on familiar test trials (TL and LL measures), training trials (Train 1 = % total looking to target objects, Train 2 = % total looking to target objects and experimenter), and novel test trials (TL and LL measures).

CHILD	FAM TL	FAM LL	TRAIN 1	TRAIN 2	NOV TL	NOV LL
1	53.12	56.99	81.46	90.77	57.92	54.35
2	47.81	49.97	55.26	92.18	70.66	68.18
3	79.35	79.58	84.34	100	63.13	52.08
4	69.83	68.4	54.52	96.96	58.87	44.11
5	55	52.66	53.26	99.92	57.24	57.74
6	58.15	59.52	77.35	100	49.3	43.19
7	55.35	55.34	65.17	93.96	59.66	54.8
8	65.55	69.42	63.49	90.3	50.15	53.75
9	61.68	62.54	59.03	98.03	44.68	48.51
10	69.57	75.15	66.23	92.87	56.05	47.55

APPENDIX E: SAMPLE DEBRIEFING INFORMATION IN EXPERIMENT 3 (REINFORCEMENT AND EXPOSURE CONDITIONS)

Can babies from 12 to 18 months learn to comprehend new words after limited reinforced training?

Thank you very much for taking part in this study!

Overall, the study aims to test for the possibility that babies can learn new words for objects that are unfamiliar to them after a brief amount of training in which the link between word and object is established. Your baby falls into one of two age groups: 12-14 or 16-18 months. All age groups follow the same procedure, and their results are compared.

The first part of the study aimed to teach your baby the link between a strange object (e.g. the blue and yellow triangular object) and a strange word (e.g. 'zag'). In the room you saw a black board on which I placed one or two objects. Above each object on the board were cameras, which we used to assess the direction of your baby's looking throughout the session. In the training phase, I placed both strange objects on the board and asked, "Where's the zag?" When your baby looked towards the correct object, I turned on flashing lights around that object, and said "Yes! There it is!"

Next your baby was tested to see whether s/he looked longer at the blue and yellow object when we presented the word 'zag'. In these trials, I placed two objects on the board and asked, "Where's the zag?", for example. The video cameras in the board allow us to code these trials for the direction of your baby's looks.

In the second part of the study, we investigated whether the baby would *reach towards* the blue and yellow object when we said 'zag'. We use this test because it more closely resembles a natural play situation, where the baby is encouraged to handle new objects and not only to look at them.

The final part of the study tested to see whether the baby could produce the strange words that I presented earlier in the session.

Unfortunately, I can't tell you exactly what your baby did throughout this session. When we have completed coding and analysis of the video-tapes, I can let you know our overall study results, however. If you are interested in these results, please let me know, and I will contact you once we have completed the study.

Thanks again for your interest and support,

Paula Gurteen

Can babies from 12 to 18 months learn to comprehend new words after limited exposed training?

Thank you very much for taking part in this study!

Overall, the study aims to test for the possibility that babies can learn new words for objects that are unfamiliar to them after a brief amount of exposure in which the link between word and object is established. Your baby falls into one of two age groups: 12-14 or 16-18 months. Both age groups follow the same procedure, and their results are compared.

The first part of the study aimed to teach your baby the link between a strange object (e.g. the blue and yellow triangular object) and a strange word (e.g. 'zag'). In the room you saw a black board on which I placed one or two objects. Above each object on the board were cameras, which we used to assess the direction of your baby's looking throughout the session. In the exposure phase, I placed both strange objects on the board and turned on flashing lights around one of them to capture the baby's attention. Then I pointed to the object and said, "Where's the zag?" I also played music and encouraged the baby throughout in order that they would find the session enjoyable. We are interested in discovering whether this simple exposure, repeated ten times, is enough for babies to learn to understand new words.

Next your baby was tested to see whether s/he looked longer at the blue and yellow object when we presented the word 'zag'. In these trials, I placed two objects on the board and asked, "Where's the zag?", for example. The video cameras in the board allow us to code these trials for the direction of your baby's looks.

In the second part of the study, we investigated whether the baby would *reach towards* the blue and yellow object when we said 'zag'. We use this test because it more closely resembles a natural play situation, where the baby is encouraged to handle new objects and not only to look at them.

The final part of the study tested to see whether the baby could produce the strange words that I presented earlier in the session.

Unfortunately, I can't tell you exactly what your baby did throughout this session. When we have completed coding and analysis of the video-tapes, I can let you know our overall study results, however. If you are interested in these results, please let me know, and I will contact you we have completed the study.

