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The relation between gestural imitation and naming in young children

Camoes-Costa, Vera

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The relation between gestural imitation and naming in young children.

Vera Camões-Costa

Thesis submitted to the School of Psychology, Bangor University, in fulfilment of the requirements of the degree of Doctor of Philosophy.

September, 2011

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This thesis is dedicated to the memory of my father, Luis Camões (1945 – 1983), and to my best friend and wonderful husband Dr. Ricardo Costa.

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Summary

Humans are distinguished from other animals by their extensive imitation repertoires, but the determinants of this behaviour are still not fully established. The present programme of research explored the relationship between children's ability to name the components of modelled actions and their matching accuracy, in tests that presented them with modelling of empty-handed gestures that terminated on different parts of body. A total of 106 children, aged between 2 and 4 years, participated in seven experiments.

The first two studies, presented in Chapter 5 and Chapter 6, employed correlational group designs to establish which body parts and movements children can accurately name in response to the experimenter's modelling, and produce in response to the experimenter's verbal instructions. Children's responses were more accurate for body parts than for body movements; they responded best to those body parts that commonly feature in naming-and-matching games played with their caregivers; and their patterns of errors were similar to those previously observed in imitation tests. Next, three single-case experiments presented in Chapter 7 systematically tested the effects of tact and listener training of previously unnamed body parts on children's generalised imitation of gestures that terminated on these locations. Children's matching of hand-to-body gestures markedly improved as the result of body part naming training. Next, a single-case experiment presented in Chapter 8, and a group experiment presented in Chapter 9, tested the effects of training the children to name the movements "across" and "to the side" on the accuracy of their matching of hand-to-body gestures that incorporated these movements. This training was effective in reducing the rates of ipsilateral mismatches to contralateral models, which are typically very high in imitation tests.

These results are in agreement with the predictions of the naming account of Horne and Lowe (1996), who consider naming to be the earliest form of self-instructional behaviour. The present results show that the ability to name features of the actions that they see is an important determinant of imitation in children. These findings have wide-reaching implications for the interpretation of children's performances in matching tests, and for the evaluation of behaviour-analytic and cognitive-developmental accounts and theories of imitation.

CHAPTER ONE: Introduction

1.1 Introduction to the Study of Imitation

Imitation had been a topic of investigation for over a century. It is widely recognised that careful study of the determinants and mechanisms of imitation is needed to inform the various accounts of imitation in the domains of cognition, action, perception and, more recently, neuroscience. Authors of varied theoretical persuasions, including cognitive-developmental psychologists and behaviour analysts, agree that imitation is a key behavioural repertoire that allows children to acquire new responses, such as instrumental manipulation of novel objects and tools, social and conventional actions, and language, quickly and efficiently. In comparative psychology, imitation has long been a topic of study because this repertoire is said to be unique to humans; in developmental psychology, it has been proposed that this ability is at the core of children's cognitive and social development. Indeed, developmental psychologists have often used imitation as a probe in tests of learning, categorisation (e.g., McDonough & Mandler, 1998), and memory (e.g., Barr, Dowden, & Hayne, 1996; Barr, Vieira, & Rovee-Collier, 2001; Bauer, Wenner, Dropik, & Wewerka, 2000; Herbert, Gross, & Hayne, 2006). In behaviour analysis, generalised imitation has been studied as a prime example of a higher-order class of behaviour. Because the study of imitation has such a long and varied history, the literature exploring the mechanisms underlying imitative behaviours is extensive. Nonetheless, there is still little agreement about the provenance of generalised imitation, its determinants, and its mechanisms. Although many definitions of imitation had evolved through years of research, there is at present no agreement on how best to classify this important behavioural repertoire.

Definitions of Imitation

Imitation was first defined scientifically by Thorndike (1898, in Hayes, 1996) as an act learnt from seeing it done. In the developmental literature, definitions have often been even less precise than this; in many studies, children producing a behaviour that is similar to that modelled to them are said to be imitating, with no further controls, and no analyses of the contingencies operating in each matching episode (Mitchell, 1987; Want and Harris, 2002). By contrast, more varied classification systems and the associated control procedures have evolved in comparative psychology, where researchers have long recognised that not all matching is necessarily the result of imitation (e.g., Miller & Dollard, 1941; Zentall, 1998, 1996, 2006). Want and Harris (2002) have argued that similar categorisations ought to be employed by developmental researchers. Below is a brief overview of the main issues debated in different research domains; key empirical and theoretical contributions from developmental psychology and the behaviour analytic literature are presented in more detail in the following two chapters.

Novelty as a Key Criterion for Imitation

Thorpe (1963, p. 135) described "true imitation" as "the copying of a novel or otherwise improbable act or utterance, or some act for which there is clearly no instinctive tendency". Visalberghi and Fragaszy (1990) agreed that the definition of imitation should include "novelty" in its pragmatic criterion, referring to the need for the copied behaviour to be absent from the organism's existing repertoire (see also, Byrne & Russon, 1998; Carpenter, Nagell, & Tomasello, 1998; Hayne, 1998; Tomasello, Kruger, & Ratner, 1993a). However, Heyes (1993; 1995) argued that in practice it is impossible to differentiate between entirely novel behaviours and re-combinations of known behaviours. In developmental psychology, Meltzoff (1995) attempted to identify different forms of novelty, and in the behaviour analytic literature, Horne and Erjavec (2007) introduced a pragmatic test for the novelty of target behaviours as a standard. Overall, it is now recognised that novelty is an important issue that needs to be addressed in any study of imitation (but see Heyes, 2005 for an argument to the contrary).

Defining Imitation by Exclusion

Comparative psychologists have often defined imitation by exclusion; they have produced lists of alternative matching mechanisms, many of them social, which needed to be excluded as possible explanations for apparently imitative performances through appropriate experimental controls – or were studied in their own right. For example, according to the frequently cited accounts of Zentall (2006) and Whiten and Ham (1992), non-imitative matching mechanisms include behavioural contagion, mimicry, observational conditioning, social facilitation, incentive motivation, stimulus and local enhancement, object affordances, goal emulation, object movement reenactment, response facilitation, and trained (operant) matching.

More recently, imitation definitions have incorporated goal-directness (Bekkering, Wohlschläger, & Gattis, 2000), intentionality, and understanding (Tomasello, Kruger, & Ratner, 1993b). These were said to be necessary for the imitation of instrumental tasks (see, Gergely, Bekkering, & Király, 2002; Williamson & Markman, 2006) and for differentiating imitation from other forms of social learning (see, Carpenter et al., 1998; Meltzoff, 1995). For example, Visalberghi (1997) suggested that imitation involves the learning of new rules in handling instrumental tasks, as opposed to mimicking ("rote copying"; also see Heyes, 1994). Others have argued that goal directedness or intention reading should not be included in the definition of imitation as a necessary criterion, because they are not required for imitation of arbitrary actions without specific environmental consequences (Custance, Whiten, & Bard, 1995; Hayes, 1994).

Overall, most of the classifications mentioned here – and there are too many instances in the literature to list in the present thesis – have been theoretically driven; unsurprisingly, they differ across research groups and domains. In recent years, developmental psychologists and behaviour analysts have recognised the utility of some of these distinctions – mostly those derived from comparative research – and accordingly they have tightened the experimental controls employed in studies of imitation. These are explained in Chapter 4.

Classifications and Experimental Tasks

Piaget (1953) was the first developmental psychologist to differentiate between various kinds of imitation, because he considered that they differ in difficulty. He linked the development of imitative abilities to what he defined as sensory-motor stages in the first two years of life and distinguished between immediate versus deferred imitation (the latter was said to require full representation ability and better memory); imitation of known versus novel acts; and imitation of visible (e.g., hand movements) versus invisible acts (e.g., facial movements; these were said to be more difficult to imitate as visual feedback was not available to the child). In various guises, these distinctions are still made in developmental psychology (Barr et al., 1996; Bekkering et al., 2000; Herbert et al., 2006; Learmonth, Lamberth, & Rovee-Collier, 2004; Meltzoff, 1988a, 1988b) and some have been adopted in comparative psychology (Zentall, 2006). Piaget's theory is described in Chapter 3.

In comparative psychology, most imitation tests involve instrumental tasks, such as operating an apparatus or using tools to obtain a food reward (Galef, 1988; Want & Harris, 2002; Whiten & Ham, 1992; Zentall, 1988, 1996, 2006). In developmental psychology, imitation tasks differ across the age span: During first few months of life, the most studied behaviours are facial expressions and oral movements (Meltzoff & Moore, 1977, 1983, 1989). In older infants and toddlers, imitation tests typically employ actions directed at objects (e.g., Barr et al., 1996; Heimann & Nilheim, 2004; Learmonth et al., 2004; Meltzoff, 1988a, 1988b, 1995), whereas preschool children are most often presented with modelling of empty-handed gestures (Bekkering et al., 2000; Gleissner, Meltzoff, & Bekkering, 2000; Wohlschläger, Gattis, & Bekkering, 2003). In the behaviour analytic literature, a mixture of actions on objects, body movements, and empty-handed gestures has been used, often within the same study. (In addition to this, there exists a large literature on vocal imitation; this is not considered in the present thesis.) Children from special populations have been presented with similar tasks, in the developmental and behaviour analytic literature (Baer, Peterson, & Sherman, 1967; Baer & Sherman, 1964; Garcia, Baer, & Firestone, 1971; Libby, Powell, Messer, & Jordan, 1997; Metz, 1965; Peterson, 1968). Each of these tests presents challenges to the researchers, both practical and theoretical. The most important issue is that of adequate experimental control. This is discussed in detail in Chapter 4.

1.2 Introduction to the Present Thesis

Theoretical Position, Methodology, and Definition of Imitation

The author of this thesis is a behaviour analyst by training, but the research reported here employed a mixture of behaviour analytic and mainstream developmental methodology. This was done the better to address the experimental questions, which are of importance to all those interested in the relationship between verbal repertoire development and generalised imitation in children, and the determinants of imitation in general, regardless of their theoretical perspectives.

In behaviour analysis, a distinction is made between the trained (operant) matching repertoire, and generalised imitation – a truly generative repertoire (Gewirtz & Stingle, 1968). The notion of operant training and reinforcement is seldom explicitly discussed in contemporary developmental psychology, although comparative researchers typically recognise the importance of ruling out trained responses in imitation tests. If a child presented with a novel modelled behaviour succeeds in producing a corresponding behaviour herself, even though she has never been directly trained to do so and there is no external reinforcement, and if her response is directly controlled by the behaviour of the modeller rather than some other event in the environment, behaviour analysts would recognise this as an instance of generalised imitation. A summary of the behaviour analytic account of imitation is presented in Chapter 3, alongside the key theoretical perspectives from mainstream developmental psychology.

For the purpose of this thesis, imitation is considered to have occurred if a child, after seeing a novel modelled behaviour, emits a behaviour that is topographically similar to that of a model; the behaviour emitted is directly caused by seeing the model's behaviour, and the match of behaviour to model does not require external reinforcement (Horne & Erjavec, 2007). This definition is compatible with the behaviour analytic definition of generalised imitation. By contrast, the term 'matching' is used throughout the thesis to describe the episodes in which an observer produces a behaviour that is physically similar to that of a model, without specifying the determinants of this behaviour. Imitation will always involve matching, but few instances of matching will qualify as imitation.

In practice, it is difficult to establish the novelty of each target behaviour presented in an imitation task, because the experimenter cannot know the participant's history well enough. If a child emits a correct match to a behaviour modelled by an experimenter on the first trials, we could conclude either that the child has been trained previously to match that behaviour, or that the child is demonstrating spontaneous generalised imitation. However, unless a child consistently emits correct responses at the outset, for a wide range of behaviours, it is parsimonious to conclude that an occasional correct response is the result of previous training. Therefore, Horne and Erjavec (2007) introduced a pre-test for novelty of actions that considers any correct responses emitted at the outset of generalised imitation testing as evidence of such training. In their research (also see Erjavec, Horne, & Lovett, 2009) it has been confirmed that infants and toddlers seldom match unreinforced target models during their first couple of trials. Therefore, their stringent definition of generalised imitation and their pre-test for novelty of target actions have been adopted in the present thesis, to avoid false positive results (and see Chapter 3 for a discussion of other non-imitative matching mechanisms and their appropriate controls).

Structure and Content of the Thesis

At the core of this thesis are five experimental chapters. Each of these chapters contains a different paper submitted for publication in peer-reviewed journals prior to the completion of the thesis. Three theoretical chapters, presented first, contain a focused literature review and give the rationale behind the development of the present research; the final chapter contains a general discussion.

Chapter 2 presents a critical review of the key theories of imitation and the experiments that have been used to generate and test these theories.

Chapter 3 presents a critical review of the procedures commonly used in the study of imitation, and of behaviour analytic tests for generalised imitation. It describes the non-imitative matching mechanisms and corresponding control procedures that need to be used in all experimental tests of imitation, including those employed in the present research.

Chapter 4 presents an overview of behaviour analytic accounts of verbal behaviour, and particularly of the naming account. It ends with a summary that sets the scene for the experimental work reported in the following chapters.

Chapter 5 describes the results of a group study in which children were asked to name the body parts touched by the experimenter, and to touch these parts of body in response to the experimenter's verbal instructions. These data identify the most- and least-frequently named parts of body; the latter were targeted by a naming intervention in one of the subsequent studies. These results also point to the social origin of children's body knowledge.

Chapter 6 presents the results of a group study in which children were asked to name complex hand-to-body gestures modelled by the experimenter, and to perform these gestures in response to detailed verbal instructions. The children's errors in these tasks were very similar to those previously recorded in imitation tests. The children's responses were poorest for body movements, prompting the design of the naming intervention employed in the last two studies in this thesis.

Chapter 7 presents the results of three single-participant experiments exploring the relationship between children's ability to name parts of the body and their success on imitation tests that employed hand touches to these body parts. This study established that naming of body parts could increase the accuracy of children's responses in generalised imitation tests.

Chapter 8 presents the result of another single-participant experiment that explored the relationship between the children's ability to name body movements and the accuracy of their performances in generalised imitation tests that employed gestures containing the same movements.

Chapter 9 presents the results of a study that confirmed, within a larger group design, that learning to name body movements can substantially reduce children's imitation errors. These data contradict the predictions of one of the key theories of imitation, and confirm that learning history and language are key determinants of imitation in preschool children.

Chapter 10 presents a general discussion that brings together the findings from the reported studies, their implications, and suggestions for future research.

Journal Submissions and Papers Presented at Conferences

Chapter 5

Camões-Costa, V., Erjavec, M., & Horne, P. (2011). Comprehension and production of body-part labels in 2- to 3-year-old children. *British Journal of Developmental Psychology. 29*, 552–571. doi:10.1348/026151010X523040

Chapter 6

Camões-Costa, V., Erjavec, M., & Horne, P. (in submission). Patterns of error in the description and performance of empty-handed gestures by 2- to 3-year-old children: Similarities with gestural imitation. Paper submitted to *Journal of Experimental Child Psychology.*

Camões-Costa, V., Erjavec, M., & Horne, P. (2008). The performance and description of action sequences in 2- to -3 year old children. Paper presented at the British Psychological Society Developmental Conference, Oxford, UK.

