DOCTOR OF PHILOSOPHY

Naming and categorisation in pre-school infants

Randle, Valerie R. L

Award date:
1999

Awarding institution:
University of Wales, Bangor

UNIVERSITY OF WALES

NAMING AND CATEGORISATION IN PRE-SCHOOL INFANTS

VALERIE. R. L. RANDLE

PH. D.

1999

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Dr. Pauline Horne and Professor Fergus Lowe for their constant support, guidance and above all patience.

Thanks go out to the staff, children and parents of Tir Na N'Og, Parc Menai, and the Student Union crèches without whom there would be no data and hence no thesis.

I am also grateful for the help and witty quips of the technical support staff, especially young (and most definitely blonde) Gaz for help with the graphics, the ever shrinking big Steve for cleaning my heads, and to Dave Robinson for lurking around in the back room looking nervous.

A special thank you must also go out to the exotically coiffeured Mr Edward Ingram for learning me to write proper and checking my spelling mistrakes.

I would also like to acknowledge the various helpful roles of the other long-suffering post-graduates: Mags for being there with that most essential of advice - telling me what my thesis is all about; Fay for providing the stepping stones; Sam for providing sequin filled moments of distraction and especially for her inexhaustible and frankly astounding knowledge of the fast-mapping literature; Enlli Mon for being a haven of Welshness whose skills in translation of the vernacular are second to none; Janette for valuable fruit information; and George for stopping me overdosing on caffeine by stealing all my tea bags.

As being a post-grad entails having no life, I would like to thank Jenny for keeping us all up to date on the real world by virtue of her undoubted skills at espionage. Finally, by popular demand, I must mention the wonder that is Comedy Kev, whose name deserves to be in print ... so here it is!

SUMMARY

Horne and Lowe (1996) define naming as a fusion of speaker (i.e. tact and echoic) and listener relations. Within a name relation, all objects that evoke the same speaker-listener behaviour become functionally related to each other, thereby forming a category, whether or not these stimuli bear a physical resemblance to one another. Horne and Lowe's account predicts that the categorisation of physically different stimuli will not occur unless both common speaker and listener relations have been established to sets of such stimuli.

The first study sought to falsify Naming Theory by training common listener relations, but not common speaker relations, to two potential stimulus classes of physically dissimilar stimuli, and then testing for categorisation. Of nine participants (age group, 1.5 - 4.5 years), none succeeded in passing the categorisation tests. However, after subsequently receiving training in speaker relations, and hence establishing naming, six went on to pass the categorisation tests.

Study 2 replicated the methodology of Study 1 with participants from 2.5 - 4.5 years of age. This time, however, rather than establishing only common listener relations between members of each potential stimulus class, the participants also received concurrent off-task echoic training of the required speaker responses. This investigated whether this training alone, and in the absence of direct training of the common tact responses necessary to complete the full name relation, yield untrained categorisation of physically different objects. Of the 6 participants five categorised the arbitrary stimulus sets into two classes consistent with the experimental names. All five of these participants only categorised when concurrent evidence of the establishment of both listener and tact relations was also shown.

The final study of this thesis trained a common tact response to two potential stimulus classes. After this training, all three participants (aged between 3.5 and 4.5 years of age) demonstrated successful categorisation and also the corresponding common listener relations.

The findings of all three studies support the view that naming is necessary for categorisation of physically different stimuli. It is argued that these results cannot be explained by the competing accounts of both Sidman's (1990) Equivalence theory, and Hayes' (1986) Relational Frame theory of emergent stimulus classes. It has also been suggested that there exists a relationship between the rapid advances in children's productive repertoires (the naming explosion) and the onset of exhaustive categorisation (Gopnik & Meltzoff, 1989, 1992). Implications of the current research to this issue is also considered.

CONTENTS

“LEGE ET LACRIMA”

CHAPTER 1

THE RELATIONSHIP BETWEEN LANGUAGE, CATEGORISATION AND STIMULUS CLASSES.

At approximately 18 months of age, infants exhibit some dramatic changes in their development. Not only is there a marked increase in their ability to produce words, but also the manner in which they interact with objects, and sort them into categories, is transformed. This raises a number of questions. Are these two developments related? If so how? Does the ability to produce more words cause the changes in categorisation, or vice versa? Are either or both these behaviours innate, or, alternatively, either or both dependent on the child's learning history?

These questions remain largely unanswered. Exploration of the issues which arise from them forms the basis of the experimental work contained in this thesis.

* * *

The main theoretical perspective of this thesis is grounded in the work of Horne and Lowe (1996). Their paper, *On the origins of naming and other symbolic behaviour* draws on theory from both the behaviour analytic and developmental traditions of psychology. It identifies naming as the basic unit of verbal behavior, describes the conditions under which it is learned, and outlines its role in the development of bi-directional stimulus classes (that is, categorisation) and, hence, of symbolic behaviour.

Chapter 1 provides a review of theory and empirical work in the area of language and categorisation.

The first half contains a summary of the literature from the developmental perspective that investigates the relationships between language and other cognitive abilities in the pre-school child. This is specifically concerned with events that occur in the child's development between approximately 18 months and two years of age and the phenomenon of the so called *naming explosion.*

The second half of Chapter 1 addresses the behaviour analytic account of the derivation of stimulus classes. Much of the recent research in this field has concentrated on the area of *stimulus equivalence.* Put simply, this area is concerned with the analysis of how untrained relationships between stimuli come into being, these relationships not conforming to the known laws of learning theory.
This section provides a detailed description of the stimulus equivalence paradigm and discusses the many controversies within this area. An emphasis is placed on the relationship between this phenomenon and language.

A synopsis of naming theory, including predictions that lead from Horne and Lowe's assertions, and how the experiments within this thesis aim to test them, is contained in Chapter 2.

* * *

THE DEVELOPMENTAL PERSPECTIVE.

Features of Early Language Development.

At the age of 10-12 months, infants start to produce their first words (Nelson, 1973). They are, however, able to comprehend, that is, to respond in a culturally acceptable manner, to many other words (Huttenlocher & Smiley, 1987). Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick, & Reilly (1993) report that, on average, by the age of 13 months, a child might be able to produce only 10 words yet demonstrate comprehension of 110 words.

Research has shown evidence for robust dissociations between comprehension and production of words in early language learning (Bates, Dale, & Thal, 1995). For example, many studies have shown that comprehension of words tends to precede production in the majority of children (e. g., Benedict, 1977, 1979; Gunzi, 1993; Harris 1997; Harris, Yeeles, Chasin & Oakley, 1995), with most children beginning to produce their first words when they could comprehend around 20 words (Nelson, 1988). Other children, however, show different patterns; some have a comprehension vocabulary of over 150 words before productive language emerges (Bates, 1993; Bates, Bretherton, & Snyder, 1988); some began to produce their first words when they could only comprehend one or two words (Harris et. al., 1995).

It has also been suggested that different word types are acquired at different points in a child's development. In productive and expressive vocabularies the most common of these are names for individuals, objects, or substances (Bates, et. al., 1988; Benedict, 1977, 1979; Fenson, Dale, Reznick, Thal, Bates, Hartung, Pethick, & Reilly, 1993; Gunzi, 1993; Harris & Chasin, 1993).

Some of these early words may be "context bound" (e.g. Bloom, 1973; Gopnik, 1981, 1982; Harris, Barrett, Jones, & Brookes, 1988; Tomasello 1992); for example, the word "shoe" may be used only to name one exemplar of an object, such as the child's own shoes and not any other pair of shoes. Names may also be used in only one particular situation; for example, when the shoes are put on the child by the caregiver and not when they are taken off. Some words, on the other hand, are contextually flexible. For example, Harris et. al (1995) found that if a child's initial production of a word was context bound, then it was likely that prior comprehension of that word was also restricted to the same behavioural context. Similarly, if initial production was context flexible then comprehension of that word was likely to have been flexible.

It has also been suggested (Dore, 1978, 1985; Kamhi, 1986; McShane, 1979, 1980; Nelson, 1983; Nelson & Lucariello, 1985) that some types of words are not acquired until much later, that is, after the so-called vocabulary spurt (occurring at approximately 18 months on average, and to be detailed later). These include certain words which appear to refer to the properties, qualities, and location of objects. Examples of such words include: "more", "gone", "down" and "nice" (Barrett 1995), however not all children conform to such patterns of development. Harris, et. al. (1988) found these kinds of "referential" words can appear in the first few words that a child acquires, well before the age of 18 months.

Not all infants acquire language in the same manner, and it is important to remember that there is remarkable variation in early vocabulary development which makes it extremely difficult to make claims for universal developmental patterns (see Bates, Dale, & Thal, (1995) for an overview). Children may vary in the rate of vocabulary acquisition; at the age of 16 months, for example, the number of words comprehended can range from 78 - 303; whilst productive levels for this age can range from 0 -154 words (Fletcher & MacWhinney, 1995); girls tend to acquire vocabulary faster than boys (Fenson et. al., 1993).

Children also vary in their style of acquisition; some tend to acquire a vocabulary rich in nouns, whilst others acquire more personal and social words (Nelson, 1973); differences have been seen in early phonological development with some infants emphasising segmental features and others suprasegmental features; early utterances may be limited to single words or conversely to longer imitative phrases or sentences (see Bates et. al., 1995).

The Naming Explosion or the Vocabulary Spurt?

At approximately 18 months of age, a dramatic and as yet not fully explained phenomenon occurs. Prior to this point words are acquired slowly and inefficiently, as if the child laboriously learns every word as a special case (Dromi, 1987). It has, however, been widely documented that infants then demonstrate a marked acceleration of productive word learning; this has been termed the *naming explosion* or the *vocabulary spurt.* Infants also start to combine words into two word phrases at around the same time (Dromi, 1987; Goldfield and Reznick, 1990; Gopnik & Meltzoff, 1987; Nelson, 1973). Likewise, the beginnings of this combinatorial language has been linked to developments in symbolic play performance (Casby & Della Corte, 1987; Shore, O'Connell & Bates, 1984).

Most research in this area has concentrated on the infant's acceleration in productive vocabulary learning, possibly due to the difficulties inherent in assessing comprehension levels; however, a few have claimed that there is a corresponding acceleration of comprehension (Lucariello, 1987; Reznick & Goldfield, 1992). Reznick and Goldfield (1992) found a correspondence between spurts in production and comprehension. Of 24 children in their study, 18 showed a spurt in comprehension, with most of these children showing a parallel spurt in production. or did not spurt in either. Overall it was found that children either spurted in both comprehension and production, or spurted in neither. (but see also Woodward, Markman, & Fitzsimmons (1994) for a critique).

Reznick and Goldfield (1990) have claimed that there is a lack of universality in claims for a productive vocabulary spurt. They cite evidence that some infants instead exhibit a continuous vocabulary growth and that others demonstrate a series of short bursts of word acquisition. Of 18 children in their study, 5 showed a steady rate of acquisition, as opposed to a sudden burst of word learning.

However, Mervis and Bertrand (1995) dispute Goldfield and Reznik's claims. In an earlier investigation of the naming explosion (Mervis & Bertrand, 1994), they also found that 3 of their 16 participants showed no evidence of a spurt, even after their production levels had reached an average of 86 words. Those of Goldfield and Reznick's participants who had evidenced a spurt, had done so prior to attaining a 50 word vocabulary (mean 28 words, range = 15-48). The vocabulary acquisition of Mervis and Bertrand's three non-spurters was monitored further.

Their results showed that all three eventually showed evidence of a vocabulary spurt (mean = 112 words). It was also found that during the spurt, the new words acquired were predominantly nouns. This phenomenon has also been reported by Goldfield and Reznick (1990). Mervis and Bertrand concluded that reports of previous failures to spurt may be a result of the researchers' failure to monitor vocabulary development for long enough. They also concluded that it was not the number of words acquired that was predictive of the occurrence of a spurt; rather, the important factor seemed to be the proportion of nouns in the child's vocabulary.

The vocabularies of both "late spurters" and "regular spurters" (of the original 1994 study) averaged about 50 percent of nouns just prior to exhibiting a spurt. After the spurt had begun, the late spurters also demonstrated a faster rate of noun acquisition (mean = 34.6 new words per week) than had the regular spurters (mean = 8 words per week). These results suggest that the term "naming explosion" may indeed be a more suitable name for this phenomenon.

What Causes the Naming Explosion?

There have been many attempts to explain the causes of the naming explosion. Some researchers believe that children may have a sudden insight that objects have names, or should have names (Baldwin & Markman, 1989; Dore, 1974, 1978; Kamhi, 1986; Lock, 1980; McShane, 1979; Reznick & Goldfield, 1992). This leaves one pondering the question of not only how to characterise this "insight", but also its cause.

Others hypothesise that this phenomenon may be attributed to global changes in development. These changes may have the effect of causing infants to suddenly produce words that they have comprehended for a while. These changes may include: changes in memory, that is, children gain the ability to recall and not just recognise object names (Huttenlocher, 1974); developments in articulatory control, or a re-organisation in articulatory ability (Menn, 1976); a re-organisation in phonetic segmentation, (Plunkett 1993); or developmental shifts in representational capacity (Brownell, 1988; Piaget, 1953, 1955, 1962; Shore, 1986).

Recent research has shown that the naming explosion is unlikely to be caused by such global developments. Instead it has been postulated that there exist specific relations between certain cognitive abilities and the acquisition of particular lexical items. It is this issue that will be discussed next.

The Relationship Between Language and other Cognitive Abilities.

Gopnik and Meltzoff (1993) have hypothesised that there are very specific links between particular cognitive developments and particular linguistic developments; this they term the *specificity hypothesis.* According to this hypothesis there should be a strong correlation between specific cognitive and specific semantic developments that are independent of global advancements in the child's development. Moreover, each of these specific relationships may develop independently of other cognitive and semantic developments.

For example, in a series of correlational studies, Gopnik and Meltzoff (1984, 1986a, 1986b) examined the relationship between two cognitive abilities: the attainment of Stage 6 of object permanence, and developmental Stage 6 of means-end abilities (see Piaget, 1953, 1955, 1962). Both these abilities appear at around 18 months of age.

They found a positive correlation between the onset of Stage 6 object permanence and the appearance in production of relational words suggesting disappearance (e.g., "gone"). There was also a relationship between words encompassing success or failure (e.g., "there" and "uh-oh"), and Stage 6 means-end abilities. Conversely, the acquisition of success/failure words was not related to object permanence; likewise, disappearance words were not related to means-end performance.

These data suggest that the link between cognitive and linguistic factors is highly specific. Some children acquire disappearance words and object permanence months before they acquire both success-failure words and means-end abilities. Other children reverse this pattern.

Gopnik and Meltzoff conclude that as each of these specific relationships are acquired independently of the other relations measured, one cannot attribute the changes in language, categorisations, object permanence and means-end abilities to the kinds of global developments discussed earlier.

Language and Categorisation

In the same series of studies, Gopnik and Meltzoff found a positive correlation between the onset of the naming explosion and categorisation, but not between the onset of categorisation and object permanence, or means-end understanding (see also Mervis & Bertrand, 1994).

The assessment of sorting ability (i. e., categorisation), was conducted thus. Eight objects, four of each of two categories, were placed in front of the participants. The experimenters then asked them to , "Fix these up. Put them where they go". The participants were then allowed to manipulate the objects (Gopnik & Meltzoff, 1987).

Children presented with a mixed array of objects containing exemplars of physically different, yet with similar within-category properties (e.g., different types of hats and cups), have shown developmental differences in their sorting of these objects.

Between the ages of 9 and 12 months of age, they tend to focus on, and manipulate, only one class of objects within an array. This is *termed single category grouping* (Langer, 1982; Mandler & Bauer, 1988; Nelson, 1973; Ricciuti, 1965; Starkey, 1981; Sugarman, 1983).

Between 15 and 21 months they may also begin to touch all objects in one category followed by all objects in another; this is termed *serial exhaustive touching*. At approximately 18 months of age they may begin to exhibit *exhaustive sorting*. That is, they are able to sort all the objects into two separate and spatially distinct groups

(Gopnik & Meltzoff, 1987; Langer, 1982; Nelson, 1973; Ricciuti, 1965; Starkey, 1981; Sugarman, 1983).

It is this latter level of categorisation, exhaustive sorting, that was found to have a positive correlation with the onset of the productive naming explosion. Gopnik and Meltzoff (1992) have found "strong and specific" relations between naming and the exhaustive sorting of both *basic level* (i. e., physically similar, yet not identical objects, such as four different shaped cars) categories of objects, and also identical categories of objects. For both these categories of objects, the children who were able to sort exhaustively had more names than those children who failed to sort in this manner. They concluded that this may involve a general naming ability as they found no reliable relation between the names of the items sorted and the knowledge of these names. It may be the case, however, that the children had different object names (perhaps their own idiosyncratic versions) than those designated by the experimenters.

"Basic level" categories have been originally defined by Rosch and Mervis (1975) as the level of abstraction at which objects are most naturally divided into categories. Mandler (1997) however, sees this as being a confusing and unsatisfactory definition, pointing out that although this term is usually meant to refer to conceptual rather than perceptual categories, it is usually an objectively determined level of categorisation. This term has been used to describe objects with similar shapes (e. g., Mervis & Crisafi, 1982), and also as a knowledge based form of categorisation determined by culture (e. g., Mervis & Mervis, 1982).

Due to this lack of proper definition and to avoid confusing usage of the term, this thesis will describe the objects used in categorisation studies as being either, (i)physically identical, (ii) physically similar, or (iii) physically dissimilar, providing further information when necessary.

Sugarman (1983) has also found that spontaneous utterances during sorting and free play paralleled spatial grouping. She found that children verbally marked objects from one category at the same time as they formed single class spatial grouping. For example, one child repeated "Blue blue blue blue" whilst collecting two blue socks (p.

172). Children also verbally marked two groups of objects as exhaustive sorting occurred. For example, one child said, "She's a lady. That's a lady" whilst pointing at each of two dolls, followed by, "That is a boat. This is two. That and that makes four" whilst grouping all four boats together (p. 173).

Cross-Linguistic Studies.

Supporting evidence for the Gopnik and Meltzoff's specificity hypothesis has been shown in a series of cross cultural studies. Gopnik and Choi (1990, 1992) compared the development of Korean speaking and English speaking children. The Korean language differs from English in that it has a very rich verb morphology: Korean depends on verb endings to make important semantic distinctions and tends to consist of highly inflected verbs and very few nouns.

The Korean children proved to be comparatively, and significantly, delayed in both emergence of the naming explosion and the development of exhaustive sorting (using identical object categories). The opposite however, was found for developments of means-end abilities and success/failure words, where the Koreans were significantly more advanced. There were no significant differences on the object permanence performances, although the Koreans were slightly advanced in their development as compared to the English children.

Gopnik, Choi, and Baumberger (1996) have replicated these findings. They also examined the effects of maternal speech input. Korean and English mothers' speech interactions with their children were recorded in two different play scenarios: one where they were given wordless picture books, and one where they played with a doll's house. Their production of nouns and verbs was measured. They found that Korean mothers tended to produce more verbs whilst English mothers emphasised object names.

Poulin-Dubois, Graham, and Sippola (1996) supply corroborative evidence in both French and English populations. They also found a correlation between the onset of the naming explosion and the categorisation of basic (physically similar) level categories of objects; the best categorisers were those who had a high proportion of general nominals in their vocabularies.

Gopnik and Meltzoff conclude that there is a close and specific link between naming and categorisation. In their earlier study (1987) they found that exhaustive sorting (of identical classes of objects) emerged *before* the naming explosion in 7 of their 12 participants, and emerged in the same session (measurements were taken once every three weeks) for the remaining 5 participants. They concluded from this that the understanding that objects belong in categories emerges first in sorting and then in language.

Following their later research (1992), which utilised both identical and physically similar categories of objects, and suggested that there may be some independence between the ability to sort these two types of object category, Gopnik and Meltzoff concluded instead that exhaustive categorisation and accelerated word production, may facilitate each other (1993).

They argue that their findings support the theoretical standpoint of Vygotsky (1962), whose interactionist viewpoint states that semantic knowledge facilitates and modifies conceptual development. Neither of these accounts, however, explains exactly how this facilitation might occur.

Mervis and Bertrand (1994) have attempted to incorporate Gopnik and Meltzoff's specificity hypothesis into their model of cognitive and linguistic development, the Developmental Lexical Principles Framework (DLPF). The DLPF (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Mervis & Bertrand, 1993) describes a developmental sequence of lexical acquisition which is guided by a set of principles (i. e., biases or constraints) which a child adds to with development.

These principles are concerned with both linguistic and non-linguistic developments, and have the effect of prioritising a child's hypotheses for what a novel word might mean. As extra principles are acquired, inferences made about a word change.

The framework consists of six principles. The first three become available early in the child's development, and may be present even at the start of lexical acquisition. The first of these, the principle of *reference*, is concerned with how the child maps words onto representations of objects and events. This principle is acquired alongside non-verbal communicative expressions such as pointing at objects. The second, *extendibility,* is a principle that allows a child to extend a learned word to other objects. that share the same physical appearance or function. The third, *object scope*, states that a word will refer to the whole object and not to any of its parts.

These first three principles occur early in the child's development and are associated with the period when the child learns words in a slow, laborious manner.

The acquisition of the next three principles, it is claimed, allow children to acquire words in a more efficient manner. When children acquire the principle of *categorical scope* they become able to extend a word not only by its perceptual features, or by its thematic relations with other objects, but also to physically different objects that belong to a linguistically defined class, e.g. fruit or animals.

The acquisition of the *novel-name-nameless category* (N3C) principle allows a child to understand that a novel word will probably refer to an object that she or he has not learned a word for yet. The child will be able to determine this relation without instruction from others, whereas previous principles relied on input.

When the final principle, *conventionality*, is in place, the child is able to begin structuring her or his utterances to fit in with social conventions.

Mervis and Bertrand (1994) note that one of these principles, the N3C principle, involves "an insight that all objects have a name" (p. 1650). Likewise, it has been argued that this "insight" may be responsible for the naming explosion and the emergence of exhaustive categorisation (Gopnik & Meltzoff, 1987, 1992). These latter two abilities should therefore be working within the same principle as the N3C principle. Mervis and Bertrand hypothesise that all three abilities (the naming explosion, categorisation and the N3C principle) should emerge at the same point in the child's development.

Their 1994 study, consisted of two groups of children, those who had acquired the N3C principle (n = 16; mean age = 17 months 19 days), and those who had not (n = 16; mean age = 17 months 24 days). The acquisition of the N3C principle was operationally defined as being the ability to "fast map" object words, that is, to learn a new word based on very little ostensive definition (Carey, 1978).

Participants in both groups were given a categorisation test (after Gopnik & Meltzoff, 1987, and using identical classes of objects) to determine whether they could demonstrate exhaustive sorting. Their productive (i. e., spoken response) and receptive (i. e., their comprehension of a spoken word) vocabulary was also measured.

Results showed that the 16 participants who could fast map had both larger receptive and productive vocabularies than those 16 who could not fast map. There was a significant relationship between the fast mapping group and the ability to categorise: 13 of these 16 fast-mappers did show exhaustive categorisation as compared to only 6 of 16 categorisers within the non-fast mapping group. It was concluded that there is a relation between the acquisition of the N3C principle, the amount of words acquired, and the ability to demonstrate exhaustive categorisation.

However, 6 of the 16 non-mappers were able to categorise successfully, which does not demonstrate a clear dissociation between the two abilities, that is, the inability to fast map does not preclude exhaustive categorisation in all participants. Furthermore, one cannot rule out such confounds as test shyness or confusion with the required tasks, which would have affected scores on both mapping and categorisation tests.

This study did not measure the naming explosion directly, and details of each individual participants' vocabulary was not reported apart from the case of one fast-mapper who only had a productive vocabulary of four words. In the case of this child, it seems highly unlikely that she was able to demonstrate a vocabulary spurt.

In a follow up study, however, the 16 children who could not fast map had their vocabulary monitored weekly until they showed evidence of a vocabulary spurt (operationally defined as 10 new words in a 14 day period). As soon as a spurt was evidenced, the participants were given a set of new fast mapping tasks and their performance on the categorisation tests was re-assessed with new stimulus sets.

This time all participants who showed evidence of a vocabulary spurt were also able to fast map. Moreover, 13 of these 16 participants also showed evidence of categorisation, an increase of 7 participants from the first part of the study. There was a significant difference between the first and second studies in regards of both fast mapping scores and categorisation performance.

Mervis and Bertrand concluded that the N3C principle becomes available at the same time as the vocabulary spurt and exhaustive categorisation appears, and that therefore, the specificity hypothesis can be incorporated directly into the Developmental Lexical Principles Framework.

However, not all participants were able to demonstrate exhaustive categorisation, and the results taken together suggest that categorisation may become available to the child both prior to, and after the ability to fast map. Also, for three of these participants, categorisation did not occur at all. A direct measurement of the vocabulary spurt was not conducted in the first study, and was not reported for individual participants in the second. Therefore, although overall the data seem to support the above mentioned hypotheses, individual participants' data do not fit so easily into such clearly defined patterns.

Other research suggests that fast-mapping may not be temporally related to the naming explosion or exhaustive categorisation. It has been claimed that the ability to rapidly link novel names to novel objects has been shown in infants of 13 - 15 months of age (Woodward, Markman, & Fitzsimmons, 1994; Schafer & Plunkett, 1998).

Others have questioned whether this phenomenon is specifically linked to language at all. For example, the ability to rapidly link a name to an object has been found in individuals with both severe mental retardation and language impairment, suggesting that a well developed use of language is not necessary to show these relations (McIlvane, Kledaras, Munson, King, Rose, & Stoddard, 1987; McIlvane & Stoddard, 1981). Stromer (1986) also found that individuals with mild mental retardation were able to demonstrate fast mapping of novel visual- visual stimulus pairs which contrasts with the more commonly used auditory-visual relations described in the previous studies. This suggests that such mapping is possible for relations that may not be classed as linguistic. It has also been demonstrated that non-humans can also fast map (Schusterman & Kastak, 1993; Tomanaga, 1993).

Similarly, not all researchers have found such a link between exhaustive categorisation and the naming explosion. Gershkoff-Stowe, Smith, & Namy (1992, reported in Shore, Dixon, & Bauer, 1995) failed to replicate Gopnik and Meltzoff (1987). Half of their participants (n = 11) showed this categorisation (of identical classes of objects) at a mean of 90 days *before* the naming explosion, the other half at a mean of 60 days *afterwards.*

Gershkoff-Stowe, Thal, Smith, & Namy (1997) also failed to replicate Gopnik and Meltzoff, finding large variability in direction and timing of the two abilities. They concluded that differences in the two studies may have been attributed to the fact that Gopnik and Meltzoff's participants had repeated experience with the categorised items. They also criticise the fact that in Gopnik and Meltzoff's study those children who dropped out of the study before reaching the criteria for both the naming explosion or exhaustive categorisation, were then replaced with other children. No reasons why these children dropped out were given, neither were their ages, amount of vocabulary acquired, or level of categorisation reached, noted.

Further, since this form of categorisation was independent of advances in productive vocabulary growth, they stated that such developments may depend also on other abilities. Such abilities may include; the kind of prior sorting practice children received (Namy, Smith, & Gershkoff-Stowe, 1997), the properties of the stimuli (Starkey, 1981), and participants' previous exposure to such groupings by a model (Abranavel, Ferguson, & Vourlekis, 1993).

One child in Gershkoff et. al.'s (1997) study, who was the earliest categoriser (at 16 months), was also found to be severely delayed in productive language, although his comprehension of words was in the normal range. This single case suggests a dissociation between categorisation and productive language. They concluded that children's developing knowledge of kinds may be more closely tied to receptive rather than expressive vocabulary.

Shore, Dixon, & Bauer (1995) have likewise criticised studies in this area for their reliance on production as a measure of linguistic ability. They also criticise the fact that experiments have tended to use the rate of acquisition as a measurement tool, and that they overlooked the importance of style of acquisition.

They examined the differences in categorisation between two groups of children, each group being defined by their style of language acquisition. The first group of children were termed "Referential", that is, those who tended to have a high proportion of nouns in their early words. On the other hand, "Expressive" children had more personal and social words and a higher proportion of early sentences without nouns (see Nelson, 1973).

Shore et. al. also assessed the participants' comprehension and production of the names of the items used in the categorisation tests; in this case the objects within each category were identical. These tests were based on the methodology of Gopnik and Meltzoff, though only the sequential touching of the two classes of identical stimuli presented was counted as evidence of exhaustive sorting. This analysed the temporal rather than spatial grouping of the objects.

They found low amounts of grouping in general, which may be attributed to the lack of practice with the objects. Also, the children who did group, were no more likely to be able to comprehend or produce the object name than those who did not group the objects. They did, however, find that those who did group had a significantly higher proportion of referential utterances than the non-groupers. Children were classed as "referential" if parent provided multi-word examples of the child's speech contained two or more nouns, and "expressive" if these multi-word constructions contained only pronouns, or if they contained neither nouns or pronouns.

Shore et. al. conclude that in so far as relations exist between linguistic and non-linguistic categorisation, they may be reflective of individual style. It may be the case that "Referential" children have a more general interest in objects, which reflects in both linguistic and non-linguistic domains.

Methodological Problems.

The studies presented in this section have examined the relationship between language and categorisation. Most have found a close temporal link between the productive naming explosion and the onset of exhaustive categorisation, yet some have failed to find such a relationship. Also, all the studies outlined are correlational in design. It is therefore extremely difficult to reach any clear conclusion about the existence of such relationships, how they might interact, or even if one of these factors causes the changes in the other.

Compounding these difficulties are the many problems inherent in measuring the two variables of language and categorisation. These difficulties will be addressed next.

Problems in Language Assessment.

Many studies depend on a count of the number of words acquired by the child. These are typically assessed by means of diaries or checklist type inventories that are completed by the child's parents.

Parents are not generally trained to perform a systematic analysis of their child's language, and their scoring methods are thus subject to bias. There may be errors of omission or addition of words which may be attributed to parents' motivation, interpretation, or memory. For example, a child may produce babbling such as "da-da-da-da" at an early age, which may be construed as the ability to say "father". This same (or similar) consonant-vowel string may also be heard when the child is pointing at a dog, thus interpreted as the child knowing the animal's name.

Assessing receptive language, that is, comprehension of a word, is also fraught with bias. One may only infer that a child understands the meaning of a word by interpreting the child's physical responses to hearing that word spoken. For example, a parent may point or look at a cat whilst asking, "Where's the cat?"; the child may look merely in the general direction of the pointed finger, or parent's gaze and be thus credited with understanding the name.

Children may have many different behaviours that suggest they understand a word's meaning; these may include, looking towards an object, pointing, picking up, or vocal responses to adult questions. Keeping a systematic record of all these behaviours may be time consuming and the parent may not be motivated towards accuracy of these analyses.

In studies which require the repeated filling in of such inventories, these problems may be magnified. Even where both diaries and inventories are used in conjunction, one cannot be assured of the accuracy of these measurement tools.

In the literature reviewed there appears to be very little standardisation of the definition of the naming explosion. For example, Gopnik and Meltzoff (1987) use the operational definition as the first session in which more than 10 new names are acquired, tested once every three weeks. Gopnik and Choi's (1990) participants were tested every four weeks. Mervis and Bertrand (1995) defined the spurt as, "an increase of 10 new words, at least 5 of which were object words, in a two-week interval" (p. 462). Poulin-Dubois et. al. (1995) used "the criterion of 15 new general nominals" in a four week interval (p. 331).

Without standardisation of the definition of the naming explosion, it is difficult to make comparisons between studies. It is also difficult to pinpoint accurately the onset of other behaviours, such as categorisation, when intervals as far apart as one month are used. For example, in Mervis and Bertrand's study (1994), the delay between the first test for categorisation and fast mapping and the second re-test for these abilities was 69 days. It is possible that the participants could have begun to exhibit these behaviours at any point between the two test sessions.

Problems in Assessing Categorisation.

The other major variable, categorisation, is also difficult to assess with any accuracy. In studies where this is assessed on only one or two occasions, the child may be shy of the experimenter, and therefore not perform as well as she or he might. This factor has been noted by Mervis and Bertrand (1994), who noted that the lack of manipulation of the test objects in their study may have been attributable to test shyness. Children may also be confused as to what is expected of them in the experimental tasks and therefore may underperform.

The amount of categorisation evidenced also depends on the child's interest in the test objects. Sorting has been seen to vary greatly as a function of the category of stimuli used (Ricciuti, 1965; Starkey, 1981). Starkey found that there was more sorting when the stimuli varied on many dimensions. Even if the items used are standardised throughout all studies of this nature, one still may not be able to control for individual preferences in manipulation of the stimuli. Children who receive two or three sorting tasks in a row also become bored with the procedures, again compromising the measurement of successful categorisation (Gopnik & Meltzoff, 1993).

As noted earlier, there is great variability between the kinds of objects used in these tests, and even in the definition of what sort of objects are "basic level" objects (e. g. Mandler, 1997). This lack of standardisation makes it exceedingly difficult to compare data across studies. Another variable that is difficult to control is the child's prior experience of sorting such objects. General experience of sorting objects has been shown to influence the onset of subsequent exhaustive categorisation (Namy, Smith, & Gershkoff-Stowe, 1997). Also in these kinds of studies it is very difficult to assess the prior sorting experience of the familiar experimental objects used.

The role of sorting correctly by chance is also not taken into consideration in these studies. This is crucial as one example of a sorting behaviour may be sufficient for the experimenter to decide that the child had reached a certain level of sorting ability.

Researchers within the developmental perspective of psychology have conducted many studies to try to elucidate the relationship between language and categorisation. The problems of working with very young children, compounded by the use of imprecise measurement tools, have made this a difficult issue to resolve. The reliance on correlational designs, although highlighting the many interesting relationships between language and other behaviours, are of limited value in answering such important questions as whether the ability to produce more words can cause changes in categorisation, or vice versa.

THE BEHAVIOURAL ANALYTIC PERSPECTIVE

Since the late 1950's the study of language acquisition has been the bête noir of Behaviour Analysis. Skinner's seminal work, Verbal Behavior (1957), was famously criticised by Chomsky (1959) as being an inadequate explanation of language acquisition. Skinnerian theory, largely based on the animal model of behaviour, was widely held to be unable to explain some of the features that are readily observed in human language. For example, children have been found to spontaneously produce untrained utterances (Ervin, 1964), and also seem to acquire sets of grammatical rules without previous explicit training (Chomsky 1965, Foss & Hakes, 1978).

The Stimulus Equivalence Paradigm.

In the 1970's, however, Murray Sidman began his pioneering research into the area termed stimulus equivalence (Sidman, 1971; Sidman & Cresson, 1973). The stimulus equivalence paradigm has been used by behaviour analysts to study the acquisition of language. This has been seen to offer an empirical methodology for studying untrained, or emergent, behaviours of the kind that are readily evidenced in human language.

Traditionally stimulus equivalence has been studied by using matching-to-sample procedures. In these, an individual is taught to respond correctly to a series of conditional relations. For example, participants shown stimulus A, should select stimulus B, and shown stimulus B, should select stimulus C. The participants are then tested to see if new (untrained) relationships have emerged spontaneously (see Figure 1.1).

For example, the individual may show reversal of the trained relationships, that is, if shown B, they may select A, and if shown C, they may select B. This untrained reversal of stimulus relations is termed *symmetry*. Individuals may also show evidence of *transitivity*, that is, they are able to demonstrate the derived relation, if A then C. The ability to demonstrate the two behavioural relations symmetry and transitivity, along with that of *reflexivity* (e.g., if shown A, select A) are the three defining characteristics of equivalence. When an individual is able to show all three relations between a set of stimuli (A, B, and C), it is concluded that the stimuli have formed an equivalence class.

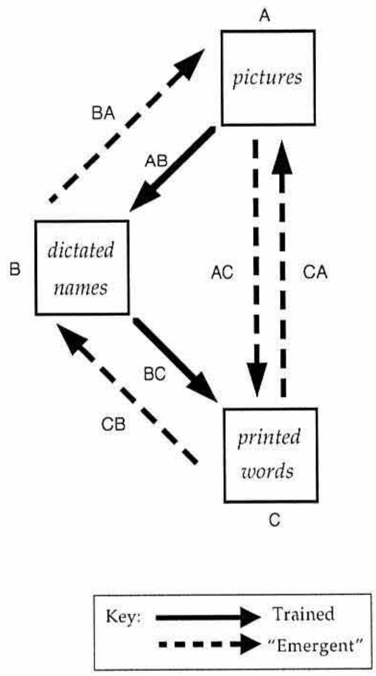


Figure 1.1. shows a schematic representation of the equivalence paradigm (Sidman, 1971). Solid arrow represent the trained conditional relations. The broken arrows represent emergent relations.

Equivalence relations have been shown in a wide range of populations: adult humans (e. g., Bentall, Jones, & Dickins, 1998; Mandell & Sheen, 1994; Randell & Remington, 1999; Roche, Barnes, & Smeets, 1997); children (e. g., Barnes, McCullagh, & Keenan, 1990; Dugdale & Lowe, 1990; Lipkens, Hayes, & Hayes; Pilgrim, Chambers, & Galizio, 1995); the handicapped (e. g., Devany, Hayes, & Nelson, 1986, Saunders & Spradlin, 1993). So far however, they have not been demonstrated in animal populations (for example, D'Amato, Salmon, Loukas & Tomie, 1985; Dugdale & Lowe, 1990; Hogan & Zentall, 1977; Holmes, 1979; Kendall, 1983; Lipkens, Kop & Matthijs, 1988: Rodewald, 1974; Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrigan, 1982).

Some studies have claimed to find equivalence with non-human subjects (McIntire, Cleary, & Thompson, 1987; Schusterman & Kastak, 1993; Vaughan, 1988). These findings, however, have been criticised (see Dugdale & Lowe, 1990; Hayes, 1989; Horne & Lowe, 1996, 1997; Saunders, 1989).

Where Does Stimulus Equivalence Come From?

This phenomenon has caused problems for Skinner's analysis of verbal behaviour. This untrained behaviour is not readily predicted from the basic laws of conditioning with its reliance on the behavioural relationship of the *three term contingency* (i. e., discriminative stimulus --> response ---> consequence). This has naturally led to a stimulating debate as to the origin of these apparently untrained behaviours.

Three main perspectives feature in this debate: (I) that equivalence behaviour is a given that underpins linguistic function; (ii) that it is an instance of learned behaviour that underlies language; and (iii) that this behaviour is a "by-product" of language development. A summary of each of these follows.

Equivalence as a Given.

Murray Sidman has postulated that the ability to demonstrate stimulus equivalence is a given. He describes this as something similar in nature to other primitives such as the stimulus functions of reinforcement, discrimination, conditioned reinforcement and conditional discrimination, and has stated that this behavioral primitive may underpin linguistic function (Sidman 1990, 1994, 1996, 1997). There is however, little evidence to support this claim. For example, there is a large body of research that suggests that the passing of equivalence tests shows developmental trends; further, passing such tests may also be intimately related to the development of verbal skills. This evidence will be reviewed below.

Relational Frame Theory.

Hayes and colleagues (Hayes, 1986, 1991, 1994; Hayes & Hayes, 1989, 1992) take a very different standpoint. They suggest that the novel performances seen in equivalence tests are actually instances of learned behaviour.

Their perspective, relational frame theory, suggests that humans may have certain training histories (that other species may lack), which facilitates the development of generalised *arbitrarily applicable relational responding.* Equivalence may be just one of these kinds of relational responding. An example from the literature (Hayes & Hayes, 1989; Lipkens, Hayes & Hayes, 1993) might clarify this argument.

A child, when learning to name an object, will be oriented towards an object whilst the caregiver says, "What's this?". Correct utterances will be reinforced and incorrect ones will receive corrective feedback. Eventually the child learns the object-name relation "given object X, say name X, and not name Y". Concurrently the child is also learning name-object relations. When the caregiver asks, "Where is X?", they are learning "given name X, point to object X and not object Y".

With enough instances of such training, which would occur in the same setting or context, it might be expected that the child on learning an object-name relation, would also derive (from previous training history with other name-object and object-name relations) the appropriate name-object relations. This, in essence, is an example of bi-directional training. Such training only occurs in certain contexts, the above being a naming context, which is indicated by such cues as the phrases, "What's this?" and "Where's the X?".

There are three defining characteristics that define arbitrarily applicable relational responding. The first of these is *mutual entailment.* That is, if event A is related by training to event B in one context, then, given the same context, B will become related to A through derivation. This may equate with a symmetrical relation.

The second relation is that of *combinatorial entailment*: if A is related to B and B is also related to C, then some relation must be entailed from A to C and also from C to A. This relation equates with that of transitivity.

The third relation is that of *transfer of functions.* That is, if an event A has a psychological function, and there is also a derived relation between event A and event B, then B may also acquire this psychological function in accordance with the derived relation, given certain contextual cues to do so. For example, when stimulus A is shown and an individual is asked to give the "opposite", if there exists a derived relation between stimulus A and stimulus B, the individual may then also give an opposite exemplar of the B stimulus without being explicitly requested to do so.

The term relational frame designates particular kinds of arbitrarily applicable relational responding, and is a type of responding that shows the above three characteristics (Hayes & Hayes, 1989. p. 171). A relational frame, as stated previously, is brought about from a history of relational responding relevant to the contextual cues involved, rather than the form of the relatae that participate in such a frame. As such relational frame theory posits that this form of responding can explain the derived relations seen between the physically different stimuli that are traditionally used in stimulus equivalence tests. There is no need to resort to the alternative explanation that these relations are mediated by language.

Equivalence relations are said to be a particular type of relational class which is built upon , what is termed, *a frame of co-ordination* (Hayes & Hayes, 1989. p. 173). A frame of co-ordination entails relations where objects are related or classed by similarity. This frame is said to be one of the first to be learned sufficiently so that its application is able to become arbitrary.

If a frame of co-ordination, or sameness, is applied to three or more stimuli (i. e., the arbitrary relation between them involves reflexivity, mutual entailment and combinatorial entailment), then an equivalence relation exists. Although it may appear that equivalence tests show examples of emergent behaviour, the relations evidenced may be actually learned. That is to say, "the action of relating two arbitrary stimuli is itself a historically and contextually situated action" (Lipkens, Hayes, & Hayes, 1993). Hayes and colleagues further argue that, "arbitrarily applicable relational responding is the definitional core of verbal events: Verbal behavior is framing relationally" (Hayes & Wilson, 1993. p. 287).

Evidence to Support Relational Frame Theory.

Lipkens, Hayes and Hayes (1993) cite evidence that purports to show that stimulus equivalence may be an instance of learned behaviour that underlies language. They conducted a longitudinal investigation into the development of derived relations in a pre-school infant aged 16 months at the start of the investigation, and 27 months at completion.

In the first part of this study a child, Charlie, was given picture-name (see picture - say name) relational training. He was then tested for the derivation of name-picture relations, that is, mutual entailment (or symmetry). In other words he was trained to produce the name of a stimulus and then tested to see if corresponding comprehension of that name emerged. At the age of 17 months, Charlie was able to demonstrate mutual entailment of these relations. After two weeks, maintenance of one of the taught picture-name relation, and its mutually entailed name-picture relation, was tested. These relations were found to be intact, and had even improved.

Two new picture -name relations were also trained. This time, however, the testing of emergent name-picture relations was delayed for seven days. In the initial training trials, Charlie was only able to produce the name (BAF) for one of the two relations on 7 of 12 trials. He was reported as having produced 0 of 12 correct responses for the second (MIESCH), however on three trials he did change his original (incorrect) responses to the required name.

After seven days, the two trained relations were checked (without reinforcement of any responses), and it was found that performance had improved for both relations; furthermore, mutual entailment of these relations was observed with 100% accuracy.

Taking all these results together, Charlie did not reliably produce the stimulus names in all training trials, leading Lipkens et. al. to assert that production of the names in training is not necessary for the derivation of the comprehension of the names (p.

214). Thus this reversal of relations may possibly be attributed to non-linguistic factors. Further, continuous feedback was not necessary for the maintenance, or even improvement, of correct responding.

Charlie was also given name- picture relational training (hear name - select picture), and was then tested for the derivation of picture-name relations (see picture - say name). That is, he was given comprehension training and tested for corresponding production of the object names.

This time Charlie found it extremely difficult to learn the name-picture relations, even after many modifications were made to the procedure. It was only after he was given additional imitative training of the stimulus names, and had also spontaneously produced the experimental names in the subsequent training trials, that he was able to demonstrate learning of the taught relations. He then also demonstrated mutual entailment of these relations (i. e., picture -name).

These results suggest that whereas it is comparatively easy to derive comprehension when naming is taught, echoic or imitative practice may be needed before an infant is able to derive naming from comprehension.

In further experiments, additional pairs of conditional relations were trained. Charlie was trained to match sounds to pictures and names to these pictures, and was then tested for both mutual entailment, and combinatorial entailment of these relations. These procedures were extremely difficult to train and it was only after 4 months of training and testing that Charlie was able demonstrate both mutual and combinatorial entailment, this performance fulfilling all the criteria for the formation of equivalence classes. It was not clear whether this performance could constitute a developmental trend, or merely be attributed to an increase in task familiarity.

Lipkens et. al. concluded from the results of the above studies that the development of derived relations could not (as suggested by Sidman) be a "given", as the onset of these relations showed clear developmental trends.

More interestingly, they claim that, " the existence of derived stimulus relations in a 17-month-old infant constricts somewhat the view that such relations are dependent upon language mediation, because only very simple language processes can be implicated" (p. 235). They suggest that the derivation of such relations as mutual entailment and combinatorial entailment are not dependent on sophisticated verbal abilities and that therefore these relations may be instances of behaviour that underlie language.

However, Charlie did have language, albeit unsophisticated. At 17 months of age he was reported as having a receptive vocabulary equivalent to that of a 24 month old child[1], and a productive vocabulary of a 20 month old child[2], although the exact number of words in his vocabulary are not reported. Also this study shows the importance of productive language in facilitating the formation of conditional relations. This is demonstrated by his comparative ease in learning, and reversing, the picture-name relations; whereas the learning and reversing of name-picture relations required extra echoic training. It appears that differences in expressive and receptive language usage may account for parallel differences in conditional discrimination learning and the subsequent derivation of other relations. This issue will be elaborated upon in Chapter 2.

Lipkens' reports that Charlie was unable to respond correctly on any of the 12 "What is this?" training trials with one of the picture-name relations (see picture - say MIESCH); yet, after 14 days, and with no further training, he improved this performance (scoring 2 of 6 trials correct). Furthermore, when tested for mutual entailment of this relation, that is tested for name-picture relations, he showed 100 percent correct responding.

These results seem, at first, impressive and appear to be examples of behaviour that cannot be attributable to language mediation. However, on closer inspection of the

---

[1] According to the MacArthur Communicative Development Inventory (MCDI) norms (Fenson et. al., 1993), this would be the equivalent of 200 words of receptive vocabulary (50th percentile scores).

[2] According to the MCDI norms this would be the equivalent of 190 words of productive vocabulary (50th percentile scores).

data, it was seen that Charlie had in fact produced the required name on 3 of the initial 12 training trials. In these trials he had responded "BAF no MIESCH" instead of the correct "MIESCH" response; yet these trials were marked as failures. His scores on the delayed test for maintenance of this relation were only 2 of 6, which seem to be comparable to the above figures and do not suggest an improvement in performance.

His perfect performance on the mutual entailment test may explained in terms of exclusion. To illustrate, in these tests, two pictures were placed in front of Charlie and he was asked, "Where's BAF or MIESCH?". Charlie had already demonstrated proficiency in the picture-name relation where BAF was the required name response, but not in the relation where MIESCH was the correct response. In the test situation, therefore, when the (unlearned) MIESCH was targeted, he may have selected the correct picture by first excluding the (learned) BAF picture. In this case an explanation based on language mediation, although not proven, also cannot be discounted.

The results from Lipkens et. al.'s studies do not show conclusive evidence that language is not a mediating variable in the formation of derived stimulus relations. These studies do, however, highlight the problems inherent in attempting to isolate the language variable from experiments investigating equivalence and other derived relations.

Evidence that supports the view that language is a prerequisite for success on equivalence tests shall be presented next.

The Naming Perspective.

The third perspective is that of Lowe and colleagues. They attribute the success seen on stimulus equivalence studies to the ability of the participants to name the stimuli involved (Dugdale & Lowe, 1990; Lowe, 1986; Lowe, Horne & Higson, 1987).

This perspective is derived from research into performances on fixed interval schedule tasks. Developmental studies have shown that pre-verbal infants show performances that resemble those of rats and pigeons. Older, and more language proficient children, however, show patterns of behaviour akin to those of adults (Bentall, 1983; Bentall, Lowe, & Beasty, 1985; Lowe, Beasty, & Bentall, 1983).

These differences in performances have been attributed to the formation of verbal rules by those participants who were linguistically proficient. This in turn has led Lowe and colleagues to suggest that success on stimulus equivalence tests may also be a function of verbal rules.

There exists a wide range of studies to support this hypothesis. For example (as stated earlier), no animal has yet demonstrated equivalence in tests. Other evidence suggests that equivalence is found only in children who have acquired language. Devany, Hayes and Nelson (1986), tested for equivalence in three groups of subjects. They found evidence of this ability in typically developing two year olds and also in a group of two to four year old children who were mentally handicapped, yet still had functional spontaneous speech and sign language. The third group, who were also aged two-four years and were mentally handicapped yet with no functional verbal skills, failed to pass the tests of equivalence. Augustson and Dougher (1992), however, failed to replicate this study.

Barnes, McCullogh and Keenan (1990) also studied three groups of subjects. These groups consisted of a group of typically developing children, a group of severely hearing impaired children with verbal ages above two years, and a group of severely hearing impaired children with verbal ages below two years. All the children learnt the conditional discriminations equally well, however only one child in the verbally impaired group formed equivalence classes. All the children in the verbally able classes were able to demonstrate equivalence formation.

Lowe and Beasty (1987) also demonstrated that success on equivalence tests was related to chronological age and development of naming skills. Children in three age groups: four to five years, three to four years, and two to three years, were given conditional discrimination training and then tested for equivalence. All ten of the older, and presumably the most language able, group were successful on these tests. Half (six) of the three to four year olds old passed. In the youngest age group, however, only one of seven passed these tests.

Studies have shown that children who initially failed tests of equivalence, yet were then taught to name the experimental stimuli, subsequently demonstrate equivalence (Dugdale & Lowe, 1990; Eikeseth & Smith, 1992).

Research using adult participants have also shown results that support the naming hypothesis. Mandell and Sheen (1994) found that the pronounceability of the sample stimuli predicted performance on equivalence tests. They used three groups of words: phonologically correct, and therefore easily pronounceable, pseudo words (e. g., SNAMB), phonologically incorrect and difficult to pronounce pseudowords (e. g., NSJBN), and a group consisting of punctuation marks (e. g., +]*^!). Participants in the pronounceable word group demonstrated equivalence class formation quicker and with less errors than the other two groups. Also subjects in the phonologically incorrect condition tended to invent their own names for the stimuli (e.g. naming HCKTR as HECTOR). In a second study it was shown that when subjects were taught to apply names for phonologically incorrect words, performance was enhanced compared to a control group.

Randell and Remington (1999) trained participants' conditional relations to sets of familiar stimuli whose names rhymed. The presence of equivalence relations was then tested. These participants required less training and testing trials, showed fewer errors, and decreased response latencies than participants in two control groups where the sample and matching stimuli were phonologically unrelated. "Full equivalence" was confined, almost exclusively, to those in the rhyming condition.

Other evidence suggests that differential naming strategies can facilitate or even impede the formation of equivalence classes.

Bentall, Dickins, and Fox (1993) measured response latencies in equivalence tests when different naming strategies were employed. Three groups of adult participants received conditional stimulus relations training, with different kinds of stimuli for each group. Group 1 received training with easily nameable pictures that were also members of clearly definable semantic categories, or common class names (e. g. physically different exemplars of plants and celestial bodies). Group 2's stimuli consisted of easily nameable, yet unrelated pictures. The stimuli of Group 3 were abstract figures that were designed to be difficult to name.

The number of errors and the response latencies were measured for four tested relations: trained associations, symmetry, transitivity and transitivity with symmetry (equivalence). It was found that equivalence was demonstrated quicker, and with less errors, by the participants in Group 1, where the stimuli were linked by a common class name. Equivalence was demonstrated most slowly and with more errors by Group 3, the unnameable stimuli condition. These findings suggest that the verbal strategies employed by the participants influence the acquisition of equivalence classes.

In a following experiment, participants were directly taught verbal labels for the abstract (and difficult to name) stimuli used in the previous experiment. These names were either individual names for each of the stimuli (Group 1), or common class names (Group 2).

Participants trained to use class names performed with less errors over all four tested relations (see above) and also faster response latencies for transitivity and equivalence acquisitions than those participants who had learned individual names for the stimuli.

These results taken together suggest that not only do verbal strategies mediate the formation of equivalence classes, but also that a common class name applied to the experimental stimuli has a greater facilitative effect than giving each stimulus an individual name.

Naming strategies not only have a facilitative effect, they can also have a disruptive effect on the formation of equivalence classes. Dickins, Bentall, & Smith (1993) taught three groups of adult participants a series of A-B and B-C baseline relations between sets of pictures. The names that the participants gave each of the stimuli were then noted.

Then, after this baseline training, yet before testing for any emergent relations, certain of the participants' names for the stimuli were arranged in pairs, so that one name in each pair referred to a visual stimulus from one potential equivalence class, and the other name referred to a visual stimulus from a different potential class. To illustrate, the denoted name of stimulus A1- "clock" from one potential equivalence class, was then paired with the denoted name for stimulus B2- "dog" from a second potential equivalence class.

Participants were then required to learn these discordant pairings by the method of paired association, where the experimenter read the first name aloud and the participant was required to produce the second word. Following this training, all participants were then tested for the trained relations (that is, of the original baseline groupings A1-B1 and B1-C1; A2-B2 and B2-C2, and so on) and also for symmetry, transitivity, and equivalence of these relations.

It was found that the later paired association training influenced the choice of comparisons in these tests of emergent relations. Some of the potential equivalence relations (as defined by the original baseline training) did not emerge; rather, they were displaced by classes derived from links between the names of stimuli.

This demonstrated that the directly trained paired associate links between the dictated names of visual stimuli were often strong enough to displace any emergent relations that might have derived from the original match-to sample training with visual stimuli alone.

These findings suggest that in the absence of common class names for the stimuli, names of individual stimuli "readily become implicated in equivalence classes and facilitate the formation of emergent relations between the visual stimuli to which they belong" (p. 724).

In a following study, Smith, Dickins, and Bentall (1996) showed that if such discordant training was given after, rather than before, testing for the trained relations and also symmetry, transitivity and equivalence, this training had far less disruptive effect. Smith et. al. hypothesise that a "crystallization" of the equivalence classes may have occurred as a result of testing, making them relatively immune to the disruptive effects of the stimulus names(p. 127).

Criticisms of the Naming Perspective.

Lowe and colleagues have criticised Hayes' relational frame theory (e. g., Horne & Lowe 1996). They have argued that relational frame theory does not specify the behavioural principles involved in the establishment of relational frames.

Likewise, the naming approach has attracted similar criticism (e. g., Hayes, 1994; Hayes & Hayes, 1992; Sidman, 1990, 1992). These critics have noted that if, as claimed, naming is necessary for passing tests of equivalence, it is also necessary to explain how this occurs. That is, how does naming account for the emergence of derived relations.

As discussed earlier Lipkens et. al. (1993) claimed that data from studies with a 17 month old infant suggests that the derivation of such relations as mutual entailment and combinatorial entailment are not dependent on sophisticated verbal abilities. Any account of the influence of naming on such relations must be able to specify exactly what level of "sophisticated verbal abilities" are necessary.

Horne and Lowe have risen to these challenges, and their account of the development of naming in infants, and how this relates to performances that have been characterised as equivalence relations, shall be summarised in Chapter 2 of this thesis.

CHAPTER 2

THE NAME RELATION

The second chapter of this thesis will be concerned first with a summary of Horne and Lowe's (1996) theory of the development of naming in the human infant. The relation of naming to the formation of stimulus classes, that is, categorisation will also be discussed.

The experimental studies that make up this thesis will investigate the three defining features of naming outlined below. Horne and Lowe define naming as:

> a higher order bi-directional behavioral relation that (a) combines conventional speaker and listener behavior within the individual, (b) does not require reinforcement of both speaker and listener behavior for each new name to be established, and (c) relates to classes of objects and events. (p. 207)

Skinner's Account of Verbal Behaviour.

Horne and Lowe's behaviour analytic account of the development of naming is based on Skinner's definitive work Verbal Behavior (1957). In this work Skinner defines verbal behaviour as, "behavior reinforced through the mediation of other persons" (p. 14); importantly, verbal behaviour is operant behaviour that develops as a result of consequences that are generated by the child's interactions with its verbal community. The basic units of verbal behaviour, as defined by Skinner, and which also are integral to the naming account shall be described next.

Skinner differentiates between two behavioural relations which form the basis of the productive or speaker repertoire of the individual. The first of these is the echoic relation. This is defined as "verbal behavior [which] is under the control of verbal stimuli, the response generates a sound pattern similar to that of the stimulus" (p. 55).

For example, on hearing the word /cup/[1] a speaker will say "cup"[2], or, in the case of an infant, some approximation such as "up".

The second of Skinner's "speaker behaviours" is the tact relation. A tact is defined as, " a verbal operant in which a response of a given form is evoked (or at least strengthened) by a particular object or event or property of an object or event" (p. 82). For example, on seeing a cup, an individual will say "cup".

The third element, and one that forms an integral part of naming theory and the experimental work of this thesis, is the behaviour of the listener. Skinner himself did not give much importance to this behaviour in his earlier work, stating, "the behavior of a man as listener is not to be distinguished from other forms of his behavior" (p. 34). Listener behaviour arises when the verbal community establishes a correspondence between a stimulus produced by a speaker and behaviour evoked in a listener (p. 357). That is, listener behaviour is a response to an auditory stimulus from others[3]. This response may be any of a range of behaviours such as, orienting to, picking up or pointing to an object on hearing the object's name spoken.

	Discriminative Stimulus	**Response**	**Reinforcer**
Echoic	hear / car /	" car" or "ca"	"good girl, that's a car"
Tact	see a car	" car"	"good boy, that's a car"
Listener Behaviour	hear / car /	orients to, points at, selects etc.	"good girl, that's a car"

Figure 2.1. The uni-directional nature of Skinner's echoic, tact and listener relations. Examples of behaviour are given for each of the events that are contained within the three term contingency: that is, discriminative stimulus, response and consequence (in this case, reinforcement).

[1] The notation /cup/ indicates a listener stimulus. That is, the hearing of an utterance.

[2] The notation "cup" indicates a speaker response. That is, an utterance that is spoken.

[3] Note that in deaf populations, "listener" behaviour may instead be a response to a visual stimulus.

Skinner's account defines these verbal behaviours within the framework of the three-term contingency. Figure 2.1 shows how the three behaviours described above would be represented within this framework.

The behaviours represented in Figure 2.1 are unidirectional and non symbolic in nature. As it stands, therefore, Skinner's account cannot explain either the generativity ubiquitous in a child's language, or how physically dissimilar objects come to be categorised without explicit training.

Horne and Lowe have attempted to extend Skinner's account of verbal behaviour thereby answering these criticisms. Lowe and colleagues (Dugdale & Lowe, 1990; Lowe, Horne, & Higson, 1987) have also claimed that naming may be responsible for success on equivalence tests. This too has raised criticism (see Catania et. al., 1989; Hayes, 1994; Hayes & Hayes, 1992; Sidman, 1990). These authors challenge Lowe et. al. to account for how naming itself comes about and how it gives rise to such derived stimulus relations. This then, is the background to Horne and Lowe's (1996) paper on the origins of naming.

Development of Naming

The specific aims of Horne and Lowe's account are; first, to specify the basic unit of verbal behavior as being "the name relation"; second, to show how this behavioural unit is learned and comes to symbolise objects and events in the "real world" (p. 185). Their account details the development of the "name relation". This is conceptualised as a circular relation, incorporating the three relations detailed earlier, that is, tact, echoic and listener behaviour.

Unlike the description of these three relations as self contained, unidirectional relations, as they are depicted in Figure 2.1, when naming is established, each of these three relations should act as a discriminative stimulus for the other relations that comprise the naming circle (Figure 2.2).

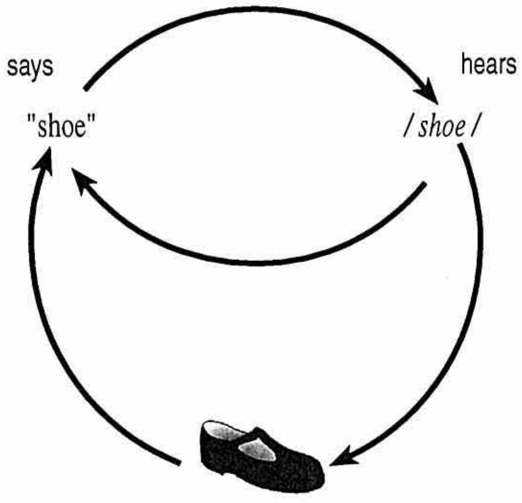


Figure 2.2. Schematic representation of the name relation. This is conceptualised as a circular relation between seeing an object (the shoe), saying "shoe", and hearing oneself saying the word /shoe/, and then re-orienting to the object (shoe), and so on.

Integral to the naming account is a conceptualisation of the individual as a speaker and listener within the same skin. When all three relations (listener, echoic and tact) have been established, the infant becomes both a speaker and a listener of his or her own speech. This initiates a circular, and therefore bi-directional, relationship between name and commonly named objects. Horne and Lowe's account of the precise developmental steps necessary to bring about the name relation shall be summarised next.

This shall be followed by a description of how, once established, this relation facilitates the categorisation of physically different objects, and perhaps also physically similar objects.

Acquisition of Listener Behaviour.

As stated earlier, Skinner gave little importance to the role of listener behaviour. In naming theory, however, it is a "crucial precursor to the development of linguistic behavior" (p. 192). The listener relation is one of the three behavioural relations that make up the name relation and is therefore integral to Horne and Lowe's account. Before the infant is able to become a speaker-listener, however, she or he must learn to discriminate the speech of others. She or he must also learn the conventional relation between a verbal stimulus and particular object related behaviours.

To illustrate, when a infant hears /where's the cup?/, the conventional behaviour of looking for the cup needs also to be taught. Similarly, when the infant hears /run/, she or he must learn to run. Listener relations are shaped in a number of ways.

For example, the caregiver often observes where the infant is looking before initiating object related speech (Collis, 1977; Collis & Schaffer, 1975; Cross, 1977; Harris, Jones, Brookes, & Grant, 1986; Harris, Jones, & Grant, 1983; Leung & Rheingold, 1981; Masur, 1982; Murphy, 1978; Tomasello & Farrar, 1986). Caregivers have also been shown to indicate the named object by pointing and infants learn to follow the latter gesture appropriately (Baldwin, 1991; Butterworth & Cochran, 1980; Butterworth & Grover, 1988; Lempers, 1976; Messer, 1978). These interactions between infant and caregiver have the effect of facilitating the learning of the relation between the spoken name and the object. In fact, it has been shown that the amount of time spent in this joint interaction is positively correlated with the child's later vocabulary size (Tomasello & Farrar, 1986; Tomasello, & Todd, 1983).