Thanks again for your interest and support,

Paula Gurteen

APPENDIX F: EXPERIMENTER INSTRUCTIONS IN WELSH (EXPERIMENT 3)

Where's the X? Can you see the X? Look at the X!
Lle mae'r X? Sbia ar yr X! Lle mae'r X?

Cup/drink
Cwpan/diod

Shoe
Esgid

Bottle
Potel

Banana
Banana

Can you look at these? Look over here! Look at these!
Sbia ar rhain! Sbia famma! Sbia ar rhain!

Look, this is an X!
Sbia! Dyma'r X!

Ooh! What's going to come up?
Ooh! Be sy nesa?

Is it one of these? The X!
Un ar rhain ydy o? Yr X!

There it is! Good girl!
Dyna fo! Hogan da!

Bye bye!
Ta-ta!

Look over here! Can you see the light?
Sbia famma! Lle mae'r golau?

Can you get the X?
Dos i nol yr X?

Can you put the X in the basket, can you put the X in, the X?
Fedri di roi yr X yn y fasged? Fedri di roi yr X i fewn, yr X?

What's this?
Be ydi hwn?

APPENDIX G: RESULTS FOR INDIVIDUAL INFANTS IN EXPERIMENT 3

Table G1. Mean individual looking scores for **17-month-old infants in the Reinforcement Condition** on familiar test trials (TL and LL measures), training trials, and novel test trials (TL and LL measures).

CHILD	FAM TL	FAM LL	TRAIN	NOV TL	NOV LL
1	64.1	67.08	96.6	65.31	65.07
2	62.16	62.05	96.93	63.38	60.76
3	79.49	77.29	95.47	61.21	62.36
4	70.09	74	96.98	54.07	48.42
5	58.83	58.04	98.61	52.33	48.34
6	72.07	74.04	96.07	61.77	57.93
7	63.26	59.89	96.48	51.22	51.25
8	74.33	72.97	99.23	64.83	68.12
9	81.59	80.02	96.36	63.91	62.9
10	69.8	64.01	93.78	61.77	58.23

Table G2. Mean individual looking scores for **13-month-old infants in the Reinforcement Condition** on familiar test trials (TL and LL measures), training trials, and novel test trials (TL and LL measures).

CHILD	FAM TL	FAMLL	TRAIN	NOV TL	NOV LL
1	56.57	56.96	89.58	58.81	53.46
2	57.87	59.74	96.3	67.07	63.64
3	44.93	41.65	93.54	58.78	58.52
4	62.32	60.5	93.4	54.77	52.84
5	63.28	66.12	100	51.69	47.42
6	61.53	63.37	92.08	59.09	58.7
7	78.13	75.46	93.65	75.68	75.34
8	74.68	73.78	95.87	56.72	57.87
9	65.85	61.54	97.57	65.49	60.18
10	59.42	58.26	98.36	47.77	46.63
11	62.46	61.74	100	83.6	81.09

Table G3. Mean individual looking scores for **17-month-old infants in the Exposure Condition** on familiar test trials (TL and LL measures), training trials, and novel test trials (TL and LL measures).

CHILD	FAM TL	FAMLL	TRAIN	NOV TL	NOV LL
1	68.04	66.31	98.58	56.37	56.87
2	55.03	53.92	94.96	48.31	52.05
3	64.42	65.37	95.52	49.13	49.2
4	64.96	64.96	86.66	39.95	40.72
5	71.12	72.44	88.79	68.7	65.18
6	62.32	60.91	87.77	62.41	60.5
7	52.38	49.73	98.43	58.31	57.46
8	71.95	69.99	81.42	29.9	30.12
9	55.98	52.68	86.02	55.8	57.25
10	46.18	44.43	97.47	38.61	32.27

Table G4. Mean individual looking scores for **13-month-old infants in the Exposure Condition** on familiar test trials (TL and LL measures), training trials, and novel test trials (TL and LL measures).

CHILD	FAM TL	FAMLL	TRAIN	NOV TL	NOV LL
1	70.68	71.87	97.95	53.22	53.12
2	80.19	78.07	100	54.17	56.75
3	60.79	60.43	100	52.88	52.86
4	58.78	59.3	91.97	53.75	53.85
5	70.13	71.89	95.92	59.59	60.32
6	50.77	51.03	89.93	41.85	41.85
7	55.54	57.63	95.6	57.89	59.42
8	69.28	64.31	97.68	58.96	51.18
9	63.87	62.78	92.77	39.45	42.96
10	54.81	57.54	96.05	63.3	63.97
11	63.48	63.32	93.65	15.4	15.4