Chapter 7

Camões-Costa, V., Erjavec, M., & Horne, P. (2011). The impact of body-part naming training on the accuracy of imitative performances in 2- to 3-year old children. Paper due to appear in November 2011 issue of *Journal of the Experimental Analysis of Behavior.*

Camões-Costa, V., Erjavec, M., & Horne, P. (2009). The impact of body-part naming training on the accuracy of children's imitative performances. Paper presented at the European Analysis of Behaviour Group Conference, London, UK.

Camões-Costa, V., Erjavec, M., & Horne, P. (2009). The impact of body-part naming training on the accuracy of children's imitative performances. Paper presented as part of the Imitation Symposium, at the Applied Behaviour Analysis International Convention, Oslo, Norway.

Chapter 8

Camões-Costa, V., Erjavec, M., & Horne, P. (in submission). Can naming of arm movements improve imitation accuracy in 2- to 3-year-old children? Paper submitted to *Journal of the Experimental Analysis of Behavior.*

Camões-Costa, V., Erjavec, M., & Horne, P. (2010). Can naming of component arm movements improve imitation accuracy in 2- to 3-year-old children? Paper presented at the Applied Behaviour Analysis 36th Annual Convention, San Antonio, Texas, USA.

Chapter One

Camões-Costa, V., Erjavec, M., & Horne, P. (2011). Can Naming of Arm Movements Improve Imitation Accuracy in 2- to 3-Year-Old Children? Paper presented as part of the Imitation Symposium, at the 6th International Conference of the Applied Behavior Analysis International, Granada, Spain.

Chapter 9

Erjavec, M., Camões-Costa, V., & Horne, P. (in submission). Learning to name arm movements improves imitation accuracy in preschool children. Paper submitted to *Child Development.*

CHAPTER TWO: Key Theories and Paradigms of Imitation

An exhaustive review of all theoretical accounts of imitation is beyond the scope of the present thesis, but the key accounts from the cognitive, developmental, and behavioural literatures are briefly outlined and evaluated in this chapter.

2.1 Piaget's Account of Imitation

Traditionally, developmental psychologists have viewed imitation as a developing skill, dependent on cognitive maturation. Piaget (1962) proposed that early imitative competence develops throughout infancy, as the child becomes progressively more able to take the others' perspective. In Piaget's account, the sensorimotor stage of development is divided into six separate sub-stages, in which new cognitive skills emerge and in turn enable the subsequent development of other skills. Piaget argued that imitation is purely reflexive during the first month of life (sub-stage of *reflexes*) as the child's coordination of sensation and action is the result of reflexive behaviours, such as sucking of objects in the mouth or closing of the hand when an object makes contact with the palm. These reflexes soon become voluntary actions; for example, closing of the hand when an object makes contact with the palm becomes intentional grasping. Piaget stated that pseudo-imitation emerged at 1- 4 months, during the sub-stage of *primary circular reactions*. Here, matching could occur: (i) by chance; (ii) when there is a source of stimulation in the shared environment that directly evokes or elicits a particular behaviour in both caregiver and the baby; or (iii) via a mechanism of social facilitation, when the orienting behaviour of the caregiver serves as a cue for the baby to approach and, hence, come under the control of the cue that is already controlling the caregiver's behaviour. For example, during feeding, as the spoon of food is raised to the baby's mouth, the caregiver may also frequently open her own mouth. Thus both the sight of an approaching spoonful of food and the caregiver's open mouth may serve as a discriminative stimulus for the baby's mouth opening (matching response). Here the baby may not be imitating a mouth opening movement at all – although this may appear to be so for the onlookers – because the relation between the caregiver's and baby's behaviour is likely to be an artefact of operant conditioning. Later, in the sub-stage of *secondary circular reactions* (between 4-8 months), the child begins to intentionally repeat her own actions in order to trigger a response in the environment, but imitation is not yet evident. Piaget asserted that 'real' imitation does not occur in human infants until around 8-12 months of age (sub-stage named *coordination of reactions*), when infants begin to imitate actions they can already perform, providing that their responses are visible and that objects are involved. Imitation of new behaviour is said to emerge during the sub-stage of *tertiary circular reactions* (12-18 months); only then can infants imitate truly novel actions and vary their responses to achieve a good match between their own behaviour and a behaviour they have observed. Further, Piaget claimed that infants are unable to show deferred imitation until around 18 months to 24 months of age (during the final sensorimotor sub-stage, *early representational thought*), because full imitation requires full representation, and this is the period in which children begin to develop symbols to represent events or objects in the world.

Evidence

Developmental data show that children's imitation abilities change over the first years of life. Several early studies have reported that imitation of a novel behaviour occurs around the end of the first year, and that training is needed before this age in order for the infant to perform any kind of matching behaviour (Abravanel, Levan-Goldschmidt &

Stevenson, 1976; Piaget, 1953; Rogdon & Kurdek, 1977; Uzgiris, 1972; Uzgiris & Hunt, 1975). It has been reported that infants up to 20 months old are more likely to imitate actions involving objects than actions involving body movements alone (e.g., Abravanel et al., 1976; Masur & Ritz, 1984). It has also been documented that until 16 to 17 months of age infants imitate meaningful (i.e., conventional) actions more reliably than non-meaningful (unconventional) actions (Masur & Ritz, 1984), but that by 22 months of age infants can imitate both kinds of actions (McCabe & Uzgiris, 1983). Older children are more likely to imitate novel actions than younger children (Masur & Ritz, 1984). In a recent review, Jones (2009) provides an overview of the evidence supporting the argument that infants do not imitate others until their second year of life, and that from this age onwards imitation of different kinds of behaviours develops gradually, as a result of the children's social, cognitive and motor experiences.

Although many early findings were in line with Piaget's predictions, in general terms if not in specific details, most contemporary developmental psychologists consider that he underestimated children's cognitive and imitative abilities. For example, it had been reported that infants are capable of deferred imitation (Meltzoff, 1988b) and novel imitation (Meltzoff, 1988a) before their first birthday. In addition, it has been reported that neonates can imitate simple facial movements (e.g., Meltzoff & Moore, 1977, 1983, 1989, 1992, 1997). These findings gave rise to another theory that gained prominence in the past 20 years, and is described next.

2.2 Active Intermodal Mapping Account of Imitation

Meltzoff and Moore (1997) have proposed that infants are born with a cross-modal matching ability; they can map the movements of the behaviour they see being modelled to their own behaviour through a process called active intermodal mapping (AIM). Thus infants are said to be able to vary their own responses until they detect, via proprioceptive feedback, that they have matched the configuration of the model. These authors propose that AIM is at the core of infants' social perceptions, enabling them to perceive others as 'like me' (Meltzoff & Moore, 1992, 1997).

Evidence

Over the years, researchers investigating neonatal imitation have restricted their studies to analyses of facial expressions and small oral movements – mainly tongue protrusion (TP) and mouth opening (MO) – due to the limited range of motor abilities of the newborn (e.g., Anisfeld, 1991; Anisfeld et al., 2001; Bjorklund, 1987; Field, Woodson, Greenberg, & Cohen, 1982; Jacobson, 1979; Jones, 1996, 2006; Meltzoff & Moore, 1977, 1983, 1989, 1992, 1997; Reissland, 1988). In a typical paradigm, infants were presented with alternating models of two target behaviours, which are not novel. If the infants produced these responses with a relatively greater frequency after observing modelling of the corresponding actions, this was taken as evidence of early (or neonatal) imitation (e.g., Meltzoff, 1988a, 1988b; Meltzoff, & Moore, 1977, 1983, 1989, 1997). While there have been many successful replications of the neonatal imitation findings of Meltzoff and Moore, these studies have also been extensively criticised for lacking appropriate experimental controls (e.g., Anisfeld, 1991; Anisfeld et al., 2001; Jacobson, 1979; Jones, 1996; McKenzie & Over, 1983).

In a large and well-controlled study, Anisfeld and his colleagues have shown that only TP occurs with a relatively higher frequency after modelling, indicating that imitation is not a plausible explanation for the neonatal findings (Anisfeld et al., 2001) – if infants were able to imitate, this ability would not be restricted to a single response. Jacobson (1979) and Jones (1996, 2006) have demonstrated that infants emit TP responses to interesting stimuli such as a moving pen or ball, or flashing lights, or even music, and that these responses decreased once the infants developed the ability to reach for objects (Jones, Exp 3, 1996). Taken together, these findings show that neonatal imitation findings can be explained parsimoniously as the result of an innate arousal releasing mechanism (and see Ferrari, Visalberghi, Paukner, Fogassi, Ruggiero, & Suomi, 2006, for a comparable finding with newborn rhesus macaques).

This re-interpretation of the data from the neonatal imitation studies is consistent with the view that imitation is not present in very young infants, but instead it develops gradually. However, such a view is still not widely shared, and until the challenges that recent work poses to the earlier studies are acknowledged, limited progress in this field is likely to be made (Heyes, 2005). The recent discovery of "mirror neurons" has contributed to renewed discussion of some of the issues concerning neonatal imitation.

2.3 Mirror Neurons and Imitation

Mirror neurons is the name given to a group of cells that are activated both by the execution of an action and by the sight of others performing the same action (Rizzolatti, Fogassi, & Gallese, 2001). This mechanism was originally found and studied in the premotor cortex of macaque monkeys (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996), and subsequently investigated in humans (Arbib, 2005; Lepage & Théoret, 2007; Wohlschläger & Bekkering, 2002). Many authors believe that the mirror neuron network provides a neural substrate necessary for the imitation of actions (e.g. Arbib, 2002; Arbib, Billard, Iacoboni, & Oztop, 2000; Iacoboni, 2005; Oztop, Kawato, & Arbib, 2006; Rizzolatti, 2005; Rizzolati et al., 2001), although this view is not shared by all comparative psychologists, who note that monkeys are not accomplished imitators.

Evidence

Mirror neuron activation has been studied across a variety of tasks, with adult participants, using neuroimaging techniques and trans-cranial stimulation. For example, Buccino et al. (2004) asked musically naïve adult participants to observe novel complex hand actions played on a guitar and, after an interval, to reproduce them. The cortical areas activated, and therefore, involved in the translation of the observed motor pattern into the executed motor pattern were assessed using event-related fMRI techniques. The authors suggested that during learning of new motor patterns by imitation, when the observed actions were decomposed into elementary motor acts, motor representations in the brain corresponded to the activation of mirror cells. Once activated, these motor representations are re-combined inside the mirror neuron system circuit to fit the observed model. Other studies have shown that the human mirror system is activated when an individual observes meaningful actions without an object (Buccino et al., 2001; Grèzes, Armony, Rowe, & Passingham, 2003), or meaningless (intransitive) arm/hand gestures (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Iacoboni, Woods, Brass, Bekkering, Mazziotta, & Rizolatti, 1999; Maeda, Kleiner-Fisman, & Pascual-Leone, 2002). Therefore, neurocognitive researchers claim that the human mirror neuron system determines the imitation of both the goal of an action and the means by which the goal is achieved (Rizzolatti, 2005). Adult data also indicate that mirror neuron activity depends on experience and knowledge, and that its activation changes through learning: it is activated when martial arts experts view martial arts displays, and when accomplished dancers view dance routines, but not vice versa (Iacoboni & Dapretto, 2006). Finally, Iacoboni (2005) has also argued that the mirror neuron system provides the bases for the perception and production of language processes that seem to be strongly related to imitation (e.g., Bates, Thal, Fenson, Whitesell, & Oakes, 1989; Goodwyn, Acredolo, & Brown, 2000).

While many researchers believe that a functional mirror neuron system (MNS) is present from birth (e.g. Meltzoff & Decety, 2003), so far this claim has not been supported by neurocognitive studies. Any statement that the newborn is equipped with a functional MNS is based on the idea that infants can imitate from birth (e.g., Meltzoff & Moore, 1977, 1983), rather than existing evidence of a mirror-neuron system at birth (Lepage & Théoret, 2007). In one of few existing developmental studies, Lepage and Théoret (2006) asked 18 children between 4- and 11-years-old to observe and then perform two types of hand actions: extended flat hand, and a precision grip. The activation of mirror neurons was measured indirectly, via EEG activity over the sensorimotor area that represents the hand, and the authors reported that similar activation patterns were recorded in observation and the execution of the actions. Lepage and Théoret (2007) have hypothesised that a rudimentary mirror-matching mechanism may emerge during infancy, is present as early as 6 months, and develops through several refinements during the first years of life (and beyond) into very complex forms, but this account is speculative given the lack of reliable behavioural evidence of mirror neuron activity in children.

2.4 Goal-Directed Theory of Imitation

Several cognitive researchers have suggested that human imitation is driven by action goals that the observer infers from cues provided in action consequences or end results (e.g., Gattis, Bekkering, & Wohlschläger, 2002; Meltzoff & Moore, 1997; Wohlschläger et al., 2003). According to the theory of goal-directed imitation (GOADI), children who observe modelling of complex actions attend to some of the action components more than to others, because actions are perceived in terms their goal structure, and goals are hierarchically organised. In other words, GOADI states that matching an action does not involve replicating a single unified motor pattern but entails the decomposition of the observed motor patterns into their constituent components and then reconstruction of the action pattern from these components to form a response (Bekkering et al., 2000; Gleissner et al., 2000). Because of their limited cognitive and processing abilities, this process is said to be inefficient in children (Gleissner et al., 2000; Wohlschläger et al., 2003). Therefore, children's matching responses are expected to be incorrect in many cases, because the goals that are high in the hierarchy are preserved but the goals that are low in the hierarchy are neglected (see also Byrne & Russon, 1998) – and the motor program most strongly associated with the achievement of the main goal is selected for execution of the action (this is referred to as the ideomotor principle; see Wohlschläger et al., 2003).

Evidence

GOADI had been developed to explain a pattern of errors observed across several studies in which children were presented with modelling of empty-handed manual gestures. Head (1920, see also Schofield, 1976; Wapner & Cirillo, 1968) observed that young children presented with contralateral movements (that cross the body midline) often respond to these models with ipsilateral movements (that do not cross the body midline). More recently, Gleissner et al. (2000) reported that 3-year-old children presented with modelling of hand-to-ear or hand-to-knee gestures typically touch the same body part as the modeller, but they frequently accomplish this touch with ipsilateral, rather than contralateral movement. In this study, the children produced the *ipsi-for-contralateral error* in 60% of the trials. Similar results have been reported in several other studies (e.g., Elsner & Hommel, 2001; Prinz, 1997). According to GOADI, these errors occur because the children reproduce the dominant goal of these actions (end point or body part touched) but neglect the inferior goals (movement path used to accomplish the touches).

Experimental support for this interpretation was provided by Bekkering et al. (2000), who first replicated the findings of earlier experiments with modelling of hand actions terminating either on body parts or on dots on a table-top. Next, the experimenters reasoned that children's movement errors ought to be reduced if the modelled movements did not terminate on any location, or if they all terminated on the same location. In both cases, this would have removed the 'top' goal and enabled the children to attend to and reproduce the goals they had previously neglected. Indeed, children's movement errors were found to decrease after these manipulations (Gleissner et al., 2000; Bekkering et al., Exp 3, 2000). This finding was considered by these researchers to support their hypothesis that goals (movement path and selection) that are lower in the hierarchy, and are made more salient when higher goals (object touched) are eliminated from the task.