Eventually the infant also learns to point at objects. This is initially to a particular object but this is then followed by pointing back to the caregiver and back to the object whilst looking at the caregiver (Bates, Camaioni, & Volterra, 1975; Masur, 1983). Caregivers respond to the infant's pointing behaviour by naming and re-naming the objects, and of course providing reinforcement of the infant's actions.

Caregiver's also tend to model the conventional ways of interacting with objects, which the infant may imitate, even when the opportunity to imitate is deferred (Meltzoff, 1988; Poulson & Kymissis, 1988). This allows the speedy acquisition of conventional object related behaviours, many of which will come under the control of the caregiver's utterances during the establishment of listener relations (Horne & Lowe, 1996. p. 194). Eventually objects will come to occasion whole sequences of socially conditioned behaviour. For example, a shoe may occasion a range of behaviours such as putting on the shoe, walking around, searching for the second shoe, and so on.

At this point the caregivers will begin to fade their "point-and-reach" cueing behaviours until the child can respond correctly to such simple requests as, "give me the shoe". When the child responds reliably to these requests by (for example) giving the shoe, and is thereupon reinforced for the behaviour, the caregiver's vocal stimulus will have gained discriminative control of the child's shoe giving. It is at this stage that we can say that the child has acquired listener behaviour.

So far we have described the acquisition of listener behaviour in terms of orienting to one stimulus. In reality, however, a caregiver will use (for example) the term *shoe* for a range of different shoes. This means that when the infant is asked, "give me the shoe" the infant will orient to, and fetch any kind of shoe in the environment, be it a real shoe or a picture of a shoe (Figure 2.3).

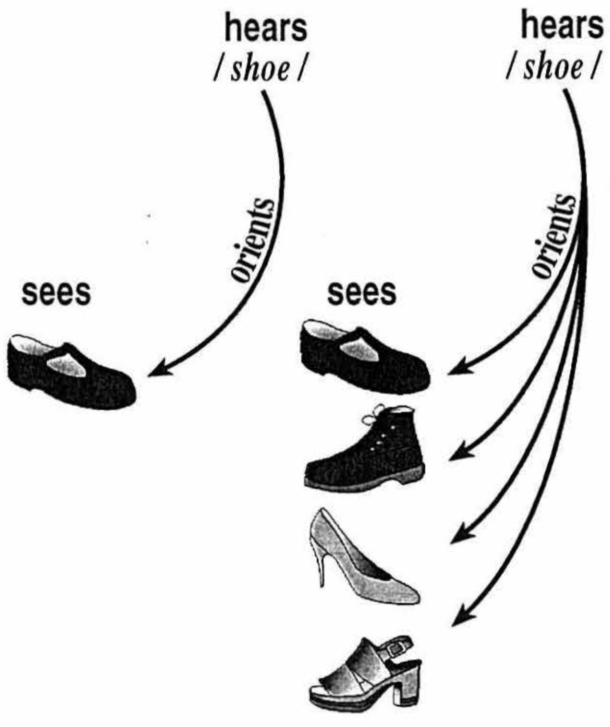


Figure 2.3. The acquisition of listener behaviour. This shows that the infant is responding as listener not to one particular shoe (left), but to a listener class comprising many types of shoes (right). This listener class is established by the caregiver's naming each of the exemplars as "shoe".

Acquisition of Echoic Behaviour.

So far the child's acquisition of listener behaviour has been summarised. At this stage the infant's listener behaviour is still under the control of the caregiver's utterances. The next important step on the road to becoming a speaker-listener in one's own right is the development of the second element of the name relation, echoic behaviour. Echoic behaviour is critical in converting a listener relation into a speaker-listener relation. This section will describe the development of echoic relations and show how they eventually come to interact with the already established listener relations.

The echoic relation is one of the earliest forms of verbal behaviour (Skinner, 1957, p. 55), and involves the reproduction of the speech of others. Prior to their ability to echo verbal stimuli, however, infants produce a range of indistinct vowel and consonant sounds or babbling (Dale, 1976). Vocal approximations to conventional verbal behaviour are not produced until the end of the first year, (Locke, 1980; Oller, Wieman, Doyle, & Ross, 1976). Raising the operant level of these vocalisations is an important step towards later, adult-like speech.

Once the infant begins to make near accurate reproductions of adult sounds, these approximations are reinforced and shaped by their caregivers.

Poulson, Kymissis, Reeve, Andreatos, & Reeve (1991) demonstrated vocal imitation in 9-13 months old children, their imitative responses being reinforced by the adult. Their results showed that generalised echoic behaviour also occurred, that is, the infants tended to imitate vocal stimuli in the absence of any reinforcement. This suggests that in training a set of echoic relations, a generalised class of echoing may have been established.

Other studies have found that not only do infants imitate their caregivers' speech (e.g. Clark, 1977; Moerk, 1992; Ryan, 1973; Slobin, 1968), but caregiver's also imitate the infants' utterances (Kaye, 1982; Moerk, 1983).

The development of the echoic repertoire interacts with the development of listener behaviour, so that the caregiver's utterance of an object's name will evoke not only an echoic response, but also the appropriate listener behaviour towards the corresponding object.

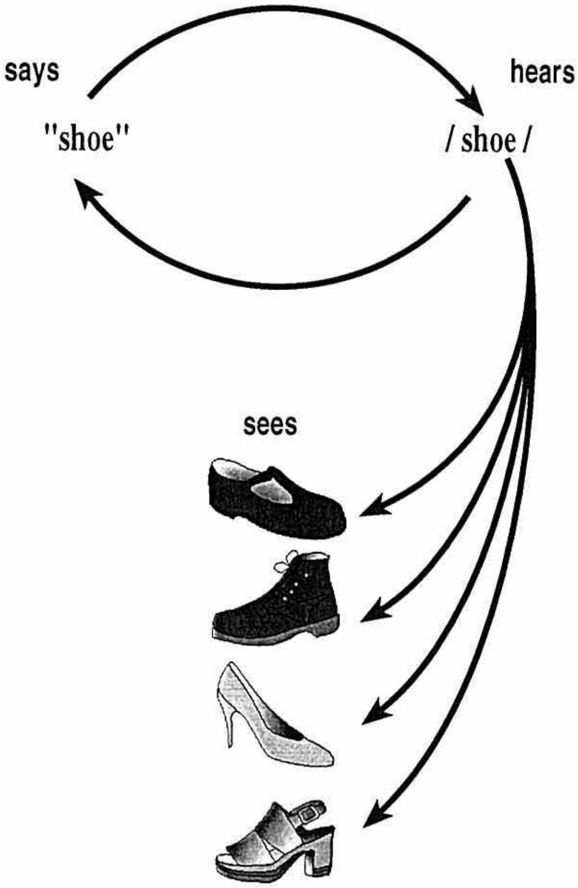


Figure 2.4. The acquisition of the echoic relation. When the infant learns to echo a word spoken by her or his caregivers (e. g., "shoe), his or her own auditory stimulus /shoe/ comes to occasion her or his looking not just at one particular shoe, but at any object so named by the caregiver for which she or he has already acquired listener behaviour.

To illustrate (see Figure 2.4), when the caregiver now says, "where's the shoe", an auditory response is generated to which the child may respond echoically, saying "shoe/oo". This in turn may also occasion the already acquired listener behaviour (as pictured in Figure 2.3). Yet at this point, the child may also respond to her or his own utterances of "shoe/oo" as a listener as well as a speaker. This may result in further examples of both echoic repetition and listener behaviour towards the shoe. It is also possible that this echoic behaviour may eventually come to be emitted at the covert level.

Although the child's behaviours continue to be reinforced by the caregiver, the child's self-echoic behaviour may also have reinforcing consequences. Skinner suggests that the child may be automatically reinforced for echoing the sounds of others (1957, p. 164). For example, Horne and Lowe suggest that the sounds uttered by caregivers may function as potent classically conditioned stimuli that have strong emotional effects on the child (p. 198). The echoing of these sounds, and in effect, re-hearing of the caregivers' voices may then generate stimuli that have similar reinforcing consequences.

The child's repeated self echoing may help sustain her or his listener behaviour; repeated echoing of the listener stimulus /sweeties/ may not only evoke classically conditioned responses, but also result in looking for, pointing at, and crawling toward any sweets in the environment.

The Development of Tacting.

With listener and echoic relations established, the infant is beginning to function as a speaker-listener. This speaker-listener behaviour, however, remains under the control of the vocalisations of others. Symbolic naming will not come about until the object itself enters into direct control of the infant's verbal behaviour, true naming being object centred behaviour. In order to close the circle, and establish the complete name relation, the final element , the tact, must be in place.

To recap, the tact occurs when a response of a given form is evoked by an object or event. For example, the infant sees a car and says "car", receiving praise for her or his utterance from the caregiver.

The tact response has been shaped by repeated echoic interactions between the infant and caregiver. As described, when the carer points to a shoe and says "shoe", this occasions listener behaviour towards the shoe. Hearing /shoe/ causes the infant both, to look at shoe and echo and re-echo "shoe".

In this way the sight of the shoe becomes a frequent antecedent for the utterance "shoe". This establishes the object (shoe) as a discriminative stimulus for the infant's own future utterances. Eventually, when the infant sees the shoe, *it alone* will occasion the tact response "shoe". The infant will also hear her or himself saying "shoe", thus occasioning all listener behaviours that she or he has learned towards that shoe, such as orienting to the shoe, putting it on, picking it up, and so on. These listener behaviours redirect the infant's attention to the shoe, which may then result in further spontaneous tacting of "shoe". It is at this stage that we can say that the infant has learned to name the shoe. All elements of the name relation are now in place and the naming circle is closed.

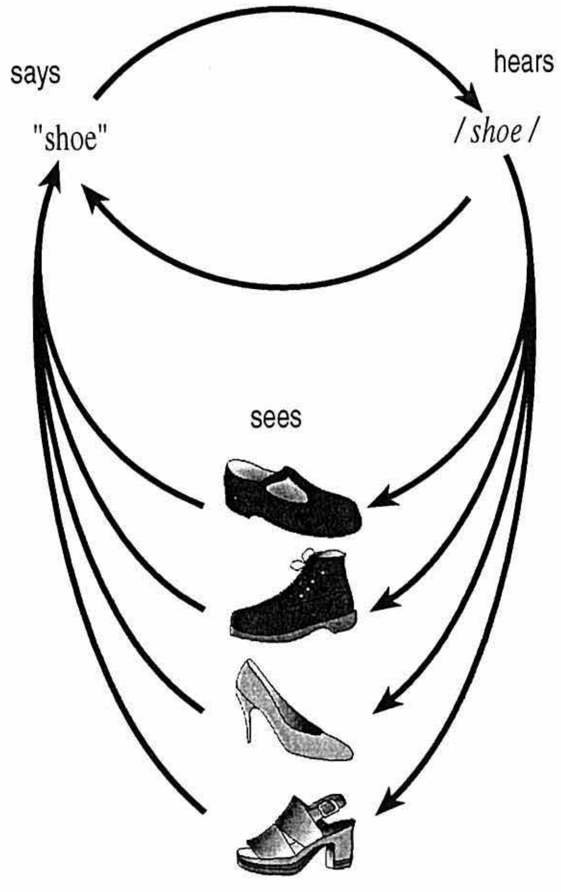


Figure 2. 5. When the child now sees a shoe to which she or he has previously oriented as a listener, this evokes the response "shoe" and, hearing her or his own auditory stimulus /shoe/, orients to any of the shoes in her or his listener class that are present. She or he may once again say "shoe" and again orient to a shoe exemplar and so on. Naming may thus be evoked initially either by seeing a shoe or by hearing /shoe/, and may be re-evoked either by seeing a shoe again or via the self-echoic relation (gray arrow). In this manner bi-directional relations are established between a class of objects and the speaker-listener behaviour they occasion.

From now on the infant does not simply respond to an auditory stimulus from others (listener behaviour), or simply echo vocal stimuli (echoic behaviour), nor does she simply vocalise when she sees an object (tacting). Rather, each of these behaviours will occasion all the other behaviours in the naming circle (see Figure 2.5). The infant has freed her or himself from the control of the caregiver's utterances and has become a speaker and listener for her or himself.

Evidence from the developmental literature supports this hypothesis. Studies such as that of Huttenlocher and Smiley (1987), and Harris et. al. (1995), suggest that it is indeed naming rather than mere tacting that is acquired at this stage. Their research shows that when a infant has learned to produce a word for an object (i.e. tact), he or she almost always demonstrates the appropriate listener behaviour to that object. That is, if the infant can say "car" she or he will also have a history of responding to "Where's the car?"

Naming involves the establishment of bi-directional (closed loop) relations. Rather than the uni-directional listener, echoic and tact relations described in Figure 2.1., when naming is established, each of these three relations will occasion the others within the naming circle.

Naming has effects on behaviour that go beyond tacting, echoing and listener behaviour on their own and an integral factor of the name relation is that it constitutes classes of objects and events.

Naming as a Higher Order Behavioural Relation.

This chapter has summarised two of the features of the name relation, that is, it combines conventional speaker and listener behaviour within the individual, and also refers to classes of events. Horne and Lowe also define naming as a higher order bi-directional behavioural relation that does not require external reinforcement of *both* listener and speaker behaviour for each new name to be established, that is, the presence of either listener or speaker function will, given certain preconditions, presuppose the presence of the others (p. 207).

In the infant's early stages of naming development, the listener, echoic and tact elements that make up the name relation are learned separately. With experience of higher order naming skills, however, it may be sufficient for a child to hear the name for a referent object in order for each constituent of the whole name relation to be learned.

The Relationship between Naming and Categorisation

Learning theory would predict that objects may come to be categorised together by stimulus generalisation, that is, on the basis of physical similarity or by sharing a similar function (e. g., a knife, fork and spoon are all used to eat with). In the case of physically different objects, and in the absence of direct training, however, this categorisation should not occur.

Naming theory, on the other hand can explain this phenomenon. When a set of physically different stimuli are members of the same name relation they are bi-directionally interrelated with each other via this common name and may thereby be categorised in a sorting task. It is the categorisation of such physically different objects that is the concern of this thesis.

Naming is classifying behaviour. As described earlier, once all elements of the name relation are established, the activation of any one of these elements will evoke the other behaviours in the name relation. Therefore, when a novel, yet physically different stimulus, is presented to the infant and the caregiver teaches the infant that it is called (for example) "hat", she or he will also exhibit the behaviours previously learned for the corresponding listener relation. For example, the child might put the new object on her or his head. Also, if the caregiver were to pick up one of the hats, and ask the child to give the others, the child may give all the objects with the common name hat from a range of exemplars. This may also include exemplars which do not formally resemble a hat, but to which the child has previously learned the appropriate listener behaviour. For example, these items may include a bag or box that the child, or one of its toys, has worn on the head, a picture of a hat, or even the written form of the word *hat* .

Naming and Stimulus Equivalence.

Naming theory, and its emphasis on the classifying nature of the name relation, is well placed to explain the examples of emergent behaviour observed in stimulus equivalence experiments. Indeed Horne and Lowe (1996, pp. 237-241) argue that the construct of stimulus equivalence may now be redundant: "success on equivalence tests may be a secondary and indirect outcome of more varied and fundamental verbal processes" (p. 237). Why study the results of these tests when one could be analysing the behaviours that are involved in producing the result?

In many cases, researchers in the field of equivalence have not recorded the subject's verbal behaviour, therefore ignoring its effects on the outcome of experiments. Indeed it would be very difficult to eliminate the effect that language has on the formation of equivalence classes, when one uses adult, and therefore linguistically sophisticated, populations. A more promising approach to resolving the different theoretical perspectives, is to analyse the development of the infant. Analysing the differences in classifying behaviour both prior to and after the onset of productive language may help to clarify the effect of naming on categorisation.

An experimentally based approach to this area will also inform and extend the correlational research of the developmental tradition of psychology. How naming theory can incorporate some of the developmental findings (as discussed in Chapter 1) will be dealt with next.

How Naming Accounts for the Developmental Data.

This chapter has already described how, according to the naming account, when the tact relation has been acquired, thus closing the naming circle, the categorisation of physically different stimuli may occur. Thus naming theory can account for the emergence of spontaneous exhaustive categorisation that has been noted to parallel increases in language production at approximately 18 months of age. It has not considered how the account might explain the naming explosion itself.

According to Horne and Lowe's account (p.202), the echoic repertoire constitutes a critical link in the development of the name relation. When the echoic repertoire is very limited, as in early word learning, what the child can echo equates with what she can name, thus determining what listener behaviour can become incorporated into the name relation. This has important implications for the development of the naming explosion.

> "It may not be possible for many new names to be acquired until a critical number of echoic relations, with differing phonetic characteristics, have been learned. As the number of these echoic relations in the repertoire increases, the combinatorial possibilities for producing more name utterances rises exponentially." (p. 202.)

Evidence in support of the above hypothesis has shown that, in some cases, infants' imitation of novel words increases dramatically (Masur, 1993, 1995) around the same time as the naming explosion. Further, at the age of 13 months, infants' imitation of words outside their imitative repertoires (i. e., the imitation of novel words as opposed to the continued imitation of known words) has been found to be a good predictor of productive vocabulary at the end of the second year (Masur, 1995). Also, these infants who tended to imitate more novel words were also found to have acquired more extensive noun vocabularies by the age of 18 months. Greater noun acquisition at this age has also been correlated with the naming explosion (Gopnik & Meltzoff, 1987; Goldfield & Reznick, 1990)

Some children also gain words like "whatsat" to request new objects (Fletcher & MacWhinney, 1995) at around the same period as the naming explosion. This increases the child's exposure to the relationship between objects and their names providing yet more opportunities for echoing and echoic learning, which may also play a part in the child's accelerated name learning.

As discussed in Chapter 1, the acquisition of both language and categorisation abilities have shown parallel developments, however the direction of causality has remained controversial. As the naming account emphasises the inter-relationships between the elements of the naming circle, developments in one of the component relations should have repercussions for developments in the other two. Horne and Lowe emphasise the importance of the establishment of tacting as being responsible for the closing of the naming circle, and hence being the catalyst for the higher level categorisation that has been seen to occur at around the eighteen month period.

The developmental evidence reviewed in Chapter 1 has described the changes in naming and categorisation behaviour in terms of an insight that all objects have a name (e. g., Gopnik & Meltzoff, 1987, 1992; Mervis and Bertrand (1994). Yet these authors do not explain how this insight is acquired, leaving another enigma to be solved. Horne and Lowe provide a detailed, step by step, behavioural account of the development of naming and categorisation that does not rely on such vague concepts as "insight" and is therefore seems the more parsimonious explanation for these phenomena.

The naming account can encompass most of the developmental findings, however there exists one contentious factor to be resolved.

Gopnik and Meltzoff (1992) have concluded that the correlation between the onset of both the naming explosion and exhaustive categorisation may involve a general naming ability. This was attributed to the fact that they found no relation between the names of the items sorted and the knowledge of these names in this particular study. As mentioned earlier, the children may have had different names than those designated by the experimenters.

Alternatively, these sorting performances may be simply be attributable to stimulus generalisation. The classes of stimuli used in the study consisted of either identical exemplars of objects, or physically similar objects, such as four different shaped pencils, cars or rings. The types of objects typically used in these experiments are those which may be familiar to the children; it cannot be ruled out therefore, that the participants may have had a prior play history with these items that could have facilitated their spatial sorting.

The correlational methodology ubiquitous in the developmental literature is not well placed to inform the issue of how naming is related to categorisation. The stimulus equivalence literature, although applying an experimental methodology to this issue, has not, in general, managed to formulate any adequate controls against the facilitative or causal effects of language on the formation of stimulus classes.

In order to provide a rigorous test of the role of naming in the formation of stimulus classes (i. e., categorisation), it is necessary for certain controls to be in place.

In order to eliminate the possibility of categorisation by stimulus generalisation, it is essential that the experimental stimuli are physically different from one another. Further, it would be necessary to reduce, as far as is possible, any physical similarity between these stimuli and other easily nameable objects, and also limit any categorisable characteristic of these stimuli such as colour, size or texture. These controls would also have the effect of eliminating the confounding effects of prior sorting histories.

In order to test the role of naming (as defined by Horne and Lowe, 1996) in the development of categorisation, rather than trying to test for the effects of verbal behaviour in a general manner, one would need to isolate the separate elements that comprise the name relation.

To this end, one would need to systematically analyse the differential effects on categorisation ability by training; (a) listener relations without also training speaker relations, and (b) speaker relations without the corresponding listener relations.

With these controls in place, there exists a methodology that may clarify some of the controversial issues within the behaviour analytic literature on stimulus equivalence.

For example, Horne and Lowe would predict that categorisation of physically different stimuli should not occur until all elements of the name relation (i. e., both speaker and listener relations) have been established.

Sidman's position, on the other hand, states that the ability to pass stimulus equivalence tests is a given, therefore he should predict that there would be no differences shown in categorisation when either of these training methods are implemented.

Those researchers subscribing to the relational frame theory explanation of the development of derived stimulus classes would also predict no differences between the two conditions, given that all other contextual cues remained constant.

The next section will describe recent research that has used the above methodology to test Horne and Lowe's naming account.

* * *

A Test of the Naming Hypothesis.

As outlined above, Horne and Lowe (1996) define naming as a fusion of speaker (i.e. tact and echoic) and listener relations. Within a name relation, all objects that evoke the same speaker-listener behaviour become functionally inter-related with each other, thereby forming a category. Note that the objects related within any category may or may not bear a physical resemblance to one another.

A prediction follows from Horne and Lowe's account. It is this.

If a child learns a common name for a set of physically different stimuli and is subsequently presented with a member of that class, and is asked to give the others, she or he may first produce (either overtly or covertly) the name of the target stimulus. The child's hearing of the name should in turn evoke her or his orientation to, and selection of, any objects for which she or he has previously learned the same common name.

An example should clarify this. If a girl learns the class name, *hat*, and one says to her, "Look at this. Can you give me the others?", she will direct her attention towards, and select, all the other items in the array that she has previously learned to name "hat", even if these items are physically dissimilar.

This prediction was first tested by Harris (see Horne & Lowe, in press). In the first of her studies, nine children (aged from 2 years 3 months to 4 years 3 months) were taught to produce one of two common tact responses to each member of a set of arbitrarily shaped stimuli. These stimuli were six physically different, green, wooden shapes which were, for training purposes, assigned to three pairs. For each pair the children learned to say "zog" when the experimenter pointed to one stimulus, asking at the same time, "What's this?", and also to say "vek" when the alternative stimulus was so indicated.

Once the children had mastered this, each child was presented with a randomised array of the six stimuli and asked, "What's this?" for each in turn. This procedure continued until the child was able to produce the correct tact for each of the six stimuli, without reinforcement, over three successive presentations of the six stimulus array.

Next, in a set of 18 unreinforced categorisation test trials, all six of the stimuli were again presented to the child, and the experimenter, selecting a different one as target in each, asked the child to look at the target and then give the experimenter the others.

As should be plain from the example of naming *hat,* given above, naming theory predicts that if a child were presented with, for example, any one of the *zog* stimuli as a target, and was asked for the others, she or he may overtly or covertly name it. If naming of the target stimulus does occur, then this in turn should evoke her or his orientation towards the other *zog* stimuli. Finally, she or he would select, from the array of five objects, the two that she or he had previously named "zog". (The converse, of course, would hold true for *veks*).

Harris' results confirm this. Three of the children sorted the stimuli correctly in all trials (i.e., their categorisation was consistent with their previous "zog"/"vek" vocal responses). Moreover, although the other six children were initially unsystematic in their selections, when the experimental instruction was changed to the effect that the experimenter said "What's this?" -- thereby prompting the participants to make an overt verbal response -- before asking, "Can you give the others?", all six subsequently categorised correctly (i.e., in each trial each child sorted the stimuli in terms of the vocal response she or he had previously produced for the target stimulus).

Thus Harris' results corroborate Horne and Lowe's account.

In Harris' experiment, although only tact relations were trained, listener behaviour, and hence naming, was also evidenced by the participants' reorientation to and selection of all objects with the same common name. The untrained categorisation behaviours exhibited by Harris' participants incorporate all the features of "emergent" stimulus classes that have been described in the literature in terms of stimulus equivalence (see Chapter 1), yet can be explained, via naming theory, as being a direct outcome of training.

Whereas Harris' research sought to confirm the naming account, the experiments described in the first study of this thesis attempted a falsification of Horne and Lowe's theory. Experiments 1 - 3 of Study 1 investigated whether the kind of categorisation behaviour seen in Harris' study would also occur if only one element of the name relation, that is, common listener relations (but not common speaker relations), were established between members of each potential stimulus class. Would this training alone, and in the absence of the full name relation, still yield untrained categorisation of physically different objects?

Participants, aged 1.5 to 2.5 years of age (Experiment 1), 2.5 to 3.5 years (Experiment 2) and 3.5 to 4.5 years (Experiment 3), were presented with three pairs of wooden stimuli, each stimulus being a different shape but the same colour as the others. For each pair, the experimenter randomly designated one stimulus to be called zog and the other to be called vek and the participants were trained to select the correct shape when asked, "Where's the zog/vek?". Then, in unreinforced tests of categorisation, the experimenter presented all six shapes to each child, selected a different one in each trial (e.g., a zog) and asked "Look at this, where are the others?".

Following unsuccessful categorisation test trials, the participants were tested for, and if necessary, taught the corresponding common speaker relations, that is to produce the names "zog" and "vek" to which they had previously only responded as listeners. They were then given a repeat of the categorisation test. If they still failed to show correct categorisation after speaker training had been given, further sets of test trials were administered using the instruction "What's this? Where are the others?", thus prompting the participant to make an overt tact response to the target stimulus, prior to sorting the remaining stimuli.

It was hypothesised that participants in the younger age group (Experiment 1), who had limited productive verbal repertoires, would be unlikely on the basis of only listener training, to also produce the necessary tact element required for the formation of the whole name relation. For participants learning only uni-directional common listener relations, this should not be sufficient for the categorisation of physically different stimuli.

The aims of Experiments 2 and 3 were more of an exploratory nature. It was speculated that these older, and more language able, participants may be able to derive the tact relations necessary to complete the name relation without explicit training, and hence demonstrate categorisation.

Chapter 4 contains the two experiments that constitute Study 2. These experiments replicated the methodology of Study 1 using two different age groups of participants; in Experiment 1 the age range of the participants was 2.5 - 3.5 years, and in Experiment 2 it was 3.5 - 4.5 years. This time, however, rather than establishing only common listener relations between members of each potential stimulus class, the participants also received concurrent off-task echoic training of the required speaker responses. Would this training alone, and in the absence of direct training of the common tact responses necessary to complete the full name relation, yield untrained categorisation of physically different objects?

The final study of this thesis repeated Harris' (see above, and Horne and Lowe, in press) original studies but with two modifications to the procedure. Experiment 1 of Study 3 (Chapter 5) trained a common tact response to two potential stimulus classes and then tested for categorisation. Unlike Harris, however, the categorisation test was administered after common tact training was given in pairs; Harris had originally tested categorising after tact training with all six stimuli present. Second, Harris did not perform a direct test of the establishment of listener relations; rather, it was inferred that listener relations had been established by the participants ability to demonstrate correct categorisation. The present study, however, conducted a direct test for these listener relations.

It was hypothesised that when participants (aged between 3.5 and 4.5 years of age) were trained a common tact response to members of two potential stimulus classes, corresponding listener relations (i. e., naming) and categorisation of the physically different stimuli would also be demonstrated.

CHAPTER 3

STUDY 1

WILL TEACHING COMMON LISTENER RELATIONS ALONE LEAD TO CATEGORY FORMATION?

GENERAL METHOD

All experiments were based on the general method which was adapted from procedures used in studies by Harris (see Horne & Lowe, in press), as outlined above. Exceptions and individual variations in procedures will be noted when necessary.

Participants

All participants were recruited, with parental consent, from the University of Wales Daycare and Child Development Centre or other pre-school nurseries in the Bangor area. Participants who completed all procedures were, on completion, tested with the Griffiths Mental Development Scales (Griffiths, 1954) to assess their development against pre-established norms for their age. Infants under the age of two and a half years also had their receptive and productive language assessed; this was by means of the MacArthur Communicative Development Inventory (Fenson et. al, 1993). This test was given prior to the start of procedures. The scores from these two tests are reported under the participant section of the relevant experiments.

Apparatus and Settings

All procedures were conducted in one of two locations.

Setting One. This was an experimental room at Tir Na n-Og, the University of Wales Daycare and Child Development Centre, the room having a floor area of 12' x 12'. It was equipped with two Colossus CCTV cameras mounted on pan and tilt heads. The cameras were set in diagonally opposing corners at differing heights, one at

68" and the other at 94.5" above floor level. This camera arrangement was designed to provide a clear visual image of the participant, unobscured by the experimenter. Radio microphones were worn by the experimenters. Video and audio inputs were transmitted from the experimental room to a central control room equipped with vision and audio mixer, multiple stack VCRs, and patch panels. The central control room thus served as a remote on-line recording and monitoring facility for all sessions.

Setting Two. This was the School of Psychology's mobile child research laboratory, a Ford Transit "high top" van. This houses a small experimental room of a floor area 5' x 8'. The room was equipped with two colour cameras (Broadcast Equipment Ltd., BEL CC-9000AF), each camera with an integral 12:1 zoom lens mounted on two pan and tilt drives (Vicon V3030APT). The cameras were set in diagonal corners of the room. Video and audio inputs were transmitted through a mixer (Panasonic WJAVE7) and recorded on two video recorders (JVC SRL900E).

In both settings participants were seated at a small table (40" x 20" x 20" in the nursery and 20" x 20"x 18" in the mobile lab) across from the experimenter. All sessions were recorded by both audio and video.

Stimuli

Two sets of stimuli were used:

The main experimental stimuli consisted of 13 physically dissimilar arbitrary wooden shapes. These were all painted a uniform green colour and were roughly the same size and thickness (See Figure 3.1).

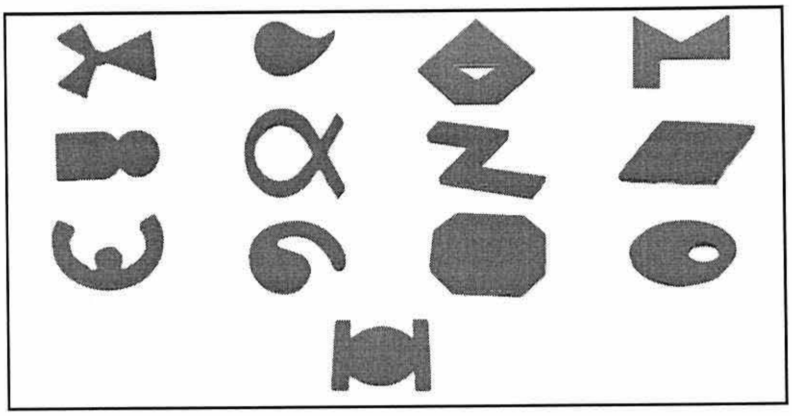


Figure 3.1 The arbitrary stimuli.

Each participant was randomly assigned six of these stimuli, three of which were randomly designated to be called "zog" (hereafter referred to as Z1, Z2 & Z3), and the other three to be called "vek" (V1, V2 & V3). The stimulus name "zog" was changed from Harris' original name of "zag" as a popular children's television programme featured a character named "zag" which may have given the children an opportunity to practice producing this name.

A second set of stimuli consisted of objects that would be well known to the child and were used to familiarise the participants with the procedures required of them during the main experiment using arbitrary shapes. The two familiar stimulus sets consisted of three toy hats and three toy cups (H1, H2, H3, C1, C2 & C3). Each of the stimuli in the sets were different in shape and colour (see Figure 3.2 below).

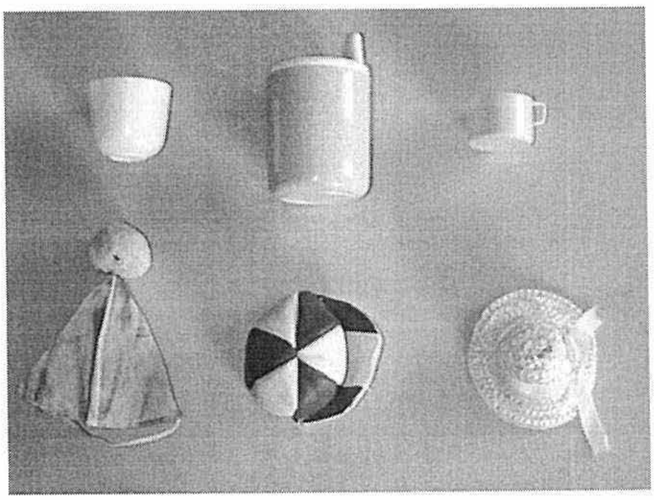


Figure 3.2 The familiar stimuli.

To minimise the possibility of inadvertent cueing from the experimenter, a "one - way" screen was used in all test sessions, (see Figure 3.3 below). The wooden framework measured 18" in width, 29" in height, and 1" in depth, and was supported by two wooden "feet"; 20" from the base of the screen was a perspex window that was occluded by a net curtain on the experimenter's side, the latter serving to prevent the participants seeing the experimenter's face during experimental trials. The gap remaining below the window was covered with a crepe paper fringing through which the experimenter was able to pass her hand to present and receive the stimuli from the child.

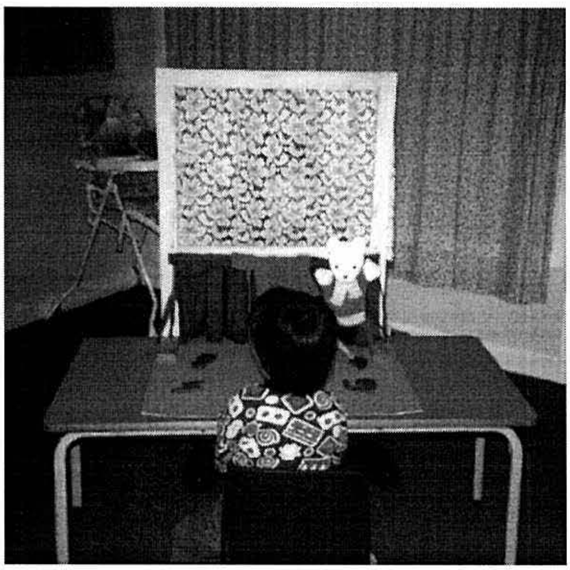


Figure 3.3 The experimental setting.

A Teddy bear glove puppet was used by the experimenter; thus responses from the participant could be directed toward the puppet rather than the experimenter. This was for two reasons: (i) in order to increase the participant's likelihood of compliance, and (ii) to reduce the possibility of any inadvertent cueing by the experimenter. As a further control against cueing, all categorisation test trials were performed by a second experimenter (E2) who had been pre-trained in the required procedures, but was unaware of the class labels assigned to the stimuli used in the tests. A small wicker basket was used to collect the stimuli from the child during the test sessions.

Reinforcement Programme.

Stickers were presented to each participant at the end of each session as reinforcers for "playing Teddy's game". During the unreinforced test sessions conducted by E2, the participants were told that if they showed E2 what they could do they would get a small toy at the end of the session. During training trials (unless stated otherwise), reinforcers were delivered following every correct response; they included such things as praise, cuddles, stickers, playing games, tokens to exchange for stickers and the like. These were tailored to suit each individual participant.

Inter-Observer Reliability

To determine inter-observer reliability, a randomly determined 25 percent of trials from each stage of the training phases (3493 training trials were compared in total), and 100 percent of all categorisation test and tact probe trials (2794 test trials in total) were scored by a trained assistant.

There was high levels of agreement on both training and testing phases with 97.2 percent agreement across training trials, and 100% agreement across testing trials.

Procedure

Phase 1: Common Listener Training and Category Training with Familiar Objects

Stage 1.1: Common listener training with familiar objects. The aim of using everyday objects in this phase was to familiarise the participant with the procedures employed in Phase 2 using the arbitrary stimulus sets. The everyday objects used were two stimulus sets consisting of three toy hats (hereafter referred to as H1, H2, H3), and three toy cups (C1, C2 & C3). Each of the stimuli in the sets were different in shape and colour (see Figure. 3.2)

During each trial two stimuli were presented --one hat and one cup -- and one was presented to each side of the child's midline. Only one stimulus was targeted per trial, and both stimuli were moved from sight before the next trial. During this phase there were four trial types; namely

1) A hat stimulus was targeted and was positioned to the right
2) A hat stimulus was targeted and was on the left.
3) A cup stimulus was targeted and was on the right.
4) A cup stimulus was targeted and was on the left.

Trials were presented in eight-trial blocks, consisting of two of each of the above trial types in a randomised order and the stimulus to be targeted was counterbalanced across the eight-trial blocks. Criterion for success was reached when the child responded correctly on seven out of eight trials in one eight-trial block, with full feedback for all responses.

The experimenter placed the first pair of hat and cup stimuli (H1/C1) on the table saying, "Look at these. Can you give Teddy the hat/cup?"

If the child could not produce the required behaviour, the experimenter gave corrective feedback saying, for example " No that's not a cup, can you give Teddy the cup?", and if necessary modelled the correct behaviour. If the child performed correctly, the experimenter rewarded the behaviour with a reinforcer suitable, as mentioned, for the individual child. The stimuli were then removed from the table and replaced in a different order, counterbalancing of this order being determined prior to the session.

When criterion performance was reached, with full feedback for all responses, for the first pair of everyday stimuli (H1/C1), the above procedure was repeated to criterion with the next two hat and cup pairs (H2/C2 and H3/C3) before moving on to the next stage of this phase.

Stage 1.2: Categorisation test with familiar objects. In this, as in all test sessions, a one-way screen was placed between the experimenter and the participant. The three hats and three cups were placed in front of the infant in a pre-determined randomised spatial array. Test trials were presented in blocks of six; in each trial a different object was used as a target sorting stimulus, thus enabling each of the six objects to be used as a target on one occasion.

The experimenter picked up the target object and said, "Look at this. Can you give Teddy the others like this?"

If the participant responded correctly, that is, giving all the other hats when a hat stimulus was the target and all the cups when a cup stimulus was the target, the experimenter continued the procedure choosing one of the other hats or cups as a target. Notice that the participants' choices were not initially reinforced.

If the participant responded incorrectly after one block of six trials, with the above instructions, the experimenter changed the request to "Can you give Teddy the other hats/cups?", correcting the participant if she or he made incorrect choices, and modeling the correct response when necessary. The two different instructions, described above, were presented interchangeably, as and when deemed necessary by the experimenter, to establish systematic categorising of the hat and cup stimuli.

When one block of six trials had been successfully performed by this method, the experimenter reverted to the original instruction. Criterion for correct performance was reached when the participant responded correctly to the instruction for each of the target stimuli in one block of six trials in the absence of reinforcement.

Phase 2: Common Listener Training with Arbitrary Stimuli.

Stage 2.1: Common listener training - with initial pairs. After participants had achieved criterion responding in both stages of Phase 1, the main experimental stimuli were substituted for the familiar objects. These consisted of 13 physically dissimilar arbitrary wooden shapes. Each participant was randomly assigned six of these stimuli, three of which were randomly designated to be called "zog" (hereafter Z1, Z2, & Z3), and the other three "vek" (V1, V2, & V3).

The procedure and criterion level during this stage was identical to that of Stage 1.1. Again, during each trial two stimuli were presented, one "zog" and one "vek" stimulus, and one to each side of the child's midline. The four trial types and the instruction "Look at these. Can you give Teddy the zog/vek?" were as that of Stage 1.1.

If the child could not produce the required behaviour, the experimenter said "No that's not a zog. Can you give Teddy the zog?", and if necessary modelled the correct behaviour. If the child performed correctly, the experimenter reinforced the behaviour, in the manner described previously.

When criterion performance was reached for the first pair of the arbitrary shapes, with full feedback to the participants' responses, the above procedure was repeated with pairs Z2/V2, and Z3/V3 before moving on to next stage of training.

Stage 2.2: Common listener training with mixed pairs. In order to check for maintenance of the individual name-object relations, the stimuli were allocated to different pairs (e.g. Z1/V3, Z2/V1, and Z3/V2) and again presented to the participant. The procedure here was the same as that used in Stage 2.1 and likewise, to the same criterion. When this criterion level was reached, with corrective feedback given when necessary, the participants were given a test for categorisation.

Phase 3 : Categorisation Test Procedure.

Before commencing this session, a different experimenter E2 , was introduced to the participant. The participant was asked if she could show E2 "what Teddy wants", and promised a big present at the end of the session if she or he did so. The original experimenter stayed in the room for the duration of the test, but sat behind the participant so as to preclude any inadvertent cueing of the participant's responses.

Stage 3.1: Categorisation test with familiar objects. This was performed as in Stage 1.2. Two categorisation test trials with familiar objects were performed, one with a hat as target and one with a cup as target. The target stimulus was picked up and the participant asked, " Look at this. Can you give Teddy the others like this?

If the participant was successful in both trials, Stage 3.2 of the procedure, described below, was implemented. If the participant was not 100 percent successful, sets of two trials were performed until the participant categorised the hats and cups with 100 percent accuracy. These further trials were initially performed with no feedback, but if the participant continued to perform incorrectly, feedback was given as described in Stage 1.2.

Stage 3.2: Categorisation test 1. This stage was also conducted by E2, and likewise the one-way screen was used. In each trial, the six arbitrary stimuli were placed in a pre-determined randomised order in front of the participant. E2 picked up one of the stimuli as a target and said, "Look at this. Can you give Teddy the others like this?" The participant's responses were not reinforced in any of these trials.

E2 then repeated the same procedure using another stimulus as a target. Each stimulus served as target on a randomly determined basis with the constraint that each of the six stimuli was targeted three times in total (unless stated otherwise), thus making eighteen test trials in total. The spatial position of the target stimulus was randomised over the eighteen trials. A correct response was deemed to have occurred when the participant selected the corresponding two "zog" stimuli when a "zog" stimulus was the target or selected the corresponding two "vek" stimuli when a "vek" stimulus was the target.

However, if the participant gave more than two of the stimuli, the experimenter said "No, Teddy doesn't want all of them, just the others like this", and the trial was deemed void and was not included in the data analysis. Only trials where the participant gave two other stimuli in response to the target were counted.

Depending on the concentration levels of the individual participant, the 18 trials performed overall were either given all together, or split up into three separate sessions, each consisting of six test trials. In cases where the trials were given in three sessions, each test session commenced with a repeat of Stage 3.1.

Mastery criterion.

The binomial distribution statistic was used to calculate how many correct test trials would indicate an above chance performance. This is mathematically defined thus:

$$p(X) = \frac{N!}{X!\,(N-X)!}\,p^{X}q^{(N-X)}$$

(Howell, 1992)

where

$p(X)$ = The probability of X correct categorisation test trials being performed.

N = The number of categorisation test trials performed in total. The standard number of test trials in this procedure was set at 18 (unless stated otherwise)

p = The probability of the participant choosing the correct two stimulus matches corresponding to the target stimulus in any one test trial. In any categorisation test trial the participant had the opportunity of selecting, from an array of five stimuli, 1 correct pair from a possible 10 stimulus pairs. Therefore the constant p was set at 0.1.

$q = (1 - p) =$ The probability of a failure on any one trial. That is, selecting any of the 9 possible incorrect stimulus pairs.

Applying this statistic showed that a correct selection of six from 18 possible trials was necessary to show above chance performance (with $N = 18$, $p=0.1$; $P(6) = 0.0052 < 0.01$). Significant categorisation was therefore deemed to have occurred when the participant scored 3 out of a possible 9 correct trials for *both* zog and vek target trials.

Phase 4: Probe for Tacting

After the participant had completed the categorisation test, probe trials were given to determine whether the participants were able to produce appropriate speaker behaviour (i.e. "zog" or "vek" responses) to the stimuli. If this was the case it could then be said that the whole name relation had been established during Phase 2: Common listener training.

The experimenter placed all six stimuli in front of the participant in a pre-determined randomised sequence, and, pointing to each stimulus in turn said "What's this?". The participant was given approximately five seconds to respond; if no response occurred, the question was repeated once more before the experimenter targeted the next stimulus.

This sequence was repeated three times (unless stated otherwise) in order that each stimulus was targeted on three separate occasions; here the spatial arrangement of the stimuli differed and was randomised on each trial. The experimenter did not respond differentially to any of the participants' responses. Participants were deemed to have named the stimuli reliably if they scored eight or more out of a possible nine correct trials for *both* the zog and vek three-stimulus sets.

If the participant passed the test for categorisation, regardless of the outcome of the probe for tacting that followed, all further procedures ceased. For participants who failed the categorisation test, the next phase of the experiment depended on the results of the probe for tacting.

i) If the participant failed the categorisation test, yet could demonstrate appropriate speaker behaviour (tacting), then the whole name relation was deemed to have been established. In this case a repeat of the categorisation test with arbitrary stimuli (Phase 3.2) was given. However this time the instruction was changed to, "What's this? Can you give Teddy the others like this?" This was to determine whether the child needed to produce the stimulus name overtly for categorisation to occur (Categorisation Test 2).

When eighteen trials of the latter categorisation test had been completed, the participant was deemed to have completed all procedures.

ii) If the participant failed the categorisation test, and also failed to demonstrate appropriate speaker behaviour in the probe for tacting, she or he proceeded to Phase 5 of the experiment for common speaker training. When the participant had completed both common listener and common speaker training, it was possible to state that the whole name relation had been established. Another categorisation test was then given (see Phase 6).

Phase 5: Common Speaker Training.

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. The procedure and criterion level during this stage was similar to that of Stage 2.1 (Common listener training with arbitrary stimuli), the differences being as follows.

The procedure began with one block of trials in which the participant was given experience of echoing the required stimulus names. In these blocks the experimenter placed the first pair of zog and vek stimuli (Z1/V1) on the table and pointed to the target stimulus and said, "This is a zog/vek. What's this?" If the participant responded correctly, saying "zog/vek" her or his behaviour was reinforced. If the participant gave an incorrect response the experimenter said "This is a zog/vek. Can you say zog/vek?" There was no criterion for this first block.

In the following blocks of trials, the experimenter pointed to the target stimulus and asked the participant, "What's this?" In each trial the participant's correct responses were reinforced, and corrective feedback was given following incorrect responses.

When criterion performance was reached, with full feedback, the above procedure was repeated with pairs Z2/V2 and Z3/V3, before moving on to next stage of this phase.

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes. In this stage, all six stimuli were placed in a random spatial array in front of the participant and the experimenter, pointing to each of the stimuli in turn, asked the participant, "What's this?" In each block of trials the experimenter targeted each of the six stimuli once. Full feedback was given to all the participant's responses at this stage. The criterion for correct performance was reached when the participant responded with 100 percent accuracy over three blocks of trials.

Stage 5.3: Reduction in reinforcement probability. Common speaker training in sixes, was repeated, but this time with no feedback. If the participant failed to reach criterion, Stage 5.2 (with full feedback) was repeated. Criterion was reached when the participant responded with 100 percent accuracy over three blocks of trials with no feedback.

Phase 6: Repeat of Categorisation Test Procedure.

Stage 6.1: Common speaker testing with arbitrary stimuli, in sixes. Prior to the main categorisation test, to test maintenance of speaker behaviour, all six stimuli were placed in front of the child and the experimenter pointed to each stimulus in turn and asked, "What's this?" Only if the participant was 100 percent accurate in her response for all six stimuli with no feedback from the experimenter, did she proceed to Stage 6.2. Otherwise the participant returned to training as in Stages 5.2 and 5.3.

Stage 6.2: Categorisation test with familiar objects. This was performed as in Stage 2.1: Categorisation test with familiar objects. Two trials were performed, one with a hat as target and one with a cup as target.

If the participant was successful in both trials, Stage 6.3 of the procedure was implemented. If the participant was not 100 percent successful, sets of two trials were performed until the participant categorised the hats and cups with 100 percent accuracy as described in Stage 3.1.

Stage 6.3: Categorisation test 1. This was a repeat of the categorisation test performed in Stage 3.2, where the instruction was "Look at this. Can you give Teddy the others like this?" Again, 18 trials were performed in total (unless stated otherwise). If the participant demonstrated correct categorisation to criterion, the experiment was terminated.

Stage 6.4: Categorisation test 2. If the participant failed the Stage 6.3 categorisation test, a repeat of the above categorisation test was given, but this time the instruction "What's this? Can you give Teddy the others like this?", was used to prompt overt production of the target stimulus name. Again, 18 trials were performed. If the participant failed to demonstrate correct categorisation, the experiment was terminated.

Stage 6.5: Repeat of Categorisation test 1. If the participant categorised successfully using this instruction, a repeat of the categorisation test using the "Look at this..." instruction, as in Stage 6.3, was given to determine whether correct categorisation would maintain across these differing instructions.

Some of the participants received training with a second set of arbitrary stimuli. For these, the above procedure was repeated, but with the omission of the familiar object training and testing in Phase 1. Any other modification of the above general procedure will be addressed under the results section for the individual participant.

* * *

EXPERIMENT 1

Experiment 1 used procedures similar to those developed by Harris, to investigate whether categorisation would occur when only common listener relations, but not common speaker relations were trained to six physically dissimilar objects. The participants in this experiment were between 1.5 and 2.5 years of age.

METHOD

Participants

Fourteen participants, six female and eight male, took part. Table 3.1 shows each participant's gender, age (in months and days), and MCDI scores for receptive and expressive vocabulary at the start of the experiment. Their recruitment was as described in the General Method section.

Table 3.1.
Participants' sex, age, and MCDI scores for receptive and expressive vocabulary at the start of the experiments.

Participant	Sex	Age at start year: months	Age at first categorisation test year: months	MCDI scores receptive	MCDI scores expressive
KF	F	1: 04	n/a	245	90
SR	M	1: 06	n/a	118	12
PF	M	1:07	n/a	194	70
JC	F	1:07	1:09	254	174
HM	F	1:07	n/a	195	113
JL	M	1:09	n/a	*	*
MJ	F	1:10	2:02	340	258
SJ	F	1:11	n/a	340	340
BH	M	1:11	2:04	234	66
HS	F	2:00	n/a	379	371
BG	M	2:01	n/a	246	63
CM	M	2:02	n/a	336	197
CG	M	2:03	n/a	314	268
TK	M	2:04	n/a	*	*

* Participant JL and TK's MCDI forms were not returned.
F = female M = male

Procedure, Apparatus, and Settings

The procedure, apparatus and settings employed in Experiment 1 were as described in the General Method section above. The flowchart in Figure 3.6 gives a graphic overview of the procedure.

Two of the participants completed all procedures with one stimulus set. However, as JC proved to be a keen participant, listener relations were trained to a second set of stimuli. These were physically dissimilar, both to each other and to the Set 1 stimuli. The same class labels, zog and vek, were utilised

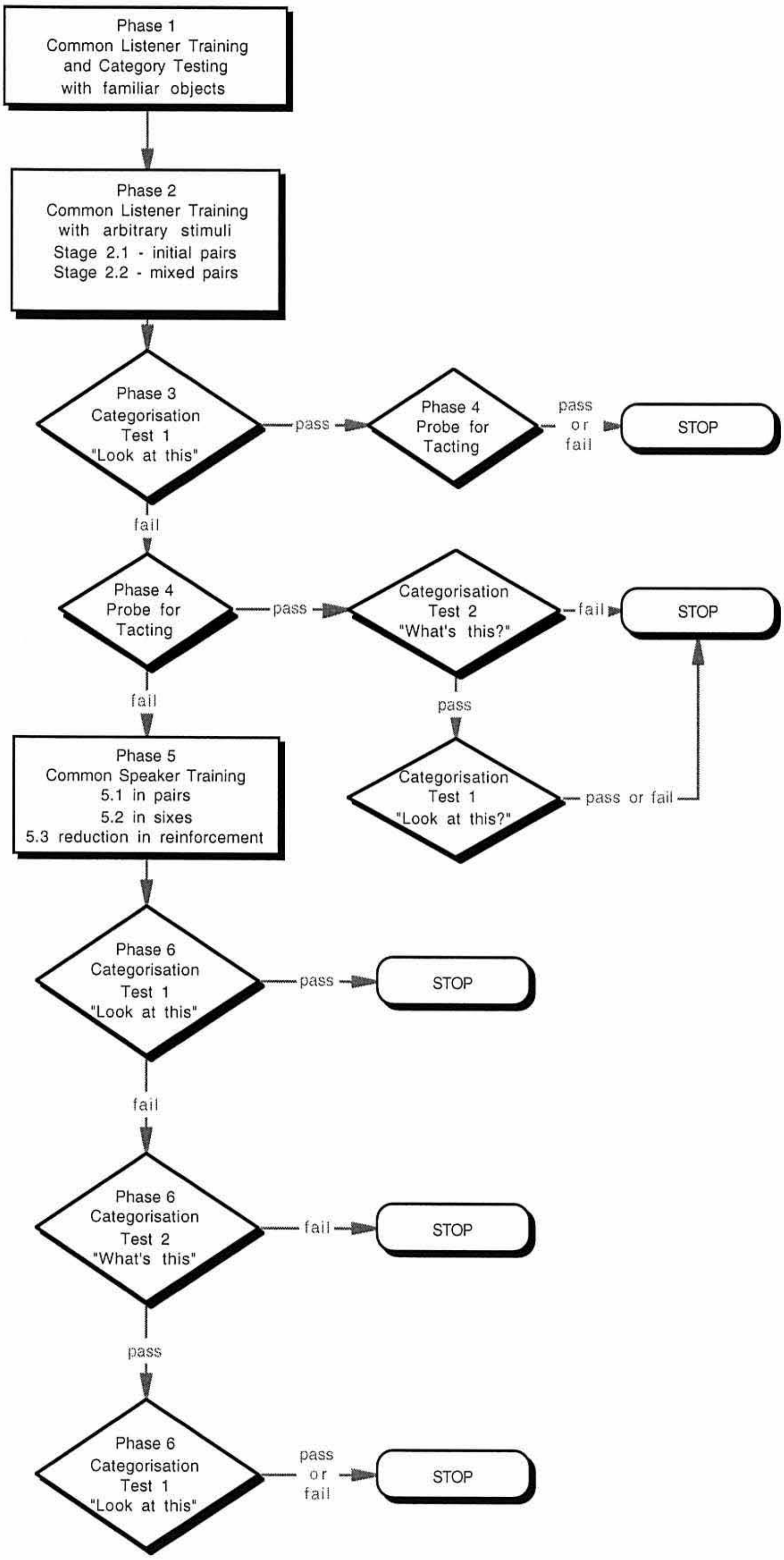


Figure 3.4: Flowchart representation of the procedure of Experiment 1.

for the Set 2 stimuli (henceforth these are termed Z4, Z5, Z6, V4, V5, and V6). The procedure was the same as for Stimulus Set 1 except that Phase 1 was omitted.

RESULTS

Tables 3.2 and 3.3 show, for all 14 participants, the data from the first two experimental phases. Only three of the participants went on to complete all phases of the experiment; data from these three will be presented as individual graphs from Phase 2 onwards.

Phase 1

Table 3.2 shows the number of eight-trial blocks each participant required in order to achieve criterion performance in Stage 1.1 listener relation learning for each of three familiar object (hat and cup) pairs. Three participants did not complete Stage 1.1 of the procedure: SR and PF failed to learn one or more of the hat/cup pairwise discriminations, while KF left the nursery early in this training stage.

Table 3.2 also shows the number of six-trial blocks required to achieve criterion performance in Stage 1.2 familiar object categorisation. For Stage 1.2 (see Table 3.2) the left hand column shows the number of training blocks each participant required to categorise the six familiar objects into two categories (one of hats and the other of cups) when shown either a hat or a cup and asked, "Look at this. Can you give me the other hats/cups?". The right hand column of data for Stage 1.2 shows the number of blocks each participant required to correctly categorise the hats and cups in response to the instruction, "Look at this. Can you give me the others like this?"

Of the 11 participants who progressed to Stage 1.2, seven learned to categorise the hats and cups appropriately in response to the instruction, "Look at this. Can you give me the others like this?" Three of the remaining participants, HM, JL, and BG failed to learn to categorise to the latter instruction and were withdrawn from the study. Participant CG left the nursery before completing this stage of the experiment.

Table 3.2.
Results of Phase 1: Common listener training and category training with familiar objects.
In Stage 1.1, H1/C1, H2/C2 and H3/C3 refer to the three familiar object (hat and cup) pairs. Two instructions were used in Stage 1.2, "Look at this. Can you give me the other hats/cups?" and "Look at this. Can you give me the others like this?" The total number of blocks to criterion have been split between these two instructions (for more details see procedure).

Participant	Stage 1.1 Common listener training in pairs			Stage 1.2 Categorisation test	
	H1/ C1	H2/C2	H3/C3	"other hats & cups"	"Others"
KF	6	_	_	_	_
SR	_	_	_	_	_
PF	3	4	_	_	_
JC	1	1	1	2	2
HM	1	1	4	1	_
JL	1	1	1	5	_
MJ	1	1	1	4	4
SJ	1	1	2	4	1
BH	1	1	1	1	3
HS	1	2	1	2	1
BG	3	1	1	1	_
CM	2	1	1	3	1
CG	3	1	1	4	_
TK	1	1	1	_	1

Phase 2

Table 3.3 shows the number of eight-trial training blocks each participant required to achieve criterion listener relation performance on the three arbitrary stimulus pairs. For Stage 2.1, the number of training blocks to criterion are shown for each of the three arbitrary (/zog/ and /vek/) pairs. All seven participants learned to respond appropriately to the listener stimuli /zog/ and /vek/ (i.e. by selecting the corresponding object from among the pair) for all 3 pairs (Z1/V1, Z2/V2, and Z3/V3). For Stage 2.2, where the stimuli were sorted into new pairings, the number of training blocks to criterion listener performance are shown for each of the new "mixed" arbitrary stimulus pairs.

Table 3.3.
Results of Phase 2: Common listener training with arbitrary stimuli. In Stage 2.1 the stimuli were divided into three zog/vek pairs; for example Z1/V1 and for Stage 2.2 the stimulus pairs were arranged into different pairings; for example Z1/V3. The mixed pairings are referred to here as Z/V a, b &c, as each participant received a different order of pairings.

	Common listener training with arbitrary stimuli					
	Stage 2.1 Initial pairs			Stage 2.2 Mixed pairs		
Participant	Z1/V1	Z2/V2	Z3/V3	Z/V a	Z/V b	Z/V c
JC	10	2	2	1	1	1
MJ	2	14	8	1	1	1
SJ	18	13	3	–	–	–
BH	2	10	16	2	4	2
HS	17	8	2	14	–	–
CM	4	14	4*	4*	8*	–
TK	2	4	6	2	1	–

* Failed to reach criterion with this stimulus pair.

Of the seven participants who started this phase, only three reached criterion with all six stimulus pairings: Participant TK left the nursery and was unable to continue the experiment, and Participants SJ, HS, and CM failed to reach criterion for all pairings.

Phases 3 - 6

For the three participants who completed the experimental procedure, data from each phase, including a review of that from Phases 1 and 2, are presented individually below.

Participant JC: Stimulus Set 1

This participant completed the procedure with two arbitrary stimulus sets, Set 1 and Set 2. Data for her performance when Set 1 stimuli were employed are shown in Figure 3.5.1 below.

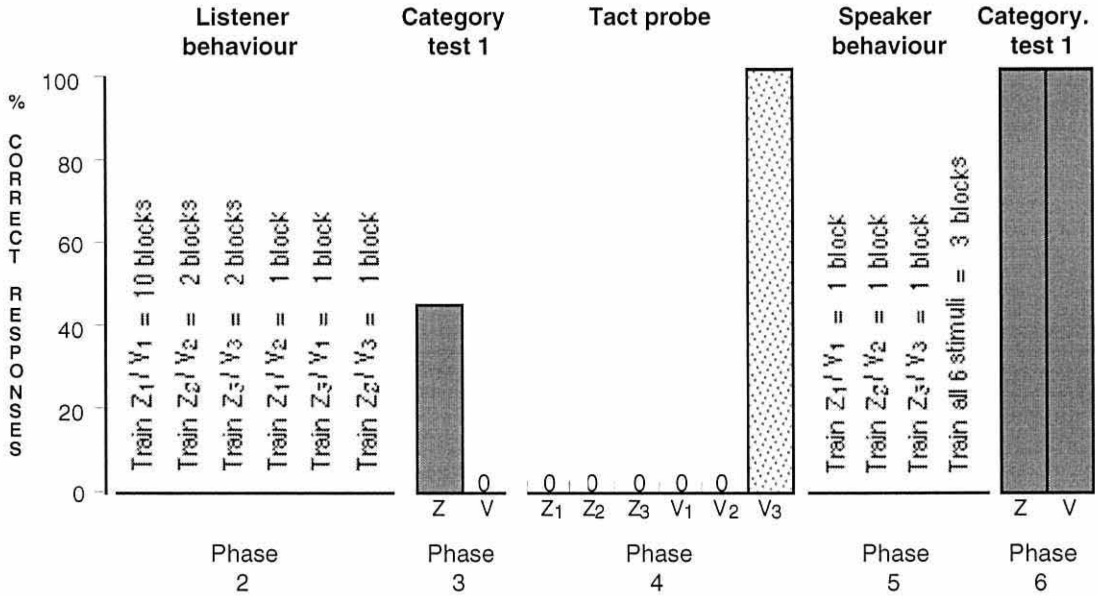


Figure 3.5.1. Results of Participant JC (Stimulus Set 1). The training phases (Phases 2 and 5) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant JC required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 3.2).

In Stage 1.2 category training with familiar objects, JC required two blocks of six trials using the instruction, "Look at this. Can you give Teddy the hats/cups", and also two blocks using the alternative instruction, "Look at this. Can you give Teddy the others like this?" to reach criterion performance.

Phase 2: Common Listener Training with Arbitrary Stimuli.

Stage 2.1: Common listener training - with initial pairs . JC required 10 blocks of eight trials, to demonstrate criterion listener relation learning with initial pair Z1/V1; she required two blocks of trials with both initial pairs Z2/V2 and Z/3/V3. In all blocks corrective feedback was given to her responses.

Stage 2.2: Common listener training - with mixed pairs. JC required one eight-trial block to demonstrate criterion performance with all three mixed pairs of stimuli (Z1/V2, Z3/V1 and Z2/V3). Corrective feedback was given to her responses when necessary.

However, as JC was absent from the nursery for a few days before a categorisation test could be given, another one block of eight trials, for each pair, was also given to check for maintenance of the learned relations. During these further blocks, no feedback was given to any of her responses. JC reached criterion level performance with all three sets of stimuli.

Phase 3: Categorisation Test 1.

Stage 3.1: Categorisation test with familiar objects. JC failed to categorise the hat and cup stimuli correctly, therefore 18 extra training trials were given (as in Stage 1.2). She completed the final five of these trials correctly and without reinforcement. To ensure that she had maintained the learned listener relations, another block of training trials were given for each of the arbitrary stimulus pairs. She reached criterion level performance with all three pairs without further reinforcement.

Stage 3.2: Categorisation test 1. JC then completed 18 trials of category test 1. This test used the,*"Look at this, can you give me the others?"* instruction. She scored 44 percent correct in trials where a zog stimulus was the target (4 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (4) = 0.07>0.01).

A post-hoc analysis of her stimulus selection during the categorisation trials showed that JC had a position preference. During these 18 trials she selected the two stimuli that were situated to the far right of the stimulus array on eight occasions, that is, the stimuli closest to her right hand. This selection "strategy" occurred at levels significantly higher than would be expected by chance in the course of the 18 test trials (with N = 18, p= 0.03; P [8] = 0.00 < 0.01).[1]

Phase 4: Probe for Tacting.

The tact probe showed that JC could name only one of the stimuli correctly (she produced the name "vek" to V3 in all three trials). For the remainder of the stimuli she generally produced incoherent responses, although she produced the word "finger" to the Z1 and Z3 stimuli on one trial respectively.

Phase 5: Common Speaker Training

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. Following the one echoic practice block for each of the three stimulus pairs, JC required one eight-trial block to demonstrate criterion speaker behaviour to each of the three arbitrary stimulus pairs.

Phase 5.2: Common Speaker Training with Arbitrary Stimuli - In Sixes.

---

[1] In analysing this selection strategy the value for p was calculated thus:
In each trial the six stimuli were randomly placed in one of six positions, each position being numbered by the experimenter from 1 - 6. One stimulus was removed from this six stimulus array to act as a target, and the participant's task was to choose two other matches from the remaining five stimuli. There existed 30 permutations; e.g. position 1 followed by position 2 (1,2) or (3,4)...etc. Therefore the probability (p) of making one type of positional choice was 1 out of 30, or 0.03.

JC required three six trial blocks (the minimum number) to reach criterion level performance. She completed all three blocks without any reinforcement.

Phase 6: Repeat of Categorisation Test 1.

JC completed another 18 trials of the categorisation test using the, "Look at this, can you give me the others" instruction (see Phase 3). Over all 18 trials she demonstrated 100 percent correct responses, that is, nine of nine correct responses when a zog stimulus was the target, and nine of nine correct when the vek stimulus was a target. According to binomial theory the probability that this would occur by chance is low and statistically significant ($N = 18$, $P(18) = 0.00 < 0.01$.)

Spontaneous Verbal Behaviour: Stimulus Set 1.

Apart from those vocalisations reported in Phase 4 (probe for tacting), JC did not produce any idiosyncratic names for the stimuli.

During Phase 2 (common listener training with arbitrary stimuli) in a total of 169 training trials, she produced the name "zog" on 50 occasions and "vek" on 54 occasions. JC often echoed the words "zog" and "vek". For example, when the experimenter said "No, that's a zog", she would echo "That's a zog".

Her production of the names zog or vek seemed to be dependent on the previous utterance of the experimenter, and were not related to her correct choice of stimulus. For example, when the experimenter said, "Can you give Teddy the zog?" she would say "That's a zog", whether or not she chose a zog stimulus.

These type of utterances appeared early on in the procedure. To illustrate, during listener training to pair Z1/V1, where 85 trials were performed, she produced the name "zog" on 45 occasions and "vek" on 46 occasions. Note that these utterances total 91, as in some cases she would say the name twice or more in succession, for example "zog, zog, zog".

Of the remainder of her spontaneous production during the listener training trials, she echoed the stimulus name produced by the experimenter on 9 of 12 occasions, but having done so, chose the incorrect stimulus on three occasions. These utterances were randomly spaced throughout the remaining 68 trials. JC did not produce any names, experimental or otherwise, to any of the stimuli during the categorisation test that followed listener training.

Summary: Stimulus Set 1

JC's results for the Set 1 stimuli support the naming hypothesis. Categorisation did not occur until both speaker and listener elements of the name relation had been trained. In the case of JC, common listener relations do not appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets, each consisting of stimuli with a common relation to one listener stimulus (/zog/ or /vek/).

Participant JC: Stimulus Set 2.

Phase 2: Common Listener Training with Arbitrary Stimuli.

Stage 2.1: Common listener training - with initial pairs . JC required one eight-trial block to demonstrate criterion listener relations with both initial pairs Z4/V4 and Z5/V5, and eight blocks of trials with initial pair Z6/V6 (see Figure 3.5.2). In all blocks she received corrective feedback when necessary.

Stage 2.2: Common listener training - with mixed pairs . JC required three eight-trial blocks to demonstrate criterion listener relations with mixed pair Z4/V6, followed by one eight-trial block for mixed pair Z6/V5, and then one block for Z5/V4. Again, she received corrective feedback for her responses.

Again, due to absences from the nursery before a categorisation test could be given, it was necessary to check for maintenance of the learned relations. To this effect, seven extra blocks of trials were given to both the initial pairs Z4/V4 and Z5/V5; to these she responded with 100 percent accuracy and without further reinforcement. For pairing Z6/V6, nine extra blocks were given; to eight of these blocks she showed criterion level performance, the last six blocks of these requiring no reinforcement.

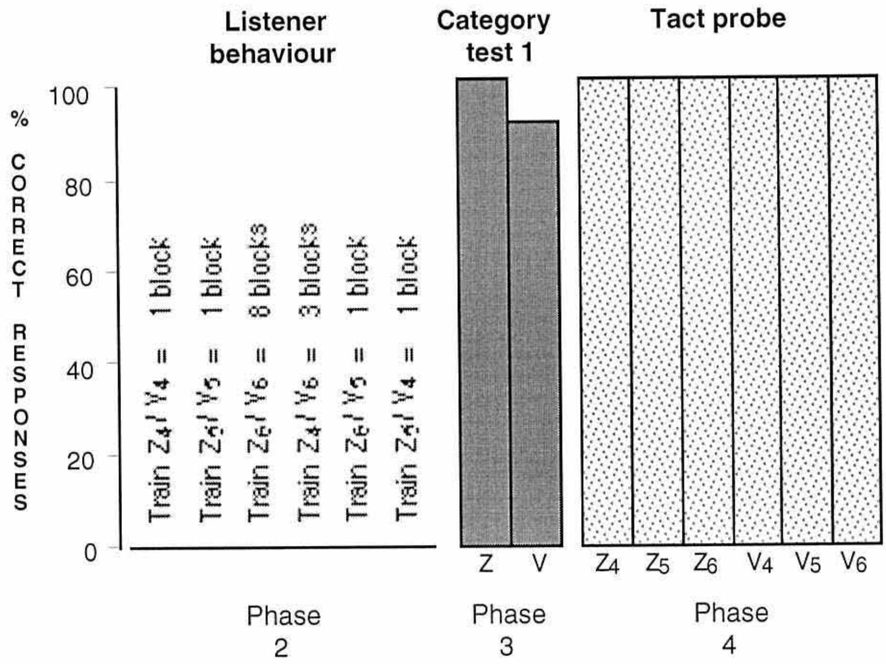


Figure 3.5.2. Results of Participant JC (Stimulus Set 2). The training phase (Phase 2) gives the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), and probe for tacting (Phase 4).

Phase 3: Categorisation Test 1.

JC completed 18 trials of the categorisation test using the, "Look at this" instruction. She scored 100 percent correct in trials where a zog stimulus was the target (9 of 9) and 89 percent correct in trials where a vek stimulus was the target (8 of 9). This was a statistically significant result (N =18, P (17) = 0.00<0.01).

Phase 4: Probe for Tacting.

The tact probe showed that she could produce the name for all of the stimuli with 100 percent accuracy over three trials.

Griffiths Test.

The result of JC's Griffiths test gave a GQ (General Development Quotient) of 112. This score is in the normal range for her age.

Spontaneous Verbal Behaviour: Stimulus Set 2.

JC did not produce any idiosyncratic names for the Set 2 stimuli. Out of a total of 311 training trials during Phase 2, she produced the name "zog" on only 23 occasions and "vek" on 17 occasions. During the first 24 training trials, she produced the names zog or vek on 9 occasions. Most of these utterances, although taking the form of a tact response, seemed to be dependent on the previous utterance of the experimenter, for example, after an incorrect response from JC, the experimenter would say "No, that's a vek", whereupon JC would say, "and that's a zog" or "where's the zog?" whilst looking at or pointing to, the remaining stimulus on the table. These appeared to be more of an intraverbal response, where the tacting of one stimulus name (e.g. zog) was a discriminative stimulus for the tacting of the other name (vek). A few of these utterances took the form of a direct echoic response of the experimenter's words, for example repeating "Teddy's got the zog". Her vocalisations at this point were unrelated to her selection of stimulus.

After this initial burst, the rate of JC's vocalisations slowed down, and she produced the experimental names on only 13 occasions throughout the next 208 trials. Of these, six utterances were of the intraverbal - tact kind described above, five were echoic responses and the remaining three were tact responses (one of which was incorrect). The amount and type of verbalisation were randomly interspersed throughout these trials.

JC then produced 18 vocalisations during the final 79 trials. All but two of these (which were echoic responses to the experimenter's speech), were tact responses. After the experimenter had asked her to give the zog/vek stimulus, JC correctly tacted the stimulus name whilst handing the stimulus to the experimenter.

JC did not produce any names, experimental or otherwise, to any of the stimuli during the categorisation test that followed listener training.

Summary: Stimulus Set 2

By the end of the procedure for Set 1, JC had been taught bi-directional speaker-listener relations, that is, naming. The results show successful classification of the stimuli into zog and vek categories. Though she was taught only listener relations for the Set 2 stimuli, the listener stimuli (/zog/ and /vek/) employed were, in fact, common to both Set 1 and Set 2. Thus, by the end of Set 2 training, JC had learned a listener class encompassing both Set 1 and Set 2 stimuli.

In testing, however, JC demonstrated correct categorisation of the Set 2 stimuli which, in the probe for tacting that followed, she also named correctly. JC's speaker repertoire had extended, without explicit training, to include the Set 2 stimuli, presumably via her echoing of the Set 2 listener stimuli during listener training for the latter set.

Since JC had formed bi-directional (or name) relations for the Set 2 stimuli, her categorising performance on the latter stimulus set is consistent with the predictions of the Naming hypothesis.

Participant MJ.

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant MJ required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.2).

In Stage 1.2, category training with familiar objects, MJ required eight six-trial blocks to demonstrate criterion performance. She needed four blocks using the instruction, "Look at this. Can you give Teddy the hats/cups" and also four blocks using the alternative instruction, "Look at this. Can you give Teddy the others like this?" to reach criterion performance.

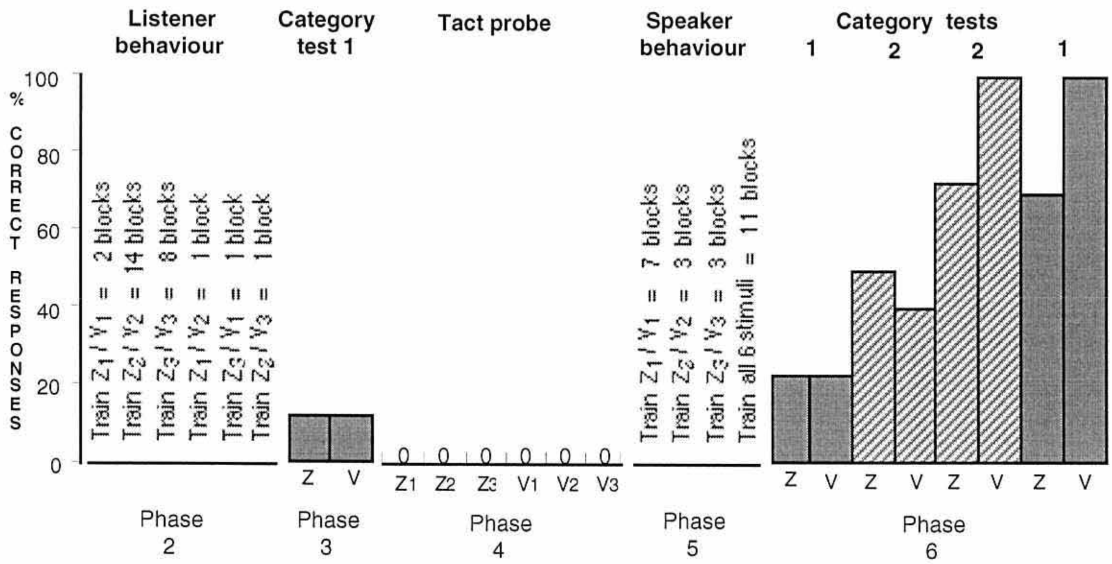


Figure 3.6. The training phases (Phases 2 and 5) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 2: Common Listener Training with Arbitrary Stimuli.

Stage 2.1: Common listener training - with initial pairs . MJ required two eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1, 14 blocks with pair Z2/V2 and eight blocks of trials with pair Z/3/V3. Corrective feedback was given to all her responses.

Stage 2.2: Common listener training - with mixed pairs . MJ required one eight-trial block to demonstrate criterion listener relation learning with all three mixed pairs of stimuli, (Z1/V2, Z3/V1 and Z2/V3). Corrective feedback was given to all her responses.

Phase 3: Categorisation Test 1.

MJ completed 18 trials of the categorisation test using the, "Look at this, can you give me the others?" instruction. She scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). This performance is as would be expected by chance (N =18, P (2) = 0.28>0.01).

Phase 4: Probe for Tacting.

The tact probe showed that she had no reliable names for any of the stimuli (only two blocks of trials were given to MJ in this phase due to her becoming upset at her inability to answer the experimenter).

Phase 5: Common Speaker Training with Arbitrary Stimuli

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. Following the one echoic practice block for each of the three stimulus pairs, MJ required seven eight-trial blocks to demonstrate criterion speaker relations with stimulus pair Z1/V1 and three blocks for both pairs Z2/V2 and Z3/V3. Corrective feedback was given to all her responses.

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes. MJ did not respond when asked to name each of the stimuli in the six stimulus array, and became quite upset because she was unable to do so. The procedure was then adapted.

Firstly criterion performance to stimulus pairs Z1/V1 and Z2/V2 was re-established; secondly a four stimulus array consisting of these stimuli was presented to her in place of the conventional six stimulus array. Each of the four stimuli within this array was targeted in turn which constituted one trial block and corrective feedback was given.

Twenty six blocks of trials were presented to MJ before she was able to produce the correct response to each stimulus in the array correctly, and also was able to attain three of these blocks in a row correctly and without reinforcement.

Criterion speaker relations was then tested for stimulus pair Z3/V3, which she reached in two eight-trial blocks. MJ received 11 blocks of trials in total, with the six stimulus array, to reach criterion level performance. She then proceeded to Phase 6.

Phase 6: Repeat of Categorisation Test .

Stage 6.3: Categorisation test 1. MJ completed 18 trials of the categorisation test using the, "Look at this, can you give me the others" instruction (see Phase 3). Over all 18 trials she demonstrated 22 percent correct responses (2 of 9 trials) when a zog stimulus was a target, and 22 percent (2 of 9) trials correct when a vek stimulus was a target. According to binomial theory this performance is as would be expected by chance (N =18, P (4) = 0.7>0.01). These data are represented by first pair of bars in Phase 6 of the graph in Figure 3.6.

Stage 6.4: Categorisation test 2. A Category test 2 was then given, this time using the *"What's this? Can you give Teddy the others like this?"* instruction. MJ completed 20 test trials (due to experimenter error). She scored 50 percent correct (5 of 10) in trials where the zog was the target and 40 percent correct when a vek was a target (4 of 10).

The probability that this would occur by chance is: $N = 20$, $P(9) = 0.00 < 0.01$. Also she gave the correct name to the target stimulus on 19 out of 20 opportunities. These data are represented by the second pair of bars in Phase 6 of the graph in Figure 3.6.

MJ completed this test in two sessions. In the first session she only showed correct categorisation on two out of a total of nine test trials, whereas in the second session she scored seven correct out of a possible 11 trials, the last five trials in a row being correct. In both sessions she completed Stage 6.1, Common speaker testing with arbitrary stimuli, accurately.

To examine if this run of correct responses would continue, another 21 categorisation test trials were given using the "What's this?" instruction. This was conducted over two sessions. This time MJ scored 73 percent correct trials with the zog targets (8 of 11) and 100 percent with the vek targets (10 of 10), again showing a statistically significant result ($N = 21$, $P(18) = 0.00 < 0.01$). These data are represented by the third pair of bars in Phase 6 of the graph in Figure 3.6.

This time, however, in the common speaker testing with arbitrary stimuli (Stage 6.1) that preceded the first session, MJ would only produce the name for the "vek" stimuli. When the experimenter pointed to a "zog" stimulus and asked "What's this?", she refused to answer, and instead pointed to one of the "vek" stimuli. saying "This one". MJ chose to give the name to all the vek stimuli first, and when the zog stimuli were targeted, and the experimenter asked "Tell Teddy what this is", she shook her head in refusal.

This behaviour was repeated in the common speaker testing session that preceded the second session. During the 21 categorisation test trials she gave the correct response to the "vek" target on 10 out of 10 occasions, yet only gave the response "zog" to the target once out of a possible 11 occasions.

Later analysis of the video recording of the actual test trials also yielded some interesting examples of behaviour. When a zog stimulus was the target in the categorisation test trials, MJ would either touch one or all of the vek stimuli before correctly selecting the other two zog stimuli. When a vek stimulus was the target however, she did not exhibit this touching behaviour; instead she immediately selected the correct vek matches.

Overall MJ scored 27 correct of 41 trials (67 percent). Of these she scored 62 percent correct when a zog was a target and 70 percent when a vek was the target.

Stage 6.5: Repeat of Categorisation test 1. This test was then repeated in order to establish if this correct categorisation would maintain with a different instruction. She completed twenty trials and scored 70 percent correct with the zog targets (7 of 10) and 100 percent with the vek targets (10 of 10) again a significant response (N =20, P (17) = 0.00<0.01). This test was conducted in two sessions and in the two common speaker tests she named all the stimuli correctly, although in the first of these tests, she chose to name the vek stimuli first. These data are represented by the fourth pair of bars in Phase 6 of Figure 3.6.

Griffiths Test

The result of MJ's Griffiths test gave a GQ of 133. This score is in the normal range for her age.

Spontaneous Verbal Behaviour

MJ did not produce any names, experimental or otherwise, to any of the stimuli during the categorisation test that followed listener training.

Out of a total of 231 training trials during Phase 2, listener training, she spontaneously produced the name "zog" on only five occasions, and "vek" on four occasions. Of these 9 utterances, 7 were produced in the very first block of training trials, and in each case were an echoic response to the experimenter's requests.

Summary MJ

MJ's results support the Naming hypothesis. Categorisation did not occur until both speaker and listener elements of the name relation had been trained. When the whole name relation had been established, MJ failed to demonstrate categorisation with the first test, which used the, "Look at this" instruction. However, in the subsequent test, using the "What's this?" instruction, and thus prompting overt production of the stimulus names, successful categorisation did occur.

In a following test, where the instruction was again changed to, "Look at this?", she maintained her successful categorisation.

In the case of MJ, the establishment of both speaker and listener elements of the name relation does not, in itself, appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. Rather, naming behaviour, as illustrated by MJ's overt naming of the target stimuli, was necessary for successful categorisation to occur.

Participant BH.

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant BH required only one eight-trial block for each of the three stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.2).

In Stage 1.2, category training with familiar objects, BH required four blocks of six trials to demonstrate criterion performance. He needed two blocks using the instruction, "Look at this. Can you give Teddy the others like this?" and also two blocks using the alternative instruction, "Look at this. Can you give Teddy the hats/cups" to reach criterion performance.

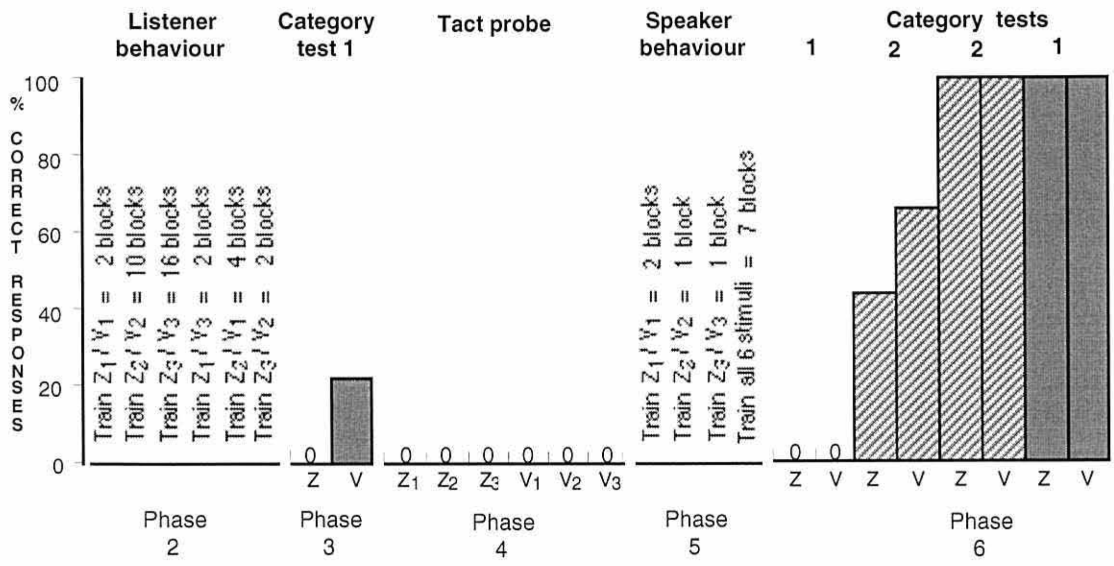


Figure 3.7. The training phases (Phases 2 and 5) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 2: Common Listener Training with Arbitrary Stimuli.

Stage 2.1: Common listener training - with initial pairs . BH required two eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1, 10 blocks with pair Z2/V2 and 16 blocks of trials with pair Z/3/V3. Corrective feedback was given to all responses.

Stage 2.2: Common listener training - with mixed pairs . He required two eight-trial blocks to demonstrate criterion listener relation learning with mixed pairs Z1/V3 and Z3/V2 and 4 blocks of trials with pair Z2/V1. Corrective feedback was given to all responses.

As the other two participants, MJ and JC, in this experiment had only required one block of trials per pair to reach criterion, an extra check for maintenance of the listener relations was given. Three more eight-trial blocks were presented for each of the stimulus pairs. From these three extra blocks, BH reached criterion in one block only for pairs Z1/V1 and Z2/V2, and in two blocks for pair Z3/V3. All of these blocks were given without reinforcement of the child's responses.

Phase 3: Categorisation Test Procedure.

Stage 3.1: Categorisation test with familiar objects. BH was unable to pass this stage immediately. Therefore 24 extra trials were administered before criterion level performance (two correct trials in a row without reinforcement) was reached. During these trials, listener relations with the arbitrary shaped stimuli were maintained by giving one block of trials per zog/vek pair per session (three sessions in total). BH completed these extra zog/vek blocks to criterion and without further reinforcement.

Stage 3.2: Categorisation test 1. After criterion with the familiar stimuli had been established, BH completed 18 trials of the categorisation test using the, "Look at this, can you give me the others?" instruction. He scored 0 percent correct in the nine trials where a zog stimulus was the target and 22 percent correct in trials when a vek stimulus was the target (2 of 9). This performance is as would be expected by chance (N =18, P (2) = 0.28>0.01).

Phase 4: Probe for Tacting.

The tact probe showed that he had no correct experimental names for any of the six stimuli. He did have his own idiosyncratic names for some of the stimuli. These are detailed below.

Z1 -  He called this stimulus "square" in two of three trials.

Z2 -  "Circle" in two trials.

Z3 -  "Circle" in all three trials.

V1 -  "Circle" in one trial.

V2 -  "Circle" in two trials.

V3 -  "zog" in all three trials.

Although BH did use the common name "circle" for four of the stimuli, this did not influence his performance in the categorisation test that preceded the probe. In this test, the only noticeable strategy was to choose the stimuli that were nearest his right hand, although no precise or statistically significant positional effects were observed.

Phase 5: Common Speaker Training

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. BH required two eight-trial blocks to demonstrate criterion speaker relations with stimulus pair Z1/V1; and one block for both pairs Z2/V2 and Z3/V3. Corrective feedback was given to all responses.

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes. BH demonstrated criterion performance after seven six-trial blocks. That is the last three blocks were performed correctly and without any feedback.

Phase 6 : Repeat of Categorisation Test Procedure.

Stage 6.1: Common speaker testing with arbitrary stimuli. In this stage, BH failed to name the stimuli correctly over two six-trial blocks. Three more blocks of trials (as in Phase 5.2) were then given, all three of which BH performed correctly and with no further reinforcement. During all of these trials BH seemed to lack concentration and whereas he would give an immediate response to the question "What's this?", he often subsequently changed his response. It was decided to cancel the categorisation test with arbitrary stimuli until the next session.

In the next session BH again failed the first two common speaker testing six-trial blocks, yet subsequently passed the next three that were given to him, with no reinforcement for his choices. The following categorisation test with arbitrary stimuli was then cancelled.

The following session, BH failed the first common speaker test block of trials, but passed the following two blocks and it was decided that he should proceed to the rest of the categorisation test session using the arbitrary stimuli.

Stage 6.3: Categorisation test 1. BH completed 18 trials of the categorisation test using the, "Look at this, can you give me the others" instruction; these were completed over two separate sessions. At the commencement of the second session he was again given two six-trial blocks of speaker behaviour, which he passed. During the categorisation test with arbitrary stimuli, he failed to respond correctly in any of the 18 test trials. The first pair of bars in Phase 6 of Figure 3.7 represent these data.

Stage 6.4: Categorisation test 2. Prior to the categorisation test, BH again showed problems with the common speaker test trials. Four blocks of trials were given and BH only responded correctly to all six stimuli in the last block. In the next session BH was given another six common speaker test trials. He failed to respond correctly to some of the stimuli in the first three blocks, and he received corrective feedback for his mistakes. He then passed the next three blocks with no reinforcement for his responses.

BH was then absent from the nursery for one week, after which the categorisation test procedure was resumed. Again he had problems with the common speaker test trials, failing to respond accurately to five blocks of trials. However it was noted that BH would respond inaccurately, then later correct his responses and this behaviour was attributed to his lack of concentration. Therefore it was decided to continue with the categorisation test with arbitrary stimuli. This time instead of asking

"What's this?" once, before asking "Can you give Teddy the others like this?"; the experimenter asked ", "What's this?" three times.

Eighteen trials of Categorisation Test 2 were then given. BH scored 56 percent correct trials with the zog targets (5 of 9) and 44 percent with the vek targets (4 of 9). This was statistically significant (N =18, P (9) = 0.00<0.01). The second pair of bars in Phase 6 of Figure 3.7 represent these data.

The number of correct responses to the question, "What's this?" were 46 out of a possible 51 opportunities to respond. The correct number of responses for the first "What's this?" question were 13 of 18 opportunities; the correct number of responses for the third "What's this?" question were 18 of 18 opportunities.

The above mentioned 18 trials were conducted over three separate sessions. During the first two sessions (consisting of 12 trials), BH showed a random performance. He scored only three correct trials out of a possible 12. In the third session, however, he performed correctly on all six test trials. In the common speaker test trial that preceded the third session, BH exhibited some interesting sorting behaviour, spontaneously ordering the six stimuli into rows consistent with the zog and vek class names. As he did so, he also overtly named the stimuli -- "That's a zog... That's a vek..." and so on. As previously stated he proceeded to categorise in the following six trials perfectly.

It was decided to give him another 12 test trials of Categorisation Test 2 to see if this correct categorisation would continue. He categorised the stimuli in these further trials with 100 percent accuracy. These data are represented separately, as the third pair of bars in Phase 6 of Figure 3.7.

Of a total of 30 test trials BH scored 73 percent (11 of 15) correct trials with a zog as target and 67 percent (10 of 15) correct when a vek was a target. This is a statistically significant result (N =30, P (21) = 0.00<0.01).

Stage 6.5: Repeat of Categorisation test 1. To correspond with the extra 12 trials given of Categorisation test 2 (outlined above), a further 12 trials using the, "Look at this" instruction were presented, in order to see if BH's correct responding would be maintained. Of these 12 trials BH responded with 100 percent accuracy. In the first two trials, he also spontaneously named the stimuli.

Griffiths Test

The result of BH's Griffiths test gave a GQ of 111. This score is in the normal range for his age.

Spontaneous Verbal Behaviour

During the training of listener relations (Phase 2), BH only produced one idiosyncratic name for a stimulus saying "that's the big one" to stimulus Z1. Out of a total of 452 training trials, he spontaneously produced the name "zog" on 22 occasions, and "vek" only once. Of these utterances, 11 could be classed as tacts, that is the seeing of the object occasioned the verbal response; however, the correct tact was produced on only six of these occasions. Five of the remaining 12 utterances were an echoic response to the experimenter's speech and bore no relation to the stimulus targeted by the experimenter; the remaining 7 took the form of intraverbal play, that is, the experimenter said, "Can you give me the..." and BH would interrupt by saying, "zog".

He did not produce any names, experimental or otherwise, to any of the stimuli during the categorisation test that followed listener training.

Summary

BH's results support the Naming hypothesis. Categorisation did not occur until both speaker and listener elements of the name relation had been trained.

When the whole name relation had been established, he failed to demonstrate categorisation with the first test, which used the, "Look at this" instruction. However, in the subsequent test, using the "What's this?" instruction, thus prompting overt production of the stimulus names, successful categorisation did occur.

In a following test, where the instruction was again changed to, "Look at this?", successful categorisation was maintained.

The establishment of both speaker and listener elements of the name relation does not, in itself, appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. BH began to categorise correctly only after a pre-test for common speaker behaviour in which, without any instruction to do so, he not only named the stimuli, but also sorted them into rows consistent with the class names zog and vek. It may be the case that his own names for the stimuli interfered with his covert production of the experimental names during the first categorisation test, thus preventing his correct performance. Only when overt production was prompted in the tact pre-test did the experimental names exert control over his naming behaviour thus enabling categorisation to occur.

DISCUSSION

Of the 14 participants who commenced this experiment, seven progressed to Phase 2 (i.e. common listener training with arbitrary stimuli), and only three completed all procedures. The majority of the participants had difficulty learning the conditional discriminations required in either Phase 1 and Phase 2, which is consistent with other research with the developmentally young (Augustson and Dougher, 1992; Lipkens et al 1993).

For example, Augustson and Dougher report a study where five participants (aged between 2 years 3 months and 2 years 9 months) were taught a series of visual-visual conditional discriminations, by means of physically dissimilar, arbitrarily shaped, same colour objects. Training on two conditional relations, A1-B1 and A2 -B2 was given, and then the two types of relation were mixed and presented to the participants again. The participants received an average of 134.8 training trials (range, 60 - 241), yet none reached criterion with the mixed trials.

In the present experiment, the seven participants who progressed to Phase 2, received an average of 188.6 training trials (range, 96 - 272), in Phase 2.1, (see Table 3.2.) These figures compare favourably with those of Augustson and Dougher, and suggest that even after large numbers of training trials, children of this age group may find it difficult to learn consecutive conditional discriminations successfully. Indeed, four of the seven participants in the present study failed to progress from Phase 2 to Phase 3.

Participants' boredom with the required tasks may explain this attrition. Children of this age find it very difficult to attend to what are, after all, very repetitive procedures. Given the length of the procedure in the present experiment, it might be more surprising that three of the participants did, in fact, complete all the required tasks.

Of the three participants who completed all procedures in Experiment 1, all showed categorisation behaviour consistent with the Naming hypothesis. No child in this age group categorised after demonstrating criterion level performance listener relations alone; categorisation occurred only after evidence of the establishment of both speaker and listener relations, that is, of naming.

After listener and speaker relations had been established, and Categorisation Test 1 was given for the second time, using the instruction, "Look at this. Can you give me the others?"; only Participant JC exhibited categorisation consistent with the zog and vek names. However, when the categorisation test was repeated with the alternative instruction, "What's this? Can you give me the others?", thus prompting the participants to make an overt common vocal response, both MJ and BH subsequently demonstrated successful categorisation.

This evidence suggests that although the establishment of the whole name relation may be necessary for categorisation to occur, it may not in itself be sufficient to drive categorisation, rather *naming behaviour* must be initiated.

Naming behaviour involves more than the ability to produce a common name to a range of stimuli in one context, or to be able to select each of a commonly named class when requested in another. Naming may initiate categorisation only when each element of the naming circle comes to occasion all the other behaviours in that circle. That is, on saying the common name for one exemplar of a class and then hearing herself say the name for that exemplar, the participant will refer back or re- orient to then select other objects in the immediate environment that have been previously given that common name.

The evidence from BH and MJ seems to suggest that overt production of the common name may sometimes be necessary in order to initiate naming behaviour and thus categorisation. Analysis of the video recordings of these participants' performances during the test trials gives some interesting insights into this issue.

In the case of BH, he had failed to categorise with Categorisation test 1 ("Look at this!") after the speaker and listener components of the name relation had been established, and he had also initially failed to categorise on the first 12 trials of Categorisation test 2 ("What's this?"). However, after he spontaneously organised the stimuli into two lines, each of which consisted of three common-named stimuli, overtly tacting the correct name to each of the stimuli as he did so, he thereafter, and without any reinforcement from the experimenter, completed 18 further test trials with 100 percent accuracy. He subsequently continued to categorise successfully on 18 further trials with the, "Look at this" instruction, spontaneously producing the stimulus names on the first two test trials.

BH's actions are remarkable in that they illustrate the exact events that led from non-categorising to categorising behaviour. His spontaneous demonstration of sorting the stimuli into two spatially distinct classes, in accordance with their class names, is wholly consistent with the predictions of naming theory, and seems to be an example of the onset of naming behaviour "in action".

Analysis of the video recordings of participant MJ also shows evidence of naming behaviour in action. She, as did BH, failed to categorise until she was prompted to overtly produce the stimulus names in the category test situation.

Once her correct categorisation was set in motion, however, her performance on the naming tests deteriorated. It is curious that MJ, initially, showed criterion level performance in the six-stimulus naming test that preceded the categorisation tests, naming both the zog and the vek stimuli easily. In the last two categorisation tests of the four that followed speaker training, in these naming tests, she either failed to name the zog stimuli, or chose to name all the veks before attempting to name the zog stimuli.

In the second categorisation test trials using the "What's this?" instruction, when a "zog" stimulus was targeted, she failed to produce the required name, and persisted in touching each of the "vek" stimuli first, before selecting the correct zog stimuli. Her selection behaviour was quite different when a vek stimulus was the target. In these cases, she named the stimulus successfully and rapidly chose the other vek matches without touching any of the zog stimuli. In fact, the only two trials where she made an incorrect selection were those in which the target was an (un-nameable) zog.

This behaviour suggests that she may have been employing a strategy to eliminate the stimuli that she could easily name (the veks), before selecting those whose names that had, for some reason, become unavailable to her.

It may be the case that MJ had in fact formed only one category, that of "veks", as her touching behaviour (described above) suggests. The onset of her successful categorisation, coincident with her problems in producing the name "zog" suggest that the former may be a source of interference to the latter. Her need to concentrate on her naming of, and categorisation of, the vek stimuli may have temporarily inhibited her ability to produce the name "zog".

One of the participants in Harris' (see Horne & Lowe, in press) study (WA) showed similar effects. Although he had reached criterion level performance in speaker training, he only formed one category, that of Veks. It may be the case that both this child and MJ had developed a preference for one of the stimuli names which exerted stronger control over their naming behaviour than the non-preferential named stimuli. Harris' participant, however, did not show any evidence of sorting the Zag stimuli by exclusion.

Even though only one category may have been formed, MJ's performance is consistent with naming theory. Her behaviour gives an insight into the intimate link between successful naming of the stimuli and correct categorisation. Although she also showed criterion level categorisation of the zog stimuli, this may have been a by-product of her ability to name the vek stimuli, the zogs being categorised successfully, that is by exclusion (e. g., Dixon, 1977; Wilkinson, Dube, & McIlvane, 1996, 1998), only after elimination of the vek stimuli.

Additional support for the naming hypothesis can be seen in the results of participant JC. Though only taught speaker relations for one set of stimuli, her speaker repertoire extended, without training, to include the stimuli within a second stimulus set, thus enabling successful categorisation to occur.

This is as predicted by Horne and Lowe (1996) who state that although the individual elements of the name relation may, at first, be established separately, eventually

> the cues of the caregiver's naming of and pointing at a new object come to be sufficient on their own to evoke the full sequence of behaviour that makes up the name relation. (p. 202)

Although the results of this experiment seem to support naming theory, there may be an alternative explanation for this data. It might possibly be argued that these results, although seemingly supporting naming theory, could be attributed to practice effects.

For example, the speaker training trials may have merely acted as extra listener training experience. It might be argued that the criterion level for listener training was not stringent enough, and that therefore if the participants were given extended listener training, this in itself may have had the effect consolidating the pairwise discriminations. This in turn, may have led to the correct categorisation of the stimuli into zog and vek classes, even without corresponding evidence of speaker behaviour. If this were the case, one would have to infer that naming theory could not account for the categorisation effects.

This, however, does not seem likely on two accounts.

First, all three participants had amply demonstrated the listener relations for all three sets of stimuli by reaching the strict criterion level required during listener training both in pairs and in mixed pairs (Stages 2.1 & 2.2).

By examining their training data (Table 3.2), it can be seen that both JC (in both stimulus sets) and BH performed the last three eight-trial blocks of listener training, for each stimulus set to criterion, and without any feedback or reinforcement.

Additionally, both JC and MJ, demonstrated that once they had reached criterion level listener relations with the initial pairs, they needed only one extra eight-trial block for each of the mixed pairs to reach criterion in Stage 2.2. This evidence suggests that the listener relations were, indeed strongly consolidated, for all three participants.

In the case of JC (Set 1), during speaker training, she needed only the minimum number of training trials to reach criterion level performance with both the three stimulus pairs, and when the stimuli were presented in sixes. It does not seem likely that this minimum amount of extra training, alone, would result in her differing performances in the two categorisation tests.

The second reason for rejecting an explanation based on practice effects is also, perhaps, the most compelling evidence for accepting an explanation based on naming theory.

In the categorisation test that immediately followed listener training, all three participants demonstrated a tendency to select the two stimuli that were nearest to their right hands. In the case of JC, evidence for this selection strategy was supported statistically. Also, all the categorisation tests were performed without feedback of the participants' selections, and, at the end of the test, participants were rewarded with a gift for their good "behaviour". The gift was given whether the child had shown correct categorisation or not.

Taking these two factors into account, it would seem that the reward for good behaviour might have resulted in the child repeating, in future tests, any selection strategy that she or he had already established.

However, this type of response rigidity failed to occur. All three participants, after being taught speaker relations, changed their right hand selection preference to a form of categorisation that was consistent with the class names zog and vek.

An explanation of this behaviour based on practice effects would not predict this change of categorisation.

In the case of BH and MJ, as described earlier, the onset of categorisation into zog and vek classes, seemed to be closely linked with the overt production of the category names.

The naming behaviour demonstrated by both BH and MJ seemed to depend on a more spontaneous and idiosyncratic demonstration of the name relation in action independent of the strictures of the test situation.

These displays of spontaneous touching and sorting of the stimuli occurred only after the whole name relation had been established; no evidence of this type of behaviour was shown when only listener relations had been taught. This is consistent with research from the developmental literature (e.g. Gopnik and Choi, 1990; 1992; Gopnik and Meltzoff, 1987, 1992; Poulin Dubois et al, 1996) where it has been demonstrated that the emergence of spontaneous categorisation, either by spatially sorting or serially touching of the objects by class membership, into two groups is positively correlated with developments in productive language.

To conclude, the results of Experiment 1 support the stated hypothesis that children of this age, with limited productive verbal repertoires, would be unlikely on the basis of only listener training to also produce the necessary tact element required for the formation of the whole name relation. For these three participants, who learned only uni-directional common listener relations, this was not sufficient for the categorisation of physically different stimuli.

* * *

As stated, the 1.5 to 2.5 year old participants in Experiment 1 had relatively limited experience of language. The second experiment of this study therefore investigated whether the same categorisation patterns would be observed in more linguistically able children. To this effect, Experiment 2 replicated the procedures in

Experiment 1 with participants who were of an age group that was approximately one year older than in the latter.

The research aims of Experiment 2 were of a more exploratory nature. This age group employed in this experiment would be expected to have more extensive linguistic repertoires; therefore it might be expected that, after listener training alone, the participants would demonstrate appropriate, and untrained, speaker relations towards the stimuli. Thus one might expect these participants to categorise after listener training alone, yet also, pass the subsequent probe for tacting, to demonstrate criterion level speaker behaviour, that is, the whole name relation.

EXPERIMENT 2

In Experiment 1, following listener training, none of the three participants in the two year old age group categorised the physically different stimuli in terms of the common listener stimuli. All three, however, subsequently categorised when taught the corresponding speaker relations, that is, the whole of the name relation. This study investigated if the same results would be observed in an older age group, that of 2.5 to 3.5 year olds.

METHOD

Participants

Four participants, one female and three male, took part. Table 3.4 shows, for each participant, her or his gender and age. All participants were given the Griffiths test of development which is reported at the end of each participant's result section.

Table 3.4.
Participants' sex and age

Participant	Sex	Age at start year: month	Age at first categorisation test year: month
CT	M	2: 06	2:11
TP	M	2: 08	n/a
LN	F	2: 10	2:11
HW	F	2: 10	3:00

F = female M = male

Procedure

The procedure employed in Experiment 2 was as described in the General Method section above.

RESULTS

Table 3.5 shows the data, for all 4 participants, of the first experimental phase. Only three of the participants went on to complete all phases of the experiment; data from these three will be presented as individual graphs from Phase 2 onwards.

Phase 1

Table 3.5 shows the number of eight-trial blocks each participant required in order to achieve criterion performance in Stage 1.1 listener relation learning for each of three familiar object (hat and cup) pairs.

Table 3.5.
Results of Phase 1: Common listener training and category training with familiar objects. In Stage 1.1, H1/C1, H2/C2 and H3/C3 refer to the three familiar object (hat and cup) pairs. Two instructions were used in Stage 1.2, "Look at this. Can you give me the other hats/cups?" and "Look at this. Can you give me the others like this?" The total number of blocks to criterion have been split between these two instructions (for more details see procedure).

	Stage 1.1 Common listener training in pairs			Stage 1.2 Categorisation test	
Participants	H1/ C1	H2/C2	H3/C3	"hats & cups"	"Others"
CT	1	1	1	3	5
TP	1	1	1	0	2
LN	1	1	1	0	2
HW	1	1	1	0	1

Table 3.5 also shows the number of six-trial blocks required to achieve criterion performance in Stage 1.2 familiar object categorisation. For Stage 1.2, the left hand column shows the number of training blocks each participant required to categorise the six familiar objects into two categories (one of hats and the other of cups) when shown either a hat or a cup and asked, "Look at this. Can you give me the other hats/cups?".

The right hand column of data for Stage 1.2 shows the number of blocks each participant required to correctly categorise the hats and cups in response to the instruction, "Look at this. Can you give me the others like this?"

All four participants learned to categorise the hats and cups appropriately in response to the instruction, "Look at this. Can you give me the others like this?", and progressed to Phase 2 of the experiment.

Phase 2

Table 3.6 shows the number of eight-trial training blocks each participant required to achieve criterion listener relation performance on the three arbitrary stimulus pairs. Full feedback was given to their responses when necessary. For Stage 2.1, the number of training blocks to criterion are shown for each of the three arbitrary (/zog/ and /vek/) pairs.

Table 3.6.
Results of Phase 2: Common listener training with arbitrary stimuli. In Stage 2.1 the stimuli were divided into three zog/vek pairs; for example Z1/V1 and for Stage 2.2 the stimulus pairs were arranged into different pairings; for example Z1/V3. The mixed pairings are referred to here as Z/V a, b &c, as each participant received a different order of pairings.

	Common listener training with arbitrary stimuli					
	Stage 2.1 Initial pairs			Stage 2.2 Mixed pairs		
Participant	Z1/V1	Z2/V2	Z3/V3	Z/V a	Z/V b	Z/V c
CT	10	4	1	4	4	1
TP	1	5*	8	-	-	-
LN	6	5	1	2	1	1
HW	1	1	2	1	8	4

* Failed to reach criterion with this stimulus pair.

Three of the four participants learned to respond appropriately to the listener stimuli /zog/ and /vek/ (i.e. by selecting the corresponding object from among the pair) for all 3 pairs (Z1/V1, Z2/V2, and Z3/V3). Participant TP left the nursery during training and was therefore unable to continue the experiment.

For Stage 2.2, where the stimuli were sorted into new pairings, the number of training blocks to criterion listener performance are shown for each of the new "mixed" arbitrary stimulus pairs.

Phases 3 - 6

For the three participants who completed the experimental procedure, data from each phase, including a review of that from Phases 1 and 2, are presented separately below.

Participant CT.

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant CT required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.6).

In Stage 1.2, category training with familiar objects, he required eight blocks of six trials to demonstrate criterion performance. He needed five blocks using the instruction, "Look at this. Can you give Teddy the others like this?" and also three blocks using the alternative instruction, "Look at this. Can you give Teddy the hats/cups", to reach criterion performance.

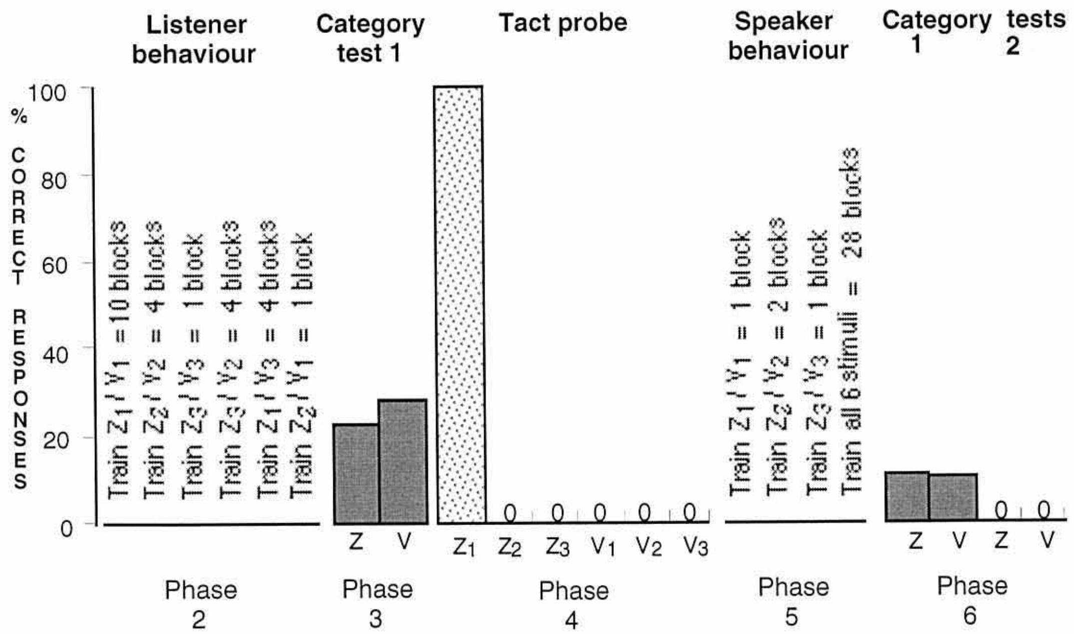


Figure 3.8. The training phases (Phases 2 and 5) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 2: Common Listener Training with Arbitrary Stimuli.

CT required 10 blocks of eight trials to demonstrate criterion listener relation learning with pair Z1/V1, four blocks with pair Z2/V2 and one block of trials with pair Z/3/V3.

He required four block of eight trials to demonstrate criterion listener relation learning with mixed pairs Z3/V2, followed by four blocks with Z1/V3 and then one block with pair Z2/V1. Corrective feedback was given to his responses when necessary in all the above mentioned blocks of trials.

Phase 3: Categorisation Test 1.

CT completed 18 trials of the categorisation test using the, "Look at this, can you give me the others?" instruction. He scored 22 percent (2 of 9) correct in the nine trials where a zog stimulus was the target and 33 percent correct in trials when a vek stimulus was the target (3 of nine). This performance is as would be expected by chance (N =18, P (5) = 0.022 >0.01).

CT's performance was only one trial short of reaching the criterion level determined for significant categorisation (i.e. three correct zog trials plus three correct vek trials). During these trials he also seemed to lack concentration with the tasks expected of him. Taking these two factors into account, another 10 test trials were administered, to see if his performance would improve. Out of these 10 trials, CT scored only two correct (one zog target and one vek).

The data for Categorisation Test 1 in Phase 3 (see Figure 3.8), represent the combined total of these trials. Of a total of 28 test trials CT scored 21 percent (3 of 14) correct trials with a zog as target and 29 percent (4 of 14) correct when a vek was a target. This performance is as would be expected by chance (N =28, P (7) = 0.013>0.01).

During these test trials CT tended to choose the two stimuli that were nearest his right hand as matches to the target stimulus.

Phase 4: Probe for Tacting

The tact probe showed that he only gave the correct name to one of the stimuli, calling stimulus Z1 "zog" on all three occasions. CT did have his own idiosyncratic names for some of the stimuli and these are described below.

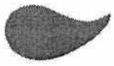
Z1 -  He called this stimulus "zog" in all three trials.

Z2 -  "Television" in the first two trials and "don't know" in the third.

Z3 -  "Circle" once and "don't know" twice.

V1 -  "Buckle" in all three trials.

V2 -  "It's a name" in one trial and "don't know" in two trials.

V3 -  "Food" in one trial and "don't know" in the other two

Phase 5: Common Speaker Training.

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. CT required one eight-trial block to demonstrate criterion speaker relations with stimulus pair Z1/V1; two blocks with Z2/V2, and one block for pair Z3/V3. Corrective feedback was given to his responses when necessary.

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes. CT performed four blocks of trials incorrectly, so speaker training of all three Z/V pairs was re-established. One block of trials was given for each pairing and he reached criterion to all pairs. Another trial was given with all six stimuli, but CT also failed to produce the correct name to all six stimuli. The procedure was then adapted.

Firstly criterion performance to stimulus pairs Z1/V1 and Z2/V2 was re-established; secondly a four stimulus array consisting of these stimuli was presented to CT in place of the conventional six stimulus array. Each of the four stimuli within this array was targeted in turn which constituted one four-trial block.

Five four-trial blocks were presented to CT before he was able to produce three consecutive correct responses to each stimulus in the array without reinforcement.

Criterion level performance was then re-established to pair Z3/V3 (this took two blocks of trials), before speaker training with all six stimuli was repeated. CT required 28 six-trial blocks in total to reach criterion level performance; the last three blocks were all performed without reinforcement. During these training trials, maintenance of the speaker relations in pairs was checked periodically. Two extra blocks of trials were given for pair Z2/V2 and three blocks for pair Z3/V3.

Phase 6: Categorisation Test

Stage 6.3: Categorisation test 1. CT completed 19 trials of the categorisation test (due to experimenter error) using the, "Look at this, can you give me the others" instruction. He demonstrated 11 percent correct responses (1 of 9 trials) when a zog stimulus was a target, and 10 percent (1 of 10) trials correct when a vek stimulus was a target. This performance is as would be expected by chance (N =19, P (2) = 0.29>0.01).

Stage 6.4: Categorisation test 2. CT failed to perform any of the 18 test trials correctly. However, he did produce the correct name to the stimuli, when asked, "What's this?", on 17 of 18 occasions (he failed to respond at all on the one other trial).

During both of these categorisation tests trials CT showed a preference for choosing the two stimuli that were nearest his right hand. This was especially evident in the final categorisation test, where he was very quick to choose the right hand stimuli.

Griffiths Test

The result of CT's Griffiths test gave a GQ of 124. This score is in the normal range for his age.

Spontaneous Verbal Behaviour

During the training of listener relations (Phase 2), CT did not produce any idiosyncratic names for the stimuli. However, of a total of 217 training trials, he spontaneously produced the name "zog" on 57 occasions, and "vek" on 52 occasions.

His utterances were contingent on the experimenter's requests. To illustrate, the experimenter said, "Can you give me the zog?", and CT would say "zog" before choosing one of the two stimuli. Of these choices, he gave the zog stimuli correctly on 48 of 57 opportunities, and the vek stimuli correctly on 42 of 52 occasions.

The increase of production of the stimulus names seemed to be related to the accuracy of his choices. To illustrate, in Phase 2.1 he had completed nine eight-trial blocks without showing criterion level performance; also during this time, production was infrequent (he produced "zog" on six occasions, and "vek" only once). The stimuli presented were then changed to the Z2/V2 pairing, and he completed three blocks, also without reaching criterion. On the fourth block with pair Z2/V2, however, his production increased (saying "zog" and "vek" twice each), and he performed correctly on all eight trials, reaching criterion.

He then reached criterion to pairs Z3/V3 and Z1/V1 in only one block each, giving the stimulus name on each of the 16 trials. His production continued at a high rate throughout Phase 2.2, where, of 87 trials performed he produced the stimuli names on 82 occasions.

His only verbalisations during the categorisation test (Phase 3) were: "That's a zog isn't it?" -- when one of the zog stimuli was a target, and "That looks like a television", to Z2.

He also called Z3 "television" on three occasions throughout speaker training (Phase 5), and called V2 "chip" once. This may suggest that his own names continued to be a source of competition with the experimental names.

He did not produce any spontaneous verbalisations during the two categorisation tests in Phase 6.

Summary

In the case of CT, categorisation did not occur, even after both speaker and listener elements of the name relation had been trained. This suggests that naming may not in itself be sufficient for the emergence of the categorisation of physically different stimuli into two common name sets.

Participant LN.

This participant completed the procedure with two arbitrary stimulus sets, Set 1 and Set 2. Data for her performance when Set 1 stimuli were employed are shown in Figure 3.9.1 below.

Stimulus Set 1.

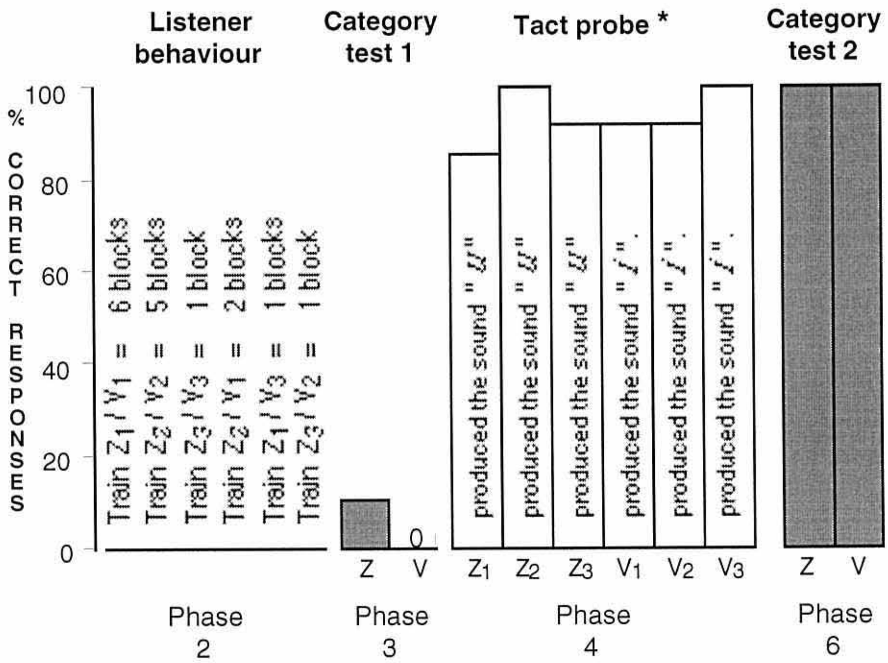


Figure 3.9.1 Results of Participant LN (Stimulus Set 1). The number of listener training trial blocks taken to reach criterion on each of six stimulus pairs are shown for Phase 2. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).
* In Phase 4, the Tact probe, the data represent the number of trials where LN gave her own approximation of the required zog/vek names (see results of Phase 4 for more details).

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant LN required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 3.6). In Stage 1.2 category training with familiar objects, she required two blocks of six trials using the instruction, "Look at this. Can you give Teddy the others like this?" to reach criterion performance.

Phase 2: Common Listener Training with Arbitrary Stimuli.

LN required six eight-trial blocks to demonstrate criterion listener relation learning with initial pair Z1/V1; five blocks of trials with pair Z2/V2 and one block with pair Z3/V3.

She required two eight-trial blocks to demonstrate criterion listener relation learning with mixed pair Z2/V1, followed by one block for pair Z1/V3, and then one block for pair Z3/V2. Corrective feedback was given, when necessary, to all blocks in Phase 2.

Phase 3: Categorisation Test 1.

LN then completed 18 trials of the categorisation test using the, "Look at this, can you give me the others?" instruction. She scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.03>0.01).

Phase 4: Probe for Tacting

The tact probe showed that LN could not produce the names "zog" and "vek" to any of the six stimuli. Instead she produced her own two sounds: "ŭ and "*i* ". She produced the sound "*u*" to the zog targets on seven of nine trials; and also produced the sound "*i* " to the vek targets on seven of nine trials.

These sounds seemed to be used with consistency, although not to the criterion level designated for correct naming of the zog and vek stimuli. Participants were deemed to have named the stimuli reliably if they scored eight or more out of a possible nine correct trials for BOTH zog and vek stimuli (see Phase 4 of the general procedure).

To examine if she would maintain her use of these sounds, in the next session she was given another four blocks of probe trials. This time she produced the sound "*u* " to the zog targets on 11 of 12 trials; and also produced the sound "*i* " to the vek targets on 12 of 12 trials. This performance fulfills the criterion for successful tacting as defined above, albeit with her own idiosyncratic speech sounds.

After this session LN was away from the nursery for three weeks. On her return she was given another seven blocks of probe trials to ascertain whether she would still name the stimuli in the way described. She produced the sounds with 100 percent accuracy, saying "*u* " to the zog targets on 21 of 21 trials; and also produced the sound "*i* " to the vek targets on 21 of 21 trials.

The data shown in Figure 3.9.1 for Phase 4: probe for tacting, represent the total tact trials from all sessions mentioned above. For each of the six stimuli, 14 test trials were given and the results for each stimulus follows below.

Stimulus Z1 produced " *u* " in 12 of 14 trials (86 percent correct)

Stimulus Z2 produced " *u* " in 14 of 14 trials (100 percent correct)

Stimulus Z3 produced " *u* " in 13 of 14 trials (93 percent correct)

Stimulus V1 produced " *i* " in 13 of 14 trials (93 percent correct)

Stimulus V2 produced " *i* " in 13 of 14 trials (93 percent correct)

Stimulus V3 produced " *i* " in 14 of 14 trials (100 percent correct)

Since LN had shown criterion performance on listener training to the /zog/ and /vek/ listener stimuli and also demonstrated class consistent (though phonetically approximate) speaker behaviour, it was considered likely that naming had been established.

Although listener responding had not been tested for with the listener stimuli /*u* / and /*i* /, corresponding to LN's tact responses (see above), the vowel sounds " *u*" and "*i* ", were deemed to be fairly accurate approximations of the vowel sounds " ɔ " (zog) and " ɛ " (vek) theoretically required to establish a bi-directional speaker-listener relation. This issue will be elaborated upon in the discussion section at the end of this experiment.

A categorisation test using the instruction " What's this? Can you give Teddy the others like this?", was then given to investigate whether her overt production of the idiosyncratic names during the tact probe would influence her categorising behaviour. No further speaker training was given.

Phase 6: Categorisation Test 2.

LN completed 18 trials of Categorisation Test 2. Over all 18 trials she demonstrated 100 percent correct responses, that is, nine of nine correct responses when a zog stimulus was the target, and nine of nine correct when the vek stimulus was a target. According to binomial theory the probability that this would occur by chance is low and statistically significant ($N = 18$, $P(18) = 0.00 < 0.01$).

LN also produced the correct response to the "What's this?" request from the experimenter on 14 of 18 trials; in the other four trials her responses were mumbled and were unable to be analysed.

Spontaneous Verbal Behaviour: Stimulus Set 1.

During the training of listener relations (Phase 2), LN only produced one idiosyncratic name:

V3 -  she called this stimulus "twll" on one occasion (this is Welsh for hole).

She did not produce any other names, experimental or otherwise, to any of the stimuli, during either listener training, or the categorisation test that followed listener training.

Summary Stimulus Set 1

LN's results for the Set 1 stimuli support the Naming hypothesis. Categorisation did not occur until evidence of both speaker and listener elements of the name relation had been demonstrated. Whereas only listener relations had been directly trained, the probe for tacting showed that LN could also produce reliable speaker behaviour towards the stimuli.

It would have been interesting to have followed the successful tact probe with a categorisation test using the, "Look at this" instruction; this would have examined whether the overt production of the experimental names in the tact probe would have been sufficient for the subsequent categorisation to occur. This change to the general procedure will be considered in future experiments.

The establishment of both speaker and listener elements of the name relation do not, in itself, appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. LN failed to demonstrate categorisation with the first test, which used the, "Look at this" instruction. However, in the subsequent test using the "What's this?" instruction, and thus prompting overt production of the stimulus names, successful categorisation did occur.

Stimulus Set 2.

As LN proved to be a keen and rapid learner, listener relations were trained to a second set of stimuli. These were physically dissimilar, both to each other and to the Set 1 stimuli. The same class labels, zog and vek, were utilised (henceforth these are termed Z4, Z5, Z6, V4, V5, and V6). The procedure was the same as for Stimulus Set 1 except that Phase 1 was omitted.