Two other studies have supported the GOADI postulate that the goal selection processes mediating imitation are specific to imitation and different from the processes mediating other perceptual-motor tasks (specialist view). Gattis et al. (2002) showed that preschool children persistently made *ipsi-for-contralateral errors* even when, in a task similar to the one employed by Bekkering et al. (2000), the experimenter wore different coloured gloves (in order to highlight the hand selection and movement path modelled), suggesting that perceptual discrimination did not affect imitative goal selection processes. Also, Wohlshläger et al. (2003) found that young children do not systematically produce *ipsi-for-contralateral errors* in a matching-to-sample procedure where they were not asked to imitate, but instead to match photographs with the same stimulus movement. Overall, GOADI proponents concluded that goal selection constraints are not due to children's inability to discriminate, but are specific to imitation tasks.

More recent tests have challenged these conclusions. Experimental manipulation of the discriminability of end-points and hands / movements has been shown to affect errors in matching and the verbal descriptions of adults who responded more accurately to the highlighted features of the display (Bird, Brindley, Leighton, & Heyes, 2007). These findings show that 'goal selection' is actually dependent on discriminability, and that general attention and perceptual processes common to other cognitive tasks also operate in imitation, contrary to the claims of GOADI. Further, it was reported that adults respond in the same manner to inanimate models, where intention-reading and goal-attribution do not apply (Leighton, Bird, & Heyes, 2010). Perra and Gattis (2008) presented a similar task to 4- to-7 year-old children, and found that their accuracy increased with age.

Erjavec and Horne (2008) also investigated the pattern of errors reported in the GOADI studies (Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Gleissner et al., 2000) and offered a more parsimonious explanation for their occurrence in children's matching performances: Ipsilateral touches to body parts are very commonly used in matching games that children play with their caregivers, whereas their contralateral counterparts have no such training history. Indeed, warm-up tasks used in some of the GOADI studies contained a naming-and-matching game of this kind. Thus it was not surprising that children's responses often contained *ipsi-for-contralateral errors*, but seldom the opposite mismatches. Erjavec and Horne (2008) tested 20 children between 2 and 3 years of age, and modelled twenty target gestures including lower- and mid-arm touches in which the touched arm was either raised or held in a rest position. The latter gestures provided a direct test of the GOADI predictions: Raising an arm presents an additional 'goal' and increases the complexity of the modelled behaviour, so this should result in a higher incidence of errors compared to the gestures that terminate on the same parts of body, but with the arm in the resting position. By contrast, if children's errors are dependent on their previous experience of matching games, Erjavec and Horne predicted that fewer errors would be emitted to a more complex model of elbow-touch (arm raised) than the less complex model of a crook-of-arm-touch (arm resting), because the latter does not typically feature in naming-and-matching games that young children play with their caregivers. The results showed that children's matching performances were more accurate in response to the raised-arm models compared to the models with the arm in rest position, and that the children often responded to the lowered-arm models with the arm in the raised position. This study showed that children's learning experiences needed to be taken into account in the interpretation of imitation test findings. A similar argument has been put forward by proponents of the associative learning sequence model of imitation which is considered next.

2.5 Associative Learning Sequence Model of Imitation

Heyes (2005) stated that the range of gestures children can imitate depends not on the perceived goals of an action, but on what they have seen or done themselves. She argued that the information processing mechanisms responsible for the translation of sensory input from observed actions into the matching of self-executed actions (the correspondence problem; e.g., Brass & Heyes, 2005) originates from sensory motor learning experiences (see also, Byrne, 2003; Heyes, 2001; Heyes & Ray, 2000). The Associative Sequence Learning (ASL) model states that imitation occurs through vertical association, a bidirectional link between the sensory representation of the observed movement (how does the movement feel from the perspective of the modeller) and its motor representation (how motor commands and somatosensory qualities are encoded). This model suggests that general processes of learning mediate the establishment of most vertical associations; children's early experiences evoke simultaneous activation of sensory and motor representations, strengthening these links. Therefore, the range of movements that children have learnt by experience, part of their seen and done behavioural repertoire, predicts the range of movements that they can imitate, because neurological associations have been made. This generalist account of imitation is entirely compatible with the "mirror neuron system" perspective on imitation (Rizzolatti, 2005) discussed earlier. It has been suggested that, rather than the mirror system having innately imitative components, general associative learning processes allow these mirror cells to acquire their imitative characteristics. Hence, monkeys are innately equipped with a mirror neuron system but, according to some authors, this system is not activated by the observation of intransitive (non-object-directed) actions (e.g., Umilta et al., 2001). In humans, however, the mirror neuron system becomes active when an intransitive action (such as a finger movement) is observed (e.g. Brass, Bekkering, Wohlschläger, & Prinz, 2000; Buccino et al., 2001; Heyes, Bird, Johnson, & Haggard, 2005; Iacoboni et al., 1999; Iacoboni et al., 2001; Koski, Iacoboni, Dubeau, Woods, & Mazziotta, 2003; Koski et al., 2002; cf. Jonas et al., 2007).

It has been also suggested that the fact that language related areas in the brain become simultaneously active during the observation of actions could be a result of covert verbalization (Iacoboni & Dapretto, 2006). This suggests that even if mirror neurons are present at birth, social learning interactions play a crucial role in the development of their imitative characteristics (e.g., Gillmeister, Catmur, Liepelt, Brass, & Heyes, 2008; Heyes, 2005). Within this body of research, it is believed that vertical associations become imprinted in the mirror tissue once learned. If this is the case, the mirror neurons system is dynamic and flexible, meaning that behavioural training can alter it.

Evidence

Studies have recently tested the hypothesis that experience mediates the formation of particular cortical connections responsible for imitation; several studies using a stimulus-response compatibility paradigm have investigated automatic imitation of intransitive actions in adults, showing that sensorimotor training is likely to change the properties and functioning of the MNS (Bertenthal, Longo, & Kosobud, 2006; Brass et al., 2000; Cook, Press, Dickinson, & Heyes, 2010; Gillmeister et al., 2008; Heyes et al., 2005; Kilner, Paulignan, & Blakemore, 2003; Press, Bird, Flach, & Heyes, 2005; Stürmer, Aschersleben, & Prinz, 2000). The common idea of these reaction time studies is that the execution of a given action (e.g., opening the hand) is faster when a compatible action is simultaneously observed (i.e., opening the hand), because it is assumed that the observation of an action will activate its associated motor representation. Therefore, if an incompatible action (e.g., closing the hand) is observed, the execution of the target action – opening hand – is negatively affected. Those studies found that the automatic tendency to execute an action that conforms to or is compatible with the observed action can be attenuated by behavioural training. So, when participants were subject to a period of incompatible training (e.g., asked to produce closing hand responses when opening hand actions were observed), the interference previously observed during testing was reduced (e.g. Gillmeister et al., 2008; Heyes et al., 2005; Press, Bird, Walsh, & Heyes, 2008; Stürmer et al., 2000).

Overall, predictions of the ASL model have not been tested with children. The adult data, which incorporated very simple and over-practiced responses such as finger and hand movements, cannot shed light on the developmental course of imitation in childhood. In a recent review, Ray and Heyes (2011) discussed a body of research in support of the argument that matching behaviour during childhood develops from children's interactions with their sociocultural environment in which seeing an action can become related to doing an action. The authors argued that simple behaviour control mechanisms operating in the context of imitogenic experiences (such as self-observation, being imitated by adults, exposure to imitative behaviour, or acquired equivalence experiences) are at the basis of the emergence of matching repertoires in young children (also see Zukow-Goldring & Arbib, 2007). Similar predictions have been made by behaviour analysts, who do not subscribe to the associative learning paradigm, but consider that imitation is learned through operant training of matching responses in infancy and early childhood.

2.6 Behaviour Analytic Accounts of Imitation

Byrne (2003) noted that the literature often distinguishes between the correspondence problem, and the transfer of skills problem. The former has been the topic of discussion in the cognitive accounts discussed earlier; the latter asks how children acquire novel behaviour through observation. Both questions have been addressed by behaviour analysts: Skinner's account of imitation deals mostly with the former, and the more recent conditioned reinforcement account of Baer and Deguchi with the latter.

Skinner's Account of Imitation

Skinner (1953; p. 120) proposed that imitation emerges in the course of conventional social interactions of children with their caregivers who shape and reinforce the child's matching responses, thereby training a repertoire of match-to-model responses. For example, considering a baby's response of waving bye-bye to someone leaving the room: This behaviour is firstly learned by gradual shaping, in which the infant's hand is moved to the correct waving position and motion. When the baby's action (even when involuntary) matches the modeller's action, this response is reinforced (usually by delivering praise). After a few prompted and reinforced instances, the baby starts to independently produce a waving response that matches a modeller's action when someone leaves the room. This example of operant conditioning is very similar to what Miller and Dollard (1941; p. 199) called matched dependent behaviour: The modeller's behaviour becomes a discriminative stimulus for the observer after a history of trials on which the observer's matching of that behaviour has been reinforced.

Skinner (1953; p. 119) proposed that novel instances of matching might be established faster as a child acquires a large repertoire of operantly trained matches. For example, if the child sees a gesture that involves a sequence of elementary actions, some of which already feature in the child's matching repertoire, the child may match the components of the gesture that are already trained, but not the others. The caregiver may then reinforce this behaviour sequence as an approximation to the model. Increasingly better approximations to the modeller's behaviours are then likely to appear in time as a result of shaping. As the child's trained repertoire becomes fine-grained, novel combinations emerge more quickly. Skinner's account does not, however, predict that a child would learn to imitate entirely novel models through this training.

Conditioned Reinforcement Account of Imitation

The conditioned reinforcement account proposes that intermittent reinforcement contingencies in operation for the matching of trained behaviours enable the matching of novel behaviours to emerge (Baer & Deguchi, 1985). According to this view, generalised imitation occurs once non-reinforced imitative responses come under the control of the reinforcement history for matching, and both reinforced and non-reinforced behaviours become one functional response class. Baer and Deguchi (1985) suggested that once the resemblance between the model and the response can be discriminated by the child, the perceived parity (similarity between the two behaviours) becomes reinforcing in its own right (see also Palmer, 1996). This is because parity is repeatedly paired with reinforcement provided by the caregivers for the child's trained matching responses. After parity becomes a conditioned reinforcer, those of the child's responses that are more similar to the behaviour modelled have stronger conditioned reinforcing properties, compared with less approximate matching responses. Thus, over successive response opportunities, a progressive and systematic convergence between the novel model and the evoked matching response topographies is expected.

This account predicts that, as long as some of the child's matching responses receive reinforcement, others may develop and be maintained without direct training or reinforcement. Thus generalised imitation is established as a higher order class of behaviour (Catania, 1998; Poulson, Kymissis, Reeve, Andreatos, & Reeve, 1991). At this point, through higher order contingencies, it becomes possible for the child to learn many new behaviours just by seeing them modelled. When exactly this transition (the establishment of higher order matching) occurs and what determines its emergence has been very much debated and investigated. A critical overview of the behaviour analytic literature on generalised imitation is presented in the next chapter.

While Skinner's account predicts that children's matching responses may become fine-grained over time, and that their combinations may come to resemble novel models, this account does not predict that children would become able to imitate novel models entirely accurately – unless additional shaping is provided by the caregivers. By contrast, the conditioned reinforcement account predicts that children's responses ought to become more accurate over time and repeated response opportunities through automatic reinforcement of increasing similarity (parity) achieved by different response configurations, which vary naturally from trial to trial. In tests of generalized imitation, the experimenters need to decide (on both theoretical and pragmatic grounds) how accurate children's responses need to be to be judged as correct. Theoretically, the acceptance of poor approximations presents a risk of false positives (i.e., trained matching responses to models that resemble target actions could be emitted in an experiment because of generalisation of trained matching to a new context; such responses could be misrecorded as instances of untrained imitation), whereas very stringent criteria may lead to underestimates of children's imitative ability. At the pragmatic level, it is important to establish coding criteria that provide a clear distinction between one matching relation and another, while at the same time allowing for some response variation. In all cases, tests for generalised imitation ought to include multiple response opportunities, to allow gradual development of more accurate responses; this would be expected to take many trials, especially with very young children.

2.7 Summary and Conclusions

This chapter presented an overview of the most influential theories of imitation, and of the experimental findings used to generate and support these theories. Whereas AIM theorists argue that human infants are born with an innate cross-modal matching mechanism that allows them to imitate from birth, the proponents of other accounts consider imitation to be a gradually developing ability. However, they disagree about its origins and developmental sequence, and about the mechanisms that underpin imitation in children and adults.

At present, the evidence points to the conclusion that imitation is not present at birth, but that matching of oral movements observed in neonates is probably a reflex proto-exploration response to interesting stimuli that diminishes as voluntary control of behaviour develops in the first six months of life (similar to Piaget's proposition). During infancy and toddlerhood, children's performances in imitation tests improve, but even older children (and adults) often produce consistent patterns of matching errors. GOADI theory explains these errors in terms of specific cognitive processes involved in imitation, which are said to involve decomposition of the observed action and construction of a response, a sequence that is limited by the imitator's ability to process multiple goals. The current evidence indicates that this account is incorrect – it is children's pre-existing matching experience that determines which actions and their features are produced in response to modelling.

ASL model and MNS accounts accept that experiences change the way in which children respond to seeing others' actions. They propose that imitation is mediated via associations made during imitogenic social experiences. These accounts do not propose that entirely new responses can easily be learned through imitation. Finally, behaviour analytic theorists agree that imitation is determined by children's learning histories, but they distinguish between two different kinds of repertoires: operantly trained matching responses, and generalised imitation. The studies of generalised imitation with infants, pre-school and older children are discussed in the next chapter.

CHAPTER THREE: Methodological Issues in Tests of Imitation

As noted in Chapter 1, many comparative researchers have long been arguing that not all matching responses should be considered imitative; they have created varied lists of non-imitative matching processes and argued that adequate controls ought to be employed in tests of imitation (e.g., Galef, 1988; Rigamonti, Custance, Prato-Previde, & Spezio, 2005; Tennie, Call, & Tomasello, 2006; Whiten, Custance, Gomez, Teixidor, & Bard, 1996; Whiten & Ham, 1992; Zentall, 1988, 1996, 2006). More recently, developmental psychologists (Bekkering et al., 2000; Gleissner et al., 2000; Want & Harris, 2002) and behaviour analysts (Erjavec & Horne, 2008; Erjavec, Lovett, & Horne, 2009; Horne & Erjavec, 2007) have started to employ better controls in their tests of imitation and generalised imitation in children.

An extensive review of non-imitative matching mechanisms is beyond the scope of the present thesis (such a review had been presented by Erjavec, 2002; see also Galef, 1988; Zentall 1996, 2006). However, several of these social learning mechanisms bear directly on the evaluation of findings from the existing developmental and behaviour analytic literature, and on the designs employed in the experimental work reported in this thesis. These are described next.

3.1 Non-Imitative Social Learning Mechanisms

Social Stimulus (Local) Enhancement and Demonstration of Object Affordances

Stimulus enhancement refers to a learning process in which the observer's attention is drawn to an object or event in the environment by the model's action (Custance, Whiten

& Freedman, 1999; Visalberghi & Fragaszy, 1990). In an imitation context, this is the mechanism by which the modeller's action draws the observer's attention to a certain stimulus or part of a stimulus (Zentall, 1996). Stimulus enhancement had been studied in its own right across different species, and found to be a potent mechanism for directing attention in most such studies (Fiorito & Scotto, 1992; Fragasky & Visalberghi, 1996; Galef, 1996; Huffman, 1996; Epstein, 1984; Tuci, Noble, & Todd, 1999; Visalberghi, 1997).