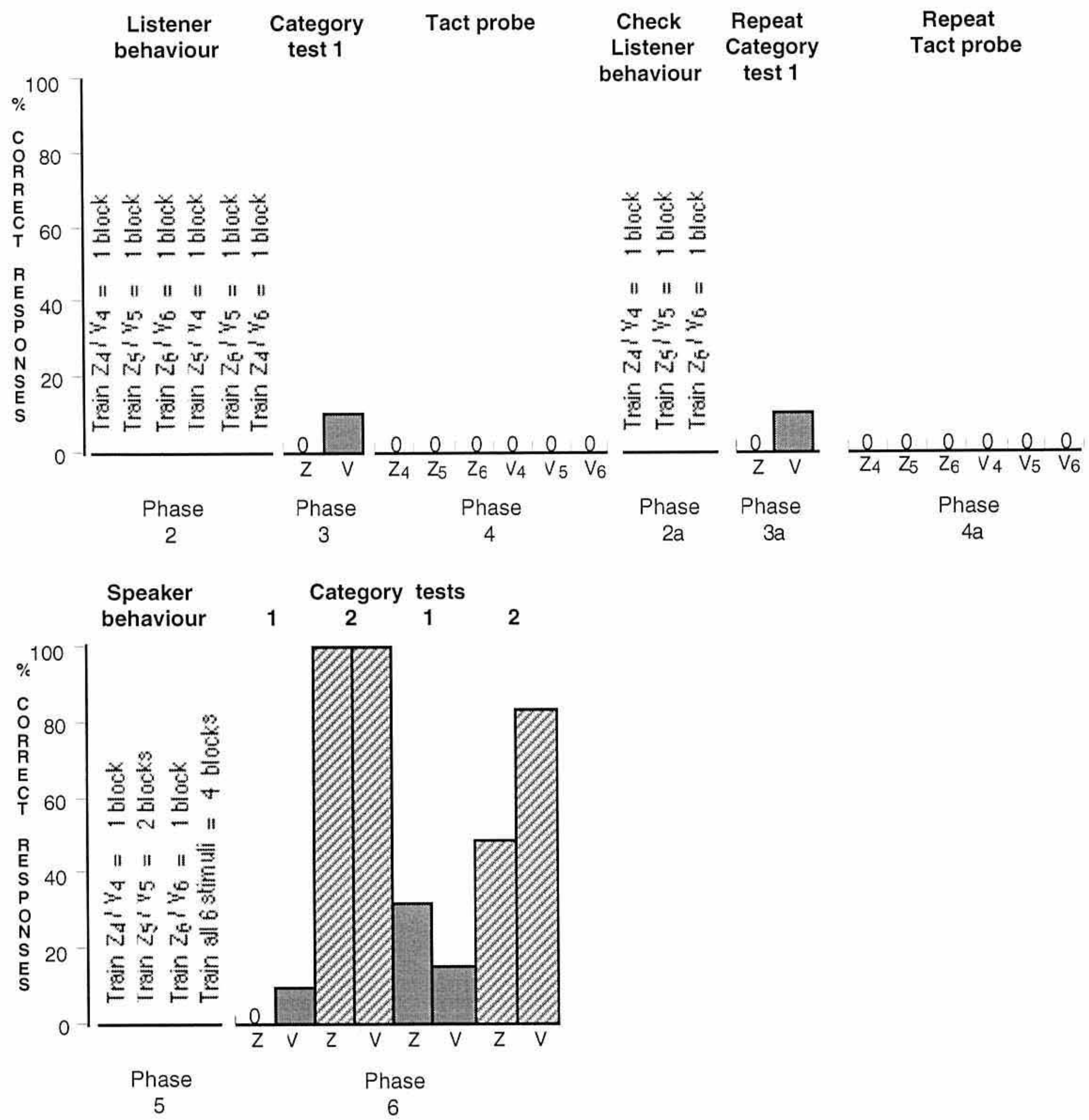


Figure 3.9.2. Results of Participant LN (Stimulus Set 2). The training phases (Phases 2, 2a, and 5) give the number of listener training blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 4a) and category re-testing (Phases 3a and 6).

Phase 2: Common Listener Training with Arbitrary Stimuli.

LN required one block of eight trials to demonstrate criterion listener relations with all three initial pairs Z4/V4, Z5/V5, and Z6/V6.

LN also required just one eight-trial block each to demonstrate criterion listener behaviour with mixed pair Z5/V4, followed by pair Z6/V5 and then Z4/V6. Corrective feedback was given, when necessary, to all blocks in Phase 2.

Phase 3: Categorisation Test 1.

LN completed 18 trials of the categorisation test using the, "Look at this" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 11 percent correct in trials where a vek stimulus was the target (1 of 9). This result is as expected by chance (N =18, P (1) = 0.3>0.01).

Phase 4: Probe for Tacting

The tact probe showed that she could not produce the names "zog" or "vek" to any of the six stimuli. LN also did not repeat the sounds "*u* " and "*i* " that she had used with the Set 1 stimuli.

She did produce some idiosyncratic responses for some of the stimuli, although these sounds were not produced consistently. To check that this behaviour was not due to boredom, another five blocks of probe trials were given in the next session. Details of the responses from all eight blocks of probe trials are given below. Figure 3.9.2. gives the results from the first three blocks of trials only.

Z4 -  She called this stimulus "dʌ " in five trials, and " aː " in one trial, and was silent in two trials.

Z5 -  She called this stimulus "dʌ " in three trials, and "ŋ " in one trial.

Z6 -  She called this stimulus "dʌ " in three trials; "ŋ " in one trial; "aː " in one trial; " *u* " in one trial; "bo " in one trial, and was silent in one trial.

V4 -  She called this stimulus "dʌ " in two trials; "aː " in one trial; " u' in one trial; "octopus" in one trial, "dolphin" in one trial and was silent in two trials.

V5 -  She called this stimulus "dʌ " in four trials; "aː " in one trial; "octopus" in one trial, and was silent in two trials.

V6 -  She called this stimulus "dʌ " in four trials; "aː " in one trial; " u' in one trial; and was silent in two trials.

LN's results on the probe for tacting were quite surprising. She had provided her own names for the stimuli in Set 1, yet these names had not transferred to the Set 2 stimuli. This may have been because the listener relations learned in Phase 2 were not intact. Therefore maintenance of these relations were re-checked.

Phase 2a: Repeat of Common Listener Training with Arbitrary Stimuli.

Three eight-trial blocks (i.e. nine blocks in total) were given to *each* of the original pairs of stimuli (Z4/V4, Z5/V5, and Z6/V6). LN reached criterion level performance to all of these extra trials, the last two blocks of trials for each pair without any reinforcement for her responses. Criterion level performance for this phase was when the participant scored seven out of eight trials correctly in one eight-trial block for each of the pairs. LN reached this level of performance in only one block of trials for each pairing and it is this figure which is represented in Figure 3.9.2, even though three blocks were given for each stimulus pair.

Phase 3a: Repeat of Categorisation Test 1.

LN then completed another 18 trials of the categorisation test using the, "Look at this" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 11 percent correct in trials where a vek stimulus was the target (1 of 9). This result is as expected by chance (N =18, P (1) = 0.3>0.01). This result was identical to that of the previous categorisation test.

Figure 3.9.2. shows the Phase 3 data from this Categorisation test only.

Phase 4a: Repeat of Probe for Tacting

A repeat of the tact probe showed that she still could not produce either the names "zog" or "vek" or the sounds "u" and "i " to any of the six stimuli. On 14 out of a possible 18 trials she made the sound "aː " to the target stimulus. Other sounds produced are detailed below.

Z5 -  She called this stimulus "ɛː " in one trial, but then spontaneously changed to "ŋ ". At the end of the third trial she pointed to the stimulus and repeated the sound "ŋ ", and then called it "nain".

V4 -  She called this stimulus "ŋ " in one trial.

V6 -  She called this stimulus "ɛː " in one trial.

Phase 5: Common Speaker Training.

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. Prior to the first training trial with the first Z/V pair, the experimenter asked LN " Can you say which is a zog and which is a vek?". LN subsequently produced the word " zɔd' to the zog stimuli and "*ɛː* " to the vek stimuli, consistently throughout the following training trials. She was reinforced throughout for her production of these sounds.

Using these interpretations of the zog and vek names throughout, she then required one eight-trial block to demonstrate criterion speaker relations with stimulus pair Z4/V4; followed by 2 blocks with Z5/V5, and one block for pair Z6/V6.

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes. LN required only four six-trial blocks to reach criterion level performance. The last three of these blocks were given without reinforcement of her responses.

Phase 6: Categorisation Test

Stage 6.3: Categorisation test 1. LN completed 18 trials of the categorisation test using the, "Look at this. Can you give me the others" instruction. She demonstrated 0 percent correct responses (0 of 9 trials) when a zog stimulus was a target, and 11 percent (1 of 9) trials correct when a vek stimulus was a target. This performance is as would be expected by chance (N =19, P (1) = 0.3>0.01).

Stage 6.4: Categorisation test 2. LN then completed 18 trials of the categorisation test using the, "What's this? Can you give me the others" instruction. She performed all trials with 100 percent accuracy. LN also produced the correct response to the "What's this?" request from the experimenter on all 18 trials, using the sounds "*zɔd*" to the zog stimuli and "*ɛː* " to the vek stimuli.

Repeat of Stage 6.3: Categorisation test 1. LN then completed another 12 categorisation trials using the, "Look at this" instruction. She demonstrated 33 percent correct responses (2 of 6 trials) when a zog stimulus was a target, and 17 percent (1 of 6) trials correct when a vek stimulus was a target. This performance is as would be expected by chance (N =12, P (3) = 0.08>0.01). She was also given one block of six common speaker test trials prior to the category test trials. In these trials it appeared that the *zog* name relation had broken down, as this time she produced the sound " *nː* " for each of the zog stimuli, however she continued to call the vek stimuli "ɛː ".

Repeat of Stage 6.4: Categorisation test 2. As LN had shown such a difference in her performance between the two experimental instructions, another 12 trials of categorisation Test 2 were given, using the "What's this? " instruction.

She responded correctly to 50 percent (3 of 6) of the trials when a zog stimulus was a target, and 83 percent (5 of 6) when a vek stimulus was a target. This performance is statistically significant (N =12, P (8) = 0.00<0.01).

LN also produced the correct response to the "What's this?" request from the experimenter on 11 of the 12 trials, using the sounds " *nː* " to the zog stimuli and "ɛː " to the vek stimuli. She also produced these sounds on the common speaker test trials prior to the category test trials.

Griffiths Test

The result of LN's Griffiths test gave a GQ (General Development Quotient) of 122. This score is in the normal range for her age.

Spontaneous Verbal Behaviour: Stimulus Set 2.

During the training of listener relations (Phase 2), LN only produced one idiosyncratic name:

Z5 -  On her first sight of this stimulus, she called it "nain" (this is Welsh for grandmother), then "nanny" and then made a "ŋ " sound.

She did not produce any names; experimental or otherwise; to any of the stimuli during the categorisation test that followed listener training.

Summary: Stimulus Set 2

By the end of the procedure for Set 1, LN had been taught listener relations, and had also shown evidence of an approximation to the corresponding common speaker behaviour. This was defined as naming. Her results show successful classification of the stimuli into zog and vek categories.

After receiving listener training to the Set 2 stimuli, LN had learned a listener class encompassing the listener stimuli (/zog/ and /vek/) for both Set 1 and Set 2 stimuli. It may have been expected then, (as was the case for Participant JC in Experiment 1), that her speaker repertoire would have extended, possibly via covert echoing, to encompass the Set 2 stimuli. This should have enabled naming, and hence categorisation, to occur. This was not the case. As can be seen, from the analysis of her spontaneous utterances, JC overtly echoed the Set 2 stimulus names during listener training; LN on the other hand did not show such behaviour.

LN did not show evidence of categorisation of the Set 2 stimuli after listener training, neither did she show evidence of any reliable or appropriate speaker behaviour towards the stimuli (either the experimental names, or her own approximation of these).

In the four categorisation tests that followed speaker training, she only categorised when she was prompted to overtly produce the target stimulus' name, that is in response to the "What's this?" instruction. She did not categorise in the two tests where the "Look at this" instruction was utilised.

During the two categorisation tests where the "What's this?" instruction was employed, she used the name "ɛː " for the vek stimuli throughout, which was consistent with her production during speaker training. However, she produced different names for the zog stimuli each time. She produced " zɔd" reliably during the first "What's this?" test ", which was consistent with her production during speaker training, yet spontaneously changed to " *n*ː " during the second test. The "breaking up" of her " zɔd " name relation at this point coincided with her decline in the number of correct categorisation test trials when a zog stimulus was the target, as opposed to her maintenance of correct categorisation when a vek stimulus was targeted.

In the case of LN, naming behaviour, as illustrated by LN's overt naming of the target stimuli, was necessary for successful categorisation to occur, for both stimulus sets. With the Set 2 stimuli, however, LN showed categorisation consistent with the zog and vek class names even though only "approximate" naming had been established. Her idiosyncratic naming of the zog stimuli, and its possible effects on her categorisation will be elaborated upon in the discussion section at the end of this experiment.

Participant HW

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant HW required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.6).

In Stage 1.2, category training with familiar objects, he required only one block of six trials to demonstrate criterion performance using the instruction, "Look at this. Can you give Teddy the others like this?"

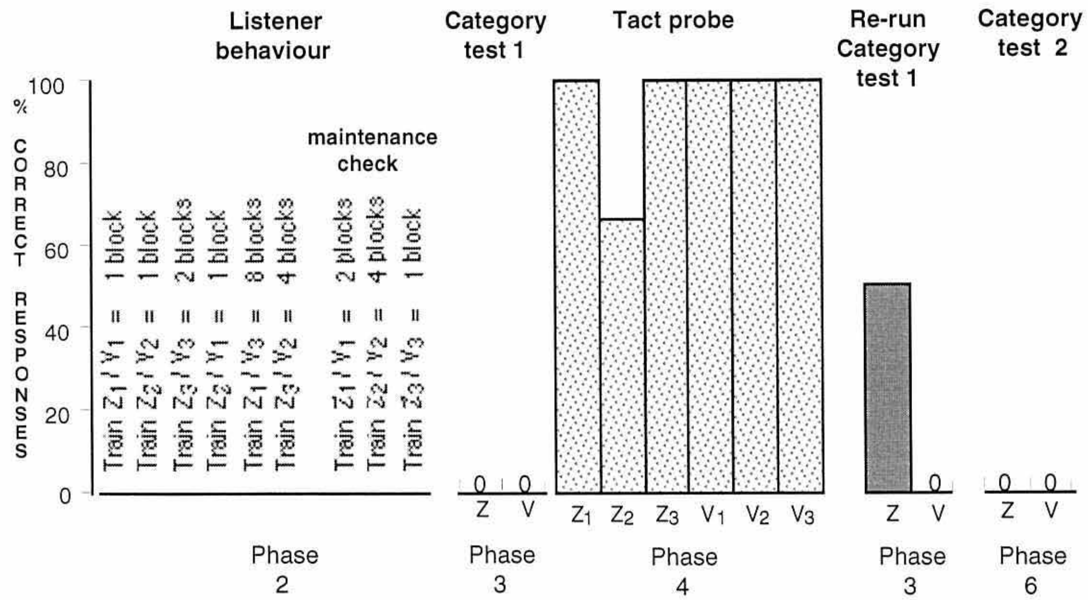


Figure 3.10. The training phase (Phases 2) gives the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 2: Common Listener Training with Arbitrary Stimuli.

HW required one block of eight trials to demonstrate criterion listener relation learning with pairs Z1/V1 and Z2/V2, and two blocks of trials with pair Z/3/V3. He required one eight-trial block to demonstrate criterion listener relation learning with mixed pair Z2/V1, followed by eight blocks with Z1/V3 and then four blocks with pair Z3/V2 (These trials are represented in Figure 3.10 above). Corrective feedback was given to his responses when necessary.

As HW took rather a lot of blocks to reach criterion to all three mixed pairs of stimuli, an extra check for maintenance of the listener relations was given. To this effect seven more eight-trial blocks were presented for each of the original stimulus pairs (i.e. 21 blocks in total). From these seven extra blocks, HW reached criterion in two blocks for pair Z1/V1 (the remaining five blocks were also passed without feedback), in four blocks for pair Z2/V2 (the final three blocks without feedback), and in one block for pair Z3/V3 (plus six blocks passed without feedback). Figure 3.10 shows the number of blocks required to reach criterion level performance only.

Phase 3: Categorisation Test 1.

HW completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He failed to categorise correctly in any of the test trials. This performance is as would be expected by chance (N =18, P (0) = 0.015>0.01).

Phase 4: Probe for Tacting

HW gave the correct name to all of the six stimuli on 17 out of 18 trials. He gave the correct name on three out of a possible three occasions to do so for five of the six stimuli. For stimulus Z2, he gave the correct name on two of three trials.
HW was deemed to have named the stimuli reliably, the criterion for successful tacting being a score of eight or more out of a possible nine correct trials for BOTH zog and vek stimuli.

Re-Run of Phase 3: Categorisation Test 1

HW had demonstrated naming; that is he showed criterion performance on both listener training and also appropriate speaker behaviour (as shown by the probe for tacting). It seemed appropriate, therefore, to investigate whether his overt production of the stimulus names during the tact probe would have an influence on his categorising behaviour.

To this effect, a change in the general procedure was implemented. Instead of following the probe test with Categorisation test 2, extra categorisation test trials were performed, this time using the instruction, "Look at this. Can you give Teddy the others like this?". Only nine test trials were given instead of the usual 18, as HW was by this point becoming bored with the tasks expected of him.

HW scored 50 percent correct in trials where a zog stimulus was the target (2 of 4) and 0 percent correct in trials when a vek stimulus was the target (0 of 5): a total of

22% correct overall. According to binomial theory this performance is as would be expected by chance ($N = 9$, $P(2) = 0.17 > 0.01$).

Phase 6: Categorisation Test 2

Stage 6.1: Common speaker testing with arbitrary stimuli HW failed to name the stimuli correctly over five blocks of test trials, then gave the correct names in a sixth block. He was being very mischievous and would not comply with the experimenter's requests. The categorisation test was then postponed until the next day.

This time he gave the correct name for all six stimuli, and moved on to the next stage.

Stage 6.4: Categorisation test 2 . HW was given 18 categorisation test trials using the instruction " What's this? Can you give Teddy the others like this?" He failed to perform any of the 18 test trials correctly. He did, however, produce the correct name to the stimuli, when asked "What's this?", on 17 of 18 occasions.

Griffiths Test

The result of HW's Griffiths test gave a GQ of 114. This score is in the normal range for his age.

Spontaneous Verbal Behaviour

During the training of listener relations (Phase 2), out of a total of 315 training trials, he spontaneously produced the name "zog" on six occasions, and "vek" also on six occasions.

HW did produce his own idiosyncratic name for some of the stimuli; these are detailed below.

Z3 -  He said "This is like a bird" on one occasion, and "This is like a triangle", on one other.

V1 -  He said "This is like a whistle" on two separate occasions.

He did not produce any names, experimental or otherwise, to any of the stimuli during the categorisation test that followed listener training.

Summary

In the case of HW, categorisation did not occur, even after both speaker and listener elements of the name relation had been trained.

This suggests that naming may not in itself be sufficient for the emergence of the categorisation of physically different stimuli into two common name sets.

DISCUSSION

All four participants in Experiment 2 progressed to Phase 2 of the procedure. Three of the four participants completed all procedures. The fourth participant left the nursery during Phase 2 training, and was therefore unable to continue the experiment.

As was expected with children of this age group, there was less participant attrition than seen in Experiment 1. This is reflected by the relative ease with which all of the 2.5 to 3.5 year old participants completed Phase 1 of the experiment. To illustrate, in Stage 1.2, only CT needed the added training instruction, "Look at this. Can you give me the hats/cups?" to aid his categorisation. In Experiment 1, however, 10 of the 11 children that participated in Stage 1.2, needed this additional instruction. This might be attributed to the older children having more real-life experience with the familiar objects used.

Leading from these findings, it might also be assumed that they would complete the required tasks in Phase 2 with more ease and celerity than the younger participants of Experiment 1. This, however was not exactly the case.

In Stage 2.1, across all three participants who completed all procedures in Experiment 1, the average number of training blocks to criterion over all three initial stimulus pairs was 33. The average for the three participants who completed Experiment 2 was 10.3 blocks, the older children being much quicker at learning the discriminations.

However, in Stage 2.2, the average number of training blocks to criterion in Experiment 1, for the three mixed pairs of stimuli, was 4.7, the average for Experiment 2 being 8.7 blocks. The older children were this time much slower in learning the new, mixed stimulus pair discriminations.

This latter finding is rather surprising and may lead one to question whether the Stage 2.2 pairwise discriminations were consolidated in the older age group. Another possible flaw in the procedure will be described next.

It is possible that participants of this age group may have been able to apply an alternative rule to enable them, eventually, to reach criterion level performance. To illustrate, if they were asked to give the /zog/ stimulus, yet gave the incorrect /vek/, the experimenter would correct them by saying, "No, that's a zog". It is quite possible that, on the first trial of a block of eight, the participants used this feedback as a cue to change all following responses to the correct ones. This would have enabled them to achieve criterion level performance, criterion being seven out of eight correct responses, without actually learning the discriminations; that is, their responses may have been exclusively based on a "win-stay, "lose shift" strategy (see Catania, 1998).

To analyse if this occurred, the individual participant's results will be considered.

Participant LN's scores compared well with that of the younger children in Stage 2.2. She took four eight-trial blocks to reach the criterion level performance, which was also the average taken by the participants in Experiment 1. HW and CT did not proceed through this stage as quickly. HW (as well as LN) however, did demonstrate reliable and untrained speaker behaviour after listener training. It might be assumed, as these speaker relations were untrained, that the corresponding listener relations were also intact, although a check for this was not given.

In the case of CT however, this is not so clear cut. He took a total of nine blocks to reach criterion with all three pairs in Stage 2.2, yet, unlike participant BH in Experiment 1, he did not receive any extra blocks of trials, without feedback, to check if the relations were intact. He also failed to demonstrate either corresponding speaker behaviour or successful categorisation after listener training. In the case of CT (unlike HW) it is reasonable to suggest that he may not have learned the necessary listener relations.

Of the three participants who completed all procedures in Experiment 2, only one, LN showed evidence of categorisation behaviour consistent with the naming hypothesis. The other two participants failed to demonstrate any form of categorisation after both listener and speaker relations had been established. Participant LN's results will be discussed first.

In the case of LN, for both stimulus sets 1 and 2, she exhibited correct categorisation. Co-existent evidence for the establishment of both speaker and listener relations was also shown. However, as described in her result section, it was questionable as to whether she had established the whole name relation, or, due to her idiosyncratic speaker behaviour, she had only demonstrated "approximate" naming. This was the case for both sets of stimuli.

For example, in Set 1, after listener training of the /zog/ and /vek/ stimuli, the probe for tacting showed that she could produce an approximation of the stimulus names - i.e. "*u* " for "zog" and "*i* " for "vek". Her listener responding to the stimuli /*u* / and / *i* / was not directly tested, so could this be classed as true naming?

LN's vocalisations were both reliable and were also a relatively accurate approximation of the experimental names. The vowel sounds produced, although not identical to the vowel sounds enunciated by the experimenter, were very similar phonologically. Both vowels were articulated in the same place in the mouth as the vowels of the required experimental names "zog" and "vek", the difference in sound being attributed to the amount in which the mouth was opened.

It must also be taken into account that the probe trial was the first time that LN had made an attempt to produce any of the experimental names, and that therefore, an exact replication of these names would be unlikely to occur. Other participants in this study have also only produced approximations of the experimental names, however in most cases it is the consonants which are modified by the child. For example participant JC produced "*zɔnk* " and " *wɛk* " instead of "zog" and "vek". Therefore it is quite probable that, for the Set 1 stimuli, true naming was in evidence.

For the Set 1 stimuli, therefore, it is concluded that LN's results support the naming hypothesis. She did, however, demonstrate categorisation only when she was prompted to overtly produce the target stimulus names, she was not given the opportunity to repeat the unprompted version of the categorisation test.

LN's idiosyncratic verbalisations with the Set 2 stimuli were more complex.

After listener training, she failed to demonstrate either correct categorisation or appropriate speaker behaviour on the subsequent probe for tacting. As she had, by this stage, learned a listener class that encompassed both the Set 1 and Set 2 stimuli, it might have been predicted that she would have also extended her speaker repertoire to include the Set 2 stimuli (as had JC in Experiment 1).

Unlike JC, however, LN did not echo any of the experimental names during listener training of the Set 2 stimuli. It may be this factor that prevented LN from extending the name relation to encompass the Set 2 stimuli. This lack of practice of the speaker element of the name relation may have led to the extinguishing of these speaker responses, evidence for which can be seen in her performance on the probe for tacting that followed the first categorisation test for the Set 2 stimuli.

In this probe, LN produced seven different sounds for the stimuli, none of which were the experimental names, nor the "*i* " that was her previous approximation of "vek". She did produce the sound " *u* " (previously used for "zog") on three occasions out of a possible 48, however on only one of these occasions was it made to the correct zog stimulus.

During speaker training, after being given feedback to her vocalisations, she changed to a more accurate approximation of the stimulus names, giving the name " *zɔd'* to the zog stimuli and the correct vowel sound, "*ɛː* " to the vek stimuli.

After speaker training, LN received four categorisation tests. Of these she only demonstrated correct categorisation on the two tests where she was prompted to overtly produce the target stimuli names. She did not maintain this correct categorisation on the two unprompted tests that used the "Look at this." instruction. This finding was quite unlike the results of participants BH and MJ in Experiment 1, who after successful categorisation on a prompted test, continued to categorise successfully on an unprompted categorisation test .

LN's changing naming of the Set 2 stimuli may also explain her inability to maintain categorisation, once naming had been initiated. On her first sighting of stimulus Z5, she spontaneously called it "nain", then "nanny", and then made a "ŋ" sound. This stimulus did closely resemble an elongated letter "N", and it may be possible that she was naming it as such. She repeated the "ŋ" sound for the Z5 stimulus on both probe tests that followed listener training, and also, in the last two of the four categorisation tests after speaker training, she changed her naming of all "zog" stimuli from "zɔd" to "ŋ". LN however, was consistent in her use of the sound "ɛː" to represent the vek stimuli within Set 2.

The sound "ŋ", as it was already established in her speaker repertoire, may have been a competing source of control over her responses. This interference may be an additional factor in her inability to transfer her Set 1 speaker repertoire to the Set 2 stimuli. Also, if the names "ŋ" and "zɔd" were mutually in control of her naming it may explain her need to overtly produce one of these names in order for it to take control over her naming behaviour , thus resulting in success on the categorisation tests. In the tests where she was not required to overtly produce the name, both names may have been competing for control of her naming behaviour, this interference resulting in unsuccessful categorisation.

It was noticed that the break down of her use of the name "zɔd", in preference for the "ŋ" name, coincided with the diminishing of her performance on the "zog" categorisation test trials. Her performance on the "vek" test trials, however, remained at strength, as did her continued production of the name "ɛː" for the vek stimuli. This phenomenon highlights the relationship between reliable naming and success in the categorisation test trials. It is also reminiscent of the results of participant MJ in Experiment 1 of this study. MJ also categorised correctly in more trials where she could easily produce the target name than in those test trials where producing the target name was problematic.

The two other participants in this experiment both failed to categorise after both elements of the name relation had been established, even after they were given the opportunity to overtly produce the target names in the categorisation test.

Why did categorisation not occur? One explanation may be that as both these children became very bored towards the end of the experiment, this may have contributed to a higher level of response rigidity. As discussed in Experiment 1, it is possible that any selection strategy used in the first categorisation test, may, in the absence of feedback to the contrary, be likely to be repeated in all future test situations.

Participants BH and MJ in the previous study, demonstrated how a change of strategy, that is, the initiation of naming behaviour via their spontaneous naming and sorting of the stimuli, came instead to control their categorising behaviour.

In the current study, however, both CT and HW failed to show any such overt naming behaviour and therefore it may be postulated that their lack of categorisation could be attributed to response rigidity.

Another factor that may influence successful categorisation reason may be interference of the establishment of the name relation due to the child having already learned their own names for the stimuli. To illustrate, if a child produces a tact response, either overtly or covertly, that is other than the common name for other stimuli in an array, then naming behaviour would not occur.
There would be no impetus for the child's re-orientation and selection of any other stimulus and thus no categorisation.

In the case of participant CT evidence for such interference was shown. Firstly, CT exhibited relative difficulty in learning the necessary speaker relations, taking 28 blocks to reach criterion level performance in Stage 5.2 (Common speaker training with arbitrary stimuli, in sixes). The other two participants had demonstrated untrained speaker relations after only receiving listener training. CT had produced his own names for five of the stimuli during the probe for tacting and he continued to use these names during speaker training. For example, he called the stimulus Z3 "television" on three occasions, the same name he had used during the probe for tacting.

To conclude, in Experiment 2, only one participant showed categorisation consistent with the naming hypothesis . Two participants did demonstrate appropriate and untrained speaker relations after listener training, but only one of these (LN) went on to show correct categorisation of the stimuli into two classes.

Two participants failed to categorise after evidence of the establishment of both listener and speaker relations, that is, naming. This suggests that the learning of the experimental names in itself, may not have been sufficient for the categorisation of physically different stimuli into two sets. In the case of CT, however, it was debatable as to whether he had indeed established reliable listener relations.

* * *

The third experiment of this study extended the age range of participants to 3.5 to 4.5 years of age. None of the 1.5 to 2.5 year old group, and only two of the participants in the 2.5 to 3.5 year old group, had shown untrained speaker relations after listener training. The aim of the next experiment was, therefore, to investigate whether these older children, being more language fluent, would do so. Also, would they be able demonstrate categorisation after establishing the whole name relation?

In response to the design criticisms made in the above discussion, two amendments were made to the general procedure.

Firstly, as stated earlier, it may have been questionable whether participant CT had indeed consolidated the pairwise discriminations in Stage 2.2 listener training. In an attempt to clarify this, Stage 2.2 of Experiment 3 was modified. Instead of presenting the stimuli in mixed pairs in this stage, the procedure continued using the initial pairings, while feedback to the participants' responses was eliminated or reduced.

Secondly, as a further check that the learned listener relations were intact, a check for maintenance of these relations was given immediately after the first categorisation test and probe for tacting were completed.

EXPERIMENT 3

In Experiments 1 and 2, none of the six participants categorised the physically dissimilar stimuli following listener training alone, yet four of these subsequently categorised when taught the corresponding speaker relations, and hence the whole of the name relation. This study aimed to replicate the earlier studies, but increased the age of the participants to between 3.5 and 4.5 years of age.

METHOD

Participants

Three participants, one male and two female, took part. Table 3.7 shows, for each participant, her or his gender and their age. All participants were given the Griffiths test to ascertain their normal development (reported at the end of each participant's result section).

Table 3.7.
Participants' sex and age

Participant	Sex	Age at start year: month	Age at first categorisation test year: month
NW	F	3:09	3:11
RE	F	3:10	4:00
TB	M	4: 00	4:01

F = female M = male

Procedure

The procedure employed in Experiment 3 was as described in the General Method section above but with the following changes to Phases 2 and 4.

Phase 2: Common Listener Training with Arbitrary Stimuli.

Stage 2.1: Common listener training - with initial pairs. This stage was performed as described in the general method.

Stage 2.2: Reduction in reinforcement probability - initial pairs. In this experiment, instead of rearranging the stimuli into different, mixed, pairs, the three sets of initial pairs were again presented to the participant in eight-trial blocks (as in Stage 2.1 above), however, no feedback was given to any of the participant's responses.

Criterion was reached when all three pairs were performed to their individual criterion level, twice in succession, without any reinforcement, and spaced in time, over two separate experimental sessions. Therefore the minimum blocks of trials performed, before criterion level performance could be met, was six. The participant then progressed to Phase 3.

If the participant's performance deteriorated with any of the pairs, extra training trials, with full feedback, were given only to that particular stimulus pairing until criterion level performance (as Stage 2.1) was resumed.

Phase 4: Probe for Tacting

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given, as described in Stage 2.2 above, for each pair without any reinforcement.

If the participant demonstrated intact listener relations with all three stimulus pairs, Phase 5 (as in the general method) commenced.

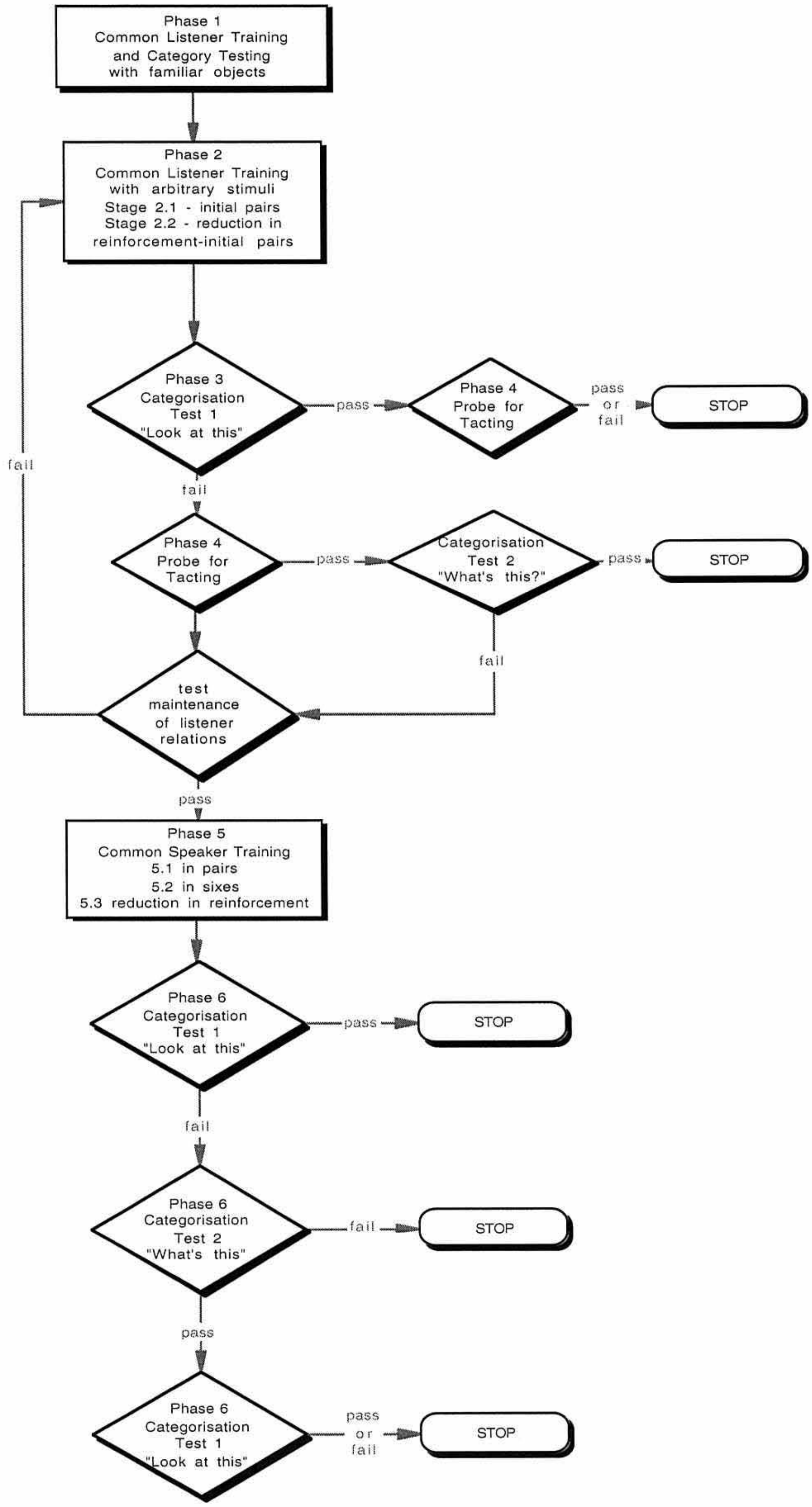


Figure 3.11: Flowchart representation of the procedure of Experiment 3.

If the participant failed to demonstrate maintenance of the listener relations, he or she returned to Stage 2.2 of the procedure.

The remainder of the procedure was as described under the general method. The flowchart in Figure 3.11 gives a graphic overview of the procedure.

RESULTS

Phase 1

Table 3.8 shows the number of eight-trial blocks each participant required in order to achieve criterion performance in Stage 1.1 listener relation learning for each of three familiar object (hat and cup) pairs. Data are presented as individual graphs from Phase 2 onwards.

Table 3.8

Results of Phase 1: Common listener training and category training with familiar objects. In Stage 1.1, H1/C1, H2/C2 and H3/C3 refer to the three familiar object (hat and cup) pairs. Two instructions were used in Stage 1.2, "Look at this. Can you give me the others like this?" and "Look at this. Can you give me the other hats/cups?" (for more details see procedure).

Participant	Stage 1.1 Common listener training in pairs			Stage 1.2 Categorisation test	
	H1/ C1	H2/C2	H3/C3	"other hats & cups"	"Others"
NW	1	1	1	_	1
RE	1	1	1	_	2
TB	1	1	1	_	1

Participant NW

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant NW required only one eight-trial block for each of the 3 stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.8).

In Stage 1.2, category training with familiar objects, NW required one six-trial block to demonstrate criterion performance using the instruction, "Look at this. Can you give Teddy the others like this?"

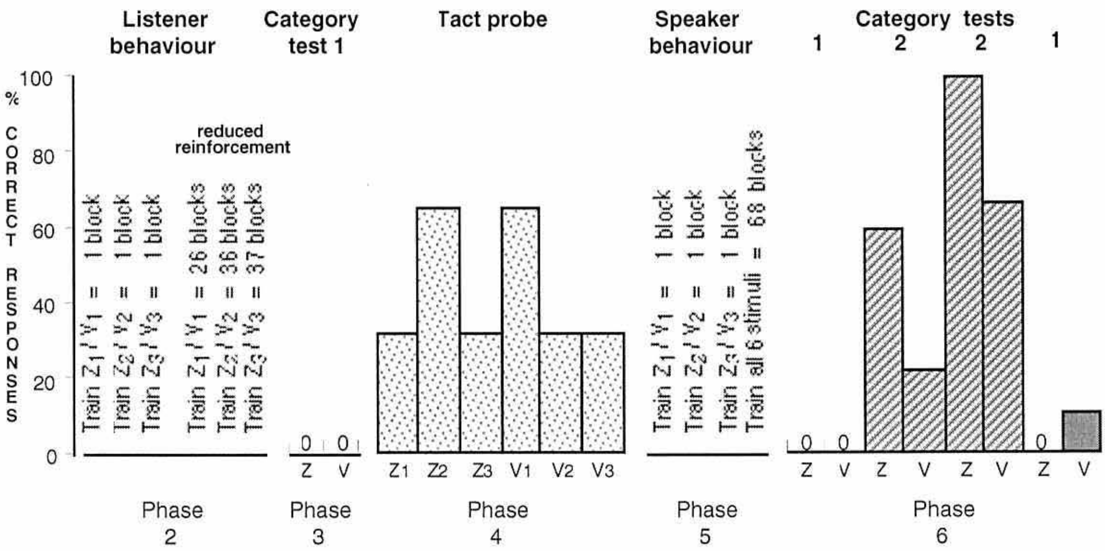


Figure 3.12. The training phases (Phases 2 and 5) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 2.1 Common Listener Training with Arbitrary Stimuli.

NW required one eight-trial block to demonstrate criterion listener relation learning with each of the three pairs (Z1/V1, Z2/V2 and Z/3/V3). Corrective feedback was given when necessary.

Stage 2.2 Reduction in reinforcement probability. NW required 26 eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1; 36 blocks with pair Z2/V2, and 37 blocks with pair Z3/V3.

Phase 3: Categorisation Test 1.

NW completed 18 trials of the categorisation test using the, "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). This performance is as would be expected by chance ($N=18$, $P(0) = 0.15>0.01$).

Phase 4: Probe for Tacting

NW could produce the sounds "zog" and "vek", however she could not do this to criterion level. Her scores out of three probe trials, for each stimulus are as follows.

Z1 - one correct trials	V1 - two correct trials
Z2 - two correct trials	V2 - one correct trials
Z3 - one correct trial	V3 - one correct trial

NW seemed to be using an intraverbal strategy during these probe trials. To illustrate, in each of the three blocks of trials, she would name the first target stimulus "zog"; the second "vek", third "zog", fourth "vek", fifth "zog", and sixth "vek". She did not change this style of response for any of the trials, thus the number of correct trials shown above may be misleadingly high.

Following the probe for tacting, another check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement. This time she reached criterion level performance with all three pairs. Speaker training then commenced.

Phase 5: Common Speaker Training.

Stage 5.1: Common speaker training with arbitrary stimuli, in pairs. NW required one block of eight trials to demonstrate criterion speaker behaviour to each of the three arbitrary stimulus pairs.

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes.

Fifteen six-trial blocks were presented without her reaching criterion level performance; therefore the procedure was adapted. She was given training with only four of the stimuli present (stimuli Z1, Z2, V1, and V2). One block consisted of each of the four stimuli being targeted in turn and the experimenter asking "What's this?" She completed 20 of these trials, the last three of which she performed with 100 percent accuracy, and without any feedback to her responses.

A further 53 blocks of trials were then presented using the six stimulus array, before NW reached criterion level performance. Figure 3.12 gives the total number of six-trial blocks performed, which was 68.

Phase 6: Categorisation Test 1.

NW completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). This performance is as would be expected by chance (N =18, P (0) = 0.015>0.01). These data are represented by the first pair of bars of the graph in Figure 3.12.

Stage 6.4: Categorisation test 2 . NW then completed another 18 trials of the categorisation test using the "What's this, can you give me the others?" instruction. She scored 60 percent correct in trials where a zog stimulus was the target (6 of 9) and 22 percent correct in trials when a vek stimulus was the target (2 of 9). According to binomial theory the probability that this would occur by chance is low and statistically significant (N =18, P (8) = 0.00<0.01), but did not meet the criterion set for this test, which was that the participant must score three out of a possible nine correct trials for both zog and vek target trials. These data are represented by the second pair of bars of the graph in Figure 3.12.

In this test NW produced the correct name for the stimuli on 17 of 18 trials. In one test trial she produced the incorrect name "zog" to a vek stimulus, but then chose the other zog matches.

Another 18 test trials (as above) were then given, to investigate whether her performance would improve. Of these 18 trials, she scored 100 percent correct in trials where a zog stimulus was the target (9 of 9) and 67 percent correct in trials when a vek stimulus was the target (6 of 9). This time her performance was statistically significant according to binomial theory (N =18, P (15) = 0.00<0.01), and also met the set criterion. These data are represented by the third pair of bars of the graph in Figure 3.12.

Repeat of Phase 6: Repeat of Categorisation Test 1.

NW was given another 18 categorisation test trials. The first 10 of these trials used the "Look at this, can you give me the others?" instruction. She failed to categorise any of the trials correctly. In the next 10 trials, the instruction was changed to "What's this?".

She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). This performance is as would be expected by chance (N =18, P (0) = 0.015>0.01). These data are represented by the fourth pair of bars of the graph in Figure 3.12.

Griffiths Test

The result of NW's Griffiths test gave a GQ of 129. This score is in the normal range for her age.

Spontaneous Verbal Behaviour

During the training of listener relations (Phase 2), out of a total of 710 training trials, she spontaneously produced the name "zog" on 10 occasions, and "vek" on 8 occasions.

She produced an idiosyncratic name for only one of the stimuli:

Z1 -  On seeing this stimulus for the first time, she said, "That's the alphabet, that's a name - what letter is that?"

She did not produce any idiosyncratic names to any of the stimuli during the categorisation tests.

Summary

NW's results support the Naming hypothesis. Categorisation did not occur until both speaker and listener elements of the name relation had been trained.

When the whole name relation had been established, NW failed to demonstrate categorisation with the first test, which used the "Look at this" instruction. However, in the subsequent test, using the "What's this?" instruction, and thus prompting overt production of the target stimulus names, successful categorisation did occur.

In a following test, where the instruction was again changed to, "Look at this?", she failed to maintain successful categorisation.

In the case of NW, the establishment of both speaker and listener elements of the name relation do not, in itself, appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. Rather, naming behaviour, as illustrated by NW's overt naming of the target stimuli, was necessary for successful categorisation to occur.

Participant RE

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant RE required only one eight-trial block for each of the three stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.8).

In Stage 1.2, category training with familiar objects, she required two six-trial blocks to demonstrate criterion performance using the instruction, "Look at this. Can you give Teddy the others like this?"

Phase 2.1 Common Listener Training with Arbitrary Stimuli.

RE required one eight-trial block to demonstrate criterion listener relation learning with all three pairs (Z1/V1, Z2/V2 and Z/3/V3). Correct feedback being given when necessary.

Stage 2.2 Reduction in reinforcement probability. RE required six eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1; six blocks with pair Z2/V2, and six blocks with pair Z3/V3.

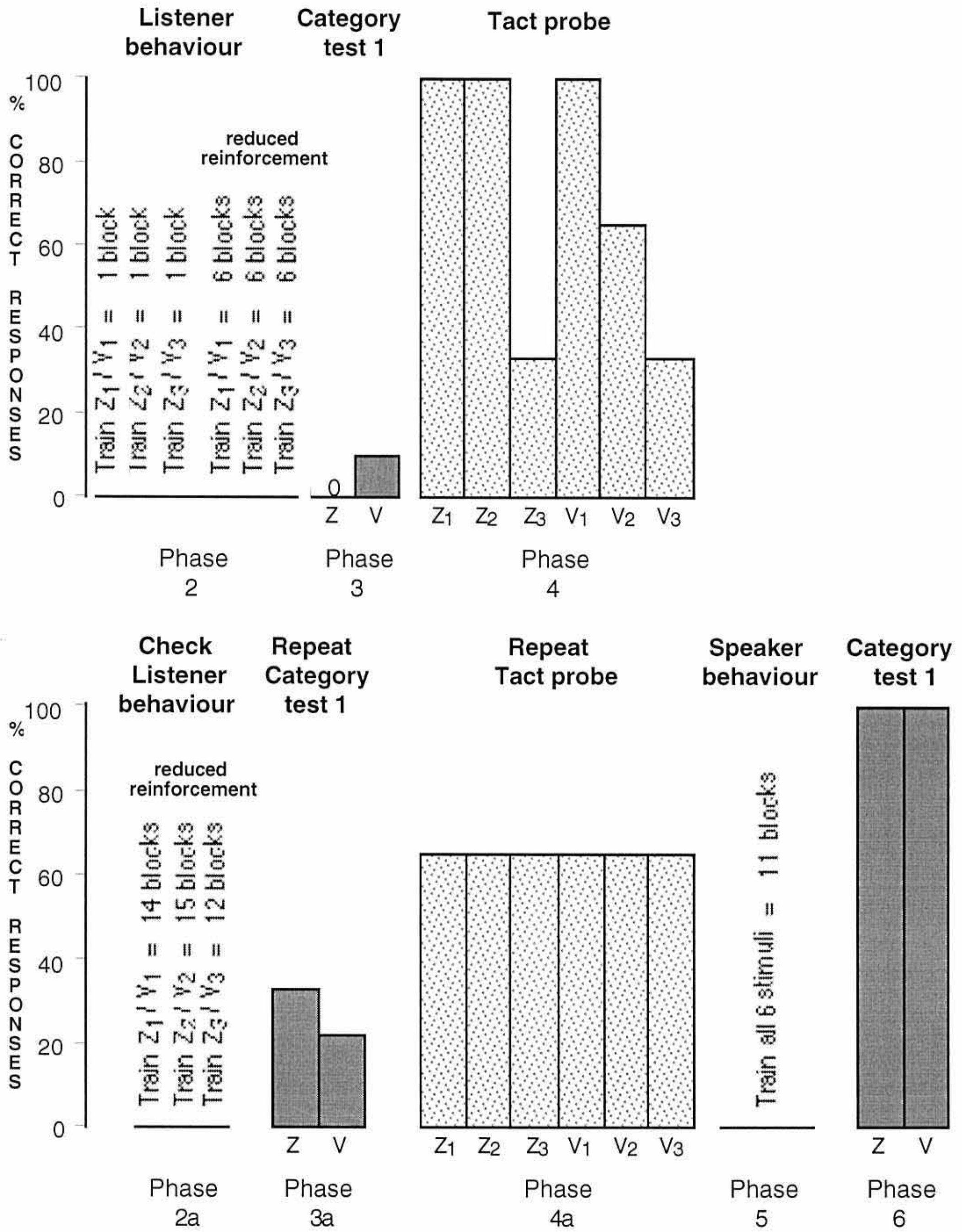


Figure 3.13. The training Phases (Phases 2, 2a and 5) give the number of blocks taken to reach criterion. The test Phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 4a), and category re-testing (Phases 3a and 6).

Phase 3: Categorisation Test 1.

RE completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). This performance is as would be expected by chance (N =18, P (1) = 0.3>0.01).

Phase 4: Probe for Tacting

Though RE could produce the sounds "zog" and "vek", she could not do this to criterion level. Her scores out of three probe trials, for each stimulus are as follows.

Z1 - three correct trials	V1 - three correct trials
Z2 - three correct trials	V2 - two correct trials
Z3 - one correct trial	V3 - one correct trial

As described earlier in the results section of participant NW, RE seemed to use the same intraverbal strategy during these probe trials. As did NW, RE named the first target stimulus "zog"; the second "vek", third "zog", fourth "vek", fifth "zog", and sixth "vek". She did not change this style of response for any of the trials, thus the number of correct trials shown above may be misleadingly high.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. It was found that her performance had deteriorated and she did not reach criterion level performance with any of the pairs. Therefore Stage 2.2 was repeated until criterion performance was re-established. Phase 3 and Phase 4 were then repeated.

Phase 2a: Repeat of Stage 2.2 Reduction in reinforcement probability. RE required 14 eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1; 15 blocks with pair Z2/V2, and 12 blocks with pair Z3/V3.

Phase 3a: Repeat of Categorisation Test 1.

RE completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 33 percent correct in trials where a zog stimulus was the target (3 of 9) and 22 percent correct in trials when a vek stimulus was the target (2 of 9). This performance is as would be expected by chance (N =18, P (5) = 0.022>0.01).

Phase 4: Repeat of Probe for Tacting

Again RE could produce the sounds "zog" and "vek", but not to criterion level. Her scores out of three probe trials, for each stimulus are as follows.

Z1 - two correct trials	V1 - two correct trials
Z2 - two correct trials	V2 - two correct trials
Z3 - two correct trial	V3 - two correct trial

RE used the same intraverbal strategy during these probe trials as she had in the earlier probe for tacting.

Following the probe for tacting, another check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement. This time she reached criterion level performance with all three pairs. Speaker training then commenced.

Phase 5: Speaker Training

Stage 5.2: Common speaker training with arbitrary stimuli, in sixes.

As RE was able to produce the required names easily, if not to criterion level, it was decided to omit Stage 5.1 speaker training in pairs, and instead start speaker training with all six stimuli present. She took 12 six-trial blocks in total to reach criterion level performance. During four of these 12 trials, RE insisted on arranging the stimuli into two rows; one row containing all the vek stimuli, the other, all the zog stimuli. In the final trials, after ordering the stimuli as described, she said, spontaneously "These are the zogs and these are the veks".

Phase 6: Categorisation Test 1.

RE then completed 18 trials of the categorisation test using the "Look at this, can you give me the others" instruction . She completed all trials with 100 percent accuracy. This result was significant (N =18, P (18) = 0.00<0.01).

Griffiths Test

The result of RE's Griffiths test gave a GQ of 121. This score is in the normal range for her age.

Spontaneous Verbal Behaviour

During the training of listener relations (Phase 2), out of a total of 495 training trials, she spontaneously produced the name "zog" on 12 occasions, and "vek" on 23 occasions. Of these, her utterances corresponded with the targeted stimulus on 30 occasions (8 times to a zog stimulus, and 22 to a vek stimulus), and she gave the wrong name to the target on 5 occasions (4 times to a zog target and once to a vek target).

However RE did produce idiosyncratic names for some of the stimuli, and these are detailed below.

Z3 -  Spontaneous utterances include: "This looks like rain dripping down"; "This looks like a raindrop"; "That looks like a wheel".

V1 -  "This looks like a vek, cos its got this to this to this".

V2 -  "This looks like a rubber ring"; "it goes round and round"; "It's twirly".

V3 -  On asking for the vek, she replied "That big one is".

She did not produce any names, experimental or otherwise, to any of the stimuli during the categorisation tests.

Summary

RE's results support the Naming hypothesis, because categorisation did not occur until both speaker and listener elements of the name relation had been trained. Common listener relations do not appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets.

RE had also shown evidence of spontaneous naming behaviour prior to her successful categorisation test trials. During speaker training she had, without prompting, categorised the stimuli into rows consistent with the zog and vek class names.

Participant TB

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant TB required only one eight-trial block for each of the three stimulus pairs to demonstrate criterion listener behaviour in Stage 1.1 (see Table 3.8).

In Stage 1.2, category training with familiar objects, he required one six-trial block to demonstrate criterion performance using the instruction, "Look at this. Can you give Teddy the others like this?"

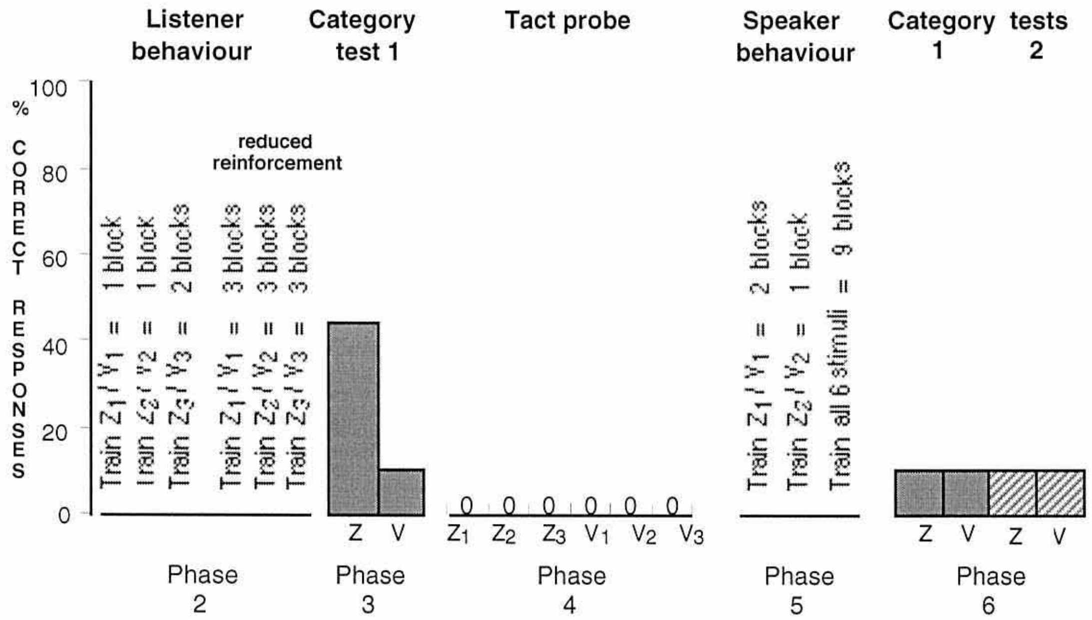


Figure 3.14. The training Phases (Phases 2 and 5) give the number of blocks taken to reach criterion. The test Phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phase 4), and category re-testing (Phase 6).

Phase 2.1 Common Listener Training with Arbitrary Stimuli.

TB required one eight-trial block to demonstrate criterion listener relation learning with pairs Z1/V1 and Z2/V2 and two blocks with pair Z3/V3. Corrective feedback was given where necessary.

Stage 2.2 Reduction in reinforcement probability. TB required three eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1; three blocks with pair Z2/V2, and three blocks with pair Z3/V3.

Phase 3: Categorisation Test 1.

TB completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He scored 44 percent correct in trials where a zog stimulus was the target (4 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). This performance did not meet the set criterion level and is as would be expected by chance ($N = 18$, $P(5) = 0.021 > 0.01$).

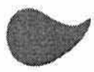
Video analysis of his stimulus selection during the categorisation trials showed that he had a position preference. During the 18 trials he tended to select the two stimuli that were situated closest to his right hand. No other sorting strategy was observed.

Phase 4: Probe for Tacting

TB did not produce the names "zog" and "vek" on any of the probe trials. He gave his own idiosyncratic responses to the target stimuli, which are detailed further below.

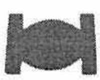
Z1 -  He called this stimulus "moon" in all three trials.

Z2 -  He called this "ball" in all three trials.

Z3 -  He called this "ball" in all three trials.

V1 -  He called this "gate" in two trials, and "square" in one trial.

V2 -  He called this "people" in all three trials.

V3 -  He called this "gate" in all three trials.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. As in Stage 2.2, one eight-trial block was performed for each of the three stimulus pairs. TB reached criterion level performance with all three pairs with no reinforcement.

Phase 5: Common Speaker Training with Arbitrary Stimuli

In the case of TB, the procedure was modified. All the other participants in Study 1 received training in speaker relations with all three pairs of arbitrary stimuli, therefore, out of interest, a change in procedure was implemented to investigate if the teaching of speaker relations to one of the pairs would then result in the transfer of the relations to the other two pairs.

Speaker relations were trained to pair Z1/V1 only; in which he took two eight-trial blocks to reach criterion; then all six stimuli were presented to him as in Stage 5.2 of the procedure.

TB then performed four six-trial blocks with the six stimulus array, but failed to reach criterion level performance.

Speaker relations were then taught to pair Z2/V2 and he reached criterion in one block of trials.

He was again presented with the six stimulus array. This time he performed all trials correctly. He reached criterion level performance, that is three correct blocks in a row without reinforcement, in five six-trial blocks. The graph in Figure 3.14 shows the total nine blocks performed.

Phase 6: Categorisation Test 1.

TB completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). This performance is as would be expected by chance (N =18, P (2) = 0.028>0.01).

In the earlier categorisation test TB had exhibited a positional preference for selecting the two stimuli nearest his right hand. During these trials (and those in the following test), however, the experimenter encouraged him to look around the stimulus array and to take his time in selecting the matches.

Phase 6: Categorisation Test 2.

TB then completed 18 trials of the categorisation test using the "What's this, Can you give me the others?" instruction. He scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). This performance is as would be expected by chance (N =18, P (2) = 0.028>0.01).

Griffiths Test

The result of TB's Griffiths test gave a GQ of 101. This score is in the normal range for his age.

Spontaneous Verbal Behaviour

During the training of listener relations (Phase 2), audio recordings were only available for a total of 64 training trials (although 104 were performed in total). In these he spontaneously tacted, correctly, the name "zog" on two occasions, and "vek" also on two occasions.

TB also produced idiosyncratic names for some of the stimuli, these are detailed below.

Z1 -  He called this stimulus "moon" during both listener and speaker training. When the experimenter corrected him, saying "this is a zog", he replied emphatically "No, this is a moon".

V2 -  He called this "people" during listener training.

His only spontaneous production during the categorisation tests was in Phase 6: Categorisation Test 2. After correctly naming the target vek stimulus, he said "zog" as he handed stimulus Z3 to the experimenter.

Summary

In the case of TB, categorisation did not occur, even after both speaker and listener elements of the name relation had been trained. This suggests that naming may not in itself be sufficient for the emergence of the categorisation of physically different stimuli into two sets.

DISCUSSION

All three participants in Experiment 3 completed the procedures. All three progressed easily to Phase 2, none of them required the added training instruction, "Look at this. Can you give me the hats/cups?" to aid categorisation.

In Stage 2.1, all three also reached criterion level performance, with the three arbitrary shaped pairs of stimuli, in the minimum possible blocks of trials.

In Stage 2.2, the average number of listener training blocks to criterion was 56.7 (453.4 trials). This appears at first to be a rather large amount when compared to the average scores of the participants in Experiments 1 and 2, however in this case, the criterion level was far more stringent. Each pair of stimuli had to be performed to their individual criterion level, twice in succession and without feedback to responses, and also this was to occur over two experimental sessions. Therefore any lapses in the participant's concentration on one of the pairs would also mean that they failed on all three sets, which may have resulted in a false negative situation.

However, even so, the number of blocks taken by these participants does raise questions about the validity of the listener training criterion levels of the previous two experiments, and this issue will be addressed further in the general discussion section.

Of the three participants, two demonstrated evidence for intact listener relations by their criterion level performance in the maintenance check that followed the categorisation test and probe for tacting. Participant RE however, failed to show criterion level responding and further listener training was given. RE's results also question the validity of the set criterion levels.

Of the three participants, two showed evidence of categorisation consistent with the naming hypothesis. Neither of these categorised after listener training alone, but one, RE subsequently did so after speaker relations had been trained, and the other, NW, went on to show categorisation after she was prompted to overtly produce the target stimulus names. However, she subsequently failed to generalise her categorisation behaviour to other test situations.

The other, TB, failed to demonstrate any form of categorisation after both listener and speaker relations had been established.

The results of the two participants who were successful, re-emphasises the importance of on-task "naming behaviour", rather than prior learning of the corresponding speaker and listener relations, in the initiation of categorisation behaviour.

In the case of NW, she only categorised after overt production of the target stimulus names was prompted. As in the case of LN (Experiment 2), NW failed to maintain correct categorisation in a further test where it was not required that she overtly named the target stimulus.

Participant RE also demonstrated a form of spontaneous categorisation that was independent of the test situation. In Phase 5.2, (speaker training-in sixes), she spontaneously ordered the stimuli into separate rows, each row consistent with the zog and vek classes. She did this on four occasions, in one of these also saying, "these are zogs and these are veks".

In Experiment 1, the participants MJ and BH showed a clear link between their spontaneous categorisation, their naming of the stimuli, and their success on the categorisation test; however this link was not so clear with RE.

Her spontaneous categorisation only occurred after speaker training, even though she had the opportunity to interact with all six stimuli during the first categorisation test and also during the probe for tacting. RE then immediately went on to pass the categorisation test and her results support the naming hypothesis.

This behaviour is, again, consistent with the findings of Gopnik and Meltzoff (1987, 1992), who found that the emergence of spontaneous categorisation was positively correlated with developments in productive rather than receptive language.

The participant who failed to categorise at all, TB, failed even after both listener and speaker relations had been established. His results again show that naming itself is not sufficient for the demonstration of successful categorisation.

Again, this lack of categorisation could be attributed to interference effects from already established names. In fact, TB was the only participant in this experiment who could not produce the experimental names on at least some trials during the probe for tacting. His idiosyncratic names in this probe were reliable for five of the six stimuli in all three trials. As described, even during speaker training, his own names for the stimuli persisted in interfering with the learning of the experimental names, for example, insisting Z1 was "moon" even after being corrected by the experimenter.

Also, as stated previously, video analysis of his stimulus selection during the first categorisation test showed that he had a positional preference, tending to select the two stimuli that were situated closest to his right hand. In the categorisation tests trials that followed speaker training a positional preference similar to that in his first test was not noted. In these trials, unlike the first test, he was encouraged to look around the stimulus array and take his time in choosing. Given the differences in opportunity for spontaneous selection, no firm conclusion about rigidity of sorting response can be made.

Surprisingly for children of this age, none of the participants demonstrated untrained and criterion level speaker relations during the probe for tacting that followed the first categorisation test. RE and NW did produce the experimental names zog and vek during the probe, however these were randomly produced and were not to criterion level. TB gave his own idiosyncratic names to the stimuli.

Horne and Lowe (1996, p207) state that when higher order naming skills have been established, if only listener behaviour is ostensively taught, the child may also exhibit the corresponding speaker behaviour if the child echoes (either overtly or covertly) the listener stimulus. However this does not seem to be the case, even in the comparatively verbally sophisticated children of this age group. It may be the case that the children's own names for the stimuli could have interfered with their ability to develop the appropriate tact relations or, alternatively speaker behaviour may have to be directly trained in order for naming to be established.

To conclude, of the three participants in Experiment 3, two participants showed categorisation consistent with the naming hypothesis; after the establishment of both listener and speaker relations, that is naming, they went on to show correct categorisation of the stimuli into two classes.

One participant failed to categorise after evidence of the establishment of both listener and speaker relations (that is, naming). This suggests that naming in itself, may not have been sufficient for the categorisation of physically different stimuli into two sets.

GENERAL DISCUSSION

Of the nine participants that completed the three experiments that comprised Study 1, none categorised the arbitrary stimulus sets into two classes consistent with the experimental names zog and vek after listener training alone.

Of these nine, two participants categorised successfully immediately after both listener and speaker elements of the name relation had been established. A further four participants subsequently demonstrated categorisation after they were prompted to overtly produce the name of the target stimulus during the categorisation test. Three participants did not show categorisation at all. Two participants also demonstrated successful categorisation with a second stimulus set. Of these, one categorised after listener training and the other after overtly naming the target stimuli.

These results strongly support one of the major predictions from Horne and Lowe's (1996) naming theory, that the establishment of both listener and speaker relations , that is the whole name relation, is necessary for the categorisation of physically different stimuli.

The results suggest however, that whereas prior learning of the speaker and listener relations that constitute a name relation is necessary for this kind of categorisation, it may not in itself be sufficient. Four of the participants did not categorise successfully until they were prompted to overtly produce the names of the target stimuli. Three of the participants did not categorise even after naming had been established. Reasons for this have been discussed previously but may be attributed to such factors as response rigidity, interference from their own names and even boredom.

The important issue arising from their results, as well as those who needed to overtly produce the names, is that naming is not sufficient for categorisation; rather, naming behaviour must be initiated. It is integral to Horne and Lowe's theory that naming is conceptualised as a process. Although all the necessary elements may be established naming behaviour will only occur when each element of the naming circle comes to occasion all other behaviours in that circle.

The evidence from video recordings of the categorisation test trials for participants BH and MJ, provide vivid illustrations of this naming behaviour in action.

These results of these nine participants also show patterns similar to the research conducted by Fay Harris (see Horne & Lowe, in press) which were discussed at the introduction to this study. To recap, her study trained two common tact response to two sets of arbitrary stimuli before testing for categorisation. The age of the nine participants in her study ranged from 2 years 3 months to 4 years 3 months of ages and were therefore comparable to the participants in the present study. Of these nine participants, three categorised successfully after common tact training to the "Look at this" instruction (compared to two of nine in the present study). The remaining six participants subsequently demonstrated categorisation after they were prompted to overtly produce the name of the target stimulus (compared to four in the present study).

Harris' results as well as those from the present study emphasise the importance of conceptualising this categorisation in terms of the initiation of naming behaviour.

A second prediction that also leads from Horne and Lowe's account is that, in verbally competent children, the training of a common listener response to such arbitrary stimuli, should also entail the establishment of the corresponding common speaker response. In the present study, however, only two of the nine participants showed these untrained speaker relations. These results suggest that, even in four year old children, speaker behaviour may have to be directly trained in order for naming to be established.

Three of the participants in this study also showed evidence of spontaneous sorting of the stimuli into classes consistent with the experimental names zog and vek. This behaviour was shown independent of the strictures of the categorisation test trials and provides an ecologically valid measurement of the relationship between naming and categorisation.

None of these three participants showed this sorting behaviour during listener training, rather the behaviour was evidenced only when speaker relations (that is the whole name relation) had been established. As described earlier, this unprompted sorting behaviour was linked intimately with their ability to demonstrate correct categorisation of the stimuli into two commonly named classes during subsequent categorisation test trials.

The findings from this study support correlational studies from the developmental literature which has shown that the onset of spontaneous categorisation is positively related to developments in productive language (e.g. Gopnik and Meltzoff 1987, 1992; Gopnik and Choi 1990, 1992; and Poulin Dubois et al 1996). Indeed the current findings elaborate upon these developmental studies by providing experimental rather than correlational data that specifies the causal factor responsible for the onset of categorisation. In the reported studies it is development in production, specifically the acquisition of the common tact relations, that drive categorisation and not vice versa. This evidence in general, and especially from those participants who do not exhibit categorisation until they have been prompted to overtly produce the stimulus names, emphasises this direction of causality.

As well as providing evidence that both supports and extends current research in the developmental literature on categorisation and language, the results of the study also informs the controversies within the behaviour analytic field of stimulus equivalence. How the current research relates to this area will be discussed next

The results from this study show strong support for the view that naming is necessary for categorisation of stimuli that physically differ. The classifying behaviour exhibited by the majority of participants has all the features of the stimulus classes that have been described in the equivalence literature as "emergent". That is, in the categorisation test trial each stimulus was shown to be substitutable for each other in the common named class. The results of this study however cannot be explained by the competing accounts of those researchers who define such classifying behaviour in terms of stimulus equivalence or relational frames.

Sidman, for instance, has suggested that equivalence may be "a basic stimulus function, not derivable from more fundamental processes" (1997, p. 259, see also Sidman 1990). He does not, however, explain how and when these relations might develop. Furthermore Sidman's viewpoint makes no distinction between speaker and listener class membership. If his rationale is to be accepted there should be no differences in the classifying behaviour seen after listener training alone or after speaker behaviour has also been established. The results from the present study show clearly that there are differences between these two conditions. Sidman's position could not account for the findings of Study 1 which show how the onset of categorisation is directly related to the establishment of the complete name relation and also how the same effects are seen in children whose ages range from 1 year 7 months to 3 years and 10 months.

Explanations based upon relational frame theory (e.g. Hayes & Hayes 1989, 1992) also cannot account for this study's data. This theory suggests that humans have certain training histories which facilitates the "development of generalised arbitrarily applicable relational responding" (Lipkens, Hayes and Hayes 1993. p.203).

An example may clarify this concept. For instance, a child may have a learning history in which she or he has been trained to put objects with the same colour, or even name, into a box. This "frame of co-ordination", where objects are related or classed by similarity, functions as a generalised operant, so that in a situation with similar contextual cues, a child may spontaneously put novel objects, that are the same colour or bear the same name, into a similar box. Although this new behaviour may be perceived as untrained, or emergent, it can be accounted for by referring to a prior learning history.

In this study, the participants are provided with such frames of co-ordination. In Phase 1 of the experiment, category training and testing with familiar objects, the participants are given experience with a number of contextual cues that should enable them to categorise successfully.

First, they have experience of the responses expected of them in the categorisation test with familiar stimuli, in that they are trained (if necessary) to supply two (and two only) matches when presented with the target stimulus. Second, they are given experience of the instruction "Look at this. Can you give Teddy the others?" (though not with the alternative prefix "What's this?"). Third, they are given experience of selecting those objects with the same name as the target object .

Relational Frame Theory should predict therefore, given this array of prior training and contextual cues, that there should be no differences in sorting behaviour in the categorisation test after listener training and that which follows speaker training. The results of this study show that this was not the case.

All six participants that did demonstrate successful categorisation only did so in the tests that followed speaker training, which would be contrary to the predictions of Relational Frame Theory. Only two of these six (JC and RE) however, categorised to the instructional cue, "Look at this" the other four requiring the alternative cue, "What's this?", thus prompting overt production of the names, before categorising. An explanation based on Relational Frame Theory could not account for the former two participants' results, yet may still question the latter data. It might be argued that this alternative instruction may have been the necessary contextual cue that enabled categorisation, with the prior training history (seemingly) being provided by real life experience with these kind of tasks.

However this alternative explanation cannot explain some of the other phenomena seen in these data, such as the naming behaviour exhibited by participants BH and MJ . Their categorisation was intimately linked with their naming behaviour, rather than being wholly consistent with the instruction used. Furthermore it cannot explain why, once initiated, categorisation was maintained when the instruction reverted to "Look at this", as seen in the results of BH, MJ and RE. An explanation based on naming theory would appear to be the most parsimonious explanation of these behaviours

This study was not without its procedural problems, the most significant being the question as to whether the listener training criterion levels were stringent enough. Another consideration was that the participants may not actually have learned the listener relations, rather that their performance could have depended on the experimenter's feedback to their selection on the first trial. For instance, if the experimenter corrected the first (incorrect) trial of an eight-trial block by saying, "No, that's a zog/vek", this would be a cue that would enable the child to perform successfully on the next seven trials, hence reaching criterion level performance.

This potential procedural flaw was countered in Experiment 3 by changing the criterion level so that participants would have to perform two successive blocks of trials per pairing, without any feedback from the experimenter. Also, a further test for maintenance of these relations was given after the categorisation test and probe for tacting.

As these changes were not implemented until Experiment 3, this must lead us to question the validity of the results of the listener training phase in Experiments 1 and 2. As established in the discussion section of Experiment 2, this factor did not appear to be of concern with participants LN and HW who both demonstrated reliable tacting after listener training. Given this demonstration of reliable tacting, one might infer that the listener relations were also intact. As discussed in Chapter 2, Harris' research (see Horne & Lowe, in press) suggests that when criterion level tact relations are established, corresponding listener relations are also exhibited.

In the case of participant CT, on the other hand, there may be a case of reasonable doubt as to whether he had indeed received an adequate amount of listener training. This is compounded by the fact that his own names for the stimuli tended to persist throughout all training.

As regards the participants in Experiment 1, both JC and BH received extra listener training trials after the initial criterion level had been reached with the mixed pairs of stimuli. In these extra trials they did not receive feedback to their responses and still reached criterion level performance. It seems therefore that it can be accepted that their listener relations were intact before the categorisation test was given.

Another issue that arises from the results of Study 1 will be discussed next. As noted, of the six participants who categorised after both listener and speaker training, four only categorised after receiving the alternative "What's this?" instruction. This instruction was only given in the categorisation tests after speaker behaviour training and not in the tests that followed listener training. It may then be the case that, if participants were given this extra instruction after listener training, they may well have categorised. This might seem to be a reasonable criticism. However, this instruction was not given after listener training and the "Look at this" categorisation test as it was the aim of the procedure to provide a more structured measure of derived tact relations by virtue of the scheduled probe for tacting trials.

* * *

The three experiments of Study 1 examined whether children from the ages of 1.5 years to 4.5 years would categorise when taught only one element of the naming relation, that is, a common listener response, to sets of arbitrarily shaped stimuli. This was an attempt to falsify naming theory as Horne and Lowe postulate that naming (i.e. the establishment of *both* listener and speaker relations) would be necessary to enable such categorisation to occur.

The results show clearly that those participants who did show evidence of categorisation of these objects into two classes consistent with the experimental names designated to those two classes, only did so when also showing concurrent evidence of both speaker and listener relations, that is the whole name relation.

A surprising finding of Study 1 was that the participants needed to be overtly taught the speaker element of the name relation before the whole name relation and hence categorisation could take place. This finding was in contrast to the expectations of Horne and Lowe who hypothesised that, at least in the older age groups of children represented in the study, training listener relations might also lead, without explicit training, to the exhibition of corresponding speaker behaviour. Most of the participants in Study 1 had also shown some level of echoing of the stimulus names during listener training; some had also shown evidence of spontaneous tacting, sometimes to the correct stimulus and sometimes not. This level of speaker behaviour was clearly not sufficient to bring about reliable tact relations and thereby naming.

Study 2 sought to examine whether the corresponding tact relations could be established without explicit training by increasing the operant level of the participant's echoic utterances. In Study 1 no reinforcement or feedback was given to the participants' spontaneous utterances which may have resulted in their failure to develop reliable tacting. By providing reinforcing consequences to their echoic responses, it might be expected that these responses would be strengthened, leading perhaps to a higher level of self-echoic or even covert echoic behaviour, both of which Horne and Lowe (1996 p.197) describe as being precursors of both tacting and hence naming behaviour.

To this end, Study 2 examined the effects of teaching two different echoic responses. First, a common echoic response was taught "off-task", that is when the experimental stimuli were hidden from view, concurrent with teaching a common listener response. A categorisation test followed and also probe trials to ascertain whether this added training had led to the establishment of tact relations.

Second, if the participant failed to categorise after this training, an "on-task" common echoic response (that is when the stimuli were in view and the link between the name and the object was stressed) was then taught. If the participant still failed to categorise or to develop tacting, common tact relations were then explicitly taught.

This study was exploratory in nature, in that no prediction was made as to when, or even if, tacting relations would be established by virtue of the additional echoic training. Naming theory would predict, however, that the participants would not categorise without evidence of the establishment of both listener relations and also tact relations.

CHAPTER 4

STUDY 2

WILL TEACHING LISTENER BEHAVIOUR, WITH CONCURRENT OFF-TASK ECHOIC TRAINING, YIELD CATEGORISATION?

EXPERIMENT 1

In Study 1, none of the nine participants categorised after listener training alone, yet six subsequently categorised after speaker training, that is after naming had been established. The purpose of the current experiment was to investigate whether additional echoic training would lead to the establishment of untrained tact relations, hence naming and categorisation. Participants, approximately three and a half to four and a half years of age, were taught listener relations between arbitrary auditory listener stimuli and arbitrary objects, whilst concurrently being taught to echo the listener stimuli off-task (i.e., not in the presence of the corresponding stimuli). If they were unable to demonstrate categorisation following this training, they were then taught to echo the listener stimulus in the presence of the corresponding stimuli and re-tested for categorisation. If this still was not sufficient to bring about categorisation, the participants were, finally, taught to tact the stimuli, that is, the whole name relation was established, and a final categorisation test given.

METHOD

Participants

Three participants took part. Table 4.1 shows, for each participant, their age and gender. All participants were given the Griffiths test to ascertain their normal development (reported at the end of each participant's result section). The MCDI test was not given to this age group.

Two of the participants received training with a second set of arbitrary stimuli. For these, any modifications of the above procedure will be addressed under the results section of the individual participant.

Table 4.1
Participants' sex and age

Participant	Sex	Age at start year: month	Age at first categorisation test year: month
TM	F	3: 09	3:10
HO	F	4: 01	4:02
LO	F	4: 02	4:05

F = female M = male

Procedure, Apparatus and Settings

The procedure, apparatus and settings employed in this experiment were as described in the General Method section, but with the following procedural exceptions. Also see Figure 4.1 for a flowchart.

OFF-TASK ECHOIC TRAINING.

At the start of *every session* of the listener training (Phases 1 and 2), the categorisation test (Phase 3), and the Probe for Tacting (Phase 4), the participants were given off task echoic training. This took the form of a general echoing game with the intention of giving the participant the opportunity to echo the words "zog" and "vek". These experimental words were presented three times each, in a randomised fashion and were interspersed with the echoing of six other familiar words. The familiar words were either taken at random from the MCDI questionnaire, or were nouns that the experimenter had heard the participant produce previously. Thus the participants were required to echo 12 names (six experimental and six familiar) in total in each session.

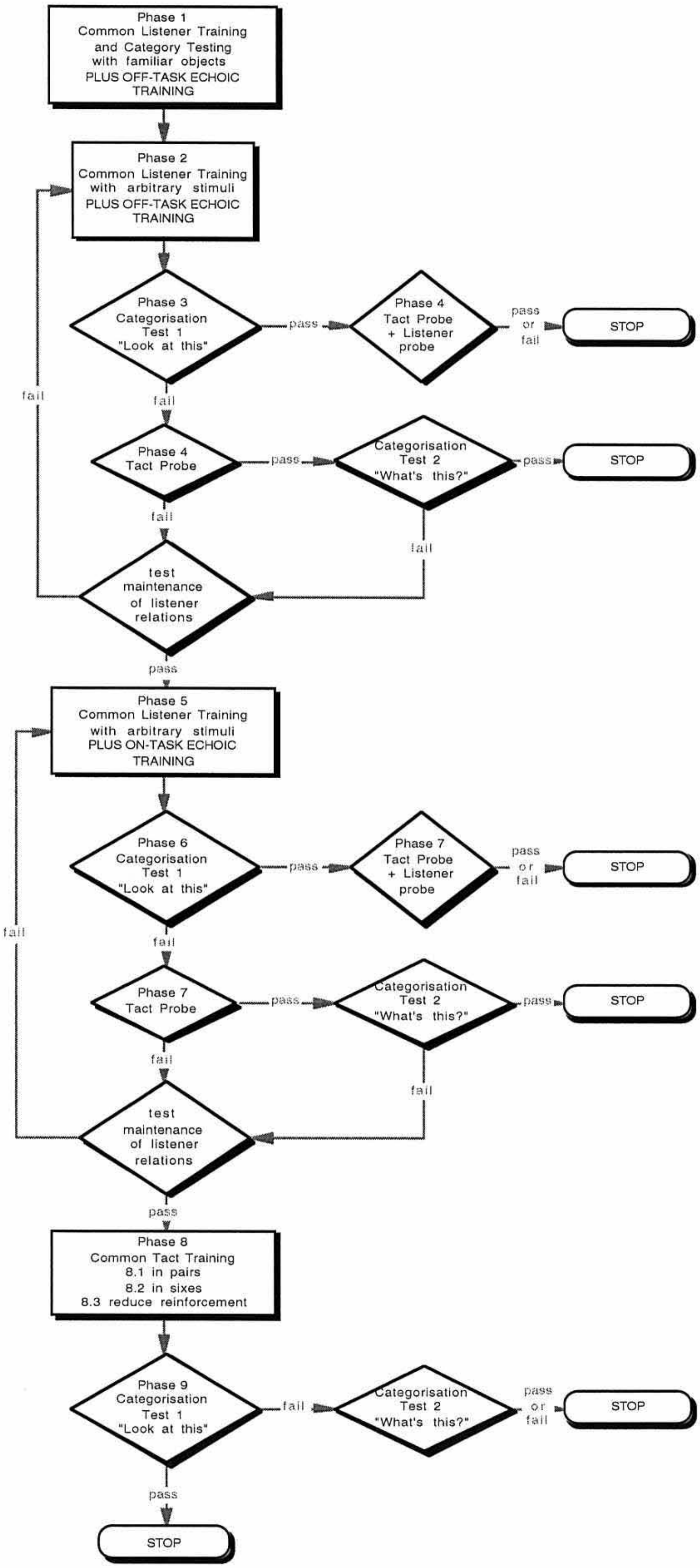


Figure 4.1: Flowchart representation of the procedure of Experiment 3.

At the beginning of this game, the experimenter said to the participant " We are going to play a silly game now. Can you say what I say? I am going to say [X][1]. What did I say? Can you say [X]?" When the child was used to this instruction, it became only necessary for the experimenter to say the target word for the participant to echo it immediately.

Reinforcement of the form "Good girl/boy, clever girl/boy" was given to all correct responses. However, when the participant correctly echoed "zog" or "vek" the strength of this reinforcement was increased, for example "That's very clever", accompanied by clapping. None of the experimental stimuli used in the main procedure were in sight of the participant during this game.

Outside of this echoic training session, if the child spontaneously produced or echoed one of the experimental names, the experimenter gave no special attention or reinforcement to the behaviour.

Details of the main procedure follow.

Phase 1: Common Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training

All stages of this phase were conducted as described in the General Method, with the exception that each session was preceded by off-task echoic training.

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

Stage 2.1: Common listener training.

This stage of this phase was conducted as described in Stage 2.1 of the General Method, each session being preceded by off-task echoic training.

---

[1] Where [X] is either one of the experimental names "Zog" or "Vek", or one of the other familiar words.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability.

This stage included the following changes to Stage 2.2 of the General Method. The stimuli were allocated to different pairs (e.g. Z1/V3, Z2/V1 and Z3/V2) and again presented to the participant as in Stage 2.1. However reinforcement was gradually reduced until the participants could respond correctly, to each pair of stimulus, without feedback to their responses. Criterion performance for this stage was met when the participant responded correctly on seven of eight trials in an eight-trial block, to all three stimulus pairs, with no feedback, over two blocks of trials per pair, and over two separate sessions. Each session was preceded by off-task echoic training.

Phase 3 : Categorisation Test Procedure.

All stages of this phase were conducted as described in Phase 3 of the General Method but were also preceded by off-task echoic training.

Phase 4: Probe for Tacting

All stages of this phase were conducted as described in Phase 4 of the General Method but were also preceded by off-task echoic training.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given, as described in Stage 2.2 above, for each pair without any reinforcement.

If the participant failed to demonstrate maintenance of the listener relations, she or he returned to Stage 2.2 of the procedure and this stage continued until criterion level performance was again shown. A repeat of Phase 3 was then given.

If the participant passed the test for categorisation, regardless of the outcome of the probe for tacting and check for maintenance that followed, all further procedures ceased. For participants who failed the categorisation test, the next phase of the experiment depended on the results of the probe for tacting.

i) If the participant failed the categorisation test, yet could demonstrate appropriate tacting, and also had demonstrated intact listener relations with all three stimulus pairs, then the whole name relation was deemed to have been established. In this case a repeat of the categorisation test was given. However this time the instruction was changed to "What's this? Can you give Teddy the others like this?" (Category Test 2).

When eighteen trials of the latter categorisation test had been completed, the participant was deemed to have completed all procedures, whether she or he passed or failed the test.

ii) If the participant failed the categorisation test and also failed to demonstrate appropriate speaker behaviour in the probe for tacting, although demonstrating intact listener relations with all three stimulus pairs, then she or he proceeded to Phase 5 of the experiment - listener plus on-task echoic training.

Phase 5: Common Listener Training with Arbitrary Stimuli and On-Task Echoic Training

Listener training (as in Stage 2.2) resumed with all three mixed stimulus pairs and reduction in reinforcement probability. However in this phase, instead of the echoic training preceding the comprehension training off-task, the participants were prompted to echo in the presence of the stimulus.

The experimenter pointed to the target stimulus and said "Can you give Teddy the zog/vek.....What did I say?", thus encouraging the child to echo the stimulus name. Correct responses were initially reinforced with praise the frequency of which was gradually reduced until the participants could respond correctly without reinforcement.

Criterion performance was met when the participant responded correctly (that is demonstrating both correct listener behaviour and correct echoing) on seven of eight trials, to all three stimulus pairs, in one session, and with no feedback.

Phase 6: Repeat of Categorisation Test 1

All stages of this phase were conducted as described in Phase 3 of the General Method.

Phase 7: Repeat of the Probe for Tacting

All stages of this phase were conducted as described in Phase 4 of the General Method .

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given, as described in Phase 5 above, for each pair without any reinforcement.

If the participant failed to demonstrate maintenance of the listener relations, she or he returned to Phase 5 of the procedure until criterion level performance was again shown. A repeat of the categorisation test (Phase 6) was then given.

If the participant passed the repeat test for categorisation, regardless of the outcome of the probe for tacting that followed, all further procedures ceased. For participants who failed the categorisation test, the next phase of the experiment depended on the results of the probe for tacting.

i) If the participant failed the categorisation test, yet could demonstrate appropriate speaker behaviour (tacting), and also had demonstrated intact listener relations with all three stimulus pairs, then Category Test 2 was given, using the "What's this? Can you give Teddy the others like this?" instruction.

When eighteen trials of the latter categorisation test had been completed, the participant was deemed to have completed all procedures, whether she or he passed or failed the test.

ii) If the participant failed the categorisation test and also failed to demonstrate appropriate speaker behaviour in the probe for tacting, then she or he proceeded to Phase 8 of the experiment - common tact training.

Phase 8: Common Tact Training with Arbitrary Stimuli

Stage 8.1: Common Tact Training with Arbitrary Stimuli - In Pairs.

This stage was conducted as described in Stage 5.1 of the General Method. Corrective feedback was given to the participant's responses where necessary. Criterion level performance for this stage was reached when the participant scored at least seven correct trials in each eight-trial block for all three pairs.

Stage 8.2: Common Tact Training with Arbitrary Stimuli - In Sixes.

This stage was conducted as described in Stage 5.2 of the General Method.

Stage 8.3: Reduction in reinforcement probability.

This stage was conducted as described in Stage 5.3 of the General Method.

Phase 9: Repeat of Categorisation Test 1

All stages of this phase were conducted as described in Phase 3 of the General Method. If the participant passed the repeat test for categorisation, all further procedures ceased.

For participants who failed the categorisation test, eighteen test trials of Category Test 2 were repeated, using the "What's this? Can you give Teddy the others like this?" instruction. After this further test, whether the participant categorised successfully or not, she or he was deemed to have completed all procedures.

RESULTS

Table 4.2 shows the data, for all 3 participants, of the first experimental phase. Data will be presented as individual graphs from Phase 2 onwards.

Phase 1: Common Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training

Table 4.2 shows the number of 8-trial blocks each participant required in order to achieve criterion performance in Stage 1.1 listener relation learning for each of 3 familiar object (hat and cup) pairs.

Table 4.2

Results of Phase 1: Common listener training and category training with familiar objects. In Stage 1.1, H1/C1, H2/C2 and H3/C3 refer to the three familiar object (hat and cup) pairs. Two instructions were used in Stage 1.2, "Look at this. Can you give me the others like this?" and "Look at this. Can you give me the other hats/cups?" The total number of blocks to criterion have been split between these two instructions (for more details see procedure).

	Stage 1:1 Common listener training in pairs			Stage 1:2 Categorisation test	
Participant	H1/ C1	H2/C2	H3/C3	"hats & cups"	"Others"
TM	1	1	1	0	1
HO	1	1	1	0	1
LO	1	1	1	0	1

Table 4.2 also shows the number of six-trial blocks required to achieve criterion performance in Stage 1.2 familiar object categorisation.

All 3 participants learned to categorise the hats and cups appropriately in response to the instruction, "Look at this. Can you give me the others like this?", and progressed to Phase 2 of the experiment. None of the participants needed the alternative instruction, "What's this? Can you give me the others like this?".

Participant TM

This participant completed the procedure with two arbitrary stimulus sets, Set 1 and Set 2. Data for her performance when Set 1. stimuli were employed are shown in Figure 4.2.1 below.

Stimulus Set 1.

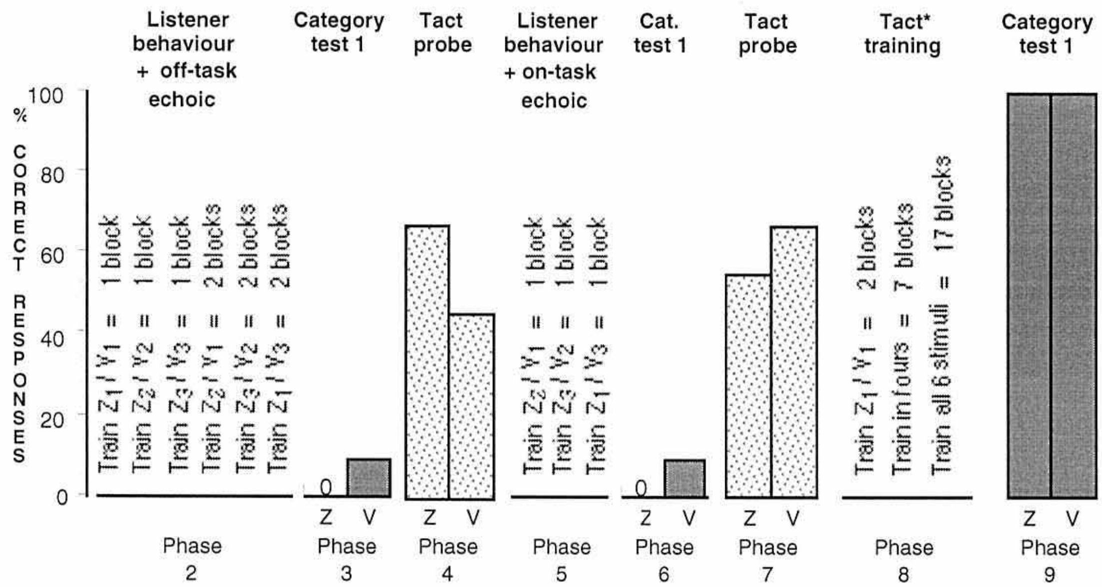


Figure 4.2.1. Results of Participant TM (Stimulus Set 1). The training phases (Phases 2,5 and 8) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 7), and category re-testing (Phases 6 and 9).
* In tact training (Phase 8), changes were made to the general procedure, see results section for details.

Phase 1: Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training

Participant TM required only one block of eight trials for each of the 3 stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 4.2).

In Stage 1.2 category training with familiar objects, she required one six-block trial using the instruction, "Look at this. Can you give Teddy the others like this?"

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

TM required 1 eight-trial block to demonstrate criterion listener relation learning with all three stimulus pairs.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. She required 2-eight trial blocks to demonstrate criterion performance with all three mixed pairs of stimuli (Z2/V1, Z3/V2 and Z1/V3).

Phase 3: Categorisation Test 1

TM completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.03>0.01).

TM seemed to be employing a selection strategy in the test trials, as in all 18 trials, she chose two stimuli from the front row of the array.

Phase 4: Probe for Tacting

TM could produce the sounds "zog" and "vek", however she could not do this to criterion level. Her scores out of three probe trials, for each stimulus are presented below.

Z1 - zero correct trials	V1 - one correct trial
Z2 - three correct trials	V2 - two correct trials
Z3 - three correct trials	V3 - one correct trial

Overall she scored 66 percent correct with the zog stimuli and 44 percent correct with the vek stimuli.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement. TM reached criterion level performance with all three pairs.

Phase 5: Common Listener Training with Arbitrary Stimuli and On-Task Echoic Training

TM reached criterion level performance, with all three pairs of stimuli, in one eight-trial block each.

Phase 6: Repeat of Categorisation Test 1

TM completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.03>0.01).

Again, TM seemed to employ the same selection strategy as in the previous categorisation test, that is, in all but one of the 18 trials, she chose two stimuli from the front row of the stimulus array.

Phase 7: Repeat of the Probe for Tacting

Again TM could produce the sounds "zog" and "vek", but not to criterion level. Her scores out of three probe trials, for each stimulus are presented below.

Z1 - one correct trial	V1 - one correct trial
Z2 - one correct trial	V2 - two correct trials
Z3 - three correct trials	V3 - three correct trials

Overall she scored 55 percent correct with the zog stimuli and 66 percent correct with the vek stimuli.

Phase 8: Common Tact Training.

Stage 8.1: Common tact training with arbitrary stimuli- in pairs. TM required two eight-trial blocks to demonstrate criterion speaker behaviour with pair Z1/V1. She was then given two blocks of training trials with pair Z2/V2 and one block with pair Z3/V3, however she would not concentrate on the tasks and tended to behave in a distracted manner. Therefore, in an attempt to regain her concentration, it was decided to present the objects in a four stimulus array, consisting of the Z1/V1 and Z2/V2 pairs.

Each of the four stimuli within this array was targeted in turn which constituted one trial block and corrective feedback was given when necessary. Seven of these four-trial blocks were needed before TM was able to produce the correct response to each of the four stimuli in the array correctly, and also show this correct performance over three blocks of trials. Her correct responses were reinforced by praise.

TM then proceeded to Stage 8.2.

Stage 8.2: Common tact training with arbitrary stimuli - in sixes. TM required 17 six-trial blocks to reach criterion level performance, that is when she responded with 100 percent accuracy over three blocks of trials with no feedback.

Phase 9: Repeat of Categorisation Test 1

TM completed another 18 trials of the categorisation test using the "Look at this, can you give me the others" instruction. Over all 18 trials she demonstrated 100 percent correct responses, that is, 9 of 9 correct responses when a zog stimulus was the target, and 9 of 9 correct when the vek stimulus was a target. The probability that this would occur by chance is low and statistically significant (N =18, P (18) = 0.00<0.01.

Spontaneous verbal behaviour: Stimulus Set 1.

During all procedures, TM did not spontaneously produce any of the experimental names. On two occasions she gave her own name to the stimuli, saying "it's like a jigsaw" to stimulus Z1 (), and "it's like a girl to Z2 ().

Summary: Stimulus Set 1

Teaching common listener relations, with either off-task or on-task echoic practice of the experimental names, does not appear to have been sufficient for the categorisation of physically different stimuli into two sets to occur. This added echoic experience did not result in accurate tacting of the experimental names in the two probes for tacting that followed the categorisation tests.

TM did not categorise until she was taught a common tact response to the arbitrary stimuli. These results support the naming hypothesis, in that only when evidence of both reliable tact and listener relations (that is, naming), was demonstrated, did categorisation also occur.

Stimulus Set 2.

As TM proved to be a quick learner, listener relations were trained to a second set of stimuli. These were physically dissimilar, both to each other and to the Set 1 stimuli. The same class labels, zog and vek, were utilised; henceforth Set 2 exemplars are termed Z4, Z5, Z6, V4, V5, and V6.

The procedure was the same as for Stimulus Set 1 with the exceptions that Phase 1, listener training with familiar stimuli, was omitted. Also, changes were made to Phase 8 of the procedure, common tact training. In the procedure for the first stimulus set, common tact training was given with all six stimuli present, before then testing for categorisation. However, with Stimulus Set 2, it was decided that it would be interesting to examine if successful categorisation would be observed when tact training was given solely in pairs.

The changes to the procedure are outlined below.

Phase 8: Common Tact Training with Arbitrary Stimuli - In Pairs.

This phase was conducted as described in Stage 5.1 of the General Method. Corrective feedback was given to the participant's responses until she had reached criterion level performance with all three pairs, that is scoring at least seven correct trials in each eight-trial block.

Corrective feedback to TM's responses was then withdrawn. Criterion level performance for this stage was reached when she scored at least seven correct trials in each eight-trial block for all three pairs, without feedback, twice in succession over two separate sessions.

Phase 9: Repeat of Categorisation Test 1

All stages of this phase were conducted as described in Phase 3 of the General Method, using the "What's this? Can you give Teddy the others like this?" instruction.

After this test all procedures ceased.

Results: Stimulus Set 2.

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

TM required 1 eight-trial block to demonstrate criterion listener relations with all three initial pairs Z4/V4, Z5/V5, and Z6/V6.

She required 3 eight-trial block to demonstrate criterion performance with all three mixed pairs (Z5/V6, Z4/V5 and Z6/V4). The last two blocks for each pairing were performed without feedback to her responses.

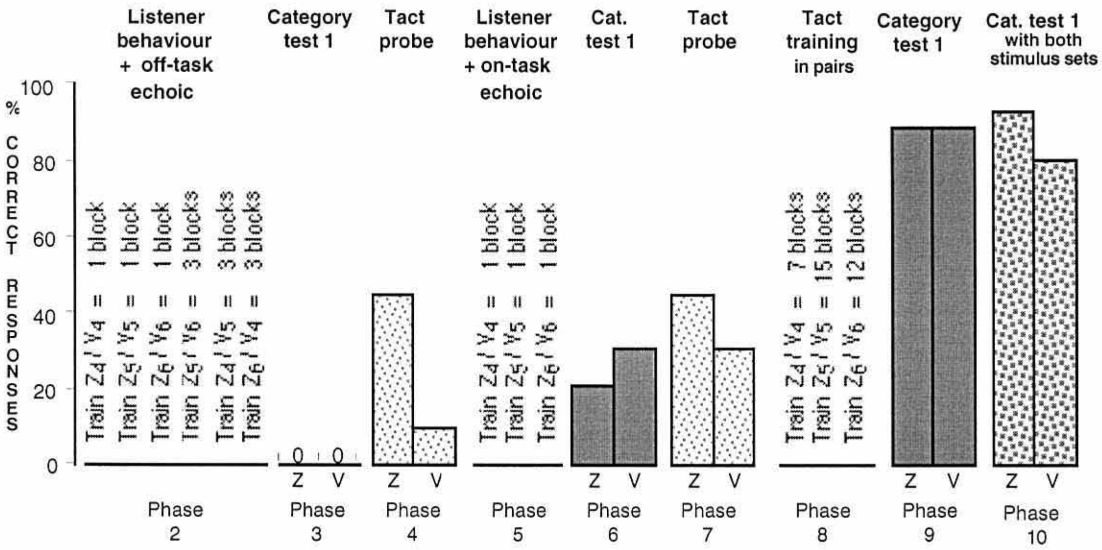


Figure 4.2.2. Results of Participant TM (Stimulus Set 2). The training phases (Phases 2,5 and 8) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 7), and category re-testing (Phases 6 and 9).

Phase 3: Categorisation Test 1.

TM completed 18 trials of the categorisation test using the "Look at this" instruction. She failed to perform any of the test trials correctly. She still appeared to be employing her selection strategy of choosing the stimuli that were at the front of the array or nearest to her right hand.

Phase 4: Probe for Tacting

TM could produce the sounds "zog" and "vek", but she could not do this to criterion level. She was given two six-trial probe blocks, but said "don't know" to all six trials in the second block. It was then decided to repeat the probe trials in pairs. Each of the zog/vek pairs was presented in turn and four trials with each pair was given where she was asked, "What's this?"

The data shown for Phase 4 in Figure 4.2.2 show the combined results from the above probe trials, that is, when each stimulus had been targeted three times each. The second six-trial block, where she said "don't know", was discounted from these data. Her verbalisations for each stimuli are presented below.

Z4 - She said "zog" once and "don't know" twice.

Z5 - She said "don't know" once and "number seven" twice.

Z6 - She said "zog" in all three trials.

V4 - She said "don't know" twice, and "zog" once.

V5 - She said "don't know" in all three trials.

V6 - She said "vek" twice and "number eight" once.

Overall she scored 44 percent correct with the zog stimuli and 11 percent correct with the vek stimuli.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. TM reached criterion level performance with all pairs Z4/V4 and Z/6/V6 in one eight-trial block without any reinforcement. However with pair Z5/V5, she gave the wrong stimulus during the first four trials but then corrected herself and gave the correct stimuli in all of a further eight trials. Therefore it was accepted that she was able to maintain accurate listener behaviour to all three stimulus pairs.

Phase 5: Common Listener Training with Arbitrary Stimuli and On-Task Echoic Training

TM reached criterion level performance, with all three pairs of stimuli, in one eight-trial block each.

Phase 6: Repeat of Categorisation Test 1

TM completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 22 percent correct in trials where a zog stimulus was the target (2 of 9) and 33 percent correct in trials when a vek stimulus was the target (3 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (5) = 0.02>0.01).

Phase 7: Repeat of the Probe for Tacting

Again, TM said "don't know" to all six trials in the first six-trial block. The probe trials in pairs were then repeated. Each of the zog/vek pairs was presented in turn and six trials with each pair were given so that each stimulus was targeted three times. The six-trial block, where she said "don't know", was discounted from these data.

Her verbalisations for each stimulus are presented below.

Z4 - She said "zog" once and "don't know" once and "vek" once.

Z5 - She said "zog" in all three trials.

Z6 - She said "don't know" on one trial and "vek" in one trial.

V4 - She said "zog" once and "don't know" once and "vek" once.

V5 - She said "vek" once and "zog" twice.

V6 - She said "vek" twice and "zog" once.

Overall she scored 44 percent correct with the zog stimuli and 33 percent correct with the vek stimuli.

Phase 8: Common Tact Training with Arbitrary Stimuli- In Pairs and Reduction in Reinforcement Probability.

TM required 7 eight-trial blocks to demonstrate criterion level performance to pair Z4/V4; 15 blocks to pair Z5/V5 and 12 blocks to pair Z6/V6.

Criterion level performance for this stage was reached when she scored at least seven correct trials in each eight-trial block for all three pairs, without feedback, twice in succession over two separate sessions.

Phase 9: Repeat of Categorisation Test 1

TM completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 89 percent correct in trials where a zog stimulus was the target (8 of 9) and 89 percent correct in trials when a vek stimulus was the target (8 of 9). The probability that this would occur by chance is low and statistically significant (N =18, P (18) = 0.00<0.01).

In 10 of the 18 categorisation test trials, TM overtly produced the names of the stimuli she selected. For example, in the first trial she said "zog" as she handed both the matching stimuli to the experimenter. This was the first categorisation test in which this behaviour was evidenced.

Spontaneous verbal behaviour: Stimulus Set 2.

During Phase 2 listener training, TM spontaneously produced the experimental names on only 3 occasions where she made tact responses to the vek stimuli. She also called stimulus Z5 (), "number seven" on one occasion.

During the remainder of the procedures, she tacted the experimental names on three other occasions and also repeated her naming of stimulus Z5 as "number seven" on two occasions.

Phase 10: Categorisation Test 1 with all 12 Stimuli.

After TM had completed all procedures with both sets of stimuli, it was decided to investigate her ability to categorise further. To this end, a further 30 trials of Category Test 1, using the "Look at this" instruction, were given. This time however, in each test trial, all 12 stimuli that made up Stimuli Sets 1 and 2 were presented. As in the usual categorisation test trials, one stimulus was selected as target and TM was asked to give the others from the remaining array of 11 stimuli.

These test trials were conducted over five separate sessions, and prior to each session maintenance of her tacting was tested for each of the two stimulus sets in turn. In these, the six stimuli that made up one set were presented together, and she was asked "What's this?" to each in turn (as in Stage 6.1 of the General Method). This represented one six-trial block. This was then repeated with the stimuli from the second stimulus set. One trial was given where all 12 stimuli were placed in front of her, however she became confused with the amount of stimuli, and all future tests were given in six stimulus arrays.

As will be described in detail below, TM did not reach criterion level performance in all of the maintenance of tacting trials. However, as this Phase was purely exploratory, and TM was beginning to tire of the procedure, it was decided, out of pure curiosity, to continue with the subsequent categorisation test trials. Throughout the following procedures, no extra training or feedback was given.

Of the 30 categorisation test trials, she categorised correctly on 26 occasions. She scored 93 percent correct in trials where a zog stimulus was the target (13 of 14) and 81 percent correct in trials when a vek stimulus was the target (13 of 16).

In the incorrect trials she gave a mixture of zog and vek stimuli on two occasions and in the remainder she gave the wrong number of stimuli. However, interestingly on these latter two trials, she still appeared to be categorising in accordance with the target stimulus' name. To illustrate, in one of these trials she only gave the experimenter four, instead of the required five stimuli; however, these four were all stimuli of the same name as the target stimulus. In the other trial she gave six stimuli, the first five of which were all of the same name as the target.

Of the four incorrect test trials, three of these occurred in the first category test session.

Her performance on the pre-test for tacting, however, was inconsistent. Over the five sessions she was required to give the names for the stimuli on 84 occasions, but she only produced the correct name on 66 of these trials (79%). Table 4.3 shows her performance over all the tact test trials. As can be seen from the table, in two of the five sessions given, she was given more than one six-trial block, in order to see if her performance would improve with that particular stimulus set.

Table 4.3
Participants TM's tact response scores in the five tact testing sessions that preceded each categorisation test with 12 stimuli. Each cell of the table represents the number of times a zog or vek was targeted per session and also the number of correct trials obtained. Also results of the categorisation test trials. Each cell represents the number of correct trials obtained.

	Tact Test Trials				Categorisation Test
	Stimulus Set 1		Stimulus Set 2		number of trials performed correctly
Session	"Zogs"	"Veks	"Zogs"	"Veks"	
1	1 of 3	2 of 3	3 of 3	3 of 3	1 of 4
2	1 of 3	2 of 3	3 of 6	3 of 6	4 of 4
3	6 of 6	6 of 6	5 of 9	8 of 9	10 of 11
4	3 of 3	3 of 3	2 of 3	3 of 3	5 of 5
5	3 of 3	3 of 3	3 of 3	3 of 3	6 of 6
Totals	14 of 18#	16 of 18*	16 of 24#	20 of 24*	26 of 30
Percentages	78%	89%	67%	83%	87%

* Significant at 0.01 level
\# Significant at 0.05 level

On analysis however, her tacting behaviour was shown to be was statistically significant. The total number of correct trials for all the stimuli of Set 1 was 30 out of a possible 36, and according to binomial theory this is statistically significant (N =36, P (30) = 0.00<0.01). The total number of correct trials for all the stimuli of Set 2 was 36 out of a possible 48, this too being statistically significant (N =48, P (36) = 0.00<0.01).

Griffiths Test

The result of TM's Griffiths test gave a GQ of 123. This score is in the normal range for her age.

Spontaneous verbal behaviour: Extra Category Test with Stimulus Sets 1 and 2 Combined.

In the first (correct) trial she said, "that's a zog" as she gave the first stimulus to the experimenter. On the thirteenth (correct) trial, she said "vek" as she handed the first match. On the fifteenth (correct) trial she said, " These are zogs" on three occasions as she gave the stimuli. On the thirtieth (correct) trial, she said "vek" as she handed over the first stimulus. All her vocalisations took the form of tacts and were all produced to the correct stimuli.

Summary: Stimulus Set 2

By the end of the procedure for Set 1, TM had been taught both elements of the name relation, that is, listener and tacting relations. After receiving listener training to the Set 2 stimuli, TM had learned a listener class encompassing the listener stimuli (/zog/ and /vek/) for both Set 1 and Set 2 stimuli. She had also received additional echoic training, both on-task and off-task, of the experimental names.

It may have been expected that her tacting repertoire would have then extended to encompass the Set 2 stimuli, enabling naming, and hence categorisation, to occur. This was not the case.

TM did not show evidence of categorisation of the Set 2 stimuli, nor of successful performance on the probes for tacting until the tact relations were directly trained. However, after this, that is after the whole name relation had been established, she categorised successfully and without the need to overtly produce the stimulus names during the categorisation test.

In the extra categorisation test trials, which used all 12 of the experimental stimuli, TM showed successful categorisation of the stimuli into two classes consistent with the zog and vek names. This was accomplished without any further listener or speaker training. In the pre-tests for tacting, however, her naming of the stimuli was erratic and this shall be discussed further in the discussion section that follows this experiment.

Participant HO

This participant also completed the procedure with two arbitrary stimulus sets, Set 1 and Set 2. Data for her performance when Set 1 stimuli were employed are shown in Figure 4.3.1 below.

Stimulus Set 1.

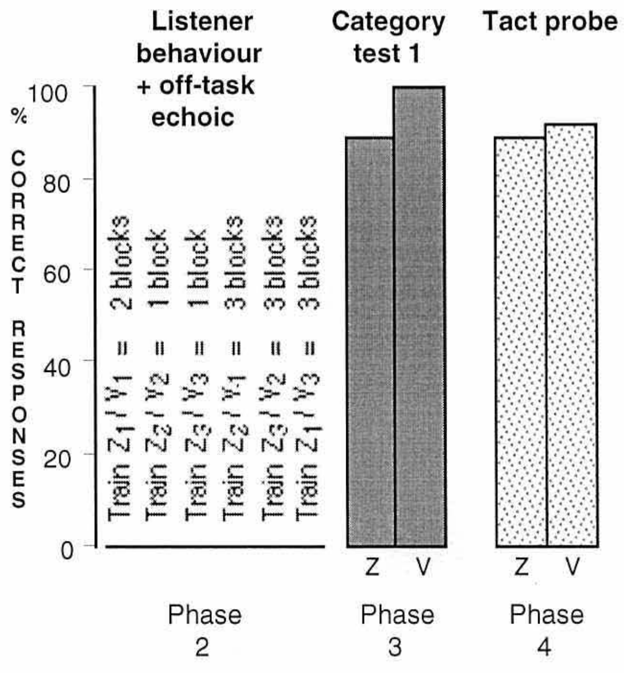


Figure 4.3.1. Results of Participant HO (Stimulus Set 1). Training phase 2 gives the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), and probe for tacting (Phase 4)

Phase 1: Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training

Participant HO required only one block of eight trials for each of the 3 stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 4.2). In Stage 1.2 category training with familiar objects, she required one six-block trial using the instruction, "Look at this. Can you give Teddy the others like this?"

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

Stage 2 1: Common listener training with initial pairs. HO required 2 eight-trial blocks to demonstrate criterion listener relation learning with pair Z1/V1 and 1 block each with pairs Z2/V2 and Z3/V3.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. She required 3-eight trial blocks to demonstrate criterion performance with all three mixed pairs of stimuli (Z2/V1, Z3/V2 and Z1/V3), that is, when she had responded correctly on seven of eight trials, to all three stimulus pairs, with no feedback, over two blocks of trials per pair, and over two separate sessions.

Phase 3: Categorisation Test 1

HO completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 89 percent correct in trials where a zog stimulus was the target (8 of 9) and 100 percent correct in trials when a vek stimulus was the target (9 of 9). The probability that this would occur by chance is low and statistically significant ($N = 18$, $P\ (17) = 0.00 < 0.01$.

Phase 4: Probe for Tacting

TM could produce the experimental names "zog" and "vek". Her scores out of the first three blocks of six probe trials, for each stimulus are presented below.

Z1 - one correct trial	V1 - two correct trials
Z2 - two correct trials	V2 - two correct trials
Z3 - three correct trials	V3 - three correct trials

This performance was not to the set criterion level, and therefore another three six-trial probe blocks were given. On these next three blocks, she did in fact give the correct name to each of the stimuli on every trial and without further reinforcement or training.

As a check to establish whether HO could indeed maintain correct tacting of the stimulus names, another three blocks of probe trials were given in the next day's session. She did not receive any extra training or feedback between these sessions. This time HO gave the correct name to all six stimuli on all three six-trial blocks.

Figure 4.3.1 (Phase 4) gives the totals for all nine blocks of probe trials conducted. Her total scores on all nine probe trials, for each stimulus are detailed below.

Z1 - seven of nine correct	V1 - eight of nine correct
Z2 - eight of nine correct	V2 - eight of nine correct
Z3 - nine of nine correct	V3 - nine of nine correct

In total, she scored 24 of 27 correct trials (89%) where a zog stimulus was a target, and 25 of 27 (93%) correct when a vek stimulus was a target. It was accepted that HO could tact reliably and that therefore naming had been established.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement and she reached criterion level performance with all three pairs.

Spontaneous verbal behaviour: Stimulus Set 1.

HO spontaneously produced the experimental names on one occasion, saying, "which one's the vek?" when asked to give the vek during listener training. She gave her own name to the stimulus Z1 () on three occasions, saying it looked like a "bird", a "zed" and "a sun". She gave no other spontaneous vocalisations.

Summary: Stimulus Set 1

HO demonstrated successful categorisation of the stimuli into two classes consistent with the experimental names after common listener training plus off-task echoic training was given. However, in the probe for tacting that followed the categorisation test, she also demonstrated reliable tact relations, that is, the whole name relation. Her results therefore support the hypothesis that categorisation would only occur with concurrent evidence of naming, that is, the establishment of listener and tact relations.

Stimulus Set 2.

HO had demonstrated categorisation of the stimuli in Set 1 after listener relations plus concurrent off-task echoic relations had been trained. As she had completed the procedures very quickly, it was decided to train her with a second set of stimuli. This time, however, listener relations were first trained *without* additional echoic training, and different class names were used for the stimuli.

The second set of six stimuli were physically dissimilar, both to each other and to the Set 1 stimuli. The class labels, *pab* and *lud*, were utilised (henceforth these are termed P1, P2, P3, L4, L5, and L6).

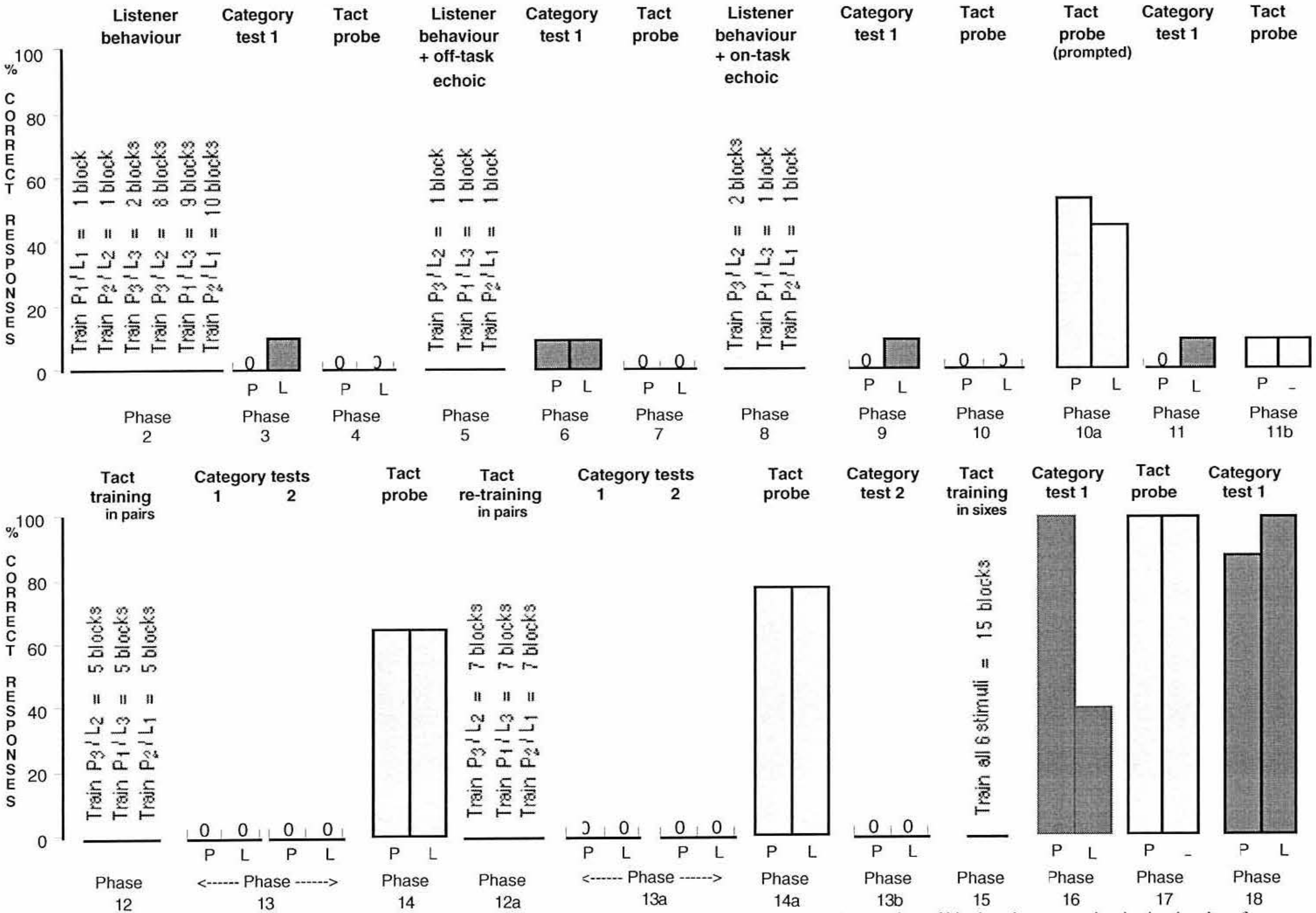


Figure 4.3.2. Results of Participant HO (stimulus Set2): The training phases (Phases 2,5, 8, 12,and 12a) give the number of blocks taken to reach criterion level performance. The test phases show the percentage correct responding during category testing and re-testing (Phases 3, 6, 9 11, 13, 13a, 13b, 16, and 18), and the probes for tacting (Phases 4, 7, 10, 10a, 11b, 14, 14a, and 17).

Phase 1 was omitted from the procedure for Stimulus Set 2 and due to the addition of the listener training without concurrent echoic training phase, certain alterations were made to the procedure. The Phases in this report therefore do not conform to those of the stated procedure for Experiment 1. All procedural changes will be specified in the headings of each phase reported.

Phase 2: Common Listener Training with Arbitrary Stimuli.- Without Concurrent Echoic Training

Stage 2 1: Common listener training with initial pairs. HO required 1 eight-trial block to demonstrate criterion listener relations with initial pairs P1/L1 and P2/L2, and two blocks with pair P3/L3.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. She required 8 eight-trial blocks to demonstrate criterion listener relations with mixed pair P3/L2; 9 blocks with pair P1/L3; and 10 blocks with pair P2/L1.

Phase 3: Categorisation Test 1

HO completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a pab stimulus was the target (0 of 9) and 11 percent correct in trials when a lud stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.03>0.01).

Phase 4: Probe for Tacting

HO did not produce the names pab or lud to any of the six stimuli. However she did produce the words "vek" and "thee". The words produced for each stimulus are presented below.

P1 - she produced the word "vek" twice and "thee" once.

P2 - she produced the word "vek" once and "thee" twice.

P3 - she produced the word "vek" twice and "thee" once.

L1 - she produced the word "vek" three times.

L2 - she produced the word "vek" twice and "thee" once.

L3 - she produced the word "vek" three times.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement. She reached criterion level performance with all three pairs.

Phase 5: Common Listener Training With Concurrent Off-Task Echoic Training

As HO had failed to demonstrate categorisation, listener training with concurrent off-task echoic training commenced. One eight-trial training block was given for each pair without reinforcement. HO reached criterion level performance, with all three pairs of stimuli (P3/L2, P1/L2, and P2/L1).

Phase 6: Repeat of Categorisation Test 1.

HO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 11 percent correct in trials where a pab stimulus was the target (1 of 9) and 11 percent correct in trials when a lud stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (2) = 0.28>0.01).

Phase 7: Repeat of the Probe for Tacting

Again, HO did not produce the names pab or lud to any of the six stimuli. However she did produce the words "vek" and "thee". The words produced for each stimulus are presented below.

P1 - she produced the word "vek" on all three trials.

P2 - she produced the word "vek" twice and "thee" once.

P3 - she produced the word "vek" twice and "thee" once.

L1 - she produced the word "vek" once and "thee" twice.

L2 - she produced the word "vek" once and "thee" twice.

L3 - she produced the word "vek" twice and "thee" once.

Phase 8: Common Listener Training with Arbitrary Stimuli With Concurrent On-Task Echoic Training

HO reached criterion level performance, with pair P3/L2 in two eight-trial blocks, followed by one block for pair P1/L3, and one block for pair P2/L1.

Phase 9: Repeat of Categorisation Test 1

HO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a pab stimulus was the target (0 of 9) and 11 percent correct in trials when a lud stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance ($N = 18$, $P\ (1) = 0.3 > 0.01$).

Phase 10: Repeat of the Probe for Tacting

Again, HO did not produce the names pab or lud to any of the six stimuli; she persisted in using the words "vek" and "thee". These data are represented in Figure 4.3.2 (Phase 10). The words produced for each stimulus are presented below.

P1 - she produced the word "vek" once and "thee" twice.

P2 - she produced the word "vek" twice and "thee" once.

P3 - she produced the word "vek" once and "thee" twice.

L1 - she produced the word "vek" once and "thee" twice.

L2 - she produced the word "thee" in all three trials.

L3 - she produced the word "vek" once and "thee" twice.

Following the probe for tacting, a check for maintenance of the trained listener relations plus on-task echoic was given to each of the three pairs of arbitrary stimuli. One eight-trial block was given for each pair without any reinforcement. She reached criterion level performance with all three pairs.

Phase 10a: Repeat of the Probe for Tacting

It was decided to give HO another three six-trial blocks of probe trials. Prior to this, however, she was told that some of the stimuli were called pab and some were called lud. These trials were conducted to see if the interference caused by the "vek" name could be eradicated. This time, she did produce the experimental words, but did not do so reliably. She scored 56 percent (5 of 9) correct when the pab stimuli were targeted, and 44% (4 of 9) correct for the lud stimuli. These data are represented in Figure 4.3.2 (Phase 10a). The words produced for each stimulus are presented below.

P1 - she produced the word "pab" on all three trials.

P2 - she produced the word "pab" twice and "lud" once.

P3 - she produced the word "lud" once and "vek" twice.

L1 - she produced the word "pab" once and "lud" twice.

L2 - she produced the word "vek" once and "lud" twice.

L3 - she produced the word "vek" once, "lud" once, and "thee" once.

Another check for maintenance of the trained listener relations plus on-task echoic was given to each of the three pairs of arbitrary stimuli. One eight-trial block was given for each pair without any reinforcement. She reached criterion level performance with all three pairs.

Phase 11: Repeat of Categorisation Test 1

To examine if the extra prompted probe trials and following test for maintenance of listener plus on-task echoic relation would have an effect on her categorisation behaviour, HO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She, again, scored 0 percent correct in trials where a pab stimulus was the target (0 of 9) and 11 percent correct in trials when a lud stimulus was the target (1 of 9).

Phase 11b: Repeat of the Probe for Tacting

Another probe for tacting was given. In the first six-trial block, she persisted in using the words "vek" and "thee". Therefore, prior to the second block, the experimenter told her that some were called pab and some were called lud. She scored 11 percent (1 of 9) correct when the pab stimuli were targeted, and 11% (1 of 9) correct for the lud stimuli. These data are represented in Figure 4.3.2 (Phase 11b). The words produced for each stimulus are presented below.

P1 - she produced the word "lud" once and "vek" twice.

P2 - she produced the word "vek" once, "pab" once, and "thee" once.

P3 - she produced the word "lud" once, "vek" once, and made no response on the third trial.

L1 - she produced the word "vek" once, "pab" once, and "thee" once.

L2 - she produced the word "vek" once, "pab" once, and "thee" once.

L3 - she produced the word "vek" twice and "lud" once.

Common tact training in pairs then commenced.

Phase 12: Common Tact Training with Arbitrary Stimuli- in pairs.

HO required five eight-trial blocks to demonstrate criterion speaker behaviour to all three pairs. The last two blocks for each pair were given without reinforcement and were conducted in separate sessions.

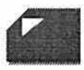
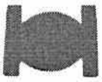
Phase 13: Repeat of Categorisation Test 1 and also Categorisation Test 2

HO completed another 18 categorisation test trials. The first nine used the "Look at this. Can you give me the others?" instruction. She did not categorise correctly in any of these trials.

In the next nine trials the instruction was changed to, "What's this? Can you give me the others?". Again, she did not categorise correctly in any of these trials. She only produced the correct name for the target stimulus on five out of the nine occasions to do so and was very slow in producing these names.

On analysis of her selections in all 18 trials, it appeared that HO was systematically categorising the stimuli, but not in a manner consistent with the pab and lud experimental names. In 16 out of the 18 trials she categorised according to the following stimulus sets.

Set A: consisted of stimuli: P3 , L1 , and L2 

Set B: consisted of stimuli: P1 , P2 , and L3 

This categorisation was significant ($N = 18$, $P(16) = 0.00 < 0.01$). On inspection of the previous categorisation tests, it was found that HO had not used this categorisation strategy before; any prior occurrence of this form of categorisation was purely random. For example, in the categorisation test that immediately preceded the present one, HO only showed this form of categorisation on 4 out of 18 trials. This performance was as would be expected by chance ($N = 18$, $P(4) = 0.07 > 0.01$).

Phase 14: Repeat of the Probe for Tacting

Another three six-trial blocks of the probe for tacting were given to check HO's maintenance of the tact relations. This time she did produce the experimental names for the stimuli, but not to criterion level. In total she produced the correct name for the pab stimuli on 6 of 9 (67%) trials and the correct name for the lud stimuli on 6 of 9 (67%) trials. The words produced for each stimulus are presented below.

P1 - she produced the word "lud" once and "pab" twice.

P2 - she produced the word "pab" on all three trials.

P3 - she produced the word "pab" once and "lud" twice.

L1 - she produced the word "lud" twice and "pab" once.

L2 - she produced the word "lud" twice and "pab" once.

L3 - she produced the word "lud" twice and "pab" once.

Since HO's tact relations were not at strength, common tact training, in pairs, was therefore repeated to try and re-establish these relations.