Social stimulus enhancement could result in false positives in tests of imitation that use object-directed actions. In a typical imitation test employed in developmental research, the performance of a group of children exposed to modelling of target actions is compared to that of a control group in which the children do not observe any actions. If the children who saw modelling proceeded to emit target actions more frequently than children in the control group, the researchers would conclude that imitation was demonstrated (Barr et al., 1996; Barr et al., 2001; Bauer et al., 2000; Gross, Hayne, Herbert, & Sowersby, 2002; Herbert et al., 2006; McDonough & Mandler, 1998; Meltzoff, 1988, 1995). This paradigm does not control for the effect of local stimulus enhancement: children who have their attention directed to action-relevant object features by modelling may show more interest and exploratory behaviour directed at those features, and are therefore more likely to produce the target actions under these alternative sources of control.

Affordance demonstrations are another possible confound operating in such imitation tests. Modelling of actions that are directed at objects typically presents the observers with demonstrations of the objects' affordances – the way in which the objects and their parts move, and often produce interesting environmental consequences. For example, in developmental research, most modelling is performed on toys that produce sounds or light or interesting changes of shape (e.g., Meltzoff, 1995). Children who see these transformations not only have their attention drawn to the action-relevant object features, which may trigger exploration, but also observe the resulting environmental consequences, which may be discriminative for well-practiced actions (such as pushing buttons, twisting dials, pulling).

A recent well-controlled study has demonstrated that stimulus enhancement and a demonstration of object affordances were sufficient to evoke the target behaviour on action-on-object trials in the absence of modelling (Horne, Erjavec, & Lovett, 2009). Fifty-two 6-month-old infants were shown a puppet wearing a removable mitten. Some infants were presented with a demonstration of the removal of the puppet's mitten modelled by the experimenter (modelling condition); others saw the puppet's mitten falling off by itself (affordance demonstration condition); another group saw the experimenter pointing to the mitten (stimulus enhancement condition); and the final group of infants was presented with the puppet with no demonstration of any action (control condition). All infants were next subjected to the same test, in which the puppet was presented to the infants and mitten removal behaviour was recorded for each group. The number of target actions recorded in the response period by the infants in the local stimulus enhancement and affordance demonstration conditions were similar to the modelling condition but significantly different to the control condition, in which infants did not see the target behaviour. These results showed that simply drawing attention to the mitten by either pointing to it or showing it fall from the puppet's arm was enough to evoke the target action of mitten removal in the babies – nothing was added by modelling the target behaviour. This demonstration of Horne and colleagues shows that imitation in infants has been over reported in many developmental studies that have used similar methodology (e.g., Barr et al., 1996; Barr et al., 2001).

One way of avoiding the confounding effects of affordance demonstrations is to employ empty-handed gestures in imitation tests. As noted earlier, a number of studies in the literature, using toddlers and preschool children, did just this (Bekkering et al., 2000; Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007; Gleissner et al., 2000; Poulson & Kymissis, 1988; Poulson, Kyparissos, Andreatos, Kymissis, & Parnes, 2002). However, stimulus enhancement may still be influential in the matching of manual gestures. For example, the model's act of touching a particular body part may draw the observer's attention to that location and, as a result, the body part touched may exert socially enhanced stimulus control over the observer's performance. This is consistent with the finding that children's matches tend to be more accurate for the body parts and table-top locations touched than for the movements used to effect these touches, reported in the GOADI studies reviewed in the last chapter. This possibility had not been discussed by the proponents of the GOADI theory.

Extra-Experimental Operant Training of Matching Responses

Another threat to the validity of many imitation tests is the possibility that some of the behaviours modelled as targets have previously been trained as matches by children's caregivers. This was referred to as matched dependent learning by Miller & Dollard (1941) and as operant training by Skinner (1953), as discussed in the last chapter, but is seldom considered by developmental researchers. It ought to be: an operantly trained matched response (e.g., a 'high five' gesture occasioned by a 'high five' model) is functionally no different from an operantly trained non-matching response (e.g., a 'low five' gesture occasioned by a 'high five' model).

Trained matching can inflate or diminish the rates of correct imitative responses in imitation tests, depending on the task. If an experiment entails modelling of a behaviour that has been established through previous learning experiences as a matching response for some of the participants, this may lead to overestimation of the children's imitative abilities. Conversely, if the modelled behaviour that has a few components, but by no means all, in common with an alternative behaviour that already features in the matching repertoire – this commonality may lead to performance of the latter via generalisation, resulting in consistent errors. Using the example of the gestures employed in the GOADI tasks, operant training of particular body part touches using an ipsilateral movement, commonly seen in young children (as demonstrated by Erjavec & Horne, 2008), may also exert an influence on children's responses to contralateral manual gestures (see Bekkering et al., 2000; Gleissner et al., 2000).

The distinction between trained matching and imitation of novel actions without training is not seen as important by some cognitive theorists, such as the proponents of ASL model (e.g., Heyes, 2005), but it is crucial for behaviour analysts, who consider the two kinds of responses to be functionally different.

3.2 A Review of the Behaviour Analytic Literature on Generalised Imitation

Catania (1998; p. 228) differentiated between *imitative responding* and *generalised imitation*. Imitative responding refers to the replication of a seen action as a result of that individual having been directly trained to match it, whereas generalised imitation refers to the production of matching responses to models of novel behaviours on non-reinforced trials that are interspersed with reinforced matching trials of other behaviours. This generalised responding is said to be an advantageous skill that enables learning of new behaviours with no need for direct behavioural training (higher order class of behaviour; see Chapter 2).

Early Evidence for Generalised Imitation

The authors of many early studies claimed that it is possible, by reinforcing at least some imitative responses, to maintain other imitative responses that have never been trained or reinforced (Baer & Sherman, 1964; Brigham & Sherman, 1968; Peterson, 1968). Further, if reinforcers were no longer provided for any trained behaviours, matching of the targets would also decrease (Baer et al., 1967; Baer & Sherman, 1964; Brigham & Sherman, 1968; Waxler & Yarrow, 1970), and then could be re-established when reinforcement of some responses was reinstated (e.g., Baer & Sherman, 1964; Brigham and Sherman, 1968; Lovaas, Berberich, Perloff, & Shaeffer, 1966; Steinman, 1970a). This provided evidence that children's matching repertoires formed an over-reaching response class. Baer et al. (1967) reported that participants with developmental disabilities who were initially non-imitative became able to imitate 'novel' unreinforced probes (such as, open mouth, nod no, put towel over face, scribble, move toy car on table, fly airplane, open and close a book) after they were presented with shaping and intensive training of a variety of matching responses. These findings were in line with the predictions of the conditioned reinforcement hypothesis, reviewed in Chapter 2.

Most behaviour analytic studies have involved single-case designs with sequential presentation of different action models to children. In the case of the trained matching set, each correct matching response was reinforced until a stable high rate of imitative responding was established; those actions acted as baseline behaviours. Then, a few target behaviour models were randomly interspersed with those presented during matching training; however, matching responses to the probes (target behaviours) were never reinforced. Generalised imitation was inferred if the children imitated the non-reinforced responses – this was considered to provide evidence that behavioural similarity has acquired reinforcing functions. This behaviour analytic paradigm has been extensively employed with children both from clinical (e.g., Baer et al., 1967; Garcia, Baer, & Firestone, 1971; Metz, 1965; Peterson, 1968) and typically developing populations (e.g., Baer & Sherman, 1964; Baer & Deguchi, 1985; Erjavec et al., 2009; Horne & Erjavec, 2007; Kymissis & Poulson, 1994; Poulson & Kymmissis, 1988; Poulson et al., 1991; Poulson et al., 2002; Steinman, 1970b; Waxler & Yarrow, 1970).

The most significant findings came from the work of Poulson and her colleagues, who reported that 9 to 13 month old infants are capable of generalised imitation of vocal responses (Poulson et al., 1991). More recently, Poulson et al. (2002) reported similar findings with typically developing infants aged between 12 and 14 months. In both studies, mothers were instructed to administer modelling and social reinforcement. In the latter study, the authors reported generalised imitation across three different target responses classes (vocal behaviour, empty-handed manual behaviour, and toy directed behaviour). They claimed that matching of target models in each response class did not increase until that response class had been targeted with the reinforcement, showing that imitation sub-classes are topographically bounded (also see Baer et al., 1967; Garcia, Baer, & Firestone, 1971; Sherman, Clark, & Kelly, 1977; Steinman, 1970b; Young, Krantz, McClannahan, & Poulson, 1994).

However, these studies have not employed adequate experimental controls for non-imitative matching mechanisms. First, the experimenters could not be certain that matching of the target sounds and actions had not been previously trained at home: As parents were used as experimenters to demonstrate the target sounds, and testing was conducted over several months, parental training of infant's matching responses may have confounded the results. Second, some of the target responses were emitted prior to any training or testing (in baseline), indicating that they were not novel. Third, the coding criteria included acceptance of a very wide variety of "correct" responses, which increases the likelihood of false positives in the data. Finally, social facilitation and affordance demonstrations could have inflated the rates of object-directed matches.

Recent Tests for Generalised Imitation

Horne and Erjavec (2007) have described a series of control procedures that should be employed in all tests of generalised imitation. They raised the possibility that most of the target behaviours presented in previous studies of infant imitation may have been already trained as matching responses by parents during the infants' everyday lives. These authors suggested that, in order to adequately control for alternative explanations for the occurrence of matching responses, it is important to establish whether or not the matching relations under investigation have been trained before. This novelty testing should be conducted at the outset of the study. For example, one of the target behaviours employed in the study by Poulson and colleagues (2002) was clapping; but this behaviour is trained during infants' social interaction with caregivers, and is commonly present at 8 to12 months of age (Kaye & Marcus, 1981). It is, therefore, highly probable that this was a trained matching relation already present in the repertoire of the 12 to 14 months old participants in Poulson et al.'s study. Horne and Erjavec proposed that caregivers should not be employed as experimenters and should be kept blind to the modelled gestures used in the study, to avoid the possibility that target gestures could be trained at home, between sessions. They also suggested that it is important to verify that the child has the motor competence to produce each target behaviour – to avoid the opposite problem of false negatives in imitation tests. Additionally, they argued that mismatching of targets should be analysed alongside correct responses, in order to establish that the child is able to discriminate between target gestures.

Having implemented all of their own recommendations, Horne and Erjavec (2007) tested generalised imitation of empty hand-to-body gestures in infants aged between 11 and 18 months at the start of the procedure. First, all infants were trained to match a set of baseline gestures; next, target gesture trials were interspersed with trained gestures trials, with no reinforcement. The authors established in probe trials at the start of their study that the target gestures were not part of the infant's trained matching repertoires, and they ensured caregivers were blind to the experimental contingencies. Horne and Erjavec also demonstrated that performance of the target gestures employed was within the infants' motor ability; this was shown through evoking those same behaviours under the control of alternative stimuli, in the absence of modelling. Nevertheless, even after these behaviours were trained in a non-imitative play situation (e.g., by asking children to remove stickers from unnamed target body locations), the infants were unable to copy them in the matching task. This finding led to the conclusion that 11 to 18 month old infants are not capable of generalised imitation, and that repeated modelling exposure and extensive motor skills training are both insufficient for the emergence of generalised matching in infants. These results are in agreement with a Skinnerian trained matching account, according to which children gradually learn to imitate through social interactions and reinforcement; they are also congruent with the idea that a trained repertoire provides only a limited basis for imitation of novel models. However, these data are not consistent with the conditioned reinforcement account of Baer and Deguchi (1985): Infant's infrequent matching responses to the targets did not systematically increase over repeated response opportunities – instead, their responses reverted to incorrect and dissimilar topographies, even on trials administered after they had produced some matching responses to target models.

Next, Erjavec and colleagues (2009) conducted a study designed to examine how much matching training infants need before generalised imitation of novel target gestures is acquired. Eleven infants, between 13 and 24 months old at the start, participated in a multiple baseline procedure. Each child was firstly trained to match eight (and not four as in the previously reported study) baseline gestures. Next, four novel target gestures were identified by presenting target gestures interspersed with models of the baseline gestures. Each target response was also evoked under alternative stimulus control (skills training phase), to examine whether failure to match was due to lack of relevant motor skills; generalised imitation tests were conducted after each target gesture was evoked in the skills training condition. If generalised imitation did not occur, the infants were next trained to match the target gestures, one at a time, with generalised imitation tests conducted after each target matching relation was trained; this was to determine whether training matching for one or more of the target behaviours would generate untrained matching of the remainder. Finally, mixed training trials for the four target gestures, followed by matching tests, were conducted. The findings were consistent with the previous results by Horne and Erjavec (2007); they showed that motor skills' training is not sufficient to establish novel matching. Also, even after training a larger number of matching relations, increased matching of interspersed novel gestures did not occur. This study showed no evidence that generalised imitation emerges before 2 years of age. For most of the target behaviours, matching had to be directly trained. Interestingly, mixed matching training established better discriminative control of each target response, compared to staggered matching training of each individual target. This finding suggests that children need to accurately and reliably discriminate which response should be produced in the context of which model, in order to perform well in generalized imitation test conditions; and also that successive training of individual behaviours was not sufficient to achieve the necessary discrimination between the target models.

Is Matching Verbally Controlled?

It is currently widely accepted that imitation (gestural and vocal) is fundamental to the acquisition of language skills (Arbib, 2002; Armstrong, Stokoe, & Wilcox, 1995; Bonvillian, Garber, & Dell, 1997; Corballis, 2002; Eikeseith, & Nesset, 2003; Gentilucci & Corballis, 2006; Goodwyn et al., 2000); however, how language development may affect children's matching performances has seldom been discussed (Miller & Dollard, 1941).

Some behaviour analysts have argued that generalised imitation is a function of social and instructional variables that operate as setting events in the imitation procedures, and influence the child's performance (e.g., Kantor, 1958; Peterson & Whitehurst, 1971; Steinman, 1970b, 1977). The presence of the experimenter, inclusion of choices, participants' reinforcement histories, and verbal variables, are some of the likely multiple sources of operant control studied in the early behaviour analytic research. For example, Peterson, Mervin, Moyer, and Whitehurst (1971) reported that various sources of control, including contingent differential reinforcement, a range of social setting events derived from the child's history of adult instructions, and the consequences for compliance or non-compliance, may be in simultaneous operation in the development of an imitative repertoire. These authors suggested that generalised imitation might occur because pairing the model with the delivery of reinforcers on reinforced trials is sufficient to develop and maintain the effectiveness of the task instruction to perform non-reinforced novel actions. There is also evidence that 3- to 9-year-old children failed to match unreinforced behaviours when they understood that it was acceptable to not match the models (Peterson

& Whitehurst, 1971; Sherman et al., 1977; Steinman, 1970a; Waxler & Yarrow, 1970). However, research conducted so far on the influential role of 'setting events' cannot shed light on the development of matching performances, because the participants enrolled in these studies were already skilled imitators and talkers, more than able to understand and respond to instructions, and to name target-behaviours. The effects of self-instruction and other forms of verbal behaviour on matching have not yet been empirically investigated in children who are only beginning to learn these behavioural repertoires.