Phase 12a: Repeat of Common Tact Training with Arbitrary Stimuli- in pairs.

HO required seven eight-trial blocks before she was able to demonstrate criterion speaker behaviour to *all* three pairs, without reinforcement and twice over two successive sessions.

Phase 13a: Repeat of Categorisation Test 1 and also Categorisation Test 2

HO completed another 18 categorisation test trials. The first nine used the "Look at this. Can you give me the others?" instruction. She did not categorise correctly in accordance with the experimental names in any of these trials.

In the next nine trials the instruction was changed to, "What's this? Can you give me the others?". Again, she did not categorise correctly in any of these trials. This time, however, she produced the correct name for the target stimulus on all nine trials.

On analysis of her selections in all 18 trials, HO was again categorising the stimuli in the idiosyncratic manner described in the last categorisation test. She did so in 17 out of the 18 test trials and this categorisation was significant ($N = 18$, $P(17) = 0.00 < 0.01$).

Phase 14 a: Repeat of the Probe for Tacting

Again it was decided to check the maintainence of HO's tact relations. To this end another three six-trial blocks of the probe for tacting were administered. Again she produced the experimental names for the stimuli, but not to criterion level. In total she produced the correct name for the pab stimuli on 7 of 9 (78%) trials and the correct name for the lud stimuli on 7 of 9 (78%) trials. The words produced for each stimulus are presented below.

P1 - she produced the word "pab" on all three trials.

P2 - she produced the word "pab" on all three trials.

P3 - she produced the word "pab" once and "lud" twice.

L1 - she produced the word "lud" on all three trials.

L2 - she produced the word "lud" on all three trials.

L3 - she produced the word "pab" twice and "lud" once.

On closer inspection of the data it was noticed that HO seemed to be tacting in accordance with her own idiosyncratic categories. Her tacting behaviour as applied to her own categories are represented below.

Idiosyncratic Set A (stimuli L1, L2 and P3)

L1 - she produced the word "lud" on all three trials.

L2 - she produced the word "lud" on all three trials.

P3 - she produced the word "pab" once and "lud" twice.

Idiosyncratic Set B (stimuli P1, P2, and L3)

P1 - she produced the word "pab" on all three trials.

P2 - she produced the word "pab" on all three trials.

L3 - she produced the word "pab" twice and "lud" once.

Criterion level performance for the probe for tacting phase was deemed to have been met when the participants scored eight or more out of a possible nine correct trials for *both* the zog and vek stimulus sets. The data for HO's idiosyncratic sets meets this criterion level.

Phase 13b: Repeat of Categorisation Test 2

In an attempt to firmly establish the experimental tact relations it was decided to train common tact relations in sixes, that is, with all six stimuli present. Before this however, it was decided to give her another category test to see whether her own idiosyncratic categorisation still maintained.

HO completed another 18 categorisation test trials using the instruction, "What's this? Can you give me the others?". Again, in the first nine test trials, she did not categorise in terms of the experimental names, instead choosing to categorise in her own idiosyncratic manner. In the next two trials, the experimenter carried out a protocol analysis of her categorisation behaviour. Two trials were given, one with a stimulus from HO's "Set A" and as a target and one from her "Set B". In these two trials, as HO gave the matching stimuli to the experimenter, she was asked, "why are you giving these ones?"

When stimulus P1 ()was targeted, she gave the matches P2 (), and L3 (). When asked "why?" HO replied "cos they're big"

In the next trial, stimulus P3 ()was targeted, and she gave the matches L1 (), and L2 (). When asked "why?" HO replied "cos they're little"

The experimenter then asked HO, "Can you think of another way to do it?" and then another 10 categorisation trials (as above) were given. After the first of these trials HO was again asked why she had given those particular stimuli, this time replying, "cos they're the same, cos they're big". In the following trial, she replied "cos they're whole". The next 8 trials continued without interruption from the experimenter and without any further verbalisation from HO.

Of the 21 trials given, HO categorised to her own idiosyncratic classes on all trials. This was a significant result (N =21, P (21) = 0.00<0.01). She gave the correct name to the target stimulus in 16 of these 21 trials. Figure 4.3.2 (Phase 13b), however, shows the data for categorisation in terms of the pab and lud common tact relations, therefore, as 0 percent correct categorisation.

Phase 15: Common Tact Training with Arbitrary Stimuli - In Sixes.

The criterion for correct performance was reached when the participant responded with 100 percent accuracy over three blocks of trials. HO reached this level of performance in 11 six-trial blocks. However she was then absent for a week, and on her return another set of trials was given to assess her maintenance of the relations. It was found that her performance had deteriorated and therefore training resumed.

She reached criterion level performance after 17 extra blocks of trials. As an extra check, another six trials were given, in a separate session, and she reached criterion level performance in all six trials and without any feedback to her responses. Figure 4.3.2 (Phase 15) shows that 27 blocks were required for HO to reach criterion level performance for the second time.

Phase 16: Repeat of Categorisation Test 1

HO then completed another 20 categorisation test trials, using the "Look at this. Can you give me the others?" instruction. This time she successfully categorised in accordance with the experimental names pab and lud. She scored 100 percent correct in trials where a pab stimulus was the target (10 of 10) and 40 percent correct in trials when a lud stimulus was the target (4 of 10). This categorisation was significant (N =20, P (14) = 0.00<0.01).

Of the incorrect trials, which were all ones where the lud stimulus had been a target, she categorised according to her own idiosyncratic classes in five of these six trials.

Phase 17: Repeat of the Probe for Tacting

As it appeared that HO found difficulties in categorising correctly when a lud stimulus was the target, another three six-trial blocks of the probe for tacting were given to examine whether she could maintain correct tacting of both the stimulus names.

She did, in fact, produce the experimental names for the stimuli correctly, and without feedback, on all of these probe trials.

Phase 18: Repeat of Categorisation Test 1

Before terminating all procedures, the experimenter carried out another protocol analysis of her categorisation behaviour. Three categorisation test trials were given, where the experimenter asked HO, "why are you giving these ones?"

She categorised in all three trials correctly, that is, in accordance with the experimental names pab and lud. After the first trial she answered the experimenter's query with, "cos that's a pab and that's a pab and that's a pab", whilst pointing at each of the stimuli selected. After the second trial she replied, "cos they're all luds", and after the third, "they're all the pamps"

HO then completed another 18 categorisation test trials, using the "Look at this. Can you give me the others?" instruction. She again successfully categorised in accordance with the experimental names pab and lud. She scored 89 percent correct in trials where a pab stimulus was the target (8 of 9) and 100 percent correct in trials when a lud stimulus was the target (9 of 9). This categorisation was significant (N =18, P (17) = 0.00<0.01).

Griffiths Test

The result of HO's Griffiths test gave a GQ (General Development Quotient) of 127. This score is in the normal range for her age.

Spontaneous verbal behaviour: Stimulus Set 2.

During listener training (without concurrent echoic training) HO spontaneously tacted the "pab" stimuli on 11 occasions and the "lud" stimuli on 3 occasions. She also called stimulus P1 "square thing", called stimulus P2 after her own name, as it presumably looked like an "H", and called stimulus L2 "little".

During listener plus off-task echoic training she tacted the "pab" stimuli on 3 occasions and the "lud" stimuli also on three occasions. In the categorisation test that followed, she said "that looks like my name" to stimulus P2.

During listener plus on-task echoic training, and the categorisation test that followed, she did not make any spontaneous vocalisations.

During tact training (in pairs) she called the lud stimulus "vek" on 8 occasions, and called the pab stimulus "vek" once. It was noted that she was very slow in producing any names for the stimuli at all at the beginning of each training session, and often had to be prompted by the experimenter to produce the experimental names. To illustrate, on occasion the experimenter would say, " what are the names Teddy wants you to use? pab/lud and ...". She would then be able to produce the required names.

During tact training (in sixes) she called the lud stimulus "vek" on 2 occasions, however on one of these she then corrected herself saying " its a lud".

Summary: Stimulus Set 2

HO failed to show successful categorisation with the differently named Set 2 stimuli after listener training alone. After receiving both off-task and on-task echoic training, she also failed to categorise correctly. The results of the probes for tacting that followed the three categorisation tests showed that she was unable to tact the stimuli reliably, and therefore, the whole name relation had not been established.

After explicitly training common tact relations in pairs, HO again failed to categorise, even when she was prompted to overtly produce the stimulus names.

Several extra probes for tacting were given during this phase, which showed clearly that she was having problems in maintaining these tact relations due to interference from the Stimulus Set 1 names she had learned previously. Based on evidence from the protocol analysis, there also appeared to be interference from her own category sorting names, "big" and "little", which were wholly consistent with her idiosyncratic but systematic sorting categories. Evidence from the tact probe in Phase 14a suggests that her own names were not only driving her categorisation but were also driving her allocation of the tacts "pab" and "lud". It appears that the experimental name "pab" became equivalent to her own category name "big", and likewise, "lud" with "little".

She eventually showed correct categorisation, that is in terms of the experimental names, after tact training was given with all six stimuli present. Her successful categorisation occurred without the need to prompt for overt production of the target stimuli names. The following tact probe showed that she was able, at this point, to maintain these speaker relations.

HO's results support the hypothesis that categorisation would not occur without evidence of naming, that is the establishment of listener and tact relations. When she was able to maintain reliable tacting, thus enabling naming to occur, categorisation of physically different stimuli into two common name sets immediately followed. Prior to this, HO appeared to have sorted randomly at first, then changing in later test sessions, to a sorting strategy based on her own category consistent names for the Set 2 stimuli.

Participant LO

Phase 1: Listener Training and Category Training with Familiar Objects and Concurrent Off-Task Echoic Training

Participant LO required only one block of eight trials for each of the 3 stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 4.2).

In Stage 1.2 category training with familiar objects, she required one six-block trial using the instruction, "Look at this. Can you give Teddy the others like this?"

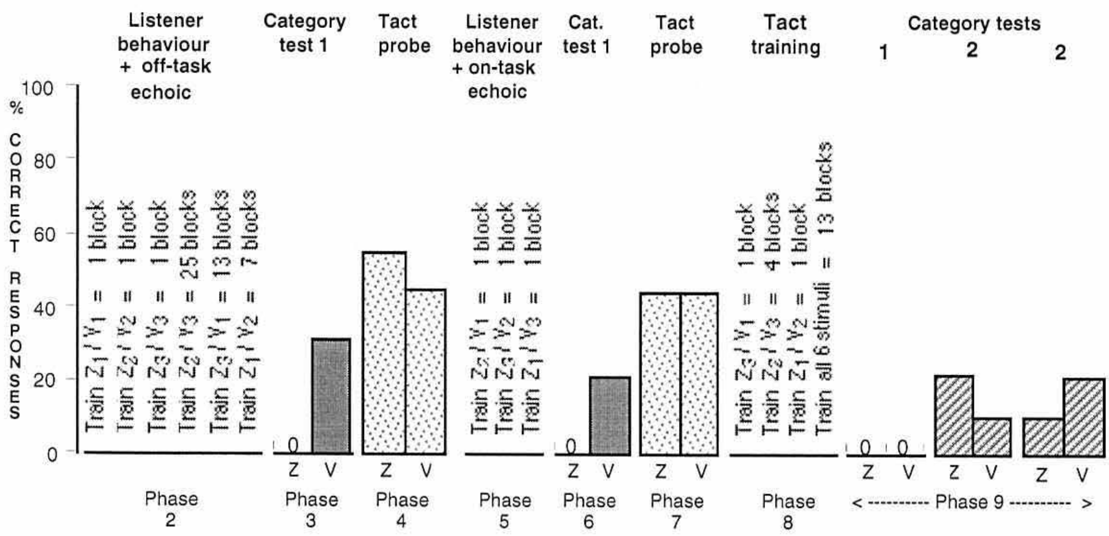


Figure 4.4. The training phases (Phases 2,5 and 8) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 7), and category re-testing (Phases 6 and 9).

Phase 2: Common Listener Training with Arbitrary Stimuli and Concurrent Off-Task Echoic Training

LO required 1 eight-trial blocks to demonstrate criterion listener relation learning with each of the original pairs (Z1/V1, Z2/V2 and Z3/V3).

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. She required 25 eight-trial blocks to demonstrate criterion performance with pair Z2/V3; 13 blocks with pair Z3/V1, and 7 blocks with pair Z1/V2.

Phase 3: Categorisation Test 1

LO completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 33 percent correct in trials when a vek stimulus was the target (3 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (3) = 0.017>0.01).

Phase 4: Probe for Tacting

LO could produce the sounds "zog" and "vek", but she could not do this to criterion level. Her scores out of three probe trials were 56 percent correct when a "zog" stimulus was targeted, and 44 percent correct when a "vek" stimulus was targeted. The scores for each stimulus are detailed below.

Z1 - two correct trials	V1 - two correct trials
Z2 - one correct trial	V2 - two correct trials
Z3 - two correct trials	V3 - zero correct trials

Following the probe for tacting, a check for maintenance of the trained listener relations plus on-task echoic was given to each of the three pairs of arbitrary stimuli. One eight-trial block was given for each pair without any reinforcement. She reached criterion level performance with all three pairs.

Phase 5: Common Listener Training with Arbitrary Stimuli and Concurrent On-Task Echoic Training

LO reached criterion level performance, with all three pairs of stimuli, in one eight-trial block each.

Phase 6: Repeat of Categorisation Test 1

LO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 22 percent correct in trials when a vek stimulus was the target (2 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (2) = 0.028>0.01).

Phase 7: Repeat of the Probe for Tacting

Again LO could produce the sounds "zog" and "vek", but not to criterion level. Her scores out of three probe trials per stimulus were 44 percent correct when a "zog" stimulus was targeted, and 44 percent correct when a "vek" stimulus was targeted. The scores for each stimulus are detailed below.

Z1 - two correct trials	V1 - zero correct trials
Z2 - one correct trial	V2 - two correct trials
Z3 - one correct trial	V3 - two correct trials

Phase 8: Common Tact Training.

Stage 8.1: Common tact training with arbitrary stimuli- in pairs. LO required four eight-trial blocks for pair Z2/V3 , and one block each for pairs Z3/V1 and Z1/V2 to demonstrate criterion speaker behaviour. Criterion level performance being when the participant scored at least seven correct trials in each eight-trial block for all three pairs.

Stage 8.2: Common tact training with arbitrary stimuli - in sixes. LO required 13 six-trial blocks to reach criterion level performance. However as an extra check another three blocks were performed, without further feedback, and she reached criterion level performance with all three.

Phase 9: Categorisation Test 1

LO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She did not categorise correctly in any of these trials. On 12 out of the 18 test trials, she chose to give the two stimuli from the front row of the five stimulus array.

LO then was given Categorisation Test 2, using the "What's this? Can you give Teddy the others like this?" instruction. In the tact test session, immediately prior to the main categorisation test, LO seemed to lack concentration and gave the wrong name to one of the stimuli in the six stimulus array. Another six-trial block was given and she still made one mistake, both to the same stimulus, Z3. However, three more six-trial blocks were then given, without feedback to her responses, and she performed correctly on all three blocks. Having again reached criterion level performance, the categorisation test trials commenced.

Eight trials were given, in which she only categorised correctly on the first two trials. It was noticed, however, that she gave the wrong name to the target stimulus on two of the trials, and that it may be the case that her tact relations had deteriorated. In order to check if this was indeed the case, seven six-trial probe blocks were given and she performed correctly on every single trial. It was noted in two of these trials, however, that she was rather hesitant in responding when stimulus Z3 was the target, although she did eventually produce the correct name for this stimulus on both occasions.

The categorisation test was resumed in the next session, again using the "What's this? Can you give Teddy the others like this?" instruction. Another 18 trials were given. This time she scored 22 percent correct in trials where a zog stimulus was the target (2 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance ($N = 18$, $P(3) = 0.017 > 0.01$). She produced the correct name to the target stimulus on 16 of 18 trials, the target stimuli being Z3 and Z2 in the incorrect trials. Figure 4.4 (Phase 9, Category Test 2) shows the data for the latter 18 test trials only. In the majority of these trials her selection strategy was to bang both her hands down onto the stimuli and give the ones that her hands happened to cover.

Another check for maintenance of the tact relations, one six-trial block of probe trials was given and she gave the correct response on all trials.

Before completing all procedures, it was decided to give LO another 18 test trials, again using the "What's this? Can you give Teddy the others like this?" instruction. This time, in an effort to keep her concentrated on the tasks, she was asked "What's this?" three times before continuing with "Can you give Teddy the others like this?"

Overall she scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 22 percent correct in trials when a vek stimulus was the target (2 of 9). According to binomial theory this performance is as would be expected by chance ($N=18$, $P(3) = 0.017 > 0.01$).

She produced the correct name to the target stimulus on 17 of 18 trials, the incorrect trial being when the target stimulus was Z2. Again her selection strategy was to bang both her hands down onto the stimuli and give the ones that her hands happened to cover.

In the final six trials the experimenter asked her to say aloud the names of the stimuli she was selecting. Only on the first of these trials did she give the correct stimuli to the target, in all others she gave a mixture of both zogs and veks. In two of these cases she gave the wrong name to the stimulus she was selecting.

Another check for maintenance of the tact relations, one six-trial block of probe trials was given and she gave the correct response on all trials and without reinforcement.

Griffiths Test

The result of LO's Griffiths test gave a GQ (General Development Quotient) of 116. This score is in the normal range for her age.

Spontaneous verbal behaviour: Stimulus Set 1.

During listener training (without concurrent echoic training) LO spontaneously produced the word "zog" stimuli on 12 occasions and the "vek" stimuli on 2 occasions. Thirteen of these utterances were as a response to the experimenter's request of "Can you give me the zog/vek?", of these she gave the correct stimulus on 11 occasions. On one occasion she tacted the stimulus correctly saying "That's the zog".

Referring to stimulus Z1, she asked to "do the circle one" on two occasions, when a pairing that did not contain this stimulus was presented. She also said that stimulus Z3 "looks like a helicopter", called stimulus V3 "a shell", and Z2 a "square".

She did not make any other spontaneous utterances to the stimuli in any of the other phases.

Summary: Stimulus Set 1

In the case of LO, categorisation did not occur, even after both listener and tact elements of the name relation had been explicitly trained. This suggests that naming may not in itself be sufficient for the emergence of the categorisation of physically different stimuli into two common name sets.

DISCUSSION

All three of the participants who commenced the experiment finished all procedures. Two of the participants completed procedures with a second set of stimuli. These results will be considered after reviewing the findings of the first set of stimuli from all three participants. All three participants completed both stages of Phase 1 in the minimum number of trials.

Two of the participants, TM and HO, completed Phase 2 (listener with off-task echoic training) very quickly, however the third participant, LO, needed a comparatively large amount of trials before learning the discriminations.

As discussed in Study 1, there was a question as to the stringency of the set criterion level . The procedure in the present experiment was modified to address this issue by testing for the maintenance of the learned relations immediately after the categorisation test and probe for tacting. All three participants who completed all procedures did indeed show evidence of maintaining intact listener relations. It seems evident therefore, that we can accept that the listener relations were intact as the participants went into the first categorisation test.

Only one of the participants, HO, categorised successfully after listener plus off-task echoic training. However, in the probe that followed the categorisation test, she also demonstrated reliable tact relations. It may be said therefore, that the whole name relation had been established. HO's results support the hypothesis that tact relations, rather than mere echoic relations, must be established in order for naming, and hence categorisation, to occur.

The other two participants received training in on-task echoing, reaching criterion level performance easily. Neither of these two, however, categorised successfully after this extra training. Both of these participants were then trained to give a common tact response to the arbitrary stimuli, in effect the name relation was explicitly trained. Only one of these two participants went on to demonstrate successful categorisation. Their results shall be dealt with individually next.

Once the name relation had been established, participant TM categorised the stimuli into two sets with 100 percent accuracy. Her results also support the hypothesis that tact relations, rather than mere echoic relations, must be established in order for naming, and hence categorisation, to occur.

Participant LO, on the other hand, failed to categorise at all, even after being prompted to overtly produce the target stimulus names. This suggests that naming may not in itself be sufficient for the emergence of the categorisation of physically different stimuli into two common name sets.

This failure may be attributed to two factors. First, LN did show evidence of using her own selection strategies which, as discussed in Study 1, are likely to persevere unless naming behaviour is initiated in some way. This "initiation" did not occur, even when she was prompted to overtly produce the target stimulus names in the categorisation test. Neither did it occur when she was prompted to overtly tact the matching stimuli as she gave them to the experimenter.

The second factor in the failure to demonstrate categorisation may lie in her inability to show 100 percent correct tacting in the categorisation tests themselves. She did though, perform to criterion levels prior to each test and also showed accurate tacting in extra probe trials to check her maintenance. Without the ability to tact the names of all the stimuli accurately naming and therefore categorisation, could not be expected to occur.

It might be assumed that some element of the test trials themselves interfered with her ability to produce the stimuli names reliably. For example, in the tact training with six stimuli present, although the experimenter did not provide feedback to LO's responses, she did have some level of control over LO's concentration. To illustrate, when LO took time in responding to the instruction "What's this?" in the tact training trials, the experimenter would prompt her by repeating the question, thus obliging LO to make a response. In the categorisation test situation, however, the experimenter did not have such control. In these trials the experimenter could only repeat the instruction "What's this? Can you give me the others?", she was unable to prompt LO to produce the names of the matching stimuli. This may have left LO eager to respond to the need to give two stimuli, yet not enough time to recall the stimulus names with accuracy.

The two participants who completed procedure with two stimulus sets shall be dealt with individually next.

By the end of the procedure for Set 1, Participant TM had been taught common listener relations, and also common speaker relations to the sets of arbitrary stimuli, that is, the whole name relation. Her results show successful classification of the stimuli into zog and vek categories, and is consistent with the hypothesis that the whole name relation, that is listener and tact relations, must be in place before categorisation can be achieved.

After receiving listener training to the Set 2 stimuli, TM had learned a listener class encompassing the listener stimuli (/zog/ and /vek/) for both Set 1 and Set 2 stimuli. As she had also been explicitly taught the corresponding tact relations for the Set 1 stimuli, combined with additional off-task and on-task echoic practice with the Set 2 stimuli, it may have been expected then that she would also easily derive the necessary tact relations and thereby establish naming. However this was not the case.

TM did not show evidence of categorisation of the Set 2 stimuli until after the common tact relations were again, explicitly taught (this time, in pairs). This time, the tact relations that had been taught to the Set 1 stimuli did not automatically transfer to the Set 2 stimuli. This is seen in the evidence from the two tact failed probes, where although producing the experimental names, she did not do so reliably. She also needed a substantial amount of tact training (in pairs) to reach criterion level performance. This was in contrast to the two listener training phases (Phases 2 and 6) where she reached criterion level very quickly, taking a near minimum amount of trials to do so.

It appears that, in certain cases, not only must the tact relations be directly trained to establish naming and thereby categorisation, but these object-name relations may also have to be re-trained when applied to novel stimuli in order for their maintenance to be consolidated.

This finding, again, contrasts with Horne and Lowe's idea that when the name relation has been established and the child has speaker and listener experience of a commonly names set of objects, it may be merely necessary to train listener relations in order for the whole name relation to be established with new exemplars of a commonly named category (see p. 202).

In Phase 10, an additional and exploratory phase of the experiment that combined both sets of stimuli in a categorisation test, a convincing example of the extension of the name relation was demonstrated.

TM showed successful categorisation of all 12 stimuli into two commonly named classes without any additional training or reinforcement. When one exemplar for these 12 stimuli was targeted, TM not only gave the corresponding commonly named stimuli from the target's original set, but also the commonly named exemplars from the other set. TM had no previous experience of categorisation tests with all 12 stimuli present, yet she extended her categorisation to encompass six stimuli in each commonly named class.

The above example illustrates how the establishment of naming can easily give rise to novel examples of categorising behaviour that have not been directly trained. Her accompanying overt and spontaneous tacting of the stimulus names as she selected them is also a convincing example of naming behaviour in action.

It cannot be doubted from this evidence that TM was able to accurately tact the names of the stimuli in order to categorise them in this statistically significant manner, however, her somewhat erratic performance in the five tact testing sessions that preceded each categorisation test needs to be addressed (see Table 4.3).

Of the five sessions, TM only performed with 100 percent accuracy in the fifth session, in all other sessions she, in differing amounts, gave the wrong name for the targeted stimuli. Overall, however her tacting was performed at a statistically significant level for both sets of stimuli.

Understandingly perhaps, TM's worst performance was in Session One where she also categorised incorrectly. It must be remembered that she did not have any extra training with the Set 1 stimuli and may have had difficulty in recalling their names accurately. By the final session her performance had improved considerably, and all stimuli were tacted correctly.

Another factor to be considered is her boredom with the experimental procedure. This factor, although not quantifiable, is nevertheless influential in painting an inaccurate picture of a child's true capabilities. In the case of TM, she had been exhibiting boredom with the procedures prior to this extra phase of the experiment, and throughout all phases of the experiment tended to lose concentration easily when bored. Evidence for this can be seen in the tact probe in Phase 7, where she would only repeat "Don't know" to all requests to name the stimuli.

It seems that the two factors discussed above may have contributed to her poor performance on these tact trials. Her ability to name the stimuli, however cannot be in doubt, considering her highly significant categorisation in terms of the two class names zog and vek.

TM's results are consistent with the naming theory. Evidence for the establishment of the whole name relation, that is listener and tact relations, was shown alongside her successful categorisation. Her performance with the Set 2 stimuli also emphasises the importance of naming behaviour in initiating categorisation, her spontaneous production of the target names in the successful categorisation test being an example of such a phenomenon. Also, with the Set 2 stimuli, it was not necessary to train tact relations in sixes for categorisation to be evidenced.

Participant HO's results with Stimulus Set 2 proved very interesting indeed and are in complete contrast to her results with the Set 1 stimuli. To recap, she completed all procedures extremely quickly with the later stimulus set and also categorised successfully on the first test after listener plus off-task echoic training. She also derived reliable tacting of the stimulus names. It might have been expected, therefore, that she would also complete the procedures with the second set of stimuli (albeit with different class names) with comparative speed. Surprisingly, this was not the case.

HO was much slower reaching criterion level performance to the listener relations when concurrent off-task echoic was withheld (as in Set 2), than when this echoic training was given (as in Set 1). To illustrate, overall, in Phase 2 training with Set 1, it took a total of 13 blocks of trials (with all three original pairs and all three mixed pairs) before she was ready for the first categorisation test. With the Set 2 stimuli, however, it took a total of 29 blocks of trials to reach the same level.

However, when concurrent echoic training was given, both off and on-task, in Phases 5 and 8 of the experiment, she reached criterion level performance very rapidly (see Figure 4.3.2 for all training data).

It was clear, however, that the Set 1 stimulus name "vek" was a competing source of control over her tacting behaviour. It was noticed that she tended to substitute "vek" for the Set 2 name "lud" (and, to a lesser extent possibly substituting the word "thee" for "pab", although this is conjecture). Evidence for this can be seen in the five probes for tacting that were given prior to the tact training phases. Also during tact training itself, she showed further evidence of this confusion, calling the "lud" stimuli "vek" on seven occasions, and also naming a "pab" stimulus "vek" on one other occasion.

HO reached criterion level performance with the tact training in pairs quite quickly. However, as the extra tact probes suggest, she had problems maintaining this level of correct tacting, again possible due to interference from her other names for the stimuli. HO did not categorise successfully with the Set 2 stimuli until tact training was given. Further, she still needed tact training with all six stimuli present before categorisation was demonstrated.

There seem to be two explanations for her relative difficulty with the Set 2 stimuli. First, the interference from the Set 1 stimuli names, which have just been discussed. The second factor which interfered with her ability to categorise in accordance with the experimental names, was that she began to categorise reliably in accordance with her own class names. Evidence from the tact probe in Phase 14a suggests that once her "vek" tact response had extinguished (and also her use of the word "thee"), they were not replaced by the experimental names, but with her own names "big" and "little" which appeared to be based on the physical attributes of the stimuli.

This evidence also suggests that her own names were not only driving her categorisation but were also driving her allocation of the tacts "pab" and "lud". It appears that the experimental name "pab" became firstly associated with and then equivalent to her already established category name "big", and likewise, "lud" with "little". These associations appear to have formed by the fact that two of the "big" stimuli were experimentally named pab, and likewise two of the "little" stimuli were named lud. The remaining two stimuli being incorporated into either pab or lud class by virtue of physical resemblance.

After being prompted to overtly tact the experimental names in the categorisation test it seems that, for example, that in producing the name "pab", she was also covertly substituting or equating this name with her own name "big" and categorising in accordance with the latter name.

It was also remarkable that this form of categorisation, which was after all in terms of the physical attributes of the stimuli, did not occur until after tact training (of the experimental names) had been given. It should be expected that this form of categorisation might have occurred on the very first categorisation test, after listener training, evidence of her application of the name "little" being seen early in Phase 2 listener training.

This phenomenon is reminiscent of the examples of spontaneous sorting demonstrated by three of the participants in Study 1. Although they had ample opportunity to exhibit such behaviour when the six stimulus array was available to them in all of the categorisation tests, none did so until the whole name relation was established.

In HO's case, the onset of her idiosyncratic categorisation may be explained as an example of the initiation of generalised naming behaviour. Presumably at this age, both the names big and little would already have been established as names, yet the confusion of the established listener relations of the Set 2 stimuli combined with the continuing influence of the established speaker behaviour of the Set 1 stimuli may have combined to interfere with the initiation of naming behaviour thus leading to categorisation.

It was not until the tact relations had been established to the pab/lud stimuli (thus lessening the control of the former confounding vek/thee names) that these former names became firmly incorporated into a name relation with the big/little physical characteristics of the stimuli.

This equivalence -like relationship meant that each word within the newly formed classes (i.e. pab/big and lud/little) became substitutable for each other. It is possible that in the subsequent categorisation tests, when, for example, the "pab" name was overtly produced, it may have occasioned a covert production of the name "big", thus leading to re-orienting and selection of the other stimuli that had been previously named "big". This appears to be an example of an intraverbal strategy, which Horne and Lowe acknoweledge to be another effective way for naming to bring about new or emergent behaviour (pp. 209-210).

Her change to "correct" categorisation, that is consistent with the pab and lud names, is also remarkable. This only occurred after tacting was trained with all six stimuli present. This suggests that the seeing of the stimuli in a six stimulus array, along with the opportunity to tact each one in turn, may have resulted in the experimental names eventually taking control of her categorisation behaviour. This is in contrast to the results from Stimulus Set 2 of participant TM. TM however, did not show such convincing evidence of interference from other pre-existing names.

HO's results shed light on the possible reasons behind the other participants' (in both this Study and Study 1) failure to categorise. Her data shows that various other factors, such as alternate names and the physical attributes of the stimuli, served as competing sources of control over her behaviour. These factors may explain her inability to categorise, or to derive appropriate tacting with the Set 2 stimuli, immediately after echoic training, unlike the celerity with which she did so with the Set 1 stimuli.

The strength of these interfering factors can be illustrated further by examining HO's Categorisation in Phase 16. She demonstrated significant categorisation when both lud and pab acted as target stimuli, performing with 100 percent accuracy on all trials where the pab stimulus was the target. She did, however, only categorise correctly in 4 of 10 trials where a lud stimulus was the target. The lud stimuli were also the ones that she persisted in calling "vek" which may explain the weaker level of control that the name "lud" had over her behaviour, suggesting that the interference effects of the former name may not have been totally extinguished.

In these test trials, furthermore, it was seen that in five of the six "lud" trials that she had performed incorrectly, she had indeed categorised in accordance with her own names of "big" and "little", which a protocol analysis later confirmed.

HO's results with both sets of stimuli support naming theory. In both sets she did not categorise to the experimental names until evidence of both listener relations and reliable tact relations were established, that is, naming. The results of Stimulus Set 2 also emphasis the importance of the establishment of intact tact relations as an initiator of naming behaviour. When categorisation did occur, HO appeared to find it easier to categorise successfully in trials where the established name "pab" was a target, than when the "lud" stimuli, which she often confused with the "vek" names, were targeted.

To conclude, the results of the two participants of this study, who completed all procedures, provide support for naming theory. Both of these did not show categorisation without also showing evidence of reliable tact relations.

* * *

As in Study 1, it was decided that it would be interesting to see if the same effects would be observed in a younger age group of children. Therefore, the second experiment of Study 2 attempted to replicate the above procedures with children who were approximately 2.5 to 3.5 years of age.

Given that in Study 1, the results from the three differing age groups were relatively similar, it was expected that this would also be the case in this study. The research hypothesis of Experiment 2 was therefore the same as that of Experiment 1. It was expected that the participants in this, new, age group would also not categorise after listener plus off-task or on-task echoic training, rather categorisation would only occur with concurrent evidence of the establishment of tact relations, that is, the whole name relation.

As the results of Participant HO (Set 2 stimuli) showed a marked difference in her ability to categorise after tact training in pairs and tact training in sixes, changes were made to the procedure of Experiment 2 to examine this phenomenon further. A categorisation test was given immediately after tacting was trained in pairs, unlike the stated procedure for Experiment 1, where a categorisation test followed tact training in both pairs and in sixes.

EXPERIMENT 2

In Experiment 1, two of the three participants, who were between 3.5 and 4.5 years of age, demonstrated successful categorisation of the arbitrary stimuli into two classes. Both of these also demonstrated concurrent evidence of the establishment of both listener and tact relations, that is the whole name relation. Experiment 2 attempted to replicate the procedures of Experiment 1. This time the participants were younger children, approximately 1.5 to 3.5 years of age.

Participants

Eight participants, five female and three male, took part. Table 4.4 shows, for each participant, her or his gender and age. Participants who completed all procedures were given the Griffiths test to ascertain their normal development (reported at the end of each participant's result section).

Table 4.4
Participants' sex and age

Participant	Sex	Age at start year: month	Age at first categorisation test year: month
PO	F	1:08	n/a
LH	F	2:01	n/a
KO	M	2:05	2:06
ER	F	2: 07	3: 01
NU	M	2: 08	n/a
RO	F	2: 10	n/a
CE	F	3:00	n/a
MRJ	M	3: 01	3:04

F = female M = male

Apparatus and Procedure

The apparatus and procedure employed in Experiment 2 was as described in Study 2, Experiment 1, with exceptions to the procedure described below.

In Experiment 1, with the Set 1 stimuli, the standard procedure was to test for categorisation after common tact training was given with all six stimuli present. In Experiment 2, however, a categorisation test was given after common tact training in pairs. The changes to the procedure are as follows.

Phase 8: Common Tact Training with Arbitrary Stimuli - In Pairs.

This stage was conducted as described in Stage 5.1 of the General Method, except that the mixed pairs of arbitrary stimuli were used, rather than the initial pairings. Corrective feedback was given to the participant's responses until they had reached criterion level performance with all three pairs, that is scoring at least seven correct trials in each eight-trial block. Feedback to their responses was then withdrawn.

Criterion level performance for this stage was reached when the participant scored at least seven correct trials in each eight-trial block for all three pairs, without feedback, twice in succession over two separate sessions.

Phase 9: Repeat of Categorisation Test 1

All stages of this phase were conducted as described in Phase 3 of the General Method. If the participant passed the repeat test for categorisation, all further procedures ceased.

For participants who failed the categorisation test, eighteen test trials of Category Test 2 were repeated, using the "What's this? Can you give Teddy the others like this?" instruction. If the participant categorised successfully at this stage, she or he was deemed to have completed all procedures.

If the participant failed Category Test 2, then she or he proceeded to Phase 10 of the experiment, common tact training in sixes.

Phase 10: Common Tact Training with Arbitrary Stimuli - In Sixes.

Stage 10.1: Common tact training - in sixes

This stage was conducted as described in Stage 5.2 of the General Method.

Stage 10.2: Reduction in reinforcement probability.

This stage was conducted as described in Stage 5.3 of the General Method.

Phase 11 : Repeat of Categorisation Test .

Stage 11.1: Category Test 1. This phase was conducted as described in Phase 3 of the General Method, using the "Look at this..." instruction.

Stage 11.2: Category Test 2. If the participant failed to categorise on the above test, the test was repeated, this time using the "What's this?" instruction.

After this test all procedures ceased.

RESULTS

Tables 4.5 and 4.6 show, for all eight participants, the data from the first two experimental phases. Only three of the participants went on to complete all phases of the experiment; data from these three will be presented as individual graphs from Phase 2 onwards.

Phase 1: Common Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training

Table 4.5 shows the number of eight-trial blocks each participant required in order to achieve criterion performance in Stage 1.1 listener relation learning for each of three familiar object (hat and cup) pairs. All eight participants completed this stage in the minimum number of blocks necessary.

Table 4.5

Results of Phase 1: Common listener training and category training with familiar objects. In Stage 1.1, H1/C1, H2/C2 and H3/C3 refer to the three familiar object (hat and cup) pairs. Two instructions were used in Stage 1.2, "Look at this. Can you give me the others like this?" and "Look at this. Can you give me the other hats/cups?"

Participant	Stage 1:1 Common listener training in pairs			Stage 1:2 Categorisation test	
	H1/ C1	H2/C2	H3/C3	"hats & cups"	"Others"
PO	1	1	1	1	1
LH	1	1	1	1*	n/a
KO	1	1	1	0	2
ER	1	1	1	0	1
NU	1	1	1	2	1
RO	1	1	1	0	1
CE	1	1	1	n/a	n/a
MRJ	1	1	1	0	1

* Participant LH could not complete Stage 2.1 (see below)

Table 4.5 also shows the number of six-trial blocks required to achieve criterion performance in Stage 1.2 familiar object categorisation.

Four of the eight participants learned to categorise the hats and cups appropriately in response to the instruction "Look at this. Can you give me the others like this?" alone. Participant NU needed two extra blocks using the "Look at this. Can you give me the other hats/cups?", and participant PO needed one extra block using this instruction. Participant LH could not complete Stage 1.2 with the "hats/cups" version of the instruction, preferring to play with the stimuli instead. It was decided in her case to proceed to Stage 2.2, returning to Stage 1.2 after training the first of the arbitrary pairs of Stage 2.1.

Subject CE became upset at being in the experimental room and was therefore withdrawn from the experiment.

Seven of the eight participants progressed to Phase 2 of the experiment.

Phase 2

Table 4.6 shows the number of eight-trial training blocks each participant required to achieve criterion listener relation performance on the three arbitrary stimulus pairs. For Stage 2.1, the number of training blocks to criterion are shown for each of the three arbitrary (/zog/ and /vek/) pairs. Only three of the seven participants learned to respond appropriately to the listener stimuli /zog/ and /vek/ (i.e. by selecting the corresponding object from among the pair) for all 3 pairs (Z1/V1, Z2/V2, and Z3/V3).

For Stage 2.2, where the stimuli were sorted into new pairings, the number of training blocks to criterion listener performance are shown for each of the new "mixed" arbitrary stimulus pairs.

Table 4.6
Results of Phase 2: Common listener training with arbitrary stimuli. In Stage 2:1 the stimuli were divided into three zog/vek pairs; for example Z1/V1 and for Stage 2:2 the stimulus pairs were arranged into different pairings; for example Z1/V3. The mixed pairings are referred to here as Z/V a, b &c, as each participant received a different order of pairings.

	Common listener training with arbitrary stimuli					
	Stage 2:1 Initial pairs			Stage 2:2 Mixed pairs		
Participant	Z1/V1	Z2/V2	Z3/V3	Z/V a	Z/V b	Z/V c
PO	10*	-	-	-	-	-
LH	15*	-	-	-	-	-
KO	1	2	1	19	15	17
#ER (set 1)	1	2	2	20	61*	23
#ER (set 2)	1	1	1	3	3	3
NU	6*	8	1*	-	-	-
RO	11	2	7*	-	-	-
MRJ	1	1	6	19	17	14

* Failed to reach criterion with this stimulus pair.
# Participant ER failed to reach criterion with one of the stimulus pairs and therefore the two problematic stimuli were substituted and training resumed with the reconstituted pairings (Stimulus Set 2). See ER's results section for further details.

Of the five participants who started this phase, only three reached criterion with all six stimulus pairings. Participants PO, LH, NU and RO failed to reach criterion for all three pairings in Stage 2.1 and were withdrawn from the remainder of the experiment.

For the three participants who completed the experimental procedure, data from each phase, including a review of that from Phases 1 and 2, are presented separately below.

Participant KO

Phase 1: Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training.

Participant KO required only one block of eight trials for each of the 3 stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 4.5).

In Stage 1.2 category training with familiar objects, he required two six-trial blocks using the instruction, "Look at this. Can you give Teddy the others like this?" to reach criterion level performance.

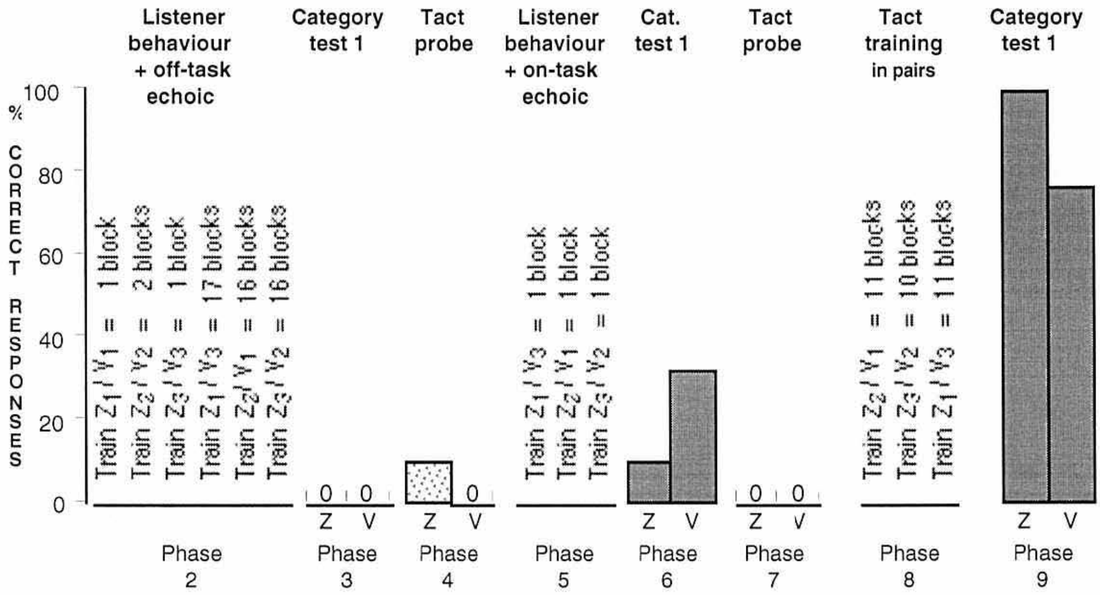


Figure 4.5. The training phases (Phases 2,5 and 8) give the number of blocks taken to reach criterion. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 7), and category re-testing (Phases 6 and 9).

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

KO required 1 eight-trial block to demonstrate criterion listener relation learning with pairs Z1/V1 and Z3/V3, and two blocks of trials with pair Z2/V2.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. He required 17-eight trial blocks to demonstrate criterion performance with pair Z1/V3, 16 blocks with pair Z2/V1, and 16 blocks with pair Z3/V2.

Phase 3: Categorisation Test 1.

KO completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He did not categorise successfully on any of these trials. According to binomial theory this performance is as would be expected by chance (N =18, P (0) = 0.15>0.01).

It was noted that KO's first choice of matching stimulus to the target, was usually the stimulus that had been paired with the target in the listener training trials prior to the categorisation test. He gave this match on 13 occasions out of a possible 18. The second match seemed to be a random choice from the remaining stimuli.

Phase 4: Probe for Tacting.

KO only produced the correct name once; saying "zog" to stimulus Z2 on one occasion. To all the other stimuli he gave his own idiosyncratic names, these are detailed further below.

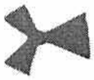
Z1 -  He called this stimulus "square" in one trial, "blackbird" in another and failed to respond once.

Z2 -  He failed to respond in the first trial, said "square" in the second, and "zog" in the third.

Z3 -  He said "house" once and "blackbird" once, and gave one incoherent response.

V1 -  "Snake" in all three trials.

V2 -  "Black" in the first trial and "blackbird" in the next two trials.

V3 -  He said "black" in the first two trials and said "blackbird " in the third.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement. KO reached criterion level performance with all three pairs.

Phase 5: Common Listener Training with Arbitrary Stimuli and On-Task Echoic Training

KO reached criterion level performance, with all three pairs of stimuli, in one eight-trial block each.

Phase 6: Repeat of Categorisation Test 1.

KO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 33 percent correct in trials when a vek stimulus was the target (3 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (4) = 0.07>0.01).

KO did not show any evidence of the sorting strategy that he had employed in the last categorisation test, but he tended to choose two of the stimuli that were in the front row (the stimuli being presented in two, three stimulus rows).

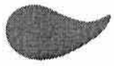
Phase 7: Repeat of the Probe for Tacting

Again, apart from on one incorrect occasion, KO only produced his own idiosyncratic names. Unfortunately, sound recordings were unavailable for the first two blocks of trials (however the experimenter noted the correct use of the experimental names during the live session). His verbalisations for the third block are detailed below.

Z1 -  He called this stimulus "car"

Z2 -  He called this stimulus "black socks"

Z3 -  He called this stimulus "black socks"

V1 -  He called this stimulus "black socks"

V2 -  He called this stimulus "bridge"

V3 -  He called this stimulus "zog"

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. KO demonstrated maintenance of the listener relations with all three pairs.

Phase 8: Common Tact Training.

Stage 8.1: Common tact training with arbitrary stimuli- in pairs. Criterion level performance for this stage was reached when the participant scored at least seven correct trials in each eight-trial block for all three pairs, without feedback, twice in succession over two separate sessions. KO required 11 eight-trial blocks with pair Z2/V1, 10 blocks with pair Z3/V2, and 11 blocks with pair Z1/V3.

Phase 9: Repeat of Categorisation Test 1.

KO completed another 18 trials of the categorisation test using the "Look at this, can you give me the others" instruction. He scored 100 percent correct in trials where a zog stimulus was the target (9 of 9) and 78 percent correct in trials when a vek stimulus was the target (7 of 9). The probability that this would occur by chance is low and statistically significant ($N = 18$, $P\ (16) = 0.00 < 0.01$.

Griffiths Test

The result of KO's Griffiths test gave a GQ (General Development Quotient) of 118. This score is in the normal range for his age.

Spontaneous verbal behaviour

During the training of listener relations with off-task echoic training (Phase 2), KO spontaneously produced the experimental names on 231 occasions. He produced the name "zog" on 117 occasions, and "vek" on 114 occasions. Only six of these utterances were produced to the incorrect stimulus.

Most of these utterances took the form of an echo-tact response. That is, in response to the experimenter's request of "Can you give me the zog/vek?", he would choose a stimulus and repeat "zog/vek" as he gave it to the experimenter. Other utterances took the form of a question, as in "is this the zog/vek?", as he selected the stimulus. All utterances were dependent on the experimenter's previous requests.

He also produced his own names for some of the stimuli. During Phase 2 he named stimulus V3 "Thomas" on four occasions, and also said "there's a hole in it" to Z2.

During Phase 8, tact training, he persisted in using his own idiosyncratic names for four of the six stimuli ; these are detailed below.

Z2 -  He named this "sun" on two occasions, "cow" once, "eggs" once, and also said, "it's got a hole in it" once.

Z3 -  He named this stimulus "lady" twice, and also once when corrected by the experimenter, he asserted "no its not, its a lady!". He also named it "play people" on one occasion.

V2 -  He named this "legs" on four occasions, "car" once, "train" once, and "itsy witsy spider" once.

V3 -  He named this "zebra" once, and "cow" once.

He did not produce any names, experimental or otherwise, to any of the stimuli during any of the categorisation tests.

Summary

In the case of KO, teaching common listener relations, along with either off-task or on-task echoic practice of the experimental names, does not appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. Categorisation did not occur until after a common tact response had been taught.

KO's results support the naming hypothesis, in that only when evidence of both reliable tact and listener relations (that is, naming), was demonstrated, did categorisation occur.

Participant ER

ER had difficulties discriminating between two of the experimental stimuli during Phase 2 of the experiment, and so two new stimuli were substituted. Training data are given first for the original set (termed Stimulus Set 1), followed by data for the completed experiment with the substitute set (termed Stimulus Set 2).

Phase 1: Listener Training and Category Training with Familiar Objects.

Participant ER required only one block of eight trials for each of the 3 familiar stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 4.5).

In Stage 1.2 category training with familiar objects, she required one six-trial block using the instruction, "Look at this. Can you give Teddy the others like this?" to reach criterion level performance.

Stimulus Set 1.

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

Stage 2.1 Common listener training with arbitrary stimuli - initial pairs. ER required 1 eight-trial block to demonstrate criterion listener relation learning with pair Z1/V1; two blocks with pair Z2/V2, and two blocks of trials with pair Z3/V3.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability.

ER received listener training with mixed pairs Z3/V1, Z1/V2, and Z2/V3. However she showed difficulty in discriminating between the stimuli that made up pair

Z2/V3, failing to reach criterion level with pair Z2/V3, even after 46 eight-trial blocks had been given.

She had reached criterion level performance with pairs Z3/V1 after 12 eight-trial blocks and Z1/V2 after 11 eight- trial blocks, however in total she received additional training with these pairs to ensure maintenance of these relations. In total she received 16 training blocks with pair Z3/V1, and 15 blocks with pair Z1/V2.

Listener training was resumed with the original pairings in an attempt to examine if this would help her to discriminate between the two stimuli that made up pair Z2/V3. She performed two eight-trial blocks to each of the three original pairs, and reached criterion level performance with all three pairs, without any feedback to her responses.

Listener training with the mixed pairs then resumed. She completed six eight-trial blocks with pairs Z3/V1 and Z1/V2 and demonstrated criterion level performance on every block, all with no further reinforcement. However, she still failed to reach criterion level performance with pair Z2/V3 after 19 blocks.

It was decided to replace these two stimuli (Z2 and V3) with two stimuli of a different shape (henceforth to be called Z4 and V4). Phase 2 of the experiment was then repeated with this new set (Stimulus Set 2).

Figure 4.6 shows the total number of mixed pair training blocks performed by ER in Stage 2.2.

Stimulus Set 2.

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

Stage 2.1 Common listener training with arbitrary stimuli - initial pairs. ER required 1 eight-trial block to demonstrate criterion listener relation learning with all three pairs (Z1/V1, Z4/V2, and Z3/V4).

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. She required three eight trial blocks with each of the mixed pairs (Z1/V4, Z4/V1 and Z3/V2) to reach criterion level performance.

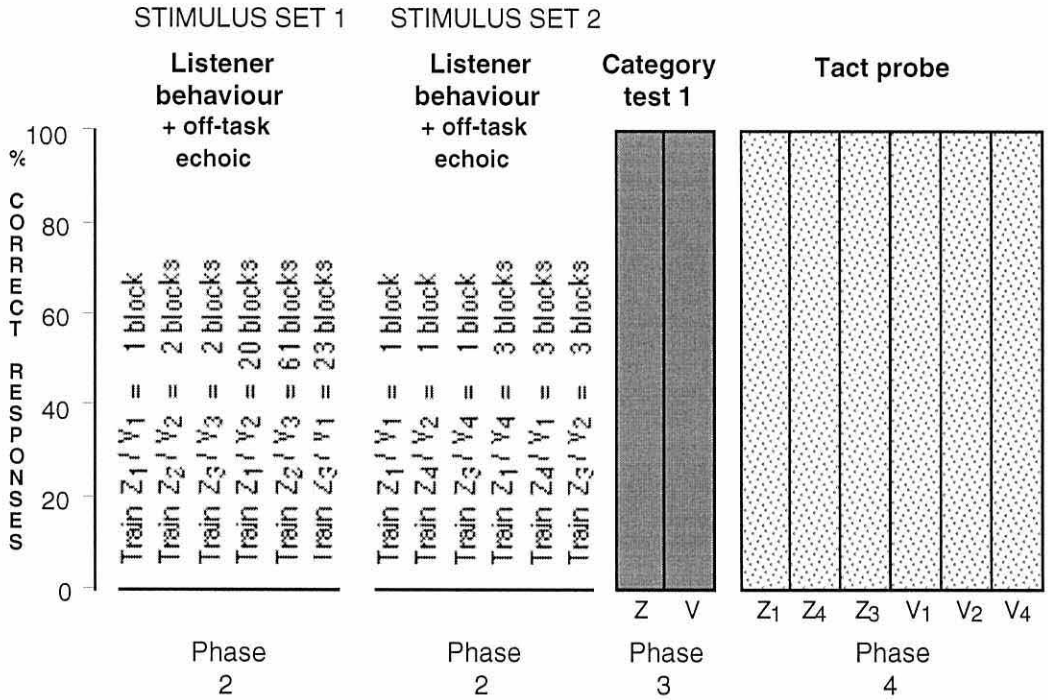


Figure 4.6. Training Phase 2 gives the total number of blocks performed with Stimulus Set 1, and also the number of training blocks taken to reach criterion with Stimulus Set 2. The test phases show the percentage correct responding during category testing (Phase 3) and probe for tacting (Phase 4).

Phase 3: Categorisation Test 1.

ER completed 18 trials of the categorisation test using the "Look at this, can you give me the others" instruction. Over all 18 trials she demonstrated 100 percent correct responses, that is, 9 of 9 correct responses when a zog stimulus was the target, and 9 of 9 correct when the vek stimulus was a target. The probability that this would occur by chance is low and statistically significant (N =18, P (18) = 0.00<0.01.

Phase 4: Probe for Tacting

The tact probe showed that she could produce the name for all of the stimuli with 100 percent accuracy over three trials. Also, in the second six-trial block, she arranged the stimuli into two lines consistent with the zog and vek experimental names.

Griffiths Test

The result of ER's Griffiths test gave a GQ (General Development Quotient) of 140. This score is above the normal range for her age.

Spontaneous verbal behaviour

During the training of listener relations with off-task echoic training (Phase 2), ER spontaneously tacted the experimental names on 26 occasions. She produced the name "zog" on 14 occasions, and "vek" on 12 occasions, on only occasion did she produce the incorrect name for the stimulus she was targeting.

Sixteen of these utterances were as a response to the experimenter's request of "Can you give me the zog/vek?", saying "zog/vek" as she gave the stimulus to the experimenter. On four occasions she extended this by saying "That's the zog/vek" as she presented the stimulus. Three utterances were of the form, "Is this the zog/vek". The remaining three utterances were general verbalisations that were not tacts nor were they dependent on the experimenter's utterances, for example, "You say zog".

She also produced her own idiosyncratic name for some of the stimuli during Phase 2, on one occasion saying, "This looks like a choo-choo train" to stimulus Z2. Her other utterances all came in one single session, where, after she and the experimenter had been reading a book together, she proceeded to name some of the stimuli after features in the story. For example, she said "this is the water" and "this is the troll", to stimulus Z2, "this is the water" to V3, and "this one is my little friend" to V1.

She did not produce any spontaneous verbalisations during the categorisation test in Phase 3.

Summary

ER's results support naming theory. Although the categorisation of physically different stimuli into two sets was demonstrated after teaching common listener relations, with concurrent off-task echoic training of the experimental names, in the probe for tacting that followed the categorisation test, ER also demonstrated reliable tact relations, that is, the whole name relation. She also showed evidence of spontaneous categorisation of the stimuli into two classes consistent with the experimental names.

Participant MRJ

Phase 1: Listener Training and Category Training with Familiar Objects and Off-Task Echoic Training

Participant MRJ required only one block of eight trials for each of the 3 stimulus pairs to demonstrate criterion listener relation learning in Stage 1.1 (see Table 4.5).

In Stage 1.2 category training with familiar objects, he required one six-block trial using the instruction, "Look at this. Can you give Teddy the others like this?" to reach criterion level performance.

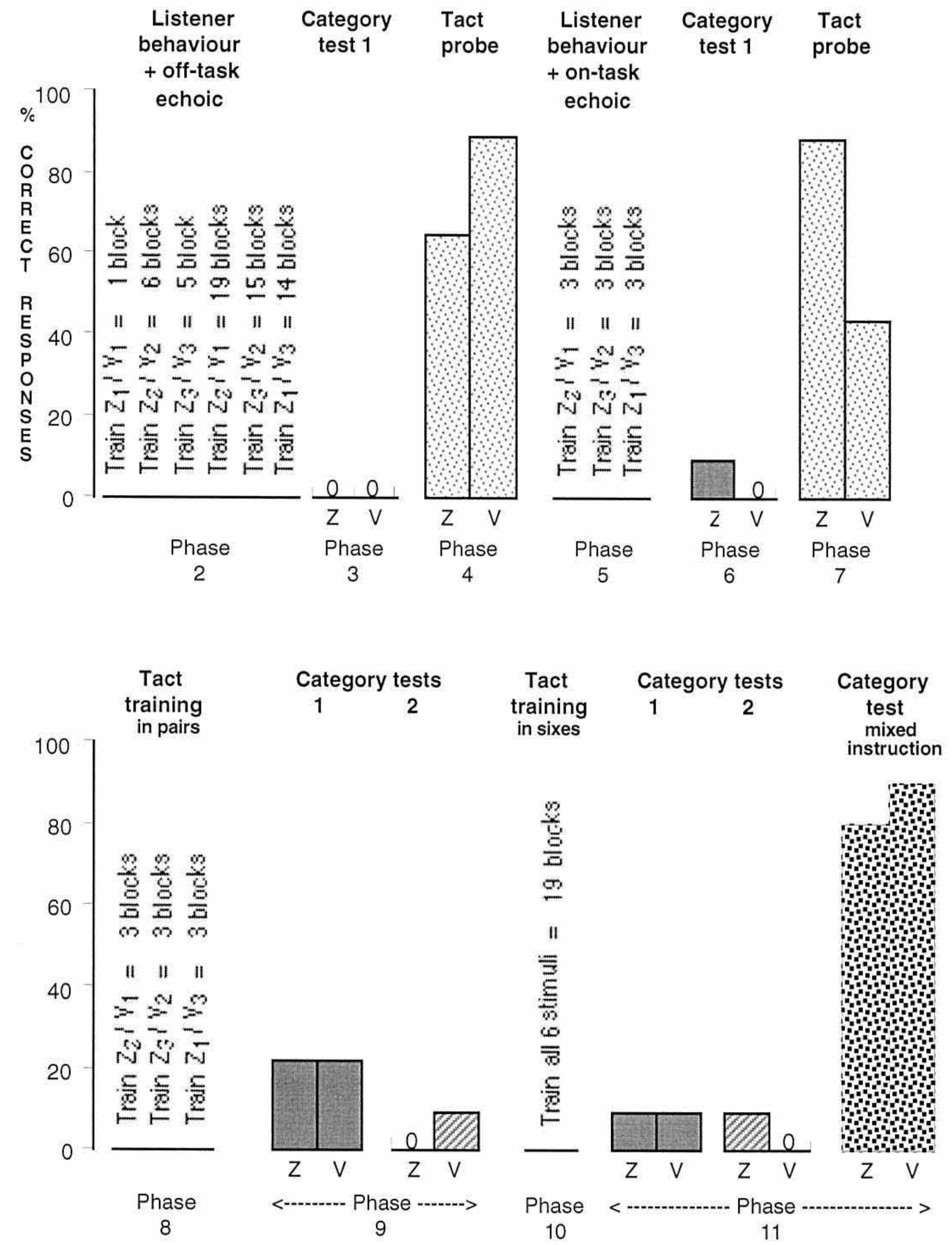


Figure 4.7. The training phases (Phases 2,5, 8, and 10) give the number of blocks taken to reach criterion level performance. The test phases show the percentage correct responding during category testing (Phase 3), probe for tacting (Phases 4 and 7), and category re-testing (Phases 6, 9 and 11).

Phase 2: Common Listener Training with Arbitrary Stimuli and Off-Task Echoic Training

MRJ required 1 eight-trial block to demonstrate criterion listener relation learning with pairs Z1/V1, six blocks with pair Z2/V2, and five blocks of trials with pair Z3/V3.

Stage 2.2: Common listener training with mixed pairs and reduction in reinforcement probability. He required 14-eight trial blocks to demonstrate criterion performance with pair Z1/V3; 19 blocks with pair Z2/V1, and 15 blocks with pair Z3/V2.

Phase 3: Categorisation Test 1.

MRJ completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). According to binomial theory this performance is as would be expected by chance ($N = 18$, $P(0) = 0.15 > 0.15$).

Phase 4: Probe for Tacting

In the first six-trial block, MRJ only produced his own idiosyncratic names for the stimuli. To discover whether he could indeed demonstrate the appropriate speaker behaviour to the stimuli, prior to the next block, he was told that some of the stimuli were called zog and some were called vek. Three more six-trial probe blocks were then given.

MRJ then produced the experimental names for the stimuli during the next two six-trial blocks, but he could not do this to criterion level. He only gave the correct name to all of the stimuli in one of the three blocks of trials. His verbalisations for each stimulus are presented below. Figure 4.7 shows the data for his production of the experimental names only.

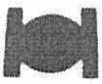
Z1 -  He said "don't know" in the first trial, "vek" on the next two trials and "zog" on the third.

Z2 -  He called this "a number", followed by "vek" once and then "zog" twice.

Z3 -  He called this stimulus "circle", then "zog" in the following three trials.

V1 -  He called this stimulus "pillow on the first trial, followed by "vek" in the next three trials.

V2 -  He said "don't know" in the first trial, "zog" in the next, followed by "vek" in the last two trials.

V3 -  He called this stimulus "chair" in the first trial and "vek" in the next three trials.

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement. MRJ reached criterion level performance with all three pairs.

Phase 5: Common Listener Training with Arbitrary Stimuli and On-Task Echoic Training

MRJ required three eight-trial blocks for each of the three pairs to reach criterion level performance. Criterion performance was deemed to be met when the participant responded correctly on seven of eight trials, to all three stimulus pairs, in one session, and with no feedback.

Phase 6: Repeat of Categorisation Test 1.

MRJ completed another 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.03>0.01).

In trial five, he produced the name "zog" as he gave the second of the stimuli to the experimenter. During trial seven of this test, which was the only trial where MRJ categorised correctly, he also spontaneously, and accurately, named the two matches as he presented them to the experimenter. These were his only verbalisations during the categorisation test.

Phase 7: Repeat of the Probe for Tacting

This time MRJ produced the experimental names "zog" and "vek", but he could not do this to criterion level. His scores out of three probe trials, for each stimulus are presented below.

Z1 - two correct trials	V1 - two correct trials
Z2 - three correct trials	V2 - one correct trial
Z3 - three correct trials	V3 - one correct trial

Following the probe for tacting, a check for maintenance of the trained listener relations with the three pairs of arbitrary stimuli was given. One eight-trial block was given for each pair without any reinforcement and MRJ reached criterion level performance with all three pairs.

Phase 8: Common Tact Training with Arbitrary Stimuli- in pairs

MRJ required 3 eight-trial blocks to demonstrate criterion speaker behaviour with all three pairs (Z1/V3,. Z3/V2, and Z2/V1).

Phase 9: Repeat of Categorisation Test 1

MRJ completed another 18 trials of the categorisation test using the "Look at this, can you give me the others" instruction. He scored 22 percent correct in trials where a zog stimulus was the target (2 of 9) and 22 percent correct in trials when a vek stimulus was the target (2 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (4) = 0.07>0.01).

Stage 9:2: Categorisation Test 2

MRJ then completed 18 trials of the categorisation test using the "What's this, can you give me the others" instruction. He scored 0 percent correct in trials where a zog stimulus was the target (0 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.3>0.01).

He produced the correct name for the target stimulus on 16 out of 18 trials.

Phase 10: Common Tact Training with Arbitrary Stimuli- in Sixes.

MRJ required 19 six-trial blocks to demonstrate criterion speaker behaviour with the six stimulus array. Criterion was reached when the participant responded with 100 percent accuracy over three six-trial blocks with no feedback.

Phase 11: Repeat of Categorisation Test 1.

MRJ completed another 18 trials of the categorisation test using the "Look at this, can you give me the others" instruction. He scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 11 percent correct in trials when a vek stimulus was the target (1 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (2) = 0.28>0.01).

Stage 11.2: Categorisation Test 2

MRJ then completed 18 trials of the categorisation test using the "What's this, can you give me the others" instruction. He scored 11 percent correct in trials where a zog stimulus was the target (1 of 9) and 0 percent correct in trials when a vek stimulus was the target (0 of 9). According to binomial theory this performance is as would be expected by chance (N =18, P (1) = 0.3>0.01).

He produced the correct name for the target stimulus on all 18 trials.

MRJ had finished all procedures and had not demonstrated correct categorisation. In Stage 1.2, an alternative instruction, "Can you give Teddy the other hats/cups?", was used when the participants showed difficulty in categorising the familiar objects; this instruction usually aided their subsequent success in this stage.

MRJ was therefore given another 20 trials of the categorisation test, in the first two trials of which the instruction "What's this? Can you give Teddy the other zogs/veks", was used. MRJ showed successful categorisation in both these trials.

The instruction then reverted to "What's this? Can you give Teddy the others?", for the next seven trials. He categorised successfully on six of these seven. In the first of these trials he said to the experimenter, "No, you have to say zogs!"

For the last nine trials, the instruction was again changed, this time to "Look at this. Can you give Teddy the others?" He categorised successfully on seven of these nine trials; the two trials that he failed were repeated, and this time he performed correctly.

Of the total 20 trials given, he scored 90 percent correct in trials where a zog stimulus was the target (9 of 10) and 90 percent correct in trials when a vek stimulus was the target (9 of 10). The probability that this would occur by chance is low and statistically significant (N =20, P (18) = 0.00<0.01).

Griffiths Test

The result of MRJ's Griffiths test gave a GQ (General Development Quotient) of 131. This score is in the normal range for his age.

Spontaneous verbal behaviour

During the training of listener relations with off-task echoic training (Phase 2), MRJ spontaneously produced the experimental names on only 15 occasions, producing the name "zog" on 5 occasions, and "vek" on 10 occasions. All 15 of these utterances were produced correctly to the targeted stimulus.

Fourteen of these utterances were as a response to the experimenter's request of "Can you give me the zog/vek?", saying "zog/vek" or "That's the zog/vek" as he gave the stimulus to the experimenter. On one occasion he directly echoed the experimenter, saying "That's not the vek".

During Phase 2, he also called stimulus V3 a "car" on two occasions.

Apart from those noted elsewhere in this results section, he did not produce any other spontaneous names for the stimuli.

Summary

MRJ did not categorise the physically different stimuli into two sets after common listener relations, along with both off-task and on-task echoic practice of the experimental names. Categorisation also did not occur when a common tact response had been taught to the stimulus sets, both when this speaker behaviour had been taught in pairs and when taught in sixes. MRJ eventually demonstrated categorisation only after he had been explicitly asked to give the other stimuli with the same common name.

In the case of MRJ, therefore, naming does not appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. Rather, his successful categorisation seemed to be dependent on the instruction used.

DISCUSSION

Of the 8 participants who commenced this experiment, one was withdrawn from the study and the remaining seven completed Phase 1 with ease. Only three of these seven completed Phase 2, common listener with off-task echoic training (with arbitrary stimuli). Four participants failed to reach criterion level performance with all of the stimulus pairings, which again, as seen from the evidence in Study 1, stresses the difficulty that children of this age have in learning the conditional discriminations required.

All three participants who completed all procedures showed evidence of maintaining intact listener relations after the first categorisation tests. Again, as in Experiment 1, we can accept that the listener relations were intact as the participants went into the first categorisation test.

Of the three participants who completed all procedures in this experiment, only one, ER, successfully categorised after listener plus off-task echoic training. Though only speaker behaviour in the form of an off-task echoic response was taught, ER also derived reliable tact responding to the experimental stimuli, as shown in the results of the probe that followed the categorisation test. It can be stated therefore, that she had formed the whole name relation, that is both listener, echoic and tact relations.

Also, in the case of ER, it was sufficient for her to be directed to the target stimulus for the name relation to be invoked, thereby enabling successful categorisation. She did not require overt production of the stimulus names.

As with three of the subjects in study 1, ER also demonstrated an example of spontaneous categorisation during the second trial of the probe for tacting. This occurred in one of the earliest opportunities to experience all six stimuli together and therefore one cannot make any assumptions that this event was related with language production, as one could with the other aforementioned participants. It is interesting, however, to note its occurrence especially as ER had by this point also demonstrated naming.

ER's results therefore support the experimental hypothesis, that is that along with listener relations, tact relations must also be established before naming, and hence the successful categorisation of physically different stimuli into two classes, is demonstrated.

The two other participants, who completed procedures, showed a different pattern of results. Neither of these participants categorised successfully after listener plus off-task echoic training and also failed to demonstrate reliable tacting of the stimulus names in the following probe trials. Both participants also failed to categorise after the subsequent on-task echoic training, again also failing to reliably tact the stimului in the following probe trials. The two participants results after common tact training will be treated individually next.

After common tact training in pairs, participant KO demonstrated successful categorisation. As with participant ER, it was not necessary for him to overtly name the stimuli for categorisation to occur. His results again support the experimental hypothesis that the tact relation must be established in order that naming can occur, and hence successful categorisation of physically different stimuli into two classes can be shown.

Participant MRJ, however, failed to categorise after common tact training, both after training had been given in pairs, and when all six stimuli were present. He also failed to categorise after being prompted to overtly produce the name of the target stimulus. He did however, categorise successfully in an extra category test. In this test he was given the additional verbal cue in the first two trials, where he was instructed to "give Teddy the zogs/veks". He did then go on to categorise the stimuli in terms of their common names.

This categorisation cannot be as clearly attributed to naming as have results with the other two participants. With the additional verbal cue his performance can be interpreted instead as an instance of generalised listener behaviour which was under control of the instruction used, rather than being an example of naming in action.

To illustrate, he received listener training to the instruction, "Can you give Teddy the zog/vek?" also the instruction during the test was "Can you give Teddy the other zogs/veks?". The instructions were virtually identical apart from the pluralising of the experimental names. It may be assumed that a child of his age would have had ample experience in real life situations with similar pluralised instructions and therefor this can be seen as an instance of generalised rather than an example of "emergent" or novel behaviour.

However, this example of categorisation behaviour does give an example of how naming may lead to categorisation in a real life setting. As a comparative example, with the youngest age group children in Phase 1 of Study 1, the categorisation test with familiar objects, it was often the case that they had to have the extra instruction "Can you give Teddy the other hats/cups?" before they would exhibit categorisation of these objects into two classes. The objects used in this phase were ones which the participants were perfectly capable of naming. As can be seen by comparing results of Phase one throughout the varying age groups of the experiments within this thesis, the older the children are, the greater their ability is to categorise without this additional instruction. These older children were perfectly able to categorise to the instruction "Can you give me the others" on their first categorisation trials with the familiar objects, and it is quite likely that children of this age may have had much more experience in real life situations of categorising to this instruction, thus the ease in generalising their knowledge and performance to the test situation.

MRJ was rather older than the age group discussed above, and he did not need the alternative instruction in order to categorise the familiar objects correctly in Phase 1 of this experiment, thus offering evidence that he did have experience with real life situations of this kind. It might have been expected that he would transfer this behaviour to the categorisation tests with arbitrary stimuli. It could be the case that lack of feedback to the contrary in the categorisation tests may have led him to believe that he was performing as the experimenter desired. In this case the new instruction would have served as an additional contextual cue that initiated the categorisation behaviour that he was already capable of. Contextual cues such as these would be prevalent in real life situations and would have an influence on, for example, whether a child would categorise objects according to colour, shape or function.

After two trials using this extra cue, the instruction was changed to that of the Category test 2 instruction, "What's this? Can you give Teddy the others?". MRJ maintained his correct categorisation. His spontaneous comment, "You have to say zogs" during the first of these trials however, suggests that his categorisation was still under control of this instruction. MRJ then continued to maintain correct performance when the instruction was changed further to, "Look at this. Can you give Teddy the others?" This suggests that he was able to categorise the stimuli previous to the added instruction.

MRJ's example of naming and categorisation provides us with a more ecologically realistic form of naming in action than the strictures of the experimental procedure provided. MRJ's results also emphasis the fact that the establishment of the whole name relation may not in itself be sufficient to drive categorisation, rather naming behaviour itself must be initiated.

The results of all three participants who completed this experiment do, however, support the experimental hypothesis. It appears that along with listener relations, common tact relations must also be established for the completion of the naming circle and thereby the initiation of categorisation.

Again, contrary to the expectations of Horne and Lowe (1996, p207), only one participant in this experiment derived tacting after listener training and even after both on and off task experience of echoing. For the two other participants, naming was only established after the tact element of the name relation was directly trained.

The fact that the two participants in this age group did not derive intact tact relations may be due to interference from other names which may have acted as competition for control over their speaker behaviour.

In the case of KO, as shown by the two probes for tacting that followed listener training with both on and off task echoing, he persisted in using his own names for the stimuli. He even continued to use these names during tact training. It was only after extensive tact training that the zog and vek experimental names took predominance and that categorisation was then exhibited.

Participant MRJ also showed this own-name interference. In the probe for tacting that followed listener plus off-task echoing, he gave his own names for the stimuli on the first six-trial block. However, he was then prompted to produce the experimental names, which he did, though not to criterion level. In the probe that followed on-task echoic training, he gave the experimental names but again, not to criterion, although there was no other evidence of interference.

Participant ER on the other hand, showed little evidence of interference from her own names. In fact, it can be concluded that she only gave her own names to one stimulus on one occasion. Her other verbalisations were prompted by a story she had just been read and were more of an instance of make believe play than an indication of stable alternative names.

To conclude, none of the three participants in this experiment demonstrated categorisation without also exhibiting evidence of the establishment of the whole name relation, that is, evidence for intact tact relations were always present. This evidence supports naming theory. However, the added echoic training was not sufficient in two of the three participants, to bring about untrained tact relations which is contrary to the expectations of Horne and Lowe (1996).

GENERAL DISCUSSION

Of the six participants that completed all procedures of the two experiments that comprised Study 2, five categorised the arbitrary stimulus sets into two classes consistent with the experimental names. All five of these participants only categorised when concurrent evidence of the establishment of both listener and tact relations was also shown. The two participants who completed procedures with a second set of stimuli showed the same results with their extra stimulus sets. These results strongly support naming theory.

Again, even more surprisingly, given the extra off-task and on-task echoic training, most of the participants did not establish common tact relations without explicit training. Of the six participants (Stimulus Sets 1), only two demonstrated untrained tact relations after listener plus off-task echoic training. Further, neither of the two participants, who completed procedures with two stimulus sets, demonstrated untrained tacting with these second sets.

As discussed in Study 1, it may be the case that tacting may have to be directly trained in order for naming to be established. An alternative explanation for these findings may be that the participants' own names for the stimuli may be interfering with the establishment of the newer, experimental names. Evidence supporting this latter explanation has already been addressed in the discussion sections for each experiment in Study 2.

Horne and Lowe hypothesise that, especially with older and more verbally sophisticated children, teaching listener relations might also lead to the derivation of tact relations, that is, naming. In support of this hypothesis, results showed that some of the participants in both Study 1 (Participants LN; Stimulus Set 1, and HW), and Study 2 (Participants HO; Stimulus Set 1, and ER), did in fact demonstrate the formation of tact relations without explicit training. In all four of these cases, the participants showed little evidence of interference by their own names for the stimuli.

An interesting phenomenon was shown with two of the above mentioned participants (LN in Study 1 and HO in Study 2). Both of these completed listener training with two stimulus sets and also showed evidence of untrained tacting with their first stimulus sets. They also showed little evidence of interference from their own names. Conversely, with their Set 2 stimuli they did not show evidence of untrained tacting, yet, this time, evidence of interference by other names was shown.

These results show an interesting double dissociation, that is, where tact relations emerge, own names are few, yet when own names are many, tact relations do not emerge. This is strong support for the hypothesis that the formation of untrained tact relations are inhibited by already established names.

Differences were noted between the two age groups in the listener plus off-task echoic training phase (Phase 2). The data for their Set 1 stimuli shall be discussed next.

In Stage 2.1, training in initial pairs, both age groups showed similar results. All six participants reached criterion level performance relatively easily. In Stage 2.2, training in mixed pairs, however, there was a marked difference in performance.

The participants of Experiment 1 (the 3.5 to 4.5 year olds) reached criterion level performance in an average of 20 blocks of trials. On the other hand, the participants of Experiment 2 (1.5 to 3.5 year olds) reached criterion level performance in an average of 68 blocks of trials.

This may be directly related to the age of the participants, the older group presumably being more language proficient and therefore more able to speedily transfer the common names to the other exemplars in that class. Apart from these training data, however, there does not seem to be any age related effects between the two groups.

The results of the present study also show interesting differences as regards the instruction used during the categorisation test trials.

In Study 2, of the five participants who categorised successfully, only one needed the "What's this?..." prompt to overtly produce the stimulus names in order to demonstrate successful categorisation. This participant, MRJ, also required an extra prompt of the form, "Can you give teddy the other zogs/veks", before he would categorise. His results again suggest that naming may not in itself be sufficient for the demonstration of categorisation. The other four categorised when the test instruction was "Look at this. Can you give teddy the others?". The two participants, who completed procedures with two sets of stimuli, also both categorised to the "Look at this..." instruction with their Set 2 stimuli.

The effects of the two different instructions contrast markedly to those of Study 1. Of the six participants in the latter study that did show categorisation, only two did so to the instruction "Look at this...". The other four categorised only when the alternate "What's this...?" instruction was utilised.

This phenomenon does not seem related to age. Participants across all three age groups in Study 1 needed the "What's this?..." instruction in order to categorise.

It may be the case that the extra echoic training received by those participants in Study 2 may explain these differences. This training may not in itself have been sufficient to bring about tacting (as discussed previously) and thereby the entire name relation, however, it may be the case that this extra speaker practice may, once naming was established, have assisted the initiation of actual naming behaviour.

According to the Horne and Lowe model of the development of naming (p. 197), the echoic training given concurrent to listener training (especially the on-task echoic training) seems to be more in accordance with the way a child would learn these relations in real life settings. Learning these two sets of relations together would lead to a situation where the child's listener behaviour to an object would occasion an echoic response to the object, and of course, the echoic response may occasion the appropriate listener behaviour towards the object.

This should then set the conditions for the development of the final element of the name relation, the tact. With the establishment of the tact relation, albeit explicitly trained, the whole name relation is in place and hence categorisation of other objects with that common name should be initiated. This, comparatively naturalistic way of acquiring the various elements of the name relation, may have been a significant factor behind the participants' ability to categorise without the need to overtly produce the target stimulus names.

Indeed two of the participants of this study, HO and ER, did in fact develop tact relations from this echoic and listener training (unlike any of the children in Study 1), and they also categorised successfully.

In contrast, in Study 1 listener relations were taught initially without any concurrent speaker training; all spontaneous echoic or tacting behaviour was ignored and not reinforced. All participants failed to categorise after this training.

Prior to the explicit training of the tact relations, therefore, the participants had received neither reinforcement for their production of the experimental names, nor any consequences that might have lead to the extinguishing of their own names for the stimuli. In this case, therefore, there would be the potential for a stronger level of interference from the participant's own names, thus explaining the failure to tact relations.

This interference would only begin to extinguish when criterion level performance had been achieved during tact training, yet perhaps not fully eradicated. It might be assumed then that these names may still have been a competing source of control during the categorisation tests, thus resulting in a need to overtly produce the stimulus names in order to categorise successfully.

In Study 2, the concurrent echoic training should have had the effect of strengthening the experimental names (to the detriment of their idiosyncratic names) at an earlier point of the procedures. By the time that tact training and a categorisation test had been given these own names would have had little or no control over their categorisation behaviour, resulting in successful categorisation without the need to overtly produce the names.

Another factor that may also have contributed to the inhibition of tact formation may have been that the criterion level set for passing the on-task echoic training phase was not stringent enough.

In the off-task echoic training phase (Phase 2), the criterion level was quite strict. This was defined as when the participant had responded correctly on seven of eight trials, to all three stimulus pairings, without feedback and over two blocks of trials per pair conducted over two separate sessions.

In the on-task echoic training phase (Phase 5) however, criterion for success was set as when the participant responded correctly to both listener and echoic elements of each trial on seven out of eight trials, for all three stimulus pairs, without feedback, and in only one session.

Most of the participants reached criterion in Phase 5 very quickly indeed, most reaching this level of performance in one eight-trial block for each of the three stimulus pairs. This, in hindsight, was not surprising. Participants had already reached criterion level performance to the listener training element in Phase 1 and were required to pass a maintenance check for these relations immediately prior to Phase 5. They were already practiced in the required echoic element of the Phase 5 trials.

With more on-task echoic training it may have been possible for the participants to have extinguished their own names for the stimuli and instead developed the tact element of the name relation.

According to Horne and Lowe (1996, p. 202) the echoic repertoire of a child is a critical link in the development of naming, as it determines whether a listener relation becomes a speaker-listener relation. That is, what the child can echo will determine what listener behaviour becomes incorporated into a name relation.

However, to develop from mere echoic response to tacting and naming, the echoic response must eventually be trained in the presence of the corresponding object. As the procedure stands, it is dubious whether the on-task training did indeed provide this necessary training experience.

One might criticise the procedures of Experiment 1 in that the listener and tacting training phases were not identical in composition. This criticism also may be applicable to Study 1 of this thesis and also to the studies performed by Harris (see Horne & Lowe, in press) and will be discussed further in the concluding chapter of this thesis.

To recollect, listener training, throughout all experiments of this thesis, was given in pairs only before the ability to categorise was assessed. In the tact training phases, however, training was given first in pairs, and then in sixes, before a categorisation test was performed.

This procedural flaw may lead to the proposition that a child may have to see and interact with all six stimuli in one place before categorisation could occur.

Experiment 2, however proved this assumption to be invalid. One of the three participants (KO) did in fact categorise after tact training when the stimuli were presented in pairs alone. Another (ER) categorised after listener training plus off-task echoing in pairs. The third (MRJ) did not categorise until after additional prompting with the class names for the stimuli.

To conclude, the results from Study 2 show strong support for the view that naming is necessary for categorisation of stimuli that physically differ. As in Study 1, these results cannot be explained by the competing theories of Sidman (1997, 1990) or Relational Frame Theory (e.g. Hayes & Hayes 1989, 1992).

* * *

Study 1 attempted to falsify naming theory by training only the listener element of the name relation before testing for categorisation. Study 2 repeated this procedure but also included concurrent off-task ,and later on-task, echoic training to investigate if this would engender the formation of the tact relations necessary to complete the name relation and initiate categorisation.

None of the 16 participants from these studies, whose ages ranged from 1 year 7 months to 4 years 2 months, demonstrated categorisation without also showing evidence of intact listener and speaker relations, that is naming.

These two studies were based on methodology first used by Fay Harris (see Horne and Lowe, in press). Her study attempted to confirm Horne and Lowe's (1996) naming hypothesis. She did this by training two common tact responses to sets of arbitrary stimuli, then testing for categorisation. The age of the nine participants in her study ranged from 2 years 3 months to 4 years 3 months of ages. Of these nine participants, three categorised successfully after common tact training, the remaining six participants subsequently demonstrated categorisation after they were prompted to overtly produce the name of the target stimulus in the categorisation trials.

In Harris' study the tact relations were trained first in pairs and then when all six stimuli were present, before a categorisation test was given. The findings of Study 2 of this thesis, however, have shown that, in the speaker training element of the procedure, it was at times necessary to teach the speaker relations with all six stimuli present before successful categorisation occurred. Changes to the experimental procedure in Experiment 2 led to evidence that showed that it is not necessary for the stimuli to be tacted when presented together in order for naming behaviour and categorisation to be initiated.

Experiment 2 of Study 2 demonstrated that categorisation can occur after the whole name relation is trained, that is training of common listener relations and common tact relations, both in pairs. Harris' procedure, however, did not include a common listener training element and her results cannot therefore be directly compared to the data presented in the first two studies of this thesis. It has not yet been demonstrated in her data that training only tacting in pairs leads to the establishment of the whole name relation and thereby categorisation.

Harris also claims that although merely common tact relations were taught, the whole name relation "emerged". Evidence for the presence of listener element of the name relation was inferred from the participants' ability to pass the categorisation tests; however, she did not include a direct test for the presence of these relations. It cannot be stated emphatically, therefore, that the whole name relation had indeed been established.

Study 3 attempted to replicate Harris' study with procedural changes to counter the above criticisms. First, tact training was administered in pairs before testing for categorisation, after which if necessary, tact training was given in sixes and a further categorisation test given. After the completion of tact training and categorisation tests, a probe for the presence of listener relations was also given.

CHAPTER 5

STUDY 3

WILL TEACHING COMMON TACT RELATIONS (IN PAIRS) LEAD TO CATEGORY FORMATION? ALSO WILL CORRESPONDING, UNTRAINED LISTENER BEHAVIOUR, THAT IS, NAMING, BE DEMONSTRATED?

EXPERIMENT 1

The aim of this experiment was to provide a replication of a study by Harris (See Horne & Lowe, in press), whose participants showed categorisation after being taught tact relations to three pairs of arbitrary stimuli. However, whereas Harris' participants learned these relations when the stimuli were presented in a six-stimulus array, in this experiment the stimuli were only presented in pairs. Also, unlike Harris' procedure, a probe for appropriate listener relations, and hence naming, was given at the end of the procedure. The age of the participants in this study ranged from 3.5 to 4.5 years.

METHOD

Participants

Three participants took part. Table 5.1 shows, for each participant, their age and gender. All participants were given the Griffiths test to ascertain their normal development (reported at the end of each participant's result section). The MCDI test was not given to this age group. Recruitment was as for the general method.

Table 5.1.
Participants' sex and age

Participant	Sex	Age at start year: month	Age at first categorisation test year: month
AH	F	3: 08	4:00
ES	M	3: 09	3:11
CW	M	4: 00	4:01

F = female M = male

Procedure, Apparatus, and Settings.

The procedure employed in Experiment 1 was based largely on the General Method section (see Chapter 3), but with the following exceptions. Also see Figure 5.1 for a flowchart representation of the procedure.

Phase 1: Common Tact Training and Category Training with Familiar Objects

Stage 1.1 : Common Tact training with familiar objects.

This stage was as the general method for Phase 1.1, with the following exceptions to the instructions used.

The experimenter placed each of the three pairs of hat and cup stimuli, in turn, on the table and, pointing to the target stimulus, said "What's this?" If the child responded incorrectly, the experimenter said "No, this is a cup/hat. Can you say cup/hat?" The stimuli were then removed from the table and replaced in a different order. Counterbalancing procedures and criteria were as in the General Method.

Stage 1.2: Categorisation test with familiar objects.

This stage was as Stage 1.2 of the general method.

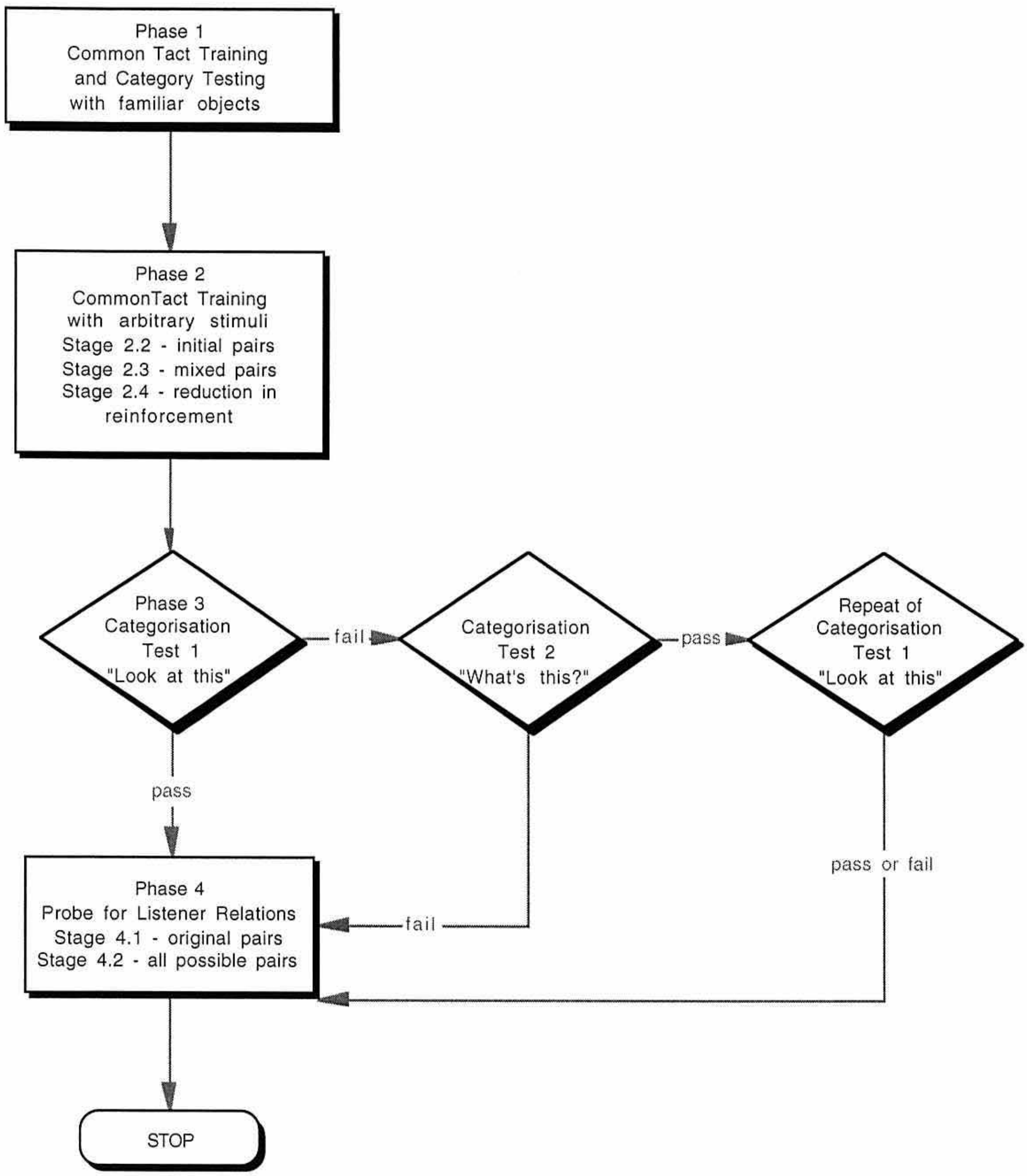


Figure 5.1: Flowchart representation of the procedure of Experiment 1.

Phase 2: Common Tact Training with Arbitrary Stimuli - In Pairs.

Stage 2.1: Common tact training - practice trials

Prior to tact training with each pair of stimuli, the participants were given one block of eight training trials to practice echoing the required speaker behaviour. In these trials the experimenter pointed to one of the stimuli, saying "This is a zog/vek. What's this?". If the participant responded correctly she or he was reinforced with praise. If the subject failed to respond, the experimenter prompted a response by saying "This is a zog/vek, Can you say zog/vek?". There was no criterion level set for this first block.

Stage 2.2: Common tact training - original pairs

The procedure during this stage was as that of Stage 5.1 (common speaker training with arbitrary stimuli - in pairs) of the general procedure.

To recap, for each of the three stimulus pairs in turn, the experimenter pointed to the target stimulus and asked the participant, "What's this?" In each trial the participant's correct responses were reinforced, and corrective feedback was given following incorrect responses. Criterion level performance was reached when the participant could respond correctly to seven out of eight trials in one eight-trial block

Stage 2.3: Common tact training - mixed pairs

The stimuli were allocated to different pairs (e.g. Z1/V3, Z2/V1, and Z3/V2, hereafter referred to as Z/Va, Z/Vb, and Z/Vc) and again presented to the participant as in Stage 2.2 (above). Criterion level was as above.

Stage 2.4: Reduction in reinforcement probability - mixed pairs

The three sets of mixed pairs were then presented to the participant successively. That is, that she or he received one eight-trial block (presented as in Stage 2.3 above) with mixed pair "a", followed by one block with mixed pair "b", and then one block of mixed pair "c". In this stage, however, no feedback was given to any of the participant's responses.

All three pairs continued to be presented successively until the participant responded correctly to seven out of eight trials, for all three pairs, without any reinforcement. A further requirement was that this had to occur twice in succession, and spaced in time, over two separate experimental sessions.

If the participant's performance deteriorated with any of the pairs, extra training trials with full feedback were given, only to that particular stimulus pairing, until criterion level performance (as Stage 2.3) was resumed. That pair would then return to being tested, as above, without any reinforcement, alongside the other two pairings.

Phase 3: Categorisation Test Procedure.

Stage 3.1: Common tact testing with arbitrary stimuli.

Prior to the main categorisation test, maintenance of the tact relations was checked. As in Stage 2.4 above, successive blocks of trials were performed with all three zog/ vek pairs, without reinforcement. However in this stage, only four (as opposed to eight) trials were given for each of the three stimulus pairs.

Only if the participant was 100 percent accurate in her or his response for all stimuli, and with no feedback from the experimenter, did she or he proceed to Stage 3.2. Otherwise the participant returned to training as in Stage 2.4. until criterion level performance was re-established.

Stage 3.2: Categorisation test with familiar objects.

This was performed as in Stage 3.1 of the general procedure.

Stage 3.3: Categorisation test 1

This was also performed as in Stage 3.2 of the general procedure. Eighteen categorisation test trials were given using the "Look at this. Can you give Teddy the others like this?" instruction.

Stage 3.4: Categorisation test 2

If the participant failed to categorise correctly in Stage 3.3, eighteen categorisation test trials were given using the "What's this. Can you give Teddy the others like this?" instruction.

Phase 4: Probe for Listener Relations.

After the participant had completed the categorisation test procedures, whether categorising successfully or not, probe trials were given to determine whether the participants were able to produce appropriate listener behaviour. That is, when hearing the appropriate auditory stimulus /zog/ or /vek/, they would give the correct zog or vek stimulus to the experimenter

As in the categorisation tests, a second experimenter conducted all test trials from behind the one-way screen.

Stage 4.1: Probe for listener relations - original pairs

The three pairs in this stage consisted of the Z/Va, Z/Vb, and Z/Vc stimuli which had been used in Stage 2.4 of this procedure.

The two stimuli that made up each pair were targeted twice, once to the right and once to the left of the child's midline. Therefore the child received 12 trials in total (four of Z/Va, four of Z/Vb and four of Z/Vc). The pairs were presented in a pre-determined randomised manner.

For each trial the experimenter placed one pair of zog and vek stimuli on the table, one stimulus to each side of the child's midline, and said "Look at these. Can you give Teddy the zog/vek?" No feedback was given to the participant's responses.

According to Binomial Probability theory, participants were deemed to have shown a significant performance in this stage if they scored 10 out of 12 trials[1] correctly.

When the 12 trials had been completed, the participants proceeded to Stage 4.2.

Stage 4.2: Probe for listener relations - all possible pairs

This stage was conducted in the same manner as Stage 4.1. However, in this case, the stimuli were combined into every possible zog/vek pair, making nine different combinations, as shown below:

Z1/V1	Z1/V2	Z1/V3	Z2/V1	Z2/V2
Z2/V3	Z3/V1	Z3/V2	Z3/V3	

The stimuli in each pair were targeted twice, once to the right and once to the left of the participant's midline. This yielded 36 probe trials in total. The pairs were presented in a pre-determined randomised manner. No feedback was given to the participant's responses. All procedures then ceased.

[1] When N (number of trials) = 12, and p (probability of selecting the correct stimulus in each trial) = 0.5; the probability of correctly completing 10 trials would be as follows: (N =12, P (10) = 0.016>0.05). The significance level of 0.05 was selected for this criterion level only due to the very small number of trials performed.

According to Binomial Probability theory, participants were deemed to have shown a significant performance in this stage if they scored 25 out of 36 trials[2] correctly.

RESULTS

Table 5.2 shows the data, for all three participants, of the first experimental phase. Data from the other phases will be presented as individual graphs from Phase 2 onwards.

Phase 1: Common Tact Training and Category Training with Familiar Objects

Table 5.2 shows the number of eight-trial blocks each participant required in order to achieve criterion performance in Stage 1.1 common tact training for each of three familiar object (hat and cup) pairs.

Table 5.2
Results of Phase 1: Common tact training and category training with familiar objects.
In Stage 1.1, H1/C1, H2/C2 and H3/C3 refer to the three familiar object (hat and cup) pairs. Two instructions were used in Stage 1.2, "Look at this. Can you give me the others like this?" and "Look at this. Can you give me the other hats/cups?"

Participant	Stage 1:1 Common tact training in pairs			Stage 1:2 Categorisation test	
	H1/ C1	H2/C2	H3/C3	"hats & cups"	"Others"
AH	1	1	1	0	1
ES	1	1	1	0	2
CW	1	1	1	0	1

[2] When N (number of trials) = 12, and p (probability of selecting the correct stimulus in each trial) = 0.5; the probability of correctly completing 25 trials would be as follows: (N =36, P (25) = 0.008>0.01).

Table 5.2 also shows the number of six-trial blocks required to achieve criterion performance in Stage 1.2 familiar object categorisation. For Stage 1.2, the left hand column shows the number of training blocks each participant required to categorise the six familiar objects into two categories (one of hats and the other of cups) when shown either a hat or a cup and asked "Look at this. Can you give me the other hats/cups?". The right hand column of data for Stage 1.2 shows the number of blocks each participant required to correctly categorise the hats and cups in response to the instruction: "Look at this. Can you give me the others like this?"

All three participants learned to categorise the hats and cups appropriately in response to the instruction "Look at this. Can you give me the others like this?", and progressed to Phase 2 of the experiment. None of the participants received the alternative instruction.

Participant AH.

Phase 1: Common Tact Training and Category training for familiar objects

Participant AH required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion tact relation learning in Stage 1.1 (see Table 5.2).

In Stage 1.2 category training with familiar objects, she required one block of six trials using the instruction "Look at this. Can you give Teddy the others like this?", to reach criterion performance.

Phase 2: Common tact training with arbitrary stimuli - in pairs.

AH required one eight-trial block, with each of the three initial pairs, to demonstrate criterion tact relation learning (See Figure 5.2).

She required one eight-trial block to demonstrate criterion level performance with mixed pair Z1/V2, followed by one block with Z2/V3 and also one block with pair Z3/V1.

In Stage 2.4 (reduction in reinforcement probability) she required 20 eight-trial blocks to reach criterion level performance with pair Z1/V2, 25 blocks with pair Z2/V3, and 21 blocks with pair Z3/V1.

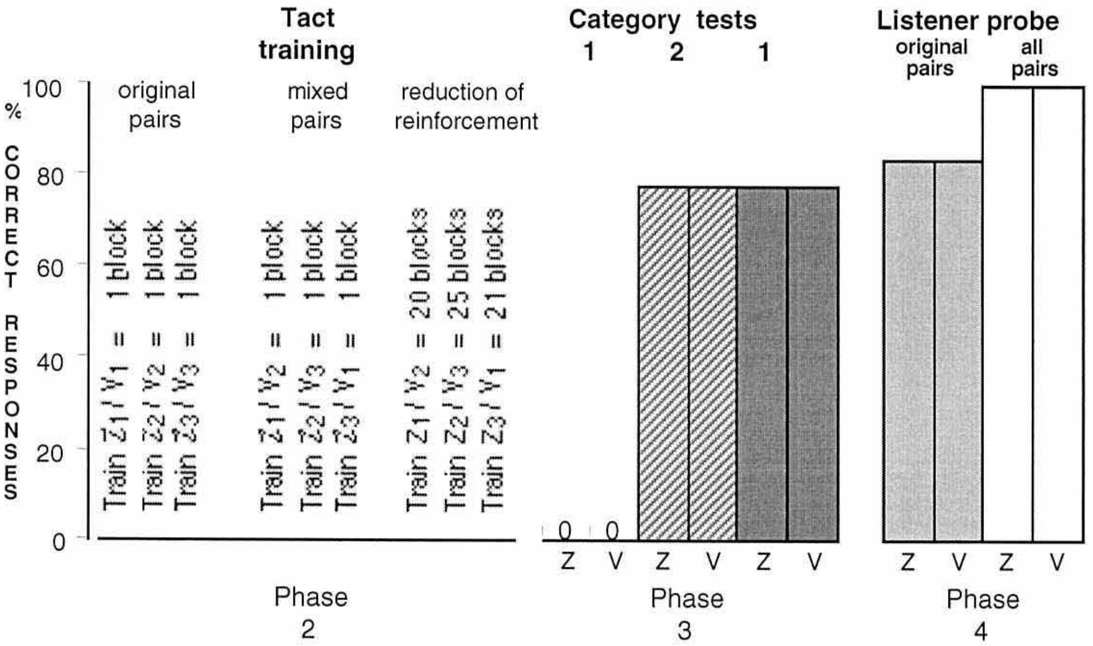


Figure 5.2. Phase 2 gives the number of blocks taken to reach criterion during all stages of common tact training. The test phases show the percentage correct responding during category testing (Phase 3) and the probes for listener relations (Phase 4).

Phase 3: Categorisation Test Procedure.

Stage 3.3: Categorisation test 1. AH completed 18 trials of the categorisation test using the "Look at this. Can you give me the others?" instruction. She failed to categorise correctly on any of the test trials.

Stage 3.3: Categorisation test 2. AH then completed 18 trials of the categorisation test using the "What's this, can you give me the others?" instruction. She showed correct categorisation on 78 percent (7 of 9) of trials where a zog stimulus was a target, and 78 percent correct (7 of 9) trials where a vek stimulus was a target. According to binomial theory the probability that this would occur by chance is low and statistically significant (N =18, P (14) = 0.00<0.01).

She also produced the correct stimulus name to the "What's this?" request on 15 out of a possible 16 occasions, in two other trials, the experimenter used the "Look at this." instruction by mistake.

Repeat of Categorisation test 1.

AH then completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. She again showed correct categorisation in 78 percent (7 of 9) trials where a zog stimulus was a target, and in 78 percent of trials (7 of 9) where a vek stimulus was a target. This performance was statistically significant (N =18, P (14) = 0.00<0.01).

Phase 4: Probe for listener relations.

Stage 4.1: Probe for listener relations - original pairs. AH completed ten out of 12 probe test trials correctly (five where a zog was a target and five where a vek was target). According to binomial theory the probability that this would occur by chance is low and statistically significant (N =12, P (10) = 0.016<0.05).

Stage 4.2: Probe for listener relations - all possible pairs. AH completed all 36 probe test trials with 100 percent accuracy. This performance was also statistically significant (N =36, P (36) = 0.00<0.01).

Griffiths Test .

The result of AH's Griffiths test gave a GQ (General Development Quotient) of 124. This score is in the normal range for her age.

Summary

When only the tact element of the name relation had been directly trained (in pairs), AH initially failed to demonstrate categorisation with the first categorisation test, which used the "Look at this" instruction. In the subsequent test however, using the "What's this?" instruction, and thus prompting overt production of the stimulus names, successful categorisation did occur. In a following test, where the instruction was again changed to "Look at this?", she maintained her successful categorisation.

The subsequent probe showed that she could also demonstrate appropriate listener behaviour towards the stimuli.

These findings support those of Harris and naming theory. Whereas only a common tact response was taught, categorisation and also appropriate listener relations (the complete name relation) naming was also shown.

In the case of AH, the establishment of both speaker and listener elements of the name relation do not, in itself, appear to have been sufficient for the emergence of the categorisation of physically different stimuli into two sets. Rather, naming behaviour, as illustrated by her overt naming of the target stimuli, was necessary for successful categorisation to occur.

Participant ES.

Phase 1: Common Tact Training and Category Training with Familiar Objects

Participant ES required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion tact relation learning in Stage 1.1 (see Table 5.2).

In Stage 1.2 category training with familiar objects, he required two blocks of six trials using the instruction "Look at this. Can you give Teddy the others like this?", to reach criterion performance.

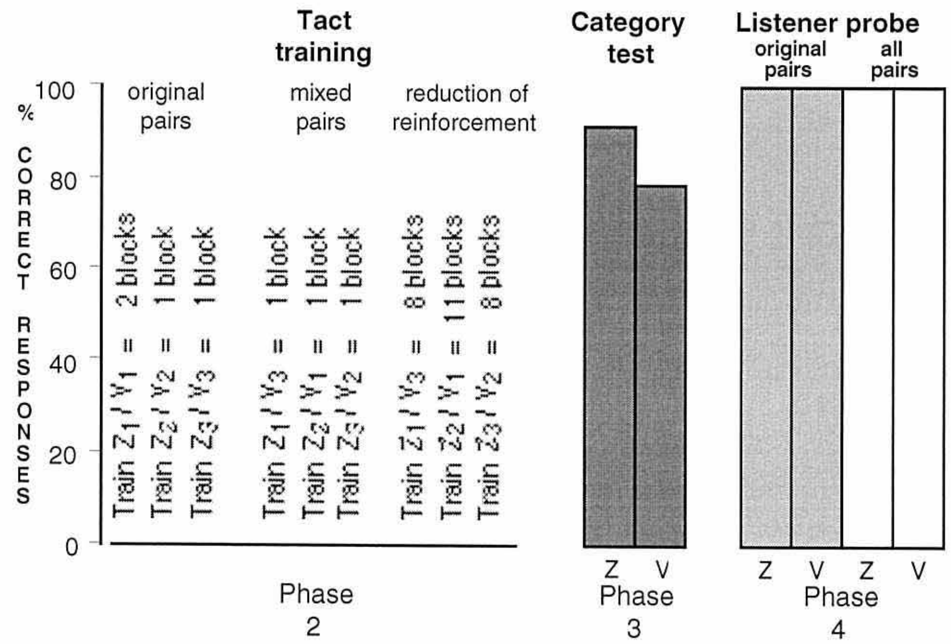


Figure 5.3. Phase 2 gives the number of blocks taken to reach criterion during all stages of common tact training. The test phases show the percentage correct responding during category testing (Phase 3) and the probes for listener relations (Phase 4).

Phase 2: Common Tact Training with Arbitrary Stimuli - in pairs.

ES required two eight-trial blocks with initial pair Z1/V1 to demonstrate criterion tact relation learning, followed by one block each with initial pairs Z2/V2 and Z3/V3.

He required one eight-trial block to demonstrate criterion level performance with mixed pair Z1/V3, followed by one block with Z2/V1 and also one block with pair Z3/V2.

In Stage 2.4 (reduction in reinforcement probability) he required 8 eight-trial blocks to reach criterion level performance with pair Z1/V2, 11 blocks with pair Z2/V3, and 8 blocks with pair Z3/V1.

Phase 3: Categorisation Test Procedure.

ES completed 17 trials (due to experimenter error) of the categorisation test using the "Look at this. Can you give me the others?" instruction. He scored 86 percent correct (6 of 7) when a zog stimulus was the target, and 70 percent (7 of 10) when the vek was a target. This was statistically significant (N =17, P (13) = 0.00<0.01).

In order to equalise the number of zog and vek trials given, and also as an additional check to see if his correct categorisation would continue, in a separate session another eleven trials of Categorisation Test 1 were administered. He categorised correctly to all of these (seven correct of seven zog trials and four of four correct vek trials).

The graph in Figure 5.3. (Phase 3) shows the combined data from the 28 test trials detailed above. These data show that, of a total of 28 test trials, he scored 93 percent correct (13 of 14) when a zog stimulus was the target, and 79 percent (11 of 14) when the vek was a target.

Phase 4: Probe for Listener Relations.

Stage 4.1: Probe for listener relations - original pairs. ES completed all 12 probe test trials with 100 percent accuracy. According to binomial theory the probability that this would occur by chance is low and statistically significant (N =12, P (12) = 0.00<0.05).

Stage 4.2: Probe for listener relations - all possible pairs. ES completed all 36 probe test trials with 100 percent accuracy. This performance was also statistically significant (N =36, P (36) = 0.00<0.01).

Griffiths Test .

The result of ES's Griffiths test gave a GQ (General Development Quotient) of 118. This score is in the normal range for his age.

Summary

ES' results support Harris' findings and also naming theory. Whereas only a common tact response was taught (in pairs), categorisation and also appropriate listener relations, that is, the complete name relation, was also shown.

Participant CW.

Phase 1: Common Tact Training and Category Training with Familiar Objects

Participant CW required only one block of eight trials for each of the three stimulus pairs to demonstrate criterion tact relation learning in Stage 1.1 (see Table 5.2).

In Stage 1.2 category training with familiar objects, he required one block of six trials using the instruction "Look at this. Can you give Teddy the others like this?", to reach criterion performance.

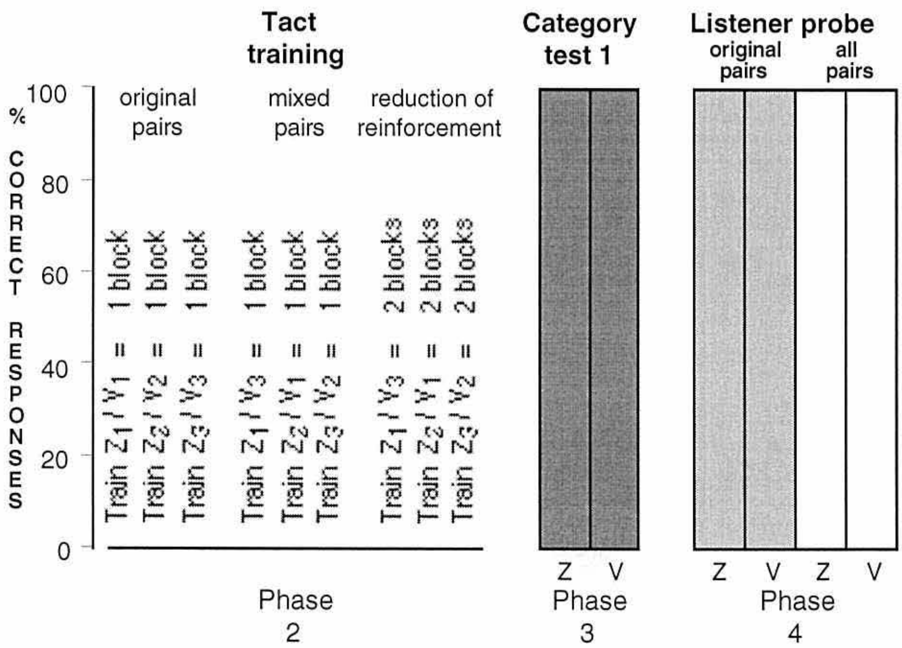


Figure 5.4. Phase 2 gives the number of blocks taken to reach criterion during all stages of common tact training. The test phases show the percentage correct responding during category testing (Phase 3) and the probes for listener relations (Phase 4).

Phase 2: Common tact training with arbitrary stimuli - in pairs.

CW required one eight-trial block, with each of the three initial pairs, to demonstrate criterion tact relation learning

He required one eight-trial block to demonstrate criterion performance with mixed pair Z1/V3, followed by one block with Z2/V1 and also one block with pair Z3/V2.

In Stage 2.4 (reduction in reinforcement probability) he required 2 eight-trial blocks to reach criterion level performance with all three pairs (Z1/V3, Z2/V1, and Z3/V2). This was the minimum number of blocks necessary.

Phase 3: Categorisation Test Procedure.

CW completed 18 trials of the categorisation test using the "Look at this, can you give me the others?" instruction. He categorised correctly to all test trials. This performance was statistically significant (N =18, P (18) = 0.00<0.01).

Phase 4: Probe for Listener Relations.

Stage 4.1: Probe for listener relations - original pairs. CW completed all 12 probe test trials with 100 percent accuracy. According to binomial theory the probability that this would occur by chance is low and statistically significant (N =12, P (12) = 0.00<0.05).

Stage 4.2: Probe for listener relations - all possible pairs. CW completed all 36 probe test trials with 100 percent accuracy. This performance was also statistically significant (N =36, P (36) = 0.00<0.01).

Griffiths Test

The result of CW's Griffiths test gave a GQ (General Development Quotient) of 114. This score is in the normal range for his age.

Summary

CW's results support Harris' findings and also naming theory. Whereas only a common tact response was taught (in pairs), categorisation and also appropriate listener relations, that is, the complete name relation, were also shown.

DISCUSSION

All three participants reached criterion to Phase 1 of the experiment very easily; two needed only the minimum necessary amount of trials. The third needed only one extra block of trials than the minimum in order to reach criterion level performance in Stage 1.2. None of these participants required the alternative, "...Can you give the hats/cups?" instruction in the Categorisation test with familiar objects. These training data are consistent with the findings of the previous two studies for this age range of children. It appears that children of this age can acquire tact relations, and categorise an array of familiar objects as readily as the children of the other studies could acquire the corresponding listener relations to the same stimuli.

In Phase 2, Common Tact Training with Arbitrary stimuli, all three participants reached criterion level performance to the first two stages (original and mixed pair training) very easily. All three needed a near minimum number of training trials to do so. In Stage 2.3, the reduction in reinforcement part of the training, only one participant (CW) reached criterion level in the minimum number of trials. The other two participants needed extended training before reaching criterion level. This fact re-emphasises the necessity of the reduction in reinforcement stage of this phase, as pointed out in the criticisms of the earlier studies.

Of the three participants that completed Study 3, all showed categorisation of the arbitrary stimulus sets into two classes consistent with the experimental names zog and vek. All three also showed evidence of reliable and untrained listener behaviour. It can be stated then that evidence for the establishment of the whole name relation had been demonstrated. All three participants categorised after training was given in pairs, none requiring extra training with all six stimuli present.

Of these three participants, two categorised successfully immediately after tact training in pairs, that is, when the instruction used in the categorisation tests was "Look at this"

The other participant, AH, did not categorise immediately to the "Look at this" version of the test, but did so when she was prompted to overtly tact the target stimuli. Once she had categorised to the alternative "What's this?" instruction, she maintained her correct categorisation when a subsequent test was given using the "Look at this" instruction . As stated, she also then demonstrated evidence of reliable listener behaviour.

AH's results are consistent with those of participants in the earlier experiments of this thesis, suggesting that naming may not in itself be sufficient to bring about successful categorisation.

These results of this experiment strongly support one of the major predictions from Horne and Lowe's (1996) naming theory. Their account predicts that the training of a common tact response to each member of a set of stimuli will also result in the (untrained) establishment of appropriate listener behaviour towards the stimuli, that is, the whole name relation. This was seen to be the case. Furthermore, when naming is established, categorisation of these stimuli into classes consistent with the category names was evidenced.

The results of the current study add strength to Harris' position. In her studies, the existence of the listener element of the name relation was not directly measured. However, from the data presented here, we can infer that Harris' participants had also formed these untrained relations.

Furthermore, it seems likely that, at least some, of Harris' participants would have categorised if tacting had been trained in pairs, rather than in sixes. The results of both Harris and the present study, therefore, cannot be explained by competing accounts.

These participants all derived listener relations easily. Participants in the two earlier studies, however, who were given listener training, did not, in general, derive tact relations. Why should this be the case?

Horne and Lowe describe listener behaviour as "a crucial precursor to the development of linguistic behaviour" (1996, p. 192). Children learn to listen long before they learn to speak and therefore these behaviours may be deemed to be a more "primitive" form of behaviour. Many studies have indeed shown that a child rarely learns to tact without also learning appropriate listener behaviour to that stimulus (e.g. Harris et. al., 1995; Huttenlocher and Smiley, 1987; Bowerman, 1980).

On the other hand, learning a listener relation does not necessarily entail the learning of the appropriate speaker relation. Furthermore, as shown in the earlier studies, interference by already established relations may also occur.

To conclude, this study supports naming theory. Teaching common tact relations in pairs also resulted in the establishment of untrained listener behaviour. This establishment of the whole name relation also resulted in the categorisation of physically dissimilar stimuli into two distinct classes. It was not necessary for the participants to be taught these relations with all six stimuli present.

CONCLUSIONS.

The experiments of this thesis set out to test Horne and Lowe's (1996) model of symbolic naming. The main experimental hypothesis of the three studies that comprise Chapters 3, 4, and 5, was that the categorisation of physically different stimuli would not occur unless the whole name relation (that is, both listener and tact relations) was first established. The procedures were designed to systematically analyse the differential effects on categorisation ability by training; (a) listener relations without also training speaker relations, and (b) speaker relations without the corresponding listener relations.

Study 1 attempted to falsify naming theory by training only unidirectional common listener responses to two sets of arbitrarily shaped stimuli, before testing for categorisation. Study 2 replicated Study 1, but also provided extra echoic training of the common class names, before categorisation testing. Study 3 trained common tact relations to the same arbitrary stimuli, and then tested for categorisation and untrained listener relations.

Table 6.1.
The number of participants who demonstrated successful categorisation after reaching criterion level performance in the differential training schedules of Studies 1, 2, and 3.

	Relations Trained				
	Listener relations only	Tact relations only	Listener relations (with concurrent echoic training)	Listener and Tact relations	Never Categorised
Study 1	0			6	3
Study 2			2	3	1
Study 3		3			0

Table 6.1 above presents a brief synopsis of the results, from all three studies, of the 18 participants who completed all training procedures. For those participants who completed procedures with two stimulus sets, data are presented for only the first set.

Without exception, all children who completed procedures, and also demonstrated correct categorisation showed evidence of both listener and tact relations, that is, the whole name relation. These results show strong support for Horne and Lowe's naming theory and show that common listener responding is not sufficient, but that naming is necessary for the categorisation of stimuli that physically differ.

* * *

At the beginning of the introductory chapter several questions were raised about the relationship between language and categorisation. The first of these questions asked if developments in language are related to developments in categorisation. The review of a range of empirical evidence, from both developmental and behaviour analytic psychology, suggests that such a relationship exists.

A second, more pertinent, issue questioned how these two abilities are related; do developments in productive language cause the changes in categorisation, or vice versa?

Horne and Lowe's (1996) naming account, reviewed in Chapter 2, asserts that it is when an array of physically dissimilar objects are implicated in the same intra-individual speaker-listener relation that categorisation of these objects may occur; common listener relations alone will not suffice. On this account it is learning the speaker behaviour that corresponds to previously learned listener behaviour which completes and "closes" the naming circle and hence is the catalysing factor behind naming behaviour and the categorisation of the said objects. The data presented herein support this viewpoint.

Two other questions were raised in the introduction: can the development in categorisation and productive language abilities be attributed to innate factors, or are they dependent on the child's learning history? The data presented here provide some answers to these two questions, each of which will be now addressed in turn.

Can these Developments be Attributed to Innate Factors?

The phenomenon of spontaneous exhaustive categorisation that has been reviewed in Chapter 1 concerns physically similar stimuli (and hence stimulus generalisation) for which the pre-experimental sorting history is unknown. The classifying behaviours demonstrated by the participants of the present studies concerned stimuli which bore no physical resemblance to each other and for which there was definitively no sorting history. As such, they have all the features of performances seen in stimulus equivalence experiments. Sidman (1990, 1994, 1996, 1997) has stated that the ability to demonstrate such "emergent" classifying behaviours as observed in equivalence tests may be a given.

> Just as the stimulus functions of reinforcement, discrimination, conditioned reinforcement, and conditional discrimination represent unanalysable primitives in the description of behavior, equivalence may represent yet another primitive. (Sidman, 1990, p. 111).

If this were the case, Sidman's perspective would predict that the ability to pass equivalence tests should be available from birth. It may just be the case that the methodology to study equivalence-like behaviour is not well placed to study the behaviours of the very young infant. Indeed the difficulty of teaching a series of conditional discriminations to the infant has been addressed in this thesis. In the first experiment of Study 1, only 3 of 14 infants (aged between 16 and 28 months) managed to reach criterion level performance in the common listener training phases.

The three infants of this age group, who did complete all procedures, all failed to categorise after listener training, yet all subsequently showed categorisation after common tact relations, and hence naming, had been taught.

Sidman's perspective should predict that, once the methodological difficulties in training the initial discriminations are overcome, there should be no differences shown in categorisation performance after listener training and after tact training. The common listener training may be generically described as the learning of the following conditional relations: if A1 then B1; if A1 then C1; if A1 then D1; and, if A2 then B2; if A2 then C2; if A2 then D2. The equivalence account would predict that A1, B1, C1, and D1 would be related symmetrically and transitively to each other as would also be the case for A2, B2, C2, and D2. The categorisation tests conducted in Studies 1 and 2 reported here provide evidence that this prediction is not borne out empirically.

The speaker training conducted during these studies involved the learning of the following conditional discriminations: if B1 then A1; if C1 then A1; if D1 then A1; and If B2 the A2; if C2 then A2; if D2 then A2. Essentially, according to the equivalence account, this learning should also give rise to symmetric and transitive relations between A1, B1, C1 and D1, and also between A2, B2, C2 and D2. The equivalence account makes no distinction about how the latter equivalence relations arise, that is, via listener or speaker training (but see Urcuioli & Zentall, 1993). In fact, Sidman (1994, p. 114-116) has proposed that the "receptive" and the "expressive" may be one and the same thing. In terms of the categorising outcome measure employed in the studies reported here this was not the case. Following listener training, the same pattern of behaviour, that is, the inability to categorise until the whole name relation had been established, was seen in children from 19 to 50 months. Sidman's viewpoint is therefore not supported by the present data.

Are these Developments Dependent on the Child's Learning History?

Could it be possible that these categorisation behaviours, although unavailable from birth, may only become available when certain (and as yet unspecified) maturational pre-requisites have been fulfilled?

This seems highly unlikely. In Studies 1 and 2 the same inability to categorise following listener training alone was observed over three age groups of children. This cross-sectional approach offers strong support to the theory that the categorisation of physically dissimilar stimuli is dependent on a child's learning history.

Supporters of the Relational Frame Theory (RFT) would suggest that the ability to succeed on such categorisation tasks is indeed dependent on a child's learning history, and that these behaviours might be explained without recourse to naming theory. As has been discussed, explanations based on RFT are unable to account for the presented data.

To recap, this theory suggests that humans have certain training histories which facilitate the "development of generalised arbitrarily applicable relational responding" (Lipkens, Hayes and Hayes, 1993. p.203). In terms of the procedures utilised in the present experiments, this would mean that prior (trained) experience of categorisation would, given the same contextual cues, provide a framework whereby the individual could apply generalised categorising behaviours to new stimuli, thus exhibiting apparently untrained behaviours.

The data presented show many instances of categorisation behaviour that cannot be accounted for by RFT. These shall be summarised next.

As discussed in Study 1, all participants were in effect given categorisation training during Phase 1 (categorisation training and testing with familiar objects). RFT should predict therefore, that given this prior training, accompanied by the contextual cues inherent in the experimental setting and procedure, categorising should emerge following only listener training; furthermore, there should be no differences between sorting behaviour in the categorisation test after listener training and that which follows subsequent speaker training. The results of this study show that there was no categorising in tests following listener training; categorising only occurred in tests that followed subsequent speaker training.

In the case where, following speaker training, participants still did not categorise until prompted, using the "What's this?" instruction, to overtly produce the target stimulus name, Relational Frame theorists might claim that the "What's this ?" instruction was a more potent contextual cue for categorising than the "Look at this ?"

counterpart. However, empirically, there were no straightforward changes in categorisation when instructions were changed from the one to the other; rather, correct categorisation was seen to be intimately linked with naming behaviour, rather than being wholly consistent with the instruction used.

The performances of Participants BH, MJ and RE (as discussed in Study 1) have illustrated how naming behaviour involves more than the ability to produce a common name to a range of stimuli in one context, or to be able to select each of a commonly named class when requested in another. Naming may initiate categorisation only when each element of the naming circle comes to occasion all the other behaviours in that circle. That is, on saying the common name for one exemplar of a class and then hearing herself say the name for that exemplar, the participant will refer back or re-orient to then select other objects in the immediate).

In the cases where categorisation did not occur in response to the "Look at this. Can you give me the others?" instruction but was initiated only when overt production was prompted by the "What's this? Can you give me the others?" instruction, it was usually the case that in the continued absence of feedback, correct categorisation was maintained when the instruction reverted to "Look at this." If correct categorisation was dependent merely on the "What's this?" instruction used, one would surely not expect successful categorisation on following tests using the "Look at this" instruction, which in RFT terms had previously served as a contextual cue for random sorting of the stimuli.

Perhaps the most compelling argument against RFT comes from the results of participants who completed training and category testing with two stimulus sets. The case of participant HoW in Study 2 is especially convincing. With her Set 1 stimulus set she reached the learning criterion very quickly when listener training was given with concurrent off-task echoic training. She then went on to categorise successfully on the first test given and also showed evidence of having established the whole name relation when a probe for tacting was subsequently given .

It might be predicted by RFT that this experience would also enable her to perform as effectively in any further categorisation contexts with novel stimulus sets, following appropriate listener training. With her Set 2 stimulus set (using different labels for the stimulus classes than those employed for Set 1), however, where only listener training was given, she failed to categorise the Set 2 stimuli in terms of the common auditory stimulus related to them in listener training until tact training was implemented, and thereby the whole name relation established.

Since it is implausible that any contextual cues differed across Set 1 and Set 2, HoW's categorisation behaviour is only explicable by reference to naming theory; RFT cannot account for such data.

Naming Theory - A More Parsimonious Account.

As discussed above, the two competing behavioural accounts of the development of derived stimulus classes, that of Sidman and RFT, cannot account for the data presented in this thesis. Criticism has been levied against naming theory from both these camps (e. g., Hayes, 1994; Hayes & Hayes, 1992; Sidman, 1990, 1992), arguing that if, as claimed, naming is necessary for passing tests of equivalence, it is also necessary to explain how this occurs.

Horne and Lowe's reply to this criticism was to provide a detailed account of what naming is, and how it develops in the pre-school infant, incorporating much empirical research from both behavioural analytic and developmental literature to support their claims. Further, all three studies within this thesis, and those of Harris (see Horne & Lowe, in press), have provided data that supports major predictions of the naming account.