In the developmental literature, Bates and her colleagues (1989) have investigated whether infants' responses to verbal descriptions of gestures may influence their imitative responses. In this study, 13- to 15-month-old infants were tested on a task in which the experimenter modelled conventional actions on a block. This modelling was accompanied by different kinds of narrative. For example, on one trial the experimenter would hold the wooden block and say, "Look it's a cup" while tilting the block up to the lips (supportive narrative condition); or the experimenter would say, "Look, watch this!" while performing the drinking gesture (neutral narrative condition); or the infant would hear the experimenter say, "Look, this is a shoe" while modelling the drinking action (contradictory narrative condition). Children's word comprehension and their production of gestures appeared to be highly correlated. The author concluded that being verbal, and responsive to instructions provided by the modeller, had an impact on the infant's imitative behaviour.

3.3 Summary and Conclusions

Some recent advances in the study of imitation have been methodological: It is becoming clear that experimenters need to employ careful control procedures during imitation tests in order to safeguard against non-imitative matching mechanisms giving rise to false-positives and over-estimates of imitation. Experimenters are advised to avoid using target actions directed at objects, to safeguard against the effects of children's previous or on-line learning of object affordances. Social stimulus enhancement and parental involvement in training of target behaviours need to be taken into account. Experimenters also need to be familiar with their participants' learning history in order to be able to interpret the results of imitation tests.

Although the early behaviour analytic research reported generalised imitation in infants and young children, more recent data, obtained with tighter controls for non-imitative matching, show no evidence that generalised imitation emerges in the first two years of life. At present, it is not known whether generalised imitation can be demonstrated in older children, or under what conditions.

From a behaviour analytic perspective, generalised imitation differs from observational learning. When caregivers play 'Simon says' type games with their children, matching of modelled behaviours is trained. Social games such as 'peek-a-boo', or 'Heads and Shoulders, Knees and Toes' are other examples of the context in which this kind of learning takes place. In these examples, matching is trained with the help of verbal instructions – naming of gestures that are modelled and matched. This points to the possibility that some of children's early matching responses could be evoked through naming, as soon as their verbal repertoires are developed enough.

Thus far, developmental psychologists and behaviour analysts have not systematically explored the relationship between children's verbal and their generalised imitative ability. Therefore, this important question has been adopted as the central focus of the experimental work reported in the present thesis. Having reviewed the relevant literature on imitation, the last theoretical chapter presents an overview of behaviour analytic accounts of children's language development.

CHAPTER FOUR: Children's Verbal Behaviour and Body Knowledge. Research Questions.

The importance of verbal behaviour have been extensively emphasised in the field of learning and education (Greer & Ross, 2004; Sundberg & Michael, 2001), and the experimental analysis of verbal behaviour has contributed greatly to the teaching of behavioural repertoires through the training of verbal component skills, in both typically developing and developmentally delayed populations (Greer & Keohane, 2005). The key behaviour analytic accounts of language are presented next.

4.1 Behaviour Analysis of Language Development

Just as Skinner's trained matching account of imitation underpins the theoretical and empirical approach in the studies described in the present thesis, the Horne and Lowe (1996; 1997) account of the name relation, which is one potential source of control over imitative performances, is based on Skinner's (1957) operant account of verbal behaviour. However, the naming account introduces a fundamental modification to Skinner's analysis in order to explain the emergent and symbolic properties of language and how verbal behaviour can come to direct other behaviour, including cognition. As described in the course of this chapter, the naming account is but one of several contemporary behavioural theories of emergent (untrained) behaviour, all of which aim to extend and address perceived shortcomings in Skinner's theoretical account of verbal behaviour. It will be useful, therefore, to first describe some of the basic operant principles in Skinner's verbal taxonomy before considering these more recent behavioural accounts of language learning.

Skinner's Account of Verbal Behaviour

Skinner's theoretical account of verbal behaviour (1957) defined the dialogue between the listener (who responds to verbal behaviour) and the speaker (who engages in verbal behaviour) in terms of a number of contingencies delivered by the listener. According to Skinner, the broader verbal community trains the listener to respond in ways that have been conditioned to reinforce the speaker's behaviour. Listener behaviour was not itself considered verbal in Skinner's account; however, he acknowledged that the listener modality reinforces, and therefore, directly maintains speaker behaviour (Skinner, 1957, p. 225). In his scientific and functional approach to verbal behaviour, Skinner's focus of study was the *verbal operants* – units of verbal behaviours that have an effect on listeners in the environment – and the variables of which they are a function (as opposed to the structural properties of this behaviour). A verbal operant can be a verbal unit of any size, shape, or form that acquires certain functions in the environment, and comes under a certain functional control when it is produced. The verbal repertoire is an accumulation of verbal operants that constitute the behaviour of the speaker; every speaker is equipped with a verbal repertoire that develops continually in the interaction between the speaking organism and the verbal community.

Skinner (1957) noted that verbal behaviour has multiple determinants; similarly, he argued that any movement that can affect another organism might be verbal. Schlinger (1995) also proposed that verbal behaviour is continuous with all other operant behaviour that operates upon the environment. Within a verbal functional analysis, the dependent variable is the strength or probability of emission of a given verbal operant, while the independent variable is the condition or event that is antecedent (in the present and past environment of the speaker) of the verbal behaviour. Through a process of operant conditioning, the reinforcement (either tangible or social) that follows the event maintains or increases the strength of the operant. Skinner (1957, p. 163) argued that automatic reinforcement (i.e., when a response automatically produces reinforcement) might occur when a child hears the sounds she produces (listener behaviour) or when she produces a verbal response similar to the response of her caregivers (speaker behaviour).

Verbal behaviour is not restricted to the vocal modality; the listener-speaker dialogue can be established in other sensory modalities. Skinner's account suggests that in the early stages of children's learning of verbal behaviour, listener and speaker behaviours are functionally independent. Within his three term contingency framework, Skinner (1957) defined different verbal operants in terms of their functional role in verbal behaviour: Some are under the control of motivation operations or non-verbal stimuli (the mand and the tact); others under the control of other verbal stimuli (the echoic, the intraverbal, and textual behaviour); or even under the control of multiple causation (autoclitic behaviour; see also Catania, 1988). The operants that are directly relevant to the work presented in this thesis are further explained next, in context of early language learning.

The Echoic

Echoic behaviour is a verbal response that produces a sound similar to a prior audible stimulus (e.g., after hearing /bread/ the speaker says "bread"). Echoic responding is often taught and prompted by caregivers as they attempt to teach a child to produce other kinds of verbal operants such as the *Tact* and the *Mand* (see below). Through the establishment of this echoic repertoire, the child becomes a speaker, and her verbal responses are gradually shaped and reinforced by her caregivers. Once an echoic repertoire is established, through generalised reinforcement, modelling of responses prompting the child to echo can easily be used to evoke new verbal operants of any type (e.g., mands, tacts, etc.); gradually, automatic reinforcement is obtained when the child hears the sound she or he produces, and she may repeat it (self-echoing). Locke (1993, p.167) noted that, from very early on, caregivers tend to respond contingently to their babies vocalizations, reproducing the child's utterance. This causes the infant to repeat this behaviour and increases her receptiveness to her own speech and that of others; self-echoing is likely to develop from this early contingent responding to the child's own utterance. Horne and Lowe (1996) have argued that this behaviour may provide the earliest basis for self-instruction, as is explained later in the chapter.

The Tact

The Tact is a verbal response controlled by the non-verbal environment, evoked by an event or object and socially reinforced. For example, a child may see a loaf of bread and say "bread" whereupon a member of the verbal community is likely to deliver generalised reinforcement (e.g., saying "Yes, well done!"); thereafter the presence of bread increases the probability of emission of the tact "bread". Caregivers shape appropriate verbal responses from a very early age, by capitalising on the child's echoic repertoire (e.g., a child may have first learned to say "bread" (or some acceptable approximation) as an echoic response to someone else saying the word "bread", but can then be prompted to do so when bread is actually present. In this case, the child is now told, "This is bread. Can you say bread?" and when she produces the response "bread" a generalised reinforcer (e.g., "Good girl!") is delivered. After several such interludes, control of the verbal response "bread" will have extended to the relevant object in the environment and a new tact relation will have been established in the child's verbal repertoire.

The Mand

The Mand is a verbal operant in which the response is reinforced by the consequence it specifies, and therefore it benefits the speaker directly by giving access to specific desired reinforcers. The mand response is functionally controlled by conditions of deprivation, satiation, or aversive stimulation (these are referred to as 'establishing or motivational operations', see, Laraway, Snycerski, Michael, & Poling, 2003; Sundberg & Michael, 2001). Mands may be of different types (e.g., commands, requests, advice, warnings) and are established when a child emits a particular verbal response (e.g., "I want some bread") as a function of motivating operations (e.g., hunger), and the verbal response is followed by specific reinforcement (e.g., getting bread), reducing the motivation (e.g., being hungry).

Skinner (1957) argued that verbal operants are functionally independent, which means that when a child learns to *mand* an object, she or he does not necessarily know how to *tact* the object. However, he noted that when a child knows how to tact an object, the corresponding mand often emerges in the child's repertoire without direct training.

A response only functions as a mand if the listener provides the reinforcement specified by the speaker (see Richelle, 1976). Skinner cautioned that it might be difficult to determine the function of a verbal response, when a mixture of controlling relations is simultaneously present; thus, he defined the *impure tact* as a situation when, for example, someone opens a cupboard and says, "There are no more biscuits"; this may be a tact if it refers to the situation in the cupboard, or a mand if someone buys more biscuits in response to this comment. Similarly, he described the *impure mand* to refer to a situation when someone asks another person, "Would you like butter or jam on your scones?" and the other person replies "jam". If the jam is made available in response to this behaviour, the verbal response "jam" served as a mand; if the jam was already present when the verbal response "jam" was emitted, then it likely involved tact operant relations. Similarly, Sundberg and Michael (2001) distinguish between 'pure mand' (when a requested item is absent) from a functional relation that is 'part tact and part mand'.

Criticisms of Skinner's Account

Several authors have noted the positive aspects of this account (see, for example, Dulany, 1959; Morris, 1958; Osgood, 1958; and more recently Knapp, 1992). However, Skinner's account of verbal behaviour has received a number of criticisms. For example, Chomsky (1959, 1965) argued that children learn their own language effortlessly in a language environment that is often chaotic (also see Dale, 2004), and they do so without systematic instruction from their caregivers. He also claimed that Skinner's account does not explain how it is that children can so readily produce novel utterances. Instead, given these perceived shortcomings, Chomsky suggested that an innate language acquisition device might be necessary to explain language development.

First, it can be argued that Chomsky greatly underestimated the amount of verbal feedback young children actually do receive from their caregivers during language acquisition. For example, the psycholinguist Ernst Moerk (1990, 2000), in a recent comprehensive Markov chain analysis of Roger Brown's language corpus collected for the 18-month-old "Eve" has shown that, contrary to Brown's (1973) earlier assertions, caregivers not only respond contingently to their infants' earliest utterances, providing verbal feedback and praise, but they do so reliably. For example, Moerk identified around 25 such instances per hour (approximately one every 2 minutes) of maternal use of verbal reinforcers as positive feedback for the child's utterances (Moerk, 1990, p. 299). He also identified a large number of language development studies, spanning the past 30 years, which report parental use of corrective feedback and its effectiveness (Moerk, 2000, pp.117-119). The implications of Skinner's concept of automatic reinforcement are also not understood. Together with recent findings from mainstream developmental research (e.g., Horst & Samuelson, 2008; Kuhl, 2007) that associative word learning mechanisms on their own may be weak and transient, this suggests that Chomsky greatly underestimated the role of social interaction and verbal feedback in early language acquisition. Second, Chomsky also appeared not to have understood Skinner's concepts of (i) multiple causation and (ii) autoclitic behaviour that can, in principle, explain how even young children may generate novel utterances. However, over the past several decades, behaviour analysts have themselves argued that Skinner may have underestimated the potential sources of generativity that can be derived from basic learning processes and have proposed that a contemporary behavioural account of language acquisition might be more persuasive if such emergent relations were to be incorporated. Three such behaviour analytic approaches were stimulus equivalence theory, relational frame theory, and the naming account. The first two of these are only briefly described next, to provide the theoretical context for the naming account, which is explained in more detail.

Stimulus Equivalence Theory

Taking up the challenge that the critics of Skinner's account have posed – to explain the apparent emergence of novel verbal behaviours – Sidman (1971) was the first to use the term 'stimulus equivalence' to define a basic behavioural attribute necessary for language learning. He argued that the property of stimulus equivalence allows the symmetric counterpart of any learned relation to emerge without being directly trained (see Sidman, 1992, and 1994, for an introduction to this account). He further proposed that this property underpins the formation of category relations among arbitrary stimuli without direct training. According to this account, verbal behaviour is not necessary for emergent (untrained) categorising, or for novel behaviour transfer within categories of stimuli.

This theory developed from the findings of matching-to-sample studies, in which a participant is required to match a sample stimulus to a particular comparison stimulus. For example, participants are presented with a stimulus A1, and trained to select stimulus B1 and not B2 in the first combination of comparison stimuli, then when A2 is the sample, to select B2 and not B1; likewise, when A1 is sample, the correct comparison in a second set of comparisons is the stimulus C1, but when A2 is sample, selection of C2 is correct. After baseline training of stimuli sets (denoted as AB and AC training), the participants are tested for the emergence of reversals of the trained relations – for example, will they select A1 rather than A2 when presented with either B1 or C1 as samples (BA and CA test)? Next, they are tested for the emergence of transitive relations – will they select C1 rather than C2 when presented with B1 (BC test)? Over many studies, human participants have often, but not always, responded correctly in the latter tests, even though they have not been directly trained to do so. Three emergent relations (that develop without direct training) were identified in these matching-to-sample studies: *reflexivity, symmetry* and *transitivity*. Reflexivity (or identity matching) is observed when participants match a stimulus to an identical stimulus in the absence of direct training ('if A then A'). Symmetry is observed when people select comparison A when presented with sample stimulus B ('if B then A'), after being trained to select B when presented with sample stimulus A ('if A then B'). Transitivity is observed when participants presented with A select C ('if A then C') after being trained on the two conditional relations 'if A then B' and 'if B then C'. As a result of the combination of these three emergent relations, the stimuli A, B, and C are said to form an equivalence class, a combination of equivalence relations, for which the distinction between stimuli and responses is removed (Sidman, 1994, 2000). According to the proponents of the stimulus equivalence account, this demonstrates the bi-directionality that is at the core of symbolic behaviour.

Although stimulus equivalence research provides a theoretical explanation for untrained relations observed in the performances of verbal humans in match to sample procedures, it does not explain these emergent relations in terms of basic learning principles. Indeed, Sidman (1990, 1992, 2000) argues that equivalence, just like reinforcement, is a primitive and biologically 'given' stimulus function; therefore, it cannot be explained or derived from other behavioural processes.

Relational Frame Theory

Based on stimulus equivalence research, Hayes and Hayes (1989, 1992), later supported by Barnes-Holmes and colleagues (e.g., Barnes-Holmes, Barnes-Holmes, Smeets, Cullinan, & Leader, 2004), developed relational frame theory (RFT). Like stimulus equivalence theory, RFT seeks to explain the apparent emergence of untrained relations.