Lowe and colleagues' (e. g., Horne & Lowe, 1996) have similarly challenged the proponents of RFT to specify the behavioural principles involved in the establishment of relational frames (but see S. C. Hayes, 1996; Hayes & Barnes, 1997).

As yet, however, RFT theorists have failed to provide such a rich and detailed response nor one which incorporates adequately the findings of the developmental research that highlights the relationship between spontaneous categorisation and the increases in productive language (specifically the increase in noun usage) that occurs at approximately 18 months of age.

Hayes' does however provide one example of how a relational frame of co-ordination might be established (Hayes, 1991, Hayes & Hayes, 1989, 1992; Lipkens et. al., 1993), and this has already been summarised in Chapter 1. In short, it is suggested that with enough experience of directly trained symmetrical responding, further examples of generalised symmetrical responding may also emerge to novel stimuli in the same context; one such context may be name learning,.

There is a paucity of experimental research with very young infants, Lipkens, Hayes, and Hayes' (1993) single case, longitudinal research into the development of derived relations being an exception. This study claims to offer support for the RFT perspective in general, and the above mentioned example of generalised symmetrical responding in particular. These conclusions are based on their claim that an infant was able to demonstrate a derived symmetrical relation at only 17 months of age. They then concluded that " the existence of derived stimulus relations in a 17-month-old infant constricts somewhat the view that such relations are dependent upon language mediation, because only very simple language processes can be implicated" (p. 235). In the introduction to their study, Lipkens et. al.'s study claimed:

> If derived relations [...] are mediated by language, they should not be evident in very young infants but should emerge as language develops. If they are instances of learned behaviour that underlying [sic] language, they should emerge early and show clear developmental trends.
> (p. 204).

Unfortunately, however, the data reported by Lipkens et. al. do not support their claims. When the 17 month old infant Charlie began tact training with his first stimulus set he failed to learn to tact over Sessions 1-4 in which he was asked to echo the appropriate vocal response in the presence of the corresponding object. When listener probes were instituted in Session 3, however, the listener relations that RFT would allege to be "derived" were already in place. That is, even before a tact had been trained, the listener relation had been learned. Exactly the same occurred in the second training set except that the point of onset of listener learning was even more clearly shown because listener trials were interspersed with the very first 'tact training' trials. Again the listener relation appeared to be learned in the very first "tact training " session, while the corresponding tact was not learned till several sessions later. This rapid onset of listener learning is entirely unsurprising given the developmental literature on listener learning by infants of Charlie's age and his stage of vocabulary development. Baldwin (1993), for example, provides empirical evidence that infants of this age learn new listener relations simply by hearing the listener stimulus while looking at the corresponding object. Thus, it appears that the very relation that Lipkens et. al. claimed to be derived was in fact trained in the first session and several sessions before the to-be-trained tact counterpart itself was learned.

Lipkens et. al. then trained Charlie on a new set of stimuli, this time, setting out to train the listener relations and test for "derived" tact relations. Charlie learned the listener relations but showed no evidence of tact responding until after many sessions, he was taught to produce the target vocal stimulus echoically. Charlie then began to produce the appropriate vocal response more frequently over succeeding tact test trials.

This outcome shows that tacting is not "derived" from listener training nor is listener behaviour "derived" from tact training. In short the Lipkens et. al. study shows no evidence of mutual entailment, the basic arbitrarily applicable relation of RFT, in the one human infant they studied. Their data are in fact more readily explained by the naming account in which Horne and Lowe (1996) describe how speaker behaviour, and hence naming, is learned when an infant echoes the listener stimulus (previously learned) during listener responding, that is, while orienting to the corresponding object.

There are however, parallels between Charlie's performance and that of JC in

Study 1 of this thesis. Following listener training on Set 1, JC failed to categorise and failed the subsequent tact test for the individual stimuli. Like Charlie, JC showed no evidence that listener training resulted in "derived" tact relations (nor a derived "equivalence-like" or category relation). She was then trained via echoic prompts to tact each of the Set 1 stimuli and went on to pass the category sorting task. JC was then trained listener relations for a second set of stimuli. Though not requested to do so, her prior echoic training for Set 1 occasioned her on-task echoing of the listener stimuli during the Set 2 listener trials. She then passed both the following categorisation test and tact tests. As was the case with Charlie, echoic training appeared to be the critical element in the "emergence" or so-called "derivation" of the corresponding tact relations. The naming account would of course argue that the latter were simply learned.

The results of the 15 infants who participated in Studies 1 and 2 of this thesis considered together, provide no support for Lipkens et. al.' claims that there might be developmental trends in the learning of arbitrarily applicable relations.

Whereas developmental trends may be implied by JC's data, the same trends were in fact demonstrated in the 15 children who participated in Studies 1-3 and whose ages ranged from 19 to 50 months. However these were not developmental maturational trends, that is to say, based on age; rather they appeared to be developmental trends *within* the establishment of task relevant naming behaviour. Naming theory seems, therefore, to be the more parsimonious explanation for these data.

Further support from the naming account can be seen by comparing the results of similar aged children in Studies 1, 2 and 3; these three studies all contained a cohort of children aged between 3.5 and 4.5 years of age. The difference between the three studies was that the order of training of the three elements that make up the name relation (i. e., listener, echoic and tact relations) was systematically manipulated.

Although all participants in these cohorts who categorised successfully did show evidence of the establishment of both listener and tact relations, that is the whole name relation, this conclusion does not reflect the differences between the different experiments. All of this age group who received listener training alone (Study 1, Experiment 3) failed to categorise on their first test, two categorising only after tact relations had been explicitly taught, and one failed to categorise at all. Those who received added echoic training (Study 2, Experiment 1) showed varying patterns of categorisation; one participant failed to categorise, one (HoW, and see above) categorised on the first test after listener and off-task echoic training, the third needed explicit tact training.

In contrast, those who received tact training first (Study 3, Experiment 1) all categorised after this training alone; none required explicit listener training and none failed to categorise.

Though the numbers are small, comparison of same aged participants across the three studies show improvements in categorisation performance that are wholly consistent with the naming account. These findings do not fit the predictions of an RFT based account (as discussed earlier) and again emphasise the parsimony of Horne and Lowe's theory.

Naming theory would predict that the procedure usually employed by caregivers and experimenters to train the tact relation is sufficient for the concurrent learning of the corresponding listener relation. Having learned to thereby name a set of physically different stimuli, the child should then sort common named stimuli together.

This prediction has been tested and supported in Study 3, with children aged between 3.5 and 4.5 years. Harris (see Horne & Lowe, in press) has also provided support for this hypothesis in nine children who were aged from 27 months to 51 months. However, a successful replication of these studies with more children of Charlie's age would provide additional support for naming theory.

This aim may be difficult in practice. As demonstrated in Lipkens et. al. it is very difficult to teach conditional discriminations to children of this age. Study 1 of the present research and research conducted by Augustson & Dougher (1992) also highlight the difficulties in teaching multiple conditional discriminations.

Implications for Behaviour Analytic Research.

So far I have discussed how the presented data have answered the predictions of the three competing accounts in the area of derived stimulus classes. These data are also able to inform other relevant issues within the behaviour analytic perspective. This shall be discussed next.

The data presented here answer many of the criticisms laid against naming theory. For example, it has been questioned (Pilgrim, 1996) whether the naming account can be falsified since Horne and Lowe have stated that the number of ways in which naming can enter control over stimulus choice in equivalence-like experiments is, "possibly infinite" (p. 222), and may include such strategies as (covert or overt) intraverbal naming, as well as common naming, of the stimuli.

Pilgrim (p. 284-286) views this as precluding a direct measurement of the putative controlling variable (i. e., naming). To illustrate, an experimenter may have defined both the common name and the class of stimuli to which that name refers, however, if the experimenter fails to observe these experimentally defined common names, this does not allow the conclusion that naming is not responsible for the accurate classification of those stimuli. As the participant may have any number of naming tactics available, she or he may be simply applying another idiosyncratic naming strategy. This would make disconfirmation of the naming account impossible.

Indeed, it is difficult to isolate the language variable from experiments using adult, or linguistically practiced participants, and in these studies Pilgrim's criticisms may be valid. It is also difficult if one does not specify what the word "language" means.

The present research, explicitly set out to disprove the naming account by testing for "emergent" relations after training only listener relations in young children with limited verbal repertoires. As such it has addressed, both conceptually and empirically, the "testability" critique leveled against the naming account while at the same time providing a test of the competing equivalence and RFT accounts.

As summarised in Chapter 1, Dickens, Bentall, and Smith (1993) found that naming strategies can have both facilitative and disruptive effects on the formation of stimulus classes. They found that training associations between participants' own individual names for the experimental stimuli could interfere with the formation of potential equivalence classes after visual-visual match-to-sample training had been given. Their findings suggested that names of individual stimuli "readily become implicated in equivalence classes and facilitate the formation of emergent relations between the visual stimuli to which they belong" (p. 724).

In a subsequent study to that of Dickins et. al. (1993), however, Smith, Dickins, and Bentall (1996) demonstrated that these disruptive effects could be lessened if, after baseline training of the original conditional discriminations, immediate testing for the emergence of derived relations was given. This was in contrast to the research of Dickins et. al., where discordant associations between participants' own stimulus names was given in between baseline training and the testing for emergent relations. Smith et. al. hypothesised that a "crystallisation" of the equivalence classes may have occurred as a result of testing, making them relatively immune to the disruptive effects of the stimulus names.

If such a "crystallisation" of potential derived relations can occur when training and testing are placed close together in time, thus lessening any interfering effects of individual names, this may have implications for the present research.

There was no direct evidence in the present research that participants formed alternative categories from their own *individual* names for the stimuli (although, many of the subjects reported individual names for the stimuli in the tact probes and, in one case, (HoW), the participant formed categories based on her own class names for the stimuli). Dickins et. al's findings that individual names may disrupt the formation of potential equivalence classes may cast light on one of the more surprising findings of the current research.

Horne and Lowe's account predicted that, in verbally competent children, the training of a common listener response to sets of arbitrary stimuli, may, if they overtly or covertly echo the listener stimulus in the presence of the corresponding object, also result in learning of the establishment of the corresponding common speaker response. This prediction, in most cases, was not supported here. The data from Studies 1 and 2 suggest that, in some cases, the participants' own names for the stimuli had a disruptive effect on both the learning of the necessary listener relations, and on categorisation performance. In some cases it has been argued that this interference may have been influential in the few cases of failure to categorise even after the whole name relation had been explicitly trained.

According to Skinner (1957) all verbal operants entail probabilities of responding. If a given stimulus evokes two (or more) tact responses, the probability of each of the latter being emitted by a speaker when the stimulus is presented will be function of (i) past learning history (e.g. which relation was learned first and reinforced more frequently) and (ii) current audience variables. It is possible that the listener training conducted in Studies 1 and 2 was sufficient to establish only a weak target tact response to each of the stimuli that featured in the listener trials but that the operant strength of pre-existing non-target tacts for the latter was greater. If this were the case, the weak target name relations would be functionally overshadowed by the strong non-target, pre-existing names for these stimuli. The category sorting test that followed listener training would not be expected to increase the response strength of the target tact relations. Indeed, it may be argued that the testing procedure may have further weakened the latter since subjects were free to sort the stimuli randomly or thematically during the test and in the latter case pre-existing names would have been to the fore and thus strengthened in the experimental test setting.

This hypothesis might be investigated by replicating the listener training studies but probing for target tact relations immediately following listener training and before the categorisation test. Any target tact frequency significantly greater than that observed in Studies 1 and 2 would support the hypothesis and hence qualify the naming account in older children, with more developed verbal repertoires. If no such differences are found, however, it must be concluded that, in general, unless subjects are explicitly required to echo the listener stimulus in the presence of the corresponding object during listener training, in general, no tact relation will be learned.

Implications for the Developmental Literature.

So far I have concentrated on the implications of the current experimental work for behaviour analytic theory; the implications of the data for the developmental literature shall be discussed next.

Naming and Exhaustive Categorisation.

In Chapter 1 research was presented that suggested a relationship between advances in children's productive repertoires and the onset of exhaustive categorisation. Gopnik and Meltzoff have proposed that there exist specific links between particular cognitive developments and particular linguistic developments; this they term the *specificity hypothesis*. In a series of correlational studies (1989, 1992, 1993) they have suggested that one such specific relationship exists between the naming explosion and the onset of exhaustive categorisation. Supporting evidence for this hypothesis has been presented by other researchers (Gopnik and Choi, 1990, 1992; Gopnik, Choi, and Baumberger, 1996; Mervis & Bertrand, 1994). In similar studies Poulin-Dubois, Graham, and Sippola (1996) and Shore, Dixon, & Bauer (1995) found that categorisation was associated with a high proportion of general nominals (names) in counts of productive vocabulary.

As highlighted earlier, certain confounds were inherent within such developmental data that made it difficult to draw any definite conclusions about the relationship between language and categorisation.

For example, developmental studies tended to use either identical or physically similar sets of objects to investigate the onset of exhaustive categorisation. This factor would not control for the effects of categorisation via stimulus generalisation, which is a phenomenon that is not related to other linguistic factors.

Also, little attempts were made to control for any confounding influences arising from the children's general sorting history, or their previous exposure to the specific objects used in such categorisation tests.

In some cases , though not all, attempts were made to assess whether the participants were able to comprehend or produce the names of the stimuli used in the categorisation tests. Some studies (e. g., Gopnik & Meltzoff, 1992; Shore, Dixon, & Bauer, 1995) have found children can sort objects into exhaustive categories but have are unable to produce or comprehend these objects names. Again these performances may be attributed to stimulus generalisation, however, the potential effects of children's own idiosyncratic names for the stimuli were not taken into account. For example, the children may have been sorting objects in terms of their own names relating to the objects' sizes, shapes or colours.

The studies presented in this thesis controlled for these variables in several ways. First, all objects physically different from one another in order to eliminate any effects of stimulus generalisation or prior sorting history as regards these objects. Second, the common names used were unlikely to have been encountered by the participants thus reducing the likelihood of previous categorisation experience in terms of such names.

Experience of sorting was also given to all participants. Phase 1 of all experiments included practice and, if necessary, explicit training of the categorisation test trials using two sets of familiar hat and cup stimuli. This would have helped equalise any differences in experience of sorting tasks.

As discussed in Chapter 2, Horne and Lowe provide a theoretical account that is well positioned to encompass the developmental data. The tightly controlled experiments contained in this thesis have provided data that strongly support their prediction that the categorisation of physically dissimilar objects can only occur when a child is able to name such objects. These experiments have shown that such categorisation will not occur if only if common listener relations are trained to such stimuli, yet if common speaker relations are subsequently taught, thus establishing naming, categorisation will occur. These data cannot be explained by reference to such factors as stimulus generalisation or prior sorting experience.

Naming behaviour is, however, essentially classifying behaviour. When the developing child is able to acquire the all important tact relations which closes the naming circle, thus initiating naming behaviour, this has both qualitative and quantitative implications for both productive language and categorisation of the child.

The quantitative effects associated with the inception of naming behaviour in the infant, include the well documented acceleration in productive language. These effects have been explained by Horne and Lowe in terms of increases in the child/s echoic repertoire which have been seen to occur around the same time as the naming explosion (Masur, 1993, 1995). At this time children also the gain of words which appear to function as generic mands, for example, "whatsat" (Fletcher & MacWhinney, 1995), and this increases the child's exposure to the relationship between objects and their names which may also play a part in the child's accelerated name learning.

These issues have already been discussed in Chapter 2 of this thesis and are not of direct concern to the empirical work of this thesis. Rather, the aim of the present experiments was to investigate the qualitative effects that the inception of naming behaviour has on categorisation behaviour. This shall be discussed next.

The data presented in this thesis support the developmental evidence that has suggested a relationship between productive language and qualitative shifts in categorisation. Further, some interesting behaviours have been noted that may shed light on some of the discrepancies found in the developmental literature. Some hypotheses posited by this literature shall be re-examined in the light of the present data.

First, and most importantly, is exhaustive categorisation related to developments in productive language? The present data provide strong evidence to suggest that this may be the case. Across all three studies it was consistently observed that, in the case of physically dissimilar objects, categorisation did not occur until the necessary tact element of the name relation had been established, whether explicitly trained or, as in certain cases in Study 2, learned from echoic practice of the stimulus names. In no case did exhaustive categorisation of such objects occur when only listener (receptive) relations were established.

Gershkoff-Stowe, Thal, Smith, & Namy (1997) have hypothesised that changes in categorisation behaviour, may be more closely tied to receptive rather than expressive vocabulary. This hypothesis was based on the result on a single child, the earliest categoriser in their study, who showed exhaustive categorisation at 16 months, yet was also found to be severely delayed in productive language, although his comprehension of words was in the normal range. Their results also showed that exhaustive categorisation occurred, in general, independent of advances in productive vocabulary growth.

The present data showed no such relation between categorisation and receptive language skills, yet naming theory can still account for Gershkoff-Stowe et. al's findings.

As discussed, naming may not in itself be sufficient in bringing about categorisation behaviour. The important factor is the initiation of task relevant naming behaviour, where each element of the name relation (i. e., listener, echoic and tact relations) must come to occasion all other relations in order for the categorisation of objects to occur. This is not dependent on the number of names in the child's productive repertoire. A child with relatively little productive language may still be capable of naming behaviour. In theory, the production of only two different names (i. e., one common name for each member of each stimulus set) should be sufficient for the categorisation of the objects into distinct categories.

As the present data suggest, even four year old children, who would have extensive productive repertoires, have failed to categorise after listener training alone.

However, when naming behaviour has been initiated, successful categorisation of physically dissimilar objects is observed.

Birge (1941) provides a useful illustration of the differences between merely acquiring all the elements of the name relation and producing actual naming behaviour.

In Birge's study school aged children participated in an experiment with three distinct phases. In Phase 1, all children were taught to name two boxes "towk" and two other boxes "meef". In Phase 2, only one of the "towk" and "meef" boxes were presented, and the children were taught that sweets could always be found under the "towk" box. In Phase 3, the other pair of boxes was presented in order to test for transfer of the choice response.

The children were assigned to one of four different naming conditions. Group 1 were required to produce the name of the box in Phases 2 and 3, Group 2 during Phase 2 only, Group 3 during Phase 3 only, and Group 4 during neither Phase 2 or 3.

The results indicated that learning a common name was not sufficient for the demonstration of transfer of choice response; neither Group 3 nor Group 4 showing evidence of transfer. Transfer only occurred for the children in Groups 1 and 2, all of whom produced the common name whilst learning the choice response in Phase 2. The best performances were recorded by the Group 1 children who had overtly named the common names throughout the experiment.

The current research has also shown that prior sorting practice (see Namy, Smith, & Gershkoff-Stowe, 1997) and previous exposure to such groupings by a model (see Abranavel, Ferguson, & Vourlekis, 1993), may indeed facilitate the sorting of physically similar stimuli, but may have little effect on the sorting of physically dissimilar objects.

To illustrate, all experiments in this thesis contained a familiar object phase. In the categorisation test stage of this phase two sets of three non-identical, yet physically similar, hats and cups were placed in front of the participant. The experimenter then picked up either a hat or cup and asked, "Look at this. Can you give me the others?"

The participants in the older age groups readily sorted these objects into two categories, but 11 participants in the youngest age group (1.5 - 2.5 years of age in Study 1, Experiment 1, and see Table 3.2) found this task relatively difficult. When the correct performance was modelled by the experimenter, all 11 infants subsequently sorted these objects correctly. Ten of these infants also received extra training where it was made explicit that they were required to categorise in terms of the object names, that is, to the instruction "Look at this. Can you give me the other hats/cups?".

This difficulty in sorting did not indicate that the infants could not demonstrate the kind of spontaneous sorting measured in Gopnik and Meltzoff's studies; many did exhibit examples of such sorting. However in the present case, the procedures measured a different type of categorisation behaviour.

The effects of modelling and sorting practice did have effects on later tests of categorisation with the physically different stimuli. That is, when asked to, "give the others", most infants (in all three studies) gave the required two stimuli (and not just one, three, four or all of the stimuli) to the experimenter. In contrast, this prior practice did not have any effect on the accuracy of categorisation. Even though they had prior training and practice in giving the hat or cup stimuli with the same name as the target stimulus to the experimenter, this did not influence correct categorisation in the tests that followed listener training.

The present studies have also found evidence that such factors as the properties of the stimuli (Starkey, 1981) may indeed have an effect on categorisation.

Such an influence was seen in the categorisation behaviour of Participant HoW (Study 2, Experiment 1) who sorted the stimuli in terms of her own names "big and "little"; this seemingly occurring via stimulus generalisation. That is, the physical attributes of the experimental stimuli resemble those already encompassed within two existing name relations, in this case, big and little.

This idiosyncratic categorisation behaviour, however, was eventually superseded by the experimental names "pab" and "lud".

Shore, Dixon and Bauer (1995) concluded that in so far as relations exist between linguistic and non-linguistic categorisation, they may be reflective of "individual style", where children who tended to use more nouns in their language (referential children) tended to categorise more than those who had few or little nouns in their initial vocabulary (non-referential children). Shore et. al. also used identical objects in their study, which, if the participants sorting was governed simply by stimulus generalisation, should not have shown such differences between the two groups of participants.

Shore et. al. attributed the differences to the "referential" children having a more "general interest" in objects, which reflects in developments in both linguistic and non-linguistic domains.

This notion also fits well into naming theory, although this account would not say that this interest causes such differences in productive language and categorisation. Rather, children who have established naming may then be oriented towards other objects in the environment that either physically resemble other objects of that name, or have the same common name. In instances where a child is oriented to, and names an object in a manner inconsistent with the conventions of the verbal community, the caregiver may provide corrective feedback, thus gaining opportunities to increase the child's naming repertoire.

Thus the more names gained in this manner, the more new objects may be named, and so on, causing naming behaviour to increase exponentially. Such behaviour may have obvious implications for the onset of the naming explosion.

This "general interest" in objects as re-interpreted above in terms of naming theory, would of course be dependent on the quality of child-caregiver interaction. Those caregivers who spend more time in general naming play, that is, naming more objects for the child and drawing more objects to the child's attention, may enhance a child's naming skills.

The Specificity Hypothesis Re-Visited.

As well as a relationship between naming and categorisation, Gopnik and Meltzoff's (1989, 1992, 1993) also found specific relationships between other linguistic and non-linguistic abilities.

To recap, it was also found that the onset of higher level object permanence abilities was correlated with the appearance of words suggesting disappearance (e. g., "gone"); similarly, words encompassing success or failure (e.g., "there" and "uh-oh") were related to the onset of higher level means-end abilities. Any theory of the development of language and its relation to other non-linguistic abilities must be able to account for such data.

Accounting for these findings is not problematic for naming theory. For example, the observed relation between the learning of the word "gone" and higher level object permanence could be explained in terms of being another case of naming-like behaviour. Although the word "gone" is not a noun, as in the names for whole objects, naming theory does not preclude such words from being included in name relations.

To illustrate, the development of "gone" would be subject to the same developmental patterns as the learning of *nouns*. The child would initially learn a variety of listener behaviours associated with this word. For example, the caregiver may frequently utter the word "gone", whilst hiding an object beneath a cloth. This may eventually lead to a listener relation between hearing the word "gone" and listener behaviours such as general searching oriented behaviours (e. g., scanning the room, lifting the cloth, imitating the caregiver's surprised facial expressions, and so on).

With repeated echoic practice of the word "gone", eventually the child will also learn to produce the name in such contexts. However unlike the conventional description of the name relation, she or he will not develop a tact relation where seeing an object becomes discriminative for the utterance of its name; rather, it is likely that seeing an instance of a disappearance of an object may be discriminatory for a tact-like utterance of "gone", thus occasioning the already acquired listener responses of searching for the object, which may occasion further utterances of "gone", and so on.

A similar naming based explanation may also account for the correlation observed between higher level means-end abilities words encompassing success or failure (e.g., "there" and "uh-oh")

Gopnik and Meltzoff (1993, p. 227) state that if the ability to solve higher level object permanence tasks simply reflected more general developmental advances, such as in motor ability, it would be difficult to see why this ability would be specifically related to words about object disappearance. The explanation based on naming theory does not rule out the effects of the development of motor abilities in the development of object permanence skills, yet explains how these developments may interact with the development of language.

The Developmental Lexical Principles Framework (DLPF)

In Chapter 1, I discussed how the Developmental Lexical Principles Framework (DLPF) (Golinkoff, Mervis, & Hirsh-Pasek, 1994; Mervis & Bertrand, 1993) attempted to incorporate the specificity hypothesis into its model. I shall now discuss how the DLPF might, in turn, be incorporated into Horne and Lowe's naming theory.

To recap, The DLPF describes a developmental sequence of lexical acquisition which is guided by a set of six principles (i. e., biases or constraints) which a child adds to with development. As extra principles are acquired, inferences made about a word change. These principles are concerned with both linguistic and non-linguistic developments, and "provide a means by which children may concentrate on the most likely possibilities for the reference of a particular word" (Mervis & Bertrand, 1994, p. 1649). Thus children are seen in terms of being active hypothesis selectors.

These principles are arranged into two tiers. The three principles contained in the first tier are purported to be in place by the beginning of the second year of life (approximately), and are concerned with the period in a child's development where words are learned in a slow, laborious manner. This equates with Horne and Lowe's description of pre-naming behaviour. When the three principles in the second tier are said to be in place, by (roughly) the middle of the second year, they are said to enable word learning to proceed rapidly and efficiently. This in turn corresponds to post-naming behaviour.

Previous research has argued that such the principles or constraints may be universal or innate (Nelson, 1988); most researchers however, have allowed for individual variations within these constraints and acknowledge the role of learning (Behrend, 1990; Gelman, 1990; Markman, 1989). Others have questioned the necessity of positing such principles, arguing that rather than being rules in the child's head, these principles may be just descriptions of behaviour (Bloom, Tinker, & Margulis, 1993; Nelson, Hampson, & Shaw, 1993). Horne and Lowe's naming account would accord with the latter position.

Whereas Golinkoff, Mervis, & Hirsh-Pasek, (1994) speak in terms of "insight" that objects have names, or of the manner in which children "prioritise" hypotheses, in accordance with the behaviour analytic perspective in general, Horne and Lowe's account of the development of naming has resisted such mentalistic explanations. Behaviour analysis rejects such explanatory fictions, which abound in the developmental literature, where observed behaviour may become confused with the verbal constructions used in the description of such events (e. g., Chiesa, 1994; Hayes, Adams, & Dixon, 1997). The observable behaviours that are described in the DLPF account of the development of language can be more parsimoniously explained by learning principles in general, and Horne and Lowe's naming account in particular.

For example, the behaviours associated with the first three principles, *reference*, *extendibility,* and *object scope*, (see Chapter 1) are described by Golinkoff et. al. in detail, yet these authors offer little in the way of explanation as how each develop in the child or indeed interact with each other. Horne and Lowe, on the other hand, have provided a dynamic account of the development of naming in which these three principles can be incorporated and explained in terms of such simple learning principles as stimulus control and stimulus generalisation.

More importantly, Horne and Lowe describe how simple behavioural processes interact to facilitate the development of more complex naming behaviours such as the categorisation of physically different objects and the naming explosion. These latter phenomena are also associated with the second tier of lexical principles, that is, the principles of *categorical scope*, the *novel-name-nameless category* (N3C) principle, and *conventionality.* The utility and validity of some of these principles shall be discussed next.

In Chapter 1, evidence was presented to suggest that the N3C principle may be available in infants younger than would be predicted by the DLPF account (Woodward, Markman, & Fitzsimmons, 1994; Schafer & Plunkett, 1998). This poses a problem to the DLPF account as the N3C principle is directly implicated with the onsets of both naming explosion or exhaustive categorisation. Mervis and Bertrand (1994) argue that these three abilities all involve "an insight that all objects have a name" (p. 1650) and should therefore be working within the same principle and thus should emerge at the same point in the child's development.

However, others have questioned whether the ability to fast-map (which is used as an index of the acquisition of the N3C principle) is specifically linked to language at all (McIlvane, Kledaras, Munson, King, Rose, & Stoddard, 1987; McIlvane & Stoddard, 1981; Schusterman & Kastak, 1993; Stromer, 1996; Tomanaga, 1993). Given this array of evidence it seems unlikely that neither fast-mapping, the naming explosion or the onset of exhaustive categorisation fit as neatly into the DLPF account as Golinkoff et. al. and Mervis and Bertrand suggest.

Another possible anomaly within the DLPF account arises directly from the data presented in this thesis. A central claim of this theory is that lexical principles are acquired in a developmental sequence with differential performances on certain tasks being attributed to the lack of, or gain of, the availability of a certain principle.

To illustrate, if the child only has the principle of extendibility available they are said to be able to extend the use of a word by virtue of perceptual similarities. When children acquire the principle of categorical scope however, they are purported to become able to extend a word not only by its perceptual features, or by its thematic relations with other objects, but also to physically different objects that belong to a linguistically defined class.

This account of the onset of the categorisation of physically different objects does not accord with the present data. The four year old participants in Studies 1 and 2 would surely have been deemed old enough to have acquired the principle of categorical scope, yet still failed to categorise after listener training, subsequently categorising only when speaker relations were taught. It would be difficult to reconcile this performance with the DLPF account, yet is perfectly consistent with naming theory.

To summarise, the DLPF account has many flaws. It fails to accommodate both the present data and that from other research within developmental psychology. There also appears to be no need to posit a strict developmental sequence, or apply such ill-defined concepts as insight, in order to explain the behaviour observed at each stage of development. The naming account provides a more structured and parsimonious account of the development of language and such related behaviour such as categorisation.

* * *

To conclude, the central aim of this was to put Horne and Lowe's naming account to empirical test. The three studies presented have offered strong support for their position and demonstrate that naming is indeed necessary for the categorisation of physically different stimuli.

Horne and Lowe have stated that an effective behavioural theory of language acquisition should be of benefit both within and outside the behaviour analytic tradition (1996, p. 240). The data presented has wide implications for the existing research in both developmental and behaviour analytic tradition within psychology, and has illuminated controversial issues within both disciplines.

As regards behaviour analysis, the experiments in this thesis demonstrate that Horne and Lowe's naming account can provide explanations for behavioural phenomenon that are not readily explicable in terms of the competing accounts. The data has shown that such "emergent" behaviour that have been described in terms of stimulus equivalence and relational frames, are more parsimoniously explained by reference to naming theory.

Similarly the developmental literature has concentrated on finding correlations between language performance and exhaustive categorisation. The data derived from such studies is useful in detecting trends of behaviour but is not well placed to derive hypotheses that relate to the underlying causes of such abilities

Gopnik and Meltzoff (1993) is a case in point. Their conclusion that exhaustive categorisation and accelerated word production may facilitate each other, gives little explanation of exactly how this facilitation might occur and makes it difficult to derive testable hypotheses. The naming account provides such testable hypotheses and also is able to encompass the correlational research outlined above.

Future directions

The results of the experiments in this thesis have raised issues which would benefit from further empirical investigation, some of which have already been discussed. For example, these procedures could be implemented using both older and younger children to investigate whether the same patterns of categorisation behaviour will be manifested with more or less experience of language usage.

The surprising finding that children do not necessarily demonstrate the corresponding speaker behaviour after listener relations have been established also merits further investigation. Could this phenomenon be an artifact of the procedures employed? If testing for speaker relations was to be implemented directly after listener training, instead of after the interceding categorisation test trials, would this affect the results?

Horne and Lowe have also suggested that applying a common name to sets of physically different stimuli might not be the only way in which naming might come to control categorising behaviour. Categorisation may also result from the intraverbal relations between stimulus names. As has been suggested by the research of Dickens et. al (1993) and Smith et. al. (1996) the outcomes of teaching a common name to sets of stimuli are not necessarily the same when individual names are taught. This latter research was conducted on adults, and it would be interesting to conduct similar research with child populations.

Although the procedures used in the present studies were not specifically designed to compare the differences that might occur between teaching object-name (speaker relations) and the teaching of name-object relations (listener relations), it was noted that the participants tended to respond with greater ease when speaker relations were being taught. This was not analysed systematically, and must therefore be regarded as merely anectodal evidence, however, difficulties in teaching conditional discriminations that do not require a vocal response have been observed in other research (e. g., Augustson & Dougher, 1992; Devany, Hayes & Nelson, 1986).

Naming theory would posit that when a child learns to tact an object they may also demonstrate the corresponding listener behaviour to that object without being explicitly trained to do so. With both listener and speaker relations, and hence naming, established, would this also have the effect of facilitating the training of new conditional discriminations? The procedure utilised in the present studies could easily be modified to allow for a systematic comparison of the training of both listener and speaker relations, and would allow for comparison of both accuracy and speed of responding as well as comparing the number of trials necessary to reach a pre-determined criterion level.

Such a study would help to understand the phenomena observed in the developmental literature where early word learning has been seen to progress at a slow and laborious rate, whist later word learning (i. e., at approximately 18 months of age) has been shown to increase dramatically at the time of the so-called naming explosion.

Horne and Lowe's naming account has specified the conditions under which children learn to name objects; that is, how interactions between listener, echoic and tact relations combine to form bi-directional and symbolic relationships between objects and names that result in the demonstration of apparently untrained novel relationships between stimuli. Horne and Lowe explain these "emergent" behaviours in terms of being a direct outcome of prior learning histories.

The studies presented in this thesis provide empirical support for their claims and also expand their account by providing data driven explanations for those conditions where infants fail to name.

* * *

REFERENCES

Abranavel, E., Ferguson, S., & Vourlekis, D. (1993). Observing and imitating the formation of object classes during the second year of life. *Canadian Journal of Experimental Psychology. 47,* 477-492.

Augustson, K. G., & Dougher, M. J. (1992). Teaching conditional discrimination to young children: Some methodological successes and failures. *Experimental Analysis of Human Behavior Bulletin, 9,* 21-24.

Baldwin, D. A. (1991). Infant contributions to the development of joint reference. *Child Development, 62,* 875-890.

Baldwin, D. A. (1993). Infants' ability to consult the speaker for clues to word reference. *Journal of Child Language, 20,* 395-418.

Baldwin, D. A., & Markman, E. M. (1989) Establishing word- object relations: a first step. *Child Development, 60,* 381-98.

Barnes, D., McCullagh, P. D., and Keenan, M.(1990). Equivalence class formation in non-hearing impaired children and hearing impaired children. *The Analysis of Verbal Behavior, 8,* 19-30.

Barrett, M. (1995). *Early Lexical Development.* In Fletcher, P. & MacWhinney, B. (Eds.) *The Handbook of Child Language*, Oxford: Blackwell.

Bates, E. (1993). Comprehension and production in early language development. *Monographs of the Society for Research in Child Development, 58,* 222-242.

References.

Bates, E. Bretherton, I., & Snyder, L. (1988). *From first words to grammar: individual differences and dissociable mechanisms.* Cambridge: Cambridge University Press.

Bates, E., Camaioni, L., & Volterra, V. (1975). The acquisition of performatives prior to speech. *Merrill-Palmer Quarterly, 21,* 205-226.

Bates, E., Dale, P. S., & Thal, D. (1995). Individual differences and their implications for theories of language development. In Fletcher, P., & MacWhinney, B. (Eds.) *The Handbook of Child Language*, Oxford: Blackwell.

Behrend, D. A. (1990). Constraints and development: a reply to Nelson (1988). *Cognitive Development, 5,* 313-330.

Benedict, H. (1977). *Language comprehension in the 10-16-month-old infant.* (Unpublished). Doctoral dissertation, Yale University.

Benedict, H. (1979). Early lexical development: comprehension and production. *Journal of Child Language, 6,* 183-200.

Bentall, R. P., Dickins, D. W., & Fox, S. R. A. (1993). Naming and Equivalence: Response latencies for emergent relations. *Quarterly Journal of Experimental Psychology: Comparative and Physiological Psychology, 46B,* 187-214.

Bentall, R. P., Jones, R. M., & Dickins, D. W. (1998). Errors and response latencies as a function of nodal distance in 5-member equivalence classes. *The Psychological Record, 48,* 93-115.

Bentall, R. P., Lowe, C. F., & Beasty, A. (1985). The role of verbal behavior in human learning II. Developmental differences. *Journal of the Experimental Analysis of Behavior, 43,* 165-181.

References.

Birge. J. S. (1941). *The role of verbal responses in transfer.* Unpublished doctoral dissertation, Yale University.

Bloom, L. (1973). *One word at a time: the use of single word utterances before syntax.* The Hague: Mouton.

Bloom, L., Tinker, E., & Margulis, C. (1993). The words children learn: Evidence against a noun bias in early vocabularies. *Cognitive Development, 8,* 431-450.

Bowerman, M. (1980). The structure and origin of semantic categories in the language learning child. In M. Foster and S. Brandes (Eds.), *Symbol as Sense.* NY: Academic Press.

Brownell, C. (1988). Combinatorial skills: converging developments over the second year. *Child Development, 59,* 675-85.

Butterworth, G. E., & Cochran, E. (1980). Towards a mechanism of joint visual attention in human infancy. *International Journal of Behavioural Development, 3,* 253-272.

Butterworth, G. E., & Grover, L. (1988). The origins of referential communication in human infancy. In L. Weiskrantz (Ed.), *Thought without language* (pp. 5-24). Oxford: Clarendon Press.

Carey, S. (1978). The child as word learner. In M. Halle, J. Bresnan, & G. A. Miller (Eds.), *Linguistic theory and psychological reality* (pp. 264-293). Cambridge, MA: MIT Press.

Casby, M. W., & Della Corte, M. (1987). Symbolic play performance and early language. *Journal of Psycholinguistic Research, 16,* 31-42.

References.

Dale, P. (1976). *Language development: Structure and function.* New York: Holt, Rinehart & Winston.

Devany, J. M., Hayes, S. C., & Nelson, R. O. (1986). Equivalence class formation in language-able and language disabled children. *Journal of the Experimental Analysis of Behavior*; *46,* 243-257.

Dickins, D. W., Bentall, R. P., & Smith, A. B. (1993). The role of individual stimulus names in the emergence of equivalence relations: The effects of paired-associates training between names. *The Psychological Record, 43,* 713-724.

Dixon, L. S. (1977). The nature of control by spoken words over visual stimulus selection. *Journal of the Experimental Analysis of Behavior, 27,* 433-442.

Dore, J. (1974). A pragmatic description of early language development. *Journal of Psycholinguistic Research , 4,* 423-303.

Dore, J. (1978). Conditions for the acquisition of speech acts. In I. Markova (ed.), *The Social Context of Language.* Chichester: Wiley.

Dore, J. (1985), Holophrases revisited: their "logical" development from dialog. In M. D. Barrett (ed.), *Children's Single -word Speech. Chichester: Wiley.*

Dromi, E. (1987). *Early lexical development.* Cambridge. CUP.

Dugdale, N., & Lowe, C.F. (1990). Naming and stimulus equivalence. In D. E. Blackman & H. LeJeune (Eds.), *Behavior Analysis in theory and practice* (pp. 115-138). Hove, England: Erlbaum.

Eikeseth, S., & Smith, T. (1992). The development of functional and equivalence classes in high-functioning autistic children: The role of naming. *Journal of the Experimental Analysis of Behavior*; 58, 123-133.

References.

Catania, A. C., Horne, P. J., & Lowe, C. F. (1989). Transfer of function across members of an equivalence class. *The Analysis of Verbal Behavior, 7,* 99-110.

Chiesa, M. (1994). *Radical behaviorism: The philosophy and the science.* Boston: Authors Cooperative

Chomsky, N. (1959). Review of B.F. Skinner's Verbal Behavior. *Language., 35,* 16-58.

Chomsky, N. (1965). *Aspects of the theory of Syntax.* Cambridge, Mass: MIT Press.

Clark, R. (1977). What's the use of Imitation? *Journal of Child Language, 4,* 341-358.

Collis, G. M. (1977). Visual co-orientation and maternal speech. In H. R. Schaffer (Ed.), *Studies in mother-infant interaction* (pp. 355-375). London: Academic Press.

Collis, G. M., & Schaffer, H. R. (1975). Synchronisation of visual attention in mother-infant pairs. *Journal of Child Psychology and Psychiatry, 16,* 315-320.

Cross, T. (1977). Mothers' speech adjustments: The contributions of selected child listener variables. In C. Ferguson & C. E. Snow (Eds.), *Talking to children: Language input and acquisition* (pp. 151-188). Cambridge: Cambridge University Press.

D'Amato, M. R., Salmon, D. P., Loukas, E., & Tomie, A. (1985). Symmetry and transitivity of conditional relations in monkeys (Cebus apella) and pigeons (Columba livia). *Journal of the Experimental Analysis of Behavior; 44,* 35-47.

References.

Ervin, S. (1964). Imitation and structural change in children's language. In E. Lenneberg (ed.), *New directions in the study of language.* Cambridge, MA: MIT Press.

Fenson, L., Dale, P. S., Reznick, J. S., Thal, D., Bates, E., Hartung, J. P., Pethick, S., & Reilly, J. S. (1993). *MacArthur Communicative Development Inventories: user's guide and technical manual.* San Diego CA: Singular Press.

Fletcher, P., & MacWhinney, B. (Eds.) (1995). *The Handbook of Child Language*, Oxford: Blackwell.

Foss, D. J., & Hakes, D. T. (1978). *Psycholinguistics.* Englewood Cliffs; Prentice Hall.

Gelman, R. (1990). Structural constraints on cognitive development. *Cognitive Science, 14,* 3-10.

Gershkoff- Stowe, L., Smith, L. B., & Namy, L. L. (1992). A further look at the relationship between categorisation and naming in the second year. Poster presented at the 8th. International Conference on Infant Studies, Miami Beach, FL, may 1992.

Gershkoff-Stowe, L., Thal, D., Smith, L. B., & Namy, L. L. (1997). Categorization and its developmental relation to early language. *Child Development, 68,* 843-859.

Goldfield, B. A., & Reznick, J. S. (1990) Early lexical acquisition: rate, content and the vocabulary spurt. *Journal of Child Language, 17*, 171-83.

Golinkoff, R. M., Mervis, C. B., & Hirsh-Pasek, K. (1994). Early object labels: The case for lexical principles. *Journal of Child Language,* 21, 125-155.

References.

Gopnik, A. (1981). Development of non-nominal expressions in 1-2-year-olds. In P. Dale & D. Ingram (Eds.), *Child language, an international perspective* (pp. 93-104). Baltimore. MD: University Park Press.

Gopnik, A. (1982). Words and plans: Early language and the development of intelligent action. *Journal of Child Language, 9,* 303-318.

Gopnik, A., & Choi, S. (1990). Do linguistic differences lead to cognitive differences? A cross-linguistic study of semantic and cognitive development. *First-Language, 10,* 199-215.

Gopnik, A., & Choi, S. (1992). Early acquisition of verbs in Korean: A cross-linguistic study. *Journal of Child Language. 22,* 497-529.

Gopnik, A., Choi, S., & Baumberger, T. (1996). Cross-linguistic differences in early semantic and cognitive development. *Cognitive-Development, 11,* 197-227.

Gopnik, A., & Meltzoff, A. (1986a). Relations between semantic and cognitive development in the one-word stage: The specificity hypothesis. *Child-Development, 57,* 1040-1053.

Gopnik, A., & Meltzoff, A. (1986b). Words, plans, things and locations: interactions between semantic and cognitive development in the one word stage. In S. A. Kuczaj and M. D. Barrett (Eds.), *The development of word meaning* . NY: Springer Verlag.

Gopnik, A., & Meltzoff, A. (1987). The development of categorization in the second year and its relation to other cognitive and linguistic developments. *Child-Development, 58,* 1523-1531

References.

Gopnik, A., & Meltzoff, A. (1992). Categorisation and naming: Basic level sorting in 18 mth olds and its relation to language. *Child Development, 63* , 1091-1103.

Gopnik, A., & Meltzoff, A. (1993). Words and thoughts in infancy. *Advances in infancy research, 8,* 217-249.

Gopnik, A., & Meltzoff, A. (1984). Semantic and cognitive development in 15- to 21-month-old children. *Journal-of-Child-Language, 11,* 495-513.

Griffiths, R. (1954). The abilities of babies. UK: The Test Agency Limited.

Gunzi, S. (1993). *Early language comprehension and production.* Unpublished doctoral dissertation, University of London.

Harris, M. (1997). Language and its pathology. In G. Bremner & A. Slater (Eds.), *Infant development: Recent advances* (pp. 311- 330). Hove, England UK: Psychology Press/Erlbaum (UK).

Harris, M., Barrett, M., Jones, D., & Brookes, S. (1988). Linguistic input and early word meaning. *Journal of child language, 63,* 1091-1103.

Harris, M., & Chasin, J. (1993). Developing patterns in early comprehension vocabularies. In J. Clibbins & B. Pendleton (Eds.), *Proceedings of the 1993 Child Language Seminar.* University of Plymouth.

Harris, M., Jones, D., Brookes. S., & Grant, J. (1986). Relations between the nonverbal context of maternal speech and rate of language development. *British Journal of Developmental Psychology, 4,* 261-268.

Harris, M., Jones, D., & Grant, J. (1983). The nonverbal context of mothers' speech to infants. *First Language, 4,* 21-30.

References.

Harris, M., Yeeles, C., Chasin, J., & Oakley, Y. (1995). Symmetries and asymmetries in early lexical comprehension and production. *Journal of Child Language*, *22*, 1-18.

Hayes, L. J., Adams, M. A., & Dixon, M. R. (1997). Causal constructs and conceptual confusions. *Psychological-Record, 47,* 97-111.

Hayes, S. C. (1986). The case of the silent dog-Verbal reports and the analysis of rules: A review of Ericsson and Simon's *Protocol Analysis: Verbal Reports As Data. Journal of the Experimental Analysis of Behavior, 51,* 385-392.

Hayes. S. C. (1991). A relational control theory of stimulus equivalence. In L. J. Hayes & P. N. Chase (Eds.) *Dialogues in verbal behavior* (pp. 19-40). Reno, NV: Context Press.

Hayes, S. C. (1994). Relational frame theory: A functional approach to verbal events. In S. C. Hayes & L. J. Hayes (Eds.), *Behavior analysis of language and cognition* (pp. 9-29). Reno, NV: Context Press.

Hayes, S. C. (1996). Developing a theory of derived stimulus relations. *Journal of the Experimental Analysis of Behavior*; *65,* 309-311.

Hayes, S. C., & Barnes, D. (1997). Analysing derived stimulus relations requires more than the concept of stimulus class. *Journal of the Experimental Analysis of Behavior*; *68,* 235-243.

Hayes, S. C., & Hayes, L. J. (1989). The verbal action of the listener as a basis of rule governance. In S. C. Hayes (Ed.), *Rule Governed Behavior: Cognition, Contingencies, and instructional control* (pp. 153-190). NY: Plenum Press.

Hayes, S. C., & Hayes, L. J. (1992). Verbal relations, cognition, and the evolution of behavior analysis. *American Psychologist, 47,* 1383-1395.

References.

Hayes, S. C., & Wilson, K. G. (1993). Some applied implications of a contemporary behavior-analytic account of verbal events. *Behavior-Analyst*, *16*, 283-301.

Hird, J. (1989). *Stimulus equivalence in mentally handicapped and normal subjects: The role of language.* Unpublished doctoral dissertation, University of Wales, Bangor, UK.

Hird, J., & Lowe, C. F. (1985, April). *The role of language in the emergence of equivalence relations I: Evidence from studies with mentally handicapped people.* Paper presented at the annual conference of the Experimental Analysis of Behaviour Group, York, United Kingdom.

Hogan, D. E., & Zentall, T. R. (1977), Backward associations in the pigeon. *American-Journal-of-Psychology, 90,* 3-15.

Holmes, P. W. (1979). Transfer of matching performance in pigeons. *Journal of the Experimental Analysis of Behavior*; *31,* 103-114.

Horne, P. J., & Lowe, C.F. (1996). On the origins of naming and other symbolic behavior. *Journal of the Experimental Analysis of Behavior*; *65,* 185-241.

Horne, P. J., & Lowe, C.F. (1997). Towards a theory of verbal behavior. *Journal of the Experimental Analysis of Behavior*; *68,* 271-296.

Horne, P. J. & Lowe, C.F. (in press). Putting the naming account to the test: preview of an experimental program.

Howell, D. C. (1992). Statistical methods for Psychology. London: Duxbury Press.

References.

Huttenlocher, J. (1974). The origins of language comprehension. In R. L. Solso (Ed.), *Theories in cognitive psychology* (pp. 331-368). Potomac, MD: Erlbaum .

Huttenlocher, J., & Smiley, P. (1987). Early word meanings: the case of object names. *Cognitive Psychology, 19*, 63-89.

Kamhi, A. G. (1986). The elusive first word: the importance of the naming insight for the development of referential speech. *Journal of child language, 13*, 155-61.

Kaye, K. (1982). *The mental and social life of babies: How parents create persons.* Chicago: University of Chicago Press.

Kendall, S. B. (1983). Tests for mediated transfer in pigeons. *Psychological Record, 33*, 245-256.

Langer, J. (1982). From prerepresentational to representational cognition. In G. Forman (Ed.), *Action and thought* (pp. 37-63). New York: Academic Press.

Lempers, J. D. (1976). Production of pointing, comprehension of pointing, and understanding of looking behavior in young children. (Doctoral dissertation, University of Minnesota). *Dissertation Abstracts International, 37, No. 6,* 9, 3524A.

Leung, E. H., & Rheingold, H. L. (1981). Development of pointing as a social gesture. *Developmental Psychology, 17,* 215-220.

Lipkens, R., Kop, P. F., & Matthijs, W. (1988). A test of symmetry and transitivity in the conditional discrimination performances of pigeons. *Journal of the Experimental Analysis of Behavior, 49,* 395-409.

References.

Lipkens, R., Hayes, S. C., & Hayes, L. J. (1993). Longitudinal study of the development of derived relations in an infant. *Journal of Experimental Child Psychology*, *56,* 201-239.

Locke, J. (1980). The prediction of child speech errors: Implications for a theory of acquisition. In G. Yeni-Komshian, J. F. Kavanagh, & C. A. Ferguson (Eds.), *Child Phonology* (Vol. 1, pp. 194-209). New York: Academic Press.

Lowe, C.F., & Beasty, A. (1987). Language and the emergence of equivalence relations: A developmental study. *Bulletin of the British Psychological Society, 40,* A42.

Lowe, C. F., Beasty, A., & Bentall, R. P. (1983). The role of verbal behavior in human learning: Infant performance on fixed interval schedules. *Journal of the Experimental Analysis of Behavior, 39,* 157-164.

Lowe, C. F., Horne, P. J., & Higson, P. J. (1987). The hiatus between theory and practice in clinical psychology. In H. J. Eysenk & I. Martin (Eds.), *Theoretical foundations of behavior therapy* (pp. 153-165). New York: Plenum.

Lucariello, J. (1987). Concept formation and its relation to word learning and use in the second year. *Journal of Child Language, 14,* 309-332.

Mandell, C., & Sheen, V. (1994). Equivalence class formation as a function of the pronounceability of the sample stimulus. *Behavioral Processes, 32,* 29-46.

Mandler, J. M. (1997). Development of categorisation: Perceptual and conceptual categories. In G. Bremner & A. Slater (Eds.), *Infant development: Recent advances* (pp. 163-189). Hove, England UK: Psychology Press/Erlbaum (UK).

References.

Mandler, J. M., & Bauer, P. J. (1988). The cradle of categorization: Is the basic level basic? *Cognitive Development, 3,* 247-264.

Markman, E. M. (1989). Categorization and naming in children. Cambridge, MA: MIT Press.

Masur, E. F. (1982). Mothers' responses to infants' object-related gestures: Influences on lexical development. *Journal of Child Language, 9,* 23-30.

Masur, E. F. (1983). Gestural development, dual-directional signalling, and the transition to words. *Journal of Psycholinguistic Research, 12,* 93-109.

Masur, E. F. (1993). Transitions in representational ability: Infants' verbal, vocal, and action imitation during the second year. *Merrill-Palmer Quarterly, 39,* 437-456.

Masur, E. F. (1995). Infants' early verbal imitation and their later lexical development. *Merrill-Palmer Quarterly, 41,* 286-306.

McIlvane, W. J., Kledaras, J. B., Munson, L. C., King, K. A., de Rose, J. C. & Stoddard, L. T. (1987). Controlling relations in conditional discrimination and matching by exclusion. *Journal of the Experimental Analysis of Behavior, 48,* 187-208.

McIlvane, W. J., & Stoddard, L. T. (1981). Acquisition of matching-to-sample performances in severe retardation: Learning by exclusion. *Journal of Mental Deficiency Research, 25,* 33-48.

McIntire, W. J., Cleary, J., & Thompson, T. (1987). Conditional relations by monkeys: Reflexivity; symmetry and transitivity. *Journal of the Experimental Analysis of Behavior, 47,* 279-285.

References.

McShane, J. (1979). The development of naming. *Linguistics* , 17, 879-905.

McShane, J. (1980). *Learning to Talk.* Cambridge: CUP.

Meltzoff, A. N. (1988). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology, 24,* 470-476.

Menn, L. (1976). Pattern, control, and contrast in beginning speech: a case study in the development of word form and word function. Doctoral Dissertation, University of Illinois, Urbana.

Mervis, C. B., & Bertrand, J. (1993). Acquisition of early object labels: the role of operating principles and input. In A. Kaiser and D. B. Gray (Eds.), *Enhancing children's communication: Research foundations for intervention* (pp. 287-316). Baltimore: Brookes.

Mervis, C. B., & Bertrand, J. (1994), Acquisition of the Novel-Name- Nameless Category (N3C) Principle. *Child Development, 65,* 1646-1662.

Mervis, C. B., & Bertrand. J. (1995) Early lexical acquisition and the vocabulary spurt: a response to Goldfield and Reznick. *Journal of Child Language, 22,* 461-8.

Mervis, C. B., & Crisafi, M. A. (1982). Order of acquisition of subordinate, basic, and superordinate-level categories. *Child Development, 53,* 258-266.

Mervis, C. B., & Mervis, C. A. (1982). Leopards are kitty-cats: Object labelling by mothers for their thirteen-month-olds. *Child Development, 53,* 267-273.

Messer, D. J. (1978). The integration of mothers' referential speech with joint play. *Child Development, 49,* 781-787.

References.

Moerk, E. L. (1983). A behavioral analysis of controversial topics in first language acquisition: reinforcements, corrections, modelling, input frequencies, and the three term contingency. *Journal of Psycholinguistic research. 12,* 129-155.

Moerk, E. L. (1992). A first language: Taught and learned. Baltimore. MD: Paul H. Brookes.

Murphy, C. M. (1978). Pointing in the context of a shared activity. *Child Development, 49,* 371-380.

Namy, L. L., Smith, L. B., & Gershkoff-Stowe, L. (1997). Young children's discovery of classification during play. *Cognitive Development, 12* (2), 163-184.

Nelson, K. (1973). Structure and strategy in learning to talk. *Monograph of the Society for Research in Child Development, 38,* No. 149.

Nelson, K. (1983). The conceptual basis for language. In T. Seiler and W. Wannenmacher (Eds.), *Concept Development and the Development of Word Meaning.* NY: Academic Press.

Nelson, K. (1988). Constraints on word learning? *Cognitive Development, 3,* 221-46.

Nelson, K., Hampson, J., & Shaw, L. (1993). Nouns in early lexicons: evidence, explanation, and implications. *Journal of Child Language, 20,* 61-84.

Nelson, K., & Lucariello, J. (1985). The development of meaning in first words. In M. D. Barrett (ed.), *Children's Single Word Speech.* Chichester: Wiley.

Oller, D. K., Wieman, L. A., Doyle, W. J., & Ross, C. (1976). Infant babbling and speech. *Journal of Child Language, 3,* 1-12.

References.

Piaget, J. (1953). *The Origin of Intelligence in the Child,* London: Routledge and Kegan Paul.

Piaget, J. (1955). *The child's construction of reality.* London: Routledge and Kegan Paul.

Piaget, J. (1962). *Play, Dreams and Imitation,* NY: Norton.

Pilgrim, C. (1996). Can the naming hypothesis be falsified? *Journal of the Experimental Analysis of Behavior, 65,* 284-285.

Pilgrim, C., Chambers, L., & Galizio, M. (1995). Reversal of baseline relations and stimulus equivalence: II. Children. *Journal of the Experimental Analysis of Behavior, 63,* 239-254.

Plunkett, K. (1993). From rote learning to system building: acquiring verb morphology in children and connectionist nets. *Cognition. 48,* 21-69.

Poulin-Dubois. D., Graham. S., & Sippola. L. (1995). Early lexical development: the contribution of parental labelling and infant's categorisation abilities. *Journal of Child Language, 22,* 325-343.

Poulson, C. L., & Kymissis, E. (1988). Generalized imitation in infants. *Journal of Experimental Child Psychology, 46*, 324-336.

Poulson, C. L., Kymissis, E., Reeve, K. F., Andreatos, M., & Reeve, L. (1991). Generalized vocal imitation in infants. *Journal of Experimental Child Psychology, 51*, 267-279.

Randell, T., & Remington, B. (1999). Equivalence relations between visual stimuli: The functional role of naming. *Journal of the Experimental Analysis of Behavior, 71,* 395-415.

References.

Reznick, J. S., & Goldfield, B. A. (1990). Early lexical acquisition: Rate, content, and the vocabulary spurt. *Journal of Child Language, 17,* 171-183.

Reznick, J. S., & Goldfield, B. A. (1992). Rapid change in lexical development in comprehension and production. *Developmental Psychology, 28,* 406-413.

Ricciuti, H. N. (1965). Object grouping and selective ordering behaviours in infants 12 to 24 months old. *Merrill-Palmer quarterly, 11,* 129-148.

Roche, B., Barnes, D., & Smeets, P. M. (1997). Incongruous stimulus pairing and conditional discrimination training: Effects on relational responding. *Journal of the Experimental Analysis of Behavior, 68,* 143-160.

Rodewald, H. K. (1974). Symbolic matching-to-sample by pigeons. *Psychological Reports*, 34, 987-990.

Rosch, E. M. & Mervis, C. B. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7,* 573-605.

Ryan, J. F. (1973). Interpretation and imitation in early language development. In R. Hinde & J. S. Hinde (Eds.), *Constraints on learning: Limitations and predispositions* (pp. 427-443). London: Academic Press.

Saunders, K. J. (1989). Naming in conditional discrimination and stimulus equivalence. *Journal of the Experimental Analysis of Behavior, 51,* 379-384.

Saunders, K. J., & Spradlin, J. E. (1993). Conditional discrimination in mentally retarded subjects: Programming acquisition and learning set. *Journal of the Experimental Analysis of Behavior, 60,* 571-585.

Schafer, G., & Plunkett, K. (1998). Rapid word learning by 15-month-olds under tightly-controlled conditions. *Child Development, 69,* 309-320.

References.

Schusterman, R. J., & Kastak, D. (1993). A California sea lion *(Zalophus Californianus)* is capable of forming equivalence relations. *The Psychological Record, 43,* 823-839.

Shore, C. (1986). Combinatorial play: conceptual development and early multi-word speech. *Developmental Psychology, 20,* 872-80.

Shore, C., Dixon, W. E., & Bauer, P. J. (1995). Measures of linguistic and non-linguistic knowledge of objects in the second year. *First Language, 15,* 189-202.

Shore, C., O'Connell, B., & Bates, E. (1984). First sentences in language and symbolic play. *Developmental Psychology, 20,* 872- 880.

Sidman, M. (1971). Reading and auditory-visual equivalences. *Journal of Speech and Hearing Research, 14,* 5-13.

Sidman, M. (1990). Equivalence relations: Where do they come from? In D. E. Blackman & H. LeJeune (Eds.), *Behavior Analysis in theory and practice* (pp. 93-114). Hove, England: Erlbaum.

Sidman, M. (1992). Equivalence relations: Some basic considerations. In s. c. Hayes & L. J. Hayes (Eds.), *Understanding verbal relations* (pp. 15-27). Reno, NV: Context Press.

Sidman, M. (1994). *Equivalence relations and behavior: A research story.* Boston, MA: Authors Co-operative.

Sidman, M. (1997). Equivalence relations. *Journal of the Experimental Analysis of Behavior, 68,* 258-266.

References.

Sidman, M., & Cresson, O., Jr. (1973). Reading and crossmodal transfer of stimulus equivalence in severe retardation. *American Journal of Mental Deficiency, 77,* 515-523.

Sidman, M., Rauzin, R., Lazar, R., Cunningham, S., Tailby, W., & Carrigan, P. (1982). A search for symmetry in the conditional discriminations of rhesus monkeys, baboons and children. *Journal of the Experimental Analysis of Behavior; 37,* 23-44.

Skinner, B. F. (1957). *Verbal Behaviour.* NY: Appleton-Century-Crofts.

Slobin, D. I. (1968). Recall of full and truncated passive sentences in connected discourse. *Journal of Verbal Learning and Verbal Behavior, 7,* 876-881.

Smith, A. B., Dickins, D. W., & Bentall, R. P. (1996). The role of individual stimulus names in the emergence of equivalence relations: II. The effects of interfering tasks prior to and after tests for emergent relations. *Psychological Record, 46,* 109-130.

Starkey. D. (1981). The origins of concept formation: object sorting and object preference in early infancy. *Child Development, 52,* 489-497.

Stromer, R. (1986). Control by exclusion in arbitrary matching to sample. *Analysis and Intervention in Developmental Disabilities, 6, 59-72.*

Sugarman. S. (1983). Children's early thought: Developments in classification. Cambridge CUP.

Tomanaga, M. (1993). Tests for control by exclusion and negative stimulus relations of arbitrary matching to sample in a "symmetry-emergent" chimpanzee. *Journal of the Experimental Analysis of Behavior*; *59,* 215-229.

References.

Tomasello, M. (1992). The social bases of language acquisition. *Social-Development, 1,* 67-87.

Tomasello, M., & Farrar , M. J. (1986b). Joint attention and early language. *Child Development, 57,* 1454-1463.

Tomasello, M., & Todd, (1983). Joint attention and lexical style. *First Language, 4,* 197-212.

Urcuioli, P. J., & Zentall, T. R. (1993). A test of comparison-stimulus substitutability following one-to-many matching by pigeons. *The Psychological Record, 43, I 745-759.*

Vaughan, W. (1988). Formation of equivalence sets in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes, 14,* 36-42.

Vygotsky, L. S. (1962). Thought and Language. Cambridge, MA: MIT Press.

Wilkinson, K. M., Dube, W. V., & McIlvane, W. J. (1996). A crossdisciplinary perspective on studies of rapid word mapping in psycholinguistics and behavior analysis. *Developmental Review, 16,* 125-148.

Wilkinson, K. M., Dube, W. V., & McIlvane, W. J. (1998). Fast mapping and exclusion (emergent matching) in developmental language, behavior analysis, and animal cognition research. *Psychological Record, 48,* 407-422.

Woodward, A. L., Markman, E. M., & Fitzsimmons, C. M. (1994). Rapid word learning in 13- and 18-month-olds. *Developmental Psychology, 30,* 553-566.