RFT states that novel behaviour emerges through arbitrarily applicable relational responding that is established when a certain number of exemplars of a particular relation have been trained. They introduced the term *relational frame* to refer to a class of behaviours that, under the control of stimulus equivalence and other verbal activities (such as naming, rule-following, metaphor and other learned arbitrary relational responding), affects relational responding to a group of stimuli (Barnes-Holmes et al., 2004; Hayes, Barnes-Holmes, & Roche, 2001; Hayes & Berens, 2004) or, through association, impacts on other classes of stimuli (Palmer, 2004). This account views relational responding as being arbitrary, derived from experience, dependent on the individual's learning history, and controlled by context (Hayes, 1994; Hayes et al., 2001). Hence, according to this view, responding to stimuli is determined by other stimuli and contextual cues, and in the process of relational framing, people actively frame events according to their learning history and the context cues present in the environment (Blackledge, 2003). The context based responding that results from the relational frame is viewed as generalised operant conditioning, derived from multiple exemplar training. This is a process in which learning history leads to the formation of a relational operant that is under the control of a particular context.

RFT states that relations among relations are necessary to learn language. This theory predicts that once infants learn a number of listener and speaker relations, when a new speaker relation is trained, the corresponding listener relation emerges; in the same way, a new speaker relation is expected to emerge if the corresponding listener relation is trained (Hayes, 1996). According to Hayes (1994), this phenomenon is possible due to three properties that every relational frame comprises: *mutual entailment, combinatorial entailment*, and *transformation of stimulus function.* Mutual entailment refers to the reciprocal relation between two stimuli (A and B); this property allows the inference that if A is the same as B, then B is the same as A (equivalent to symmetry as defined earlier); similarly, if A is higher than B, then B is lower than A. Combinatorial entailment refers to a particular relation between stimuli A-B and B-C that allows inference of a relation between stimuli A-C. Transformation of stimulus function refers to a particular relation between stimuli A and B that allows functions of one of these stimuli to transfer, via the relational frame, to other stimuli involved in the same relational frame (Barnes-Holmes et al., 2004). For example, the functions of A can transfer to B, or to C, by specifying a relation of "sameness" in a frame. Hayes et al. (2001, pp. 43-44) defined verbal behaviour as *"the action of framing events relationally"*; they argued that the effects of verbal stimuli on other behaviour are due to its participation in relational frames.

Hayes and Barnes-Holmes (2004) suggested that a relational frame is an operant response class that results from contingent reinforcement (as described by Catania, 1998), and that relevant relational properties are established through a history of reinforcement, as a result of *multiple exemplar training*. The authors propose that stimulus equivalence is the result of the application of one particular type of relational frame where stimuli are related on the basis of sameness; thus, relational framing was taken as a core-defining element in both stimulus equivalence and naming (see also Hayes, 1994). However, RFT has failed in fully describing the learning process through which stimulus equivalence and relational frames are established (see Horne & Lowe, 1996; Palmer, 2004).

The relational frame perspective (e.g., Hayes et al., 2001; Hayes & Barnes-Holmes, 2004) does not consider naming to be necessary for stimulus equivalence. Consistent with Sidman's view (1992; 1994), RFT also does not see the need for names and verbal rules to be involved in the establishment of equivalence relations, but the role of naming in facilitating stimulus equivalence is acknowledged, since names can function as contextual cues for relational responding.

Naming Account

Horne and Lowe (1996, 1997; and Lowe & Horne, 1996) have argued that verbal behaviour is best explained *without* reference to stimulus equivalence or relational framing. They have defined naming as a bi-directional, intra-individual, speaker-listener relation. Although the speaker and listener components are first established, in accordance with Skinner's account, as separate behavioural repertoires, Horne and Lowe have argued that thereafter they become functionally interrelated, at which point they can give rise to novel, untrained verbal and non-verbal responses such as emergent category relations among arbitrary stimuli. Naming involves the establishment of bi-directional relations between a class of objects and events and the speaker-listener behaviour they evoke (Horne & Lowe, 1996; Lowe & Horne, 1996). Established as a higher order class, the name relation is a basic behavioural unit, underlying the development of untrained or new behaviour.

Emergence of Naming in Typically Developing Young Children

According to Horne and Lowe (1996), naming develops from a pre-linguistic behavioural repertoire. For example, the acquisition of skills such as discrimination of speech sounds and especially sounds of words in the native language is seen as crucial to the development of naming in young children. The verbal community shapes children's behaviour and, in this way, guides and facilitates the learning of essential discriminations (e.g., Snow, 1977; Snow & Ferguson, 1977; and Fernald, 1992) that will later lead to the development of listener behaviour, a pre-requisite of naming. For example, modelling sounds, repeating words, or speaking slowly, are common ways whereby the verbal community puts in place the component discrimination skills underlying listener behaviour.

Listener behaviour emerges when, in the presence of an object, the child repeatedly hears the name of that object, and that particular vocal stimulus becomes a discriminative stimulus for the child to attend to, or engage with, that object. The verbal community teaches early listener relations to the child through the use of social reinforcement. For example, caregivers often point or look at objects they name, while the child follows their point or gaze (e.g., Morales, Mundy, & Rojas, 1998); caregivers also often name objects that the children are already engaged with, looking at, or reaching for. Gradually through this process, the child learns that a conventional vocal behaviour is discriminative for the behaviour of looking at/reaching towards a particular object. Conventional listener behaviour is modelled and reinforced until the child is able to orient to a wide range of objects and events under the control of specific vocal stimuli (e.g., *"Where's your...?"* is discriminative for the child to receptively respond to the named stimulus by pointing to, or touching, the relevant object). Progressively, the child starts to respond to vocal stimuli not only uttered by the caregiver, but also to vocal stimuli uttered by any speaker, in various contexts. This generalisation of the learned listener behaviour means that a stimulus class had been formed. The child's responding to listener stimulus classes quickly expands to include various types of vocal stimuli, requests, objects and events.

Echoic behaviour emerges at around 6 months of age, with the onset of infant babbling. Very often caregivers will prompt infants to echo, for example by saying, "Say foot, can you say foot?" Through such interactions babies gain operant control over their vocal responses to better match the verbal stimuli they are exposed to (through gradual shaping). Caregivers' reinforcement of children's imitative vocal responses allows the children to learn a variety of echoic relations; this may eventually lead to the development of a generalised echoic repertoire (see Poulson & Kymissis, 1988; Poulson et al., 1991). This enables the child to produce echoic responses to verbal stimuli even when nobody reinforces this behaviour. Some authors believe that, when generalised vocal imitation to verbal stimuli heard in the environment starts to occur, automatic reinforcement that results from achieving parity between the sounds produced by caregiver and the child's echoic response is likely to maintain this behaviour (Palmer, 1996; Skinner, 1957). From this stage onwards, it becomes possible that echoic behaviour may occur not only when induced by others (overtly), but also when induced by one-self (covertly); therefore, it may occur unnoticed by others. Horne and Lowe (1996) explained that, when the child can echo sounds produced by others then the child may also echo his or her own vocalisations, producing self-echoic behaviour. In addition, the child's own speaker behaviour (tact) may in turn evoke self-listener behaviour that includes re-orientation towards the object that initially evoked the tact response (i.e., the child hearing her or his own utterance may point at, reach for, or pick up the object). In this interactive process children become responsive to their own uttered verbal stimuli. The fact that hearing one's own utterance (i.e., overt or covert speaker behaviour) evokes listener behaviour (e.g., looking at the object), in exactly the same way that hearing the verbal stimulus from a caregiver would, gradually leads to the development of the ability to self-instruct.

Naming emerges when the child repeatedly sees an object, while hearing the associated verbal stimulus, and saying (i.e., echoing) that same verbal stimulus related to the object. A third functional relation, the *tact* (or speaker behaviour), develops in this context; a particular object or event controls, evokes, or strengthens the child's speaker response (Skinner, 1957, p. 81–82). A child has learned a new tact when she next produces a verbal response in the presence of a particular object or event, without anyone else presenting the verbal stimulus. Thus, a particular object or event serves as the discriminative stimulus for the name that the child produces. If various objects evoke the same name, the child has learned to tact a stimulus class. For example, the child has learned to tact shoe, when she says "shoe" when seeing her shoe, without anyone providing the verbal stimulus /shoe/, and when she produces this verbal response in the presence of other shoes, meaning that any shoe has become a discriminative stimulus for her saying "shoe". In this case, the child has learned to tact shoes as a stimulus class. The circular relation that integrates listener, echoic and tact behaviours constitutes the naming relation (see Figure 4.1.).

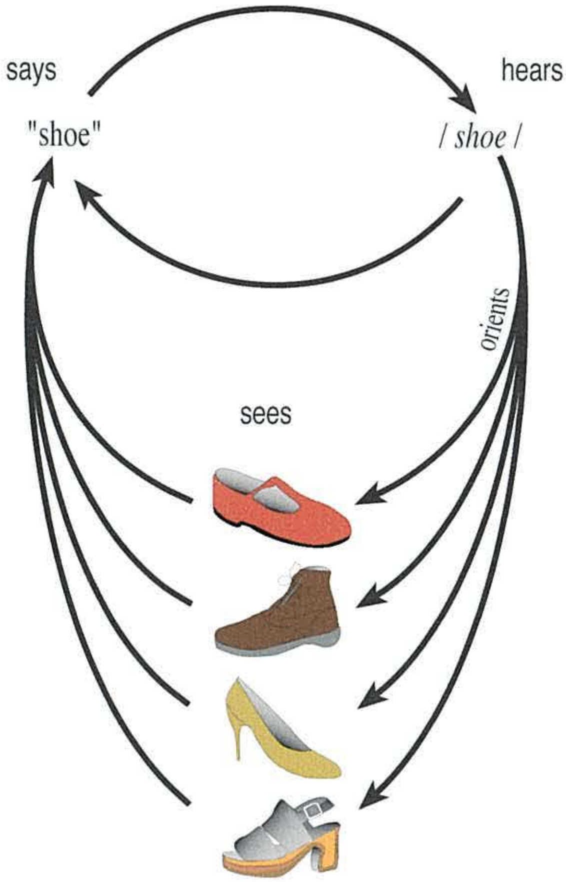

Figure 4.1. (Reproduced with the authors' permission from Horne & Lowe, 1996, p. 201). This illustrates the bidirectional relations between a class of objects and the speaker-listener behaviours they evoke. Naming can be evoked by seeing a shoe, or hearing /shoe/, and can be re-evoked by seeing a shoe again or through self-echoing. When a child sees a shoe, she says "shoe". Upon hearing this self-produced verbal stimulus /shoe/, she orients, not just to one shoe, but to any of the shoes in her environment that are part of her existing listener behaviour class. Either hearing her own verbal stimulus /shoe/, or seeing a shoe, may then again evoke her verbal response "shoe".

Naming as a Higher Order Behaviour Relation

Both listener and echoic repertoires are considered higher order classes of behaviour because, although initial instances of the class must be reinforced, new relations may emerge without explicit reinforcement (Catania, 1998). Naming established as higher order class of behaviour means that when the child is taught speaker behaviour, the corresponding listener behaviour is generally established in the same interaction. Similarly, when listener behaviour is taught, and if the child also echoes the listener stimulus, the corresponding speaker behaviour will be found to be in place too. However, if the child does not echo the listener stimulus, listener training will not give rise to the corresponding speaker behaviour and the name relation will not be established. Horne and Lowe argued that the name relation is established as a higher order behavioural relation (1996, p. 203), when the child is able to learn to name a new object in just a few trials of hearing the name, and echoing it, while looking at the corresponding object; this happens when children are about 18 months old (e.g., Nelson & Bonvillian, 1973). At this point, the child may learn new names without needing separate direct training on each component. However, reinforcement provided by caregivers will still play an important role in the development of this repertoire, despite not always being given explicitly (see Moerk, 1983, 1990, 2000).

Lowe and Horne (1996) also emphasized that, although verbal behaviour is initially overt, it becomes covert as it develops. This happens once speaker and listener functions combine within the individual, from around 18 months of age. Covert verbal behaviour (either in the form of simple names or complex rules), despite being unobservable, is also controlled by antecedents and consequences, and partly maintained by observable forms of reinforcement present in the environment.

Evidence for the Effects of Naming

It is now well established that tact training can lead to emergence of listener behaviour and naming; listener behaviour training can also establish naming, but only if accompanied by overt or covert echoing (Horne & Lowe, 1996; 1997). Further, it had been shown that naming, but not listener behaviour, gives rise to categorisation behaviours, such as transfer of functions trained to one member of the category to the others (Horne, Hughes, and Lowe, 2006; Horne, Lowe, & Harris, 2007; Horne, Lowe, & Randle, 2004; Lowe, Horne, Harris, & Randle, 2002; Lowe, Horne & Hughes, 2005). This contradicted the predictions derived from stimulus equivalence and RFT accounts, which state that naming is not necessary for the emergence of arbitrary stimulus categories. As predicted by Horne and Lowe (1996; 1997), several studies have found that the employment of naming interventions facilitates acquisition of new behaviours, such as categorisation, in typically developing children (e.g., Pilgrim, Jackson, & Galizio, 2000; Miguel, Petursdottir, Carr, & Michael, 2008). The effect of naming on conditional discriminations had also been extensively examined in matching-to-sample procedures (e.g., Stromer, Mackay, & Remington, 1996). However, a full review of research studying the relationship between naming and categorisation, in the context of arbitrary stimulus classes' formation (classes of physically different objects), is outside the scope of this thesis.

Previous developmental research has also studied the role of language in extracting relevant information of a task, its impact on the performance of higher-order cognitive abilities in children, such as analogical similarity (e.g., see Gentner & Medina, 1997; Kotovsky & Gentner, 1996), and on the enhancement of perceptual cues and attention (Smith, Colunga, & Yoshida, 2010; Waxman, 2002; Yoshida, & Smith, 2005). One early study by Smith, Jones, and Landau (1992), tested the idea that words play a role in guiding young children's on-task attention. The authors examined closely the interaction of syntactic context and perceptual salience; they sought to determine whether a shape bias is stronger for count nouns than adjectives and whether the novel word effectively directs attention to shape even in the presence of a highly salient alternative dimension. Smith and colleagues expected the noun frame to be a stronger attentional cue than the adjective frame because children know more nouns and know them earlier than they do adjectives. In the count noun condition, children were shown a novel exemplar toy and asked to judge whether test items had the same novel name as the exemplar. In the adjective condition, children were shown a novel exemplar toy and asked to judge whether a test item could be described by the same novel adjective as the exemplar. Particularly relevant to possible underlying mechanisms of cued-attention, their findings indicate that three-year-old children systematically attend to shape when interpreting novel count nouns, but their interpretation of novel adjectives is contextually determined, and may reflect the combined effects of multiple information sources (such as immediate input, task contexts and past experience), integrated into a single attentional response. More recently, Rattermann and Gentner (1998) demonstrated that children's relational performance improves when they are trained relational labels. In their study, 3- to 5-year old children were presented with a triad of objects place in front of them in size order, and asked by an experimenter who sat opposite also with a similar triad of objects ordered by size, to look for a sticker underneath the object that mapped the one in the experimenter row where she had hidden her sticker. In this cross-mapping search task, relational and object similarity were in conflict (e.g., the medium size cup of the experimenter triad was the same as the small size cup of the child's triad; the house was the biggest object in the experimenter triad, but the medium size object in the child's triad). After children were the trained the family labels Daddy/Mommy/Baby on different sets of objects, which corresponded to big, medium, and small size objects, they performed better in the original cross-mapping search task. These results show that learning of relevant names facilitated children's attention to certain aspects of the task presented to them, and generated comparisons that the children did not made prior to label training.

Verbally Controlled Behaviour

The term verbally controlled behaviour (see Horne and Lowe, 1996, p. 213; Mead, 1934, pp. 212-213) defines behaviour under the control of name relations; Skinner (1957) termed this rule-governed behaviour. The research described above shows how children's categorisation and other responses can come under the control of naming. As children become equipped with a repertoire of extensive name relations, they become able to instruct themselves about their own behaviour and its outcomes; consequently, this may transform the experimental situation itself (Horne & Lowe, 1997). Remington (1996) and Saunders and Spradlin (1996) also argued that it is possible that humans' verbal behaviour contains operating functions that may transform the environmental contingencies that are defined by the experimental situation. Although there is now a large body of evidence showing that the control of behaviour is fundamentally altered in children who have acquired naming as a higher order behaviour relation, the relationship between children's naming ability and their imitative competence had not been tested directly. The series of studies presented in this thesis has been designed to do just this.

4.2 Experimental Questions

How Verbal Behaviour and Gestural Imitation May Interact

In the cognitive developmental literature, several authors have discussed the possible link between gestures and language. For example, Gentilucci and Volta (2008) presented a review of behavioural and neurophysiological evidence that shows how gestures and words are linked in adults. This relationship has also been investigated in children: Bates et al. (1989) reported that infants' comprehension repertoires are highly correlated with their ability to reproduce modelled gestures. Recently, Ray and Heyes (2011) suggested that language might function as the link between seeing and doing an action (see also Hall, 1994; Heyes, 2005; Heyes and Ray, 2000).

In the behaviour analytic literature, Horne and Lowe have stated that the name relation is a basic component of verbal rules. In their paper about the origins of naming, they described the emergence of self-instruction:

"From listening to others to listening to oneself: Although the child can function as a speaker-listener only when her speaking is initiated by others' vocalizations, once she echoes and re-echoes those stimuli this may help, even if only briefly, to sustain her listener behaviour. This is perhaps the earliest approximation to self-instructional behaviour." (Horne & Lowe, 1996, p.199)

Let us now consider how these propositions may apply to gestural imitation. In an imitation episode, like those described in the previous chapters, the modeller may present a child with an empty-handed gesture. If the child is able to name one or more of the components of the modelled gesture, this may serve to direct and sustain her attention to those components. Depending on the extent of the child's listener and naming repertoire, she may also emit a conventional gestural listener response to her own utterance. If the child named the component(s) covertly – which is quite likely to happen because social reinforcement is seldom given for children's vocal responses in gestural imitation tests – none of the events that happen in this naming episode would have been apparent to the modeller. The researchers would assume that the modeller's behaviour evoked the child's gestural response directly (basic level of stimulus control), disregarding the mediating role that naming played in this episode (additional levels of stimulus control). Indeed, this is how imitation findings have been interpreted in the cognitive, developmental, and behaviour analytic literature. The verbal mediation that results from evoking the naming relation on task constitutes an additional level of stimulus control in the relation between seeing behaviour modelled and performing a matching response. The naming relation may serve as additional stimulus control because it may increase the probability of the matching behaviour (operant response) by evoking selective attention to discriminative stimuli of the modelled behaviour, which informs the child about the effectiveness of her matching behaviour. Therefore, in the presence of naming, the child may respond differentially to the model.

Figure 4.2. presents a hypothetical episode in which a child who has learned to name a body part "foot" responds to modelling of a hand-to-foot gesture. This example does not imply that naming may be necessary for correct matching to be achieved, but it shows that naming could result in a correct matching response to a model. Conversely, when the modelled behaviour includes various components, and the child has a limited naming repertoire, the child may not be able to name all of the modelled features.

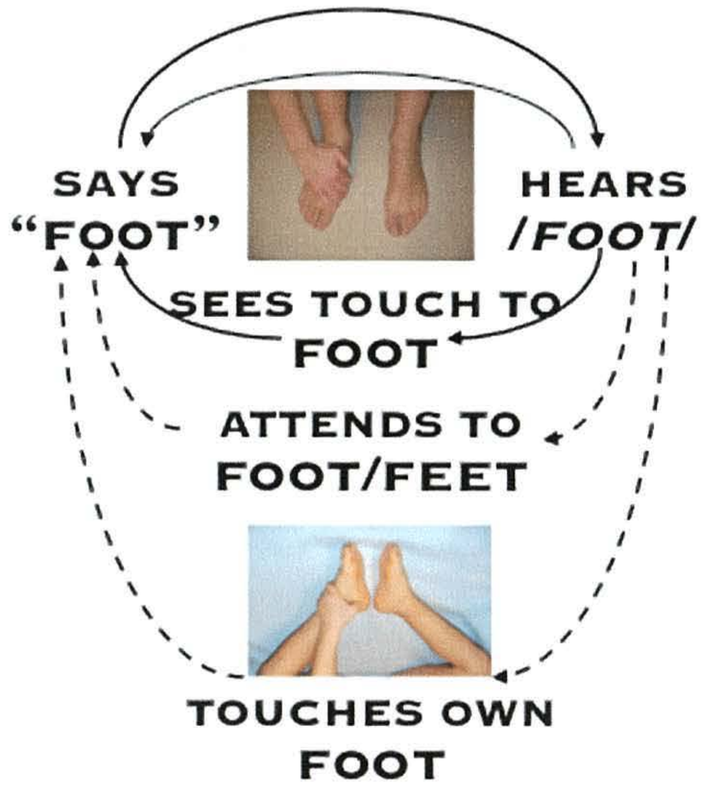

Figure 4.2. In an imitation task, seeing the experimenter touching her foot may evoke the child's naming of this body part. Thus a child may covertly say "foot"; hearing her own verbal stimulus may then direct the child's attention to her own foot, leading to the touch of this body-part (listener behaviour). This illustrates how the properties of naming may affect a child's imitative behaviour.

The present theoretical analysis is compatible with the results of gestural studies, reported in GOADI literature for preschool children (Bekkering et al., 2000; Gleissner et al, 2000; Wohlschläger et al., 2003), and in the behaviour analytic literature for infants and young children (Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007). This analysis also presents testable predictions.

As discussed in Chapter 3, infants and toddlers often respond correctly to conventional gestures that involve touching parts of body, such as 'peek-a-boo' or placing hands on head. However, in the same tests, they consistently emit incorrect responses to other untrained models of hand-to-body touches. These latter responses can be targeted by a naming intervention. If naming of body parts can lead to correct matching, as illustrated in Figure 4. 2., it follows that training the children to name the body parts may improve their matching of the gestures that terminate on these body parts.

As discussed in Chapter 2, young children's matching of gestures is typically more accurate for body parts touched than for the particular movements used to accomplish these touches. It is likely that children's naming repertoires contain body part names, and conventional responses such as touching, before the children learn to name different movements, and to respond as listeners to their own utterances by emitting these movements themselves. Nevertheless, young children could be trained to name the few simple movements employed in hand-to-body gestures that have previously been used in imitation tests. If naming is indeed one of the determinants of their matching, this training is expected to result in a reduction of their movement errors.

Research Questions

The experimental chapters reported next aim to establish whether children's naming relations, naturally taught during childhood, play a functional role in children's matching of hand-to-body gestures. Therefore, this research aims to address the following questions:

- Which body parts labels can 2- to 3-year-olds comprehend and produce?
- What are the possible determinants of children's knowledge of body part labels?
- Which features of the target behaviour do young children attend to when they see modelling of a hand-to-body gesture?
- Which modelled actions and their components can children (i) describe, and how accurately can they (ii) perform that behaviour when these are described (but not modelled) by the experimenter?
- Does young children's ability to name the arm movement involved in hand-to-body actions affect their matching accuracy of novel hand-to-body gestures?
- Does children's ability to name body parts that feature in modelling of hand-to-body actions determine whether children accurately match target body-touches?
- Is speaker (tact) training of target body parts enough to improve accuracy of performance when children are asked to imitate novel touches to those body parts?
- Does listener training increase discrimination between specific components of the body topography, and consequently enhance the accuracy of children's matching of novel body-part touches?

- Does listener training have a better impact on children's matching of body-part touches when speaker behaviour of target body part names is already established?

- Does naming of the arm movements performed in a hand-to-body gesture impact on the frequency of matching errors children produce in response to modelling of these gestures?

Methodological Notes

The present series of studies targeted children between 2 and 4 years of age, with some variation between different studies. The existing literature indicates that during this period children's imitative performances contain errors, which can be targeted by the naming interventions. The components of the naming repertoire – speaker and listener behaviour – can be trained easily to normally developing children of this age.

At the outset, a gap in the literature was identified: There are at present no data about the extent of children's naming repertoires regarding empty-handed manual gestures. Therefore, the first two studies have been designed to fill this gap. These experiments sought to establish: Which parts of the body could the children name in response to the experimenter's modelling of touches on her own body (verbal production test), and which parts could they locate on their own bodies in response to the experimenter's verbal instructions (listener behaviour test). Next, which components of empty-handed gestures could the children describe in response to the experimenter's modelling (verbal production test), and which components could they enact in response to the experimenter's verbal instructions (listener behaviour test). The results of these studies, presented in Chapter 5 and Chapter 6 respectively, informed the choice of target behaviours employed in the remaining experiments.

One of the difficulties in examining whether verbal behaviour takes place during matching tests (e.g., naming of actions) is that this may happen covertly. The series of experiments presented in this thesis sought to experimentally study the relation between covert verbal behaviour and matching in the most rigorously controlled way possible. Despite indirectly measuring a covert phenomenon, secure inferences about this empirical matter could be made through the use of behaviour analytic methodology and tight experimental controls. These studies and their rationale are presented in Chapter 7, Chapter 8, and Chapter 9.

CHAPTER FIVE: Comprehension and Production of Body-Part Labels in 2- to 3-Year-Old Children

5.1 Abstract

This study examined which body part labels children could (i) produce when the experimenter touched different locations on her own body, asking each time "What's this?" and (ii) comprehend by touching the correct locations on their own bodies in response to the experimenter asking "Where's the [body-part label]?" Seventeen children aged between 26 and 41 months, tested in a repeated measures procedure, were presented with 50 different body-part stimuli in 200 test trials per child. Overall, the children produced fewer body-part labels than they could comprehend. The accuracy of children's responses depended on (i) the location or extent of each body part (facial and broad body features were better known; joints and features in or attached to broad body parts the least well known); (ii) the amount of sensory (but not motor) representation each body part has in the human cortex; and (iii) whether a body part was commonly named by caregivers. These results present a precise mapping of the body parts that young children are able to name and locate on their own bodies in response to body-part names; they suggest several possible determinants of lexical-semantic body knowledge and add to the understanding of how it develops in childhood.

5.2 Introduction

It is widely agreed that the development of body knowledge in childhood is a key feature of the "social brain" and plays an important part in the formation of general self-awareness later in life (Barth, Povinelli, & Cant, 2006; Brownell et al., 2007; Butterworth, 1992; Meltzoff & Moore, 1995). Over the last decade, there has been a growing consensus that body-awareness is not a unitary and global dimension, but involves distinct, yet interacting, levels of representation (Goldenberg, 2003; Slaughter & Heron, 2004).

From a cognitive neuropsychological perspective there are said to be three representational levels of body perception, which develop from infancy to adulthood: (i) sensori-motor body knowledge, (ii) visuo-spatial body knowledge, and (iii) lexical-semantic body knowledge. The first level, also named "body schema", refers to the basic implicit awareness of one's body. It has been claimed that this ability emerges early in life and that the newborns' reflexive motor responses are an example of this rudimentary form of knowledge that later develops into coordinated actions (Brazelton et al., 1987; Butterworth & Hopkins, 1988). Mental representations of this knowledge are integrated at around the fifth month of life, when infants begin to demonstrate that they have some idea about how their bodies should appear (Morgan and Rochat, 1997; Schmuckler, 1996). For example, 3- to 5-month-old infants look longer at video images of their own legs in a "normal" position as compared to images of their legs in a reversed view (in which the right leg is shown on the left and the left leg is shown on the right; Morgan & Rochat, 1997). The second level, visuo-spatial body knowledge, is thought to derive from children's experience with dressing and undressing routines and extensive play involving their own body parts, or those of their dolls, which provides them with extensive visual input concerning body part locations, as well as the proximal relations and boundaries between parts of the human body (Schwoebel et al., 2004; Slaughter & Heron, 2004). Children show that they are aware of their body size and of their bodies as obstacles in space by the age of 18- to 24 months (Brownell et al., 2007). They are able to differentiate typical dolls from those with scrambled body part arrangements, whether presented with actual dolls or photographs of them (Slaughter & Heron, 2004), at the age of 15 to 18 months. The final level of lexical-semantic body knowledge represents "body semantics", which includes body part names, functions, and their associations with objects (Coslett et al., 2002).

From a developmental perspective, the second level of body knowledge is said to emerge progressively from the first, and the third from the second, through a series of increasingly complex higher-order operations that evolve from sensori-motor representations to symbolic action schemes (Müller et al., 1998; Piaget, 1953). Acquisition of the third level of knowledge is also clearly related to the development of children's verbal production and comprehension skills, which provide children with the capacity to describe and respond correctly to names of body parts. Although the importance of body-knowledge is well recognized in the literature, only a handful of studies have investigated its development in toddlers. Brownell, Nichols, Svetlova, Zerwas, and Ramani (2010) questioned whether the ability of two-year-old children to point to and/or name body parts reflected their true capacity to understand their bodies' spatial arrangement or whether their knowledge of body parts was based entirely on learned routines. They examined the relations between 20- and 30-month-old children's ability to (i) locate body parts on themselves in a nonverbal matching task, (ii) produce and comprehend body part labels, and (iii) recognise themselves in a mirror. In the body part localization task the experimenter first placed a sticker at a particular location on the body of a helper and the children were required to place a sticker at the same location on their own bodies. This nonverbal matching task showed that the older children were able to locate significantly more body parts on themselves compared to the younger children. For the body part naming and comprehension assessment, children's mothers were asked to indicate, on a checklist of 27 common body parts, which ones their children could either name, or point to in response to the name. Based on their mothers' estimates, older children knew significantly more body part names and locations than younger children. Self-awareness was measured with a mirror self-recognition task and it was found that children who recognised themselves in the mirror knew significantly more body part names (according to maternal reports) than children who showed no self-recognition. However, the performance of the self-recognisers did not differ from non-recognisers on the nonverbal body-part matching task. Finally, self-recognisers produced significantly more correct responses when asked to place the sticker on body parts for which, according to their mothers, they had not yet learned the names. This study clearly shows that some topographic representations emerge late in the second year of life. However, on the basis of the pattern of correlations described above, it is difficult to determine which, if any, of the variables reported might be responsible for this development. Moreover, before more systematic investigation can be conducted, it is important that such potential variables are specified more clearly. First, it is possible that maternal estimates of children's knowledge of body-part labels were not entirely accurate (e.g., see Bornstein, Putnick, & De Houwer, 2006; Houston-Price, Mather, & Sakkalou, 2007). Second, because production and comprehension of body part labels have not been reported separately by parents, it is impossible to determine which of these variables was more strongly associated with self-recognition in the mirror task and performance in the nonverbal body location matching task.

The few earlier studies of body part identification investigated the development of children's comprehension of body part labels but not their labelling of body parts (Bayley, 1969; MacWhinney, Cermak, & Fisher, 1987; Witt, Cermak, & Coster, 1990). Overall, these studies show that children's capacity to correctly point to named body parts increases dramatically in late infancy and toddlerhood. MacWhinney et al. (1987) examined the developmental sequence of body part identification by asking 1-, 2-, 3-, and 4-year-old children to point to 20 different named body parts on a doll. They found a developmental progression in the number of parts correctly identified, with the most marked improvement occurring between 1 and 3 years of age, a period when children experience increased motor and sensory input, improve their ability to focus attention, and in which their verbal repertoires rapidly develop (e.g., Griffiths, 1967). Witt et al. (1990) compared the method of identifying body parts on a doll (e.g., "Where's Dolly's nose?") with asking the children to point to the part of their own bodies named by the experimenter (e.g., "Where's your nose?"). They asked 11- to 25-month-old children to identify the same 20 body parts used in the MacWhinney et al. (1987) study on a doll; their older participants were also asked to identify these body parts on themselves. Witt and colleagues reported that 90% of the 2-year-old children were able to point to some of the body parts on a doll that were labelled by the experimenter, as opposed to only 30% of the 1-year-old children. Witt et al. (1990) found no significant difference between the 2-year-old children's ability to identify body parts on themselves as compared with on a doll, and no gender differences on these tasks.

To summarise. It has been shown that body-part knowledge, measured by parental reports or on experimental tasks that require children to locate the named (or indicated) body parts on their own body, or on a doll, develops over the first three years of life. This coincides with the development of representational intelligence (Piaget, 1953), and with the exponential increase in the children's ability to produce and comprehend verbal labels

(Griffiths, 1967). However, the literature on development of body knowledge has so far failed to investigate, separately and comprehensively, young children's ability to first understand and then produce body part labels. How accurately can young children respond when required to provide a lexical label for a body part pointed to by an adult, compared to when they are asked to point to a body part named by an adult? There is ample evidence that verbal comprehension skills develop ahead of verbal production skills, such as those required in a labelling task (e.g., Bates, Dale, & Thal, 1995; Benedict, 1979; Fenson, Dale, Reznick, Bates, Thal, Pethick et al., 1994; Goldin-Meadow, Seligman, & Gelman, 1976; Harris, Yeeles, Chasin, & Oakley, 1995; Horne & Lowe, 1996; Snyder, Bates, & Bretherton, 1981). Therefore it is expected that children's comprehension of body part labels would be better than their labelling, but the relationship between these two indices of lexical-semantic body knowledge remains to be investigated.

MacWhinney and colleagues (1987) reported that young children respond correctly to labels for facial body parts (e.g., eyes, nose, mouth, and ears) and to labels for discrete body parts (e.g., ears, hands, and toes) before they can respond correctly to labels for joints (e.g., wrist, ankle, and elbow). Witt et al. (1990) replicated the previous findings and reported that body parts located on the face, and fingers, hand, toes, and foot were the earliest identified. What could determine which parts of body are known first, and which are learned later? Several authors have associated the increasing ability to recognize body parts with the progressive exposure to sensory input in the developing child as she or he explores, and learns from, the environment (Ayres, 1961; Kravitz, Goldenberg, & Neyhus, 1978; Reeves, 1985; Schilder, 1964). Some body parts are associated with extensive sensory input via tactile explorations earlier in life, which may explain why they emerge early in the children's verbal (comprehension) repertoires. It is also possible that children's knowledge may develop earlier for parts of the body that are moved frequently than for body parts that are moved less often. There is a recent growing literature showing how movement facilitates infant's development of body knowledge (e.g., Booth, Pinto, & Bertenthal, 2002; Christie & Slaughter, 2010; Moore, Goodwin, George, Axelsson, & Braddick, 2007; Reid, Hoehl, Landt, & Striano, 2008). It is reasonable, therefore, to propose that sensory input and/or movement could play a role in the development of children's body knowledge.

Social experiences may account for the differences in children's body knowledge, irrespective of their age or other developmental indices. Interactions between young children and their caregivers include provision of body care, play, and social games involving touching and labelling of some body parts (e.g., the game "Heads, shoulders, knees, and toes"), but not others (e.g., thigh or armpit). It seems likely that body parts that commonly feature in social routines would be learned ahead of those that are not commonly touched or named. For example, Erjavec and Horne (2008) have reported that shaping of children's responses in social games and other interactions with caregivers correlates with the accuracy of children's body-touch responses on an imitation task. In this study, 2- to 3-year-old children performed significantly more matching responses to target models that commonly featured in nursery matching games, than to target gestures that had no such learning history, even though the two sets of target hand-to-body touches were similar in terms of complexity and production difficulty.

The present study is designed to systematically map the body parts that English-speaking children, aged from 2 to 3.5 years old, can (i) locate on their own bodies in response to the experimenter's labelling, and (ii) label in response to the experimenter asking "What's this?" as she points to locations on her own body. This study aims to contribute to the existing literature by providing an experimental comparison of children's ability to comprehend and produce different body-part labels, and by identifying some of the likely determinants of children's body knowledge. To achieve this, we employed an extensive set of 50 different body part locations and their names as stimuli, and investigated whether children's knowledge is related to (i) the location and salience of different bodily features, (ii) the extent of sensory and motor cortical representations of body parts in the human brain, and (iii) the experience of naming provided by caregivers in daily routines for some, but not other, body parts.

The procedure was administered in a naturalistic and highly engaging play setting, with the experimenter established as a familiar caregiver prior to the test sessions, to maximise the toddlers' attention and compliance with the procedure. This research complied with British Psychological Society guidelines for psychological research and was approved by the School of Psychology Ethics Committee.

5.3 Method

Participants

Seventeen children, 5 boys and 12 girls, aged between 26 months and 26 days and 41 months and 9 days at the start of the procedure (M = 35 months and 15 days), participated in this study. All children attended the Nursery and Childcare Centre at Bangor University at least two days per week and were recruited by parental consent (see Appendix A). All participants were developing normally; their Griffiths' Mental Development Scores ranged from 103 to 139 (M=113; see Griffiths, 1967; Luiz, Barnard, Knosen, Kotras, Horrocks, McAlinden et al., 2006).

Setting and Stimuli

Sessions were conducted in a specially designed quiet test room at the Nursery. During each session, the child and the experimenter sat in an inflatable boat opposite each other. A large teddy bear sat on the edge of the boat and age appropriate toys and stickers were used for playtime after testing. These items were kept in Teddy's backpack until they were presented. Two wall-mounted digital video cameras were employed to record the behaviour of the child and the experimenter. Audio and visual inputs from the two cameras and a hidden radio microphone were fed into a split-screen video recorder located in a separate audio-visual suite (see Appendix B). For all recording and coding purposes JVC SR-VS10 VHS/DV recorders, with stop- and slow-motion viewing facilities, were used.

The stimuli employed were (i) a set of body parts pointed at or touched by the experimenter on her own body when the child was asked to label them in the labelling test and (ii) a set of body part names produced by the experimenter when she asked the child to point to each labelled body part location. Table 5.1. shows all body-part names and descriptions of the corresponding movements modelled by the experimenter.

Prior to the start of the study 36 body parts that covered the body without overlap were identified. In addition to these, the experimenter employed 14 body parts that derived from children's labelling responses to the initially assigned stimulus set (see Table 5.1. and Procedure). Therefore, the final stimulus set consisted of 50 different body parts and their names.

Table 5.1.

Description of movement modelled by the experimenter for each body part in the production tests.

Body Part	Behaviour modelled by the experimenter
T1 – Crown	Hand pointing from the top of the head to the middle of the crown
T2 – Forehead	Hand pointing from the front to the middle of the forehead
T3 – Temple	Hand pointing from the side to the ipsilateral temple
T4 – Ear	Hand pointing from the side to the middle of ipsilateral ear
T5 – Cheek	Hand pointing from the side to the ipsilateral cheek
T6 – Eye	Hand pointing upwards to the contralateral eye
T7 – Teeth	Hand pointing to front teeth
T8 – Mouth	Hand pointing from the front to the centre of the mouth
T9 – Chin	Hand pointing from the front to the centre of the chin
T10 – Neck	Hand pointing from the front to Adam's apple with head slightly lifted
T11 – Chest	Hand pointing from the front in between breasts
T12 – Belly	Hand pointing from the front to belly button
T13 – Waist	Hand pointing sideways to ipsilateral side of waist
T14 – Shoulder	Hand pointing to top of contralateral shoulder
T15 – Armpit	Hand pointing sideways to contralateral armpit, with arm extended to front and side
T16 - Upper arm	Hand pointing sideways to contralateral mid-point between shoulder and crook of arm, with arm extended to front
T17 - Crook of arm	Hand pointing sideways to centre of contralateral crook of arm, with arm extended to front
T18 – Elbow	Hand pointing sideways to tip of contralateral elbow, with contralateral arm raised and bent
T19 - Lower arm	Hand pointing sideways to contralateral mid-point between crook-of-arm and wrist, with arm extended to front
T20 – Wrist	Hand pointing down to centre of contralateral wrist, with arm extended to front
T21 – Pulse	Hand pointing down to centre of contralateral inner pulse with palm turned up and arm extended to front
T22 - Back of hand	Hand pointing down to centre of contralateral back of hand, with arm extended to front
T23 – Fingers	Hand pointing down across contralateral fingers, with arm extended to front
T24 – Thumb	Hand pointing sideways to tip of contralateral "thumbs up", with arm extended to front
T25 – Palm	Hand pointing down to centre of contralateral turned up palm, with arm extended to front
T26 – Hip	Hand pointing sideways to ipsilateral hipbone
T27 – Thigh	Hand pointing sideways to mid-way between hip and knee (from ipsilateral side)
T28 – Knee	Hand pointing sideways to tip of ipsilateral knee

Table 5.1. (continued).

Body Part	Behaviour modelled by the experimenter
T29 - Back of knee	Hand pointing sideways to the back of contralateral knee
T30 – Shin	Hand pointing sideways to ipsilateral shin, mid-way between knee and ankle
T31 – Ankle	Hand pointing sideways to tip of ipsilateral ankle bone
T32 - Bridge of the foot	Hand pointing down to the top of contralateral foot arch / bridge
T33 – Sole	Hand pointing sideways to contralateral sole, with foot twisted
T34 – Heel	Hand pointing sideways to contralateral heel, with foot twisted
T35 – Toes	Hand pointing sideways in front of contralateral foot and across toes
T36 – Big toe	Hand pointing sideways to tip of contralateral big toe
T37 – Head	Hand touching the top and ipsilateral side of the head
T38 – Hair	Hand holding some hair on the ipsilateral side of the head
T39 – Eyebrow	Index finger stroking ipsilateral eyebrow from side to side
T40 – Face	Hand touching and covering front of the face
T41 – Eyelashes	Index finger stroking ipsilateral eyelashes, upwards and downwards
T42 – Lips	Index finger stroking bottom lip from side to side
T43 – Tongue	Hand pointing to tip of the tongue
T44 – Tummy	Hand rubbing tummy area in a clockwise movement
T45 – Back	Hand touching centre of the lower back with back turned to the child
T46 – Arm	Hand stroking contralateral arm, extended to front, from shoulder to wrist with a upwards and downwards movement
T47 – Hand	Hand stroking contralateral hand, extended to front, from wrist to finger tips with a upwards and downwards movement
T48 – Leg	Hand stroking contralateral leg, bent to front, from hip to shin with a upwards and downwards movement
T49 – Bottom	Hand tapping ipsilateral side of the bottom with back turned to the child
T50 – Foot	Hand stroking contralateral foot, extended to front, from ankle to toes with a upwards and downwards movement

Design and Procedure

This experiment employed a repeated-measures design. It consisted of two tests; the same set of body parts were employed in the labelling phase and in the label comprehension test (see Table 5.1.). In the labelling test the experimenter pointed to her own body parts, one at a time, and asked the child to label each of them. In the comprehension test the experimenter presented the body part names, one at a time, and asked the child to touch the named location on her or his own body. All children received the labelling test first, followed by the comprehension test. This was necessary in order to avoid false positives in the naming test. If the comprehension test had preceded the labelling test, the children would have heard all the target body part labels twice and given that their comprehension repertoires were likely to be more extensive that their corresponding labeling repertoires, the children might have engaged in verbal rehearsal of any labels that were unfamiliar as they attempted to guess (via exclusion) which of these could be related to which part of their bodies. This verbal rehearsal could in turn increase the likelihood of the children producing the new labels in a subsequent labelling task as guesses for any body parts they had not yet learned to label. Conducting the labeling test first therefore provides the purest measure of the children's existing body part label repertoires. The procedure also safeguarded against the reverse confound, because children's identification of body-parts on their own bodies would not be cued by their earlier exposure to the experimenter's pointing to body parts on herself.

Prior to this, the experimenter spent several weeks in the Nursery taking part in the daily routines to develop a rapport with each prospective participant. Thus the experimenter was established as a familiar caregiver and the children interacted freely with her. After this familiarisation period, each child was invited to the test room to play. There, the experimenter and the child discovered that a large inflatable boat was taking Teddy to school. The experimenter invited the child to sit with her in the boat (facing each other) and to "help her teach Teddy about our bodies". When the child accepted this invitation, the first test commenced.

Body-Part Labels: Production Test. First, the experimenter explained to the child that they needed to teach Teddy what the body parts are called. Prior to the presentation of the test trials an example was given to the child; the experimenter pointed to her nose saying, “What’s this?” If the child did not respond, the experimenter prompted the child by saying, “Tell Teddy: Nose”. The example was repeated and the prompt reduced until the child produced an independent verbal response. If the child produced a correct response in the example trial, the experimenter provided praise for that response. The example was presented at the start of the first session per day. In all phases, the test trials in each session were presented for as long as the child was willing to help Teddy. The majority of the tests took a single session to complete (range: 1– 3). On some occasions, if a child became bored in the first session and did not want to continue to teach Teddy, the experimenter stopped the testing and the remaining trials were administered in the subsequent session(s).

In the test trials, the experimenter prompted the child to label each body part by saying, “What’s this?” and then immediately pointed to or touched the relevant body part. If the child produced a verbal response (either correct or incorrect), the experimenter said, “OK!” and proceeded to the next trial. In the event that the child performed no response, the experimenter asked “What’s this?” once again and repeated the touch of the same body part, up to two more times. If the child still did not respond, the experimenter said, “OK” and moved to the next trial. Touches to the 36 body parts (see T1-T36 in Table 5.1.) were presented twice each in a pre-randomised order (there were 72 scheduled testing trials in total).

When the experimenter examined the children’s data, she identified the additional 14 body part labels that one or more children produced in response to her touches to the target body parts and which were not part of the stimulus set designed before the start of the study. For example, in the initial set of stimuli, when the experimenter pointed to her *Forehead*, and the children were asked "What is this?", some of them said “Eyebrow” in response—but this was not a part of the initial body part label set. Therefore, such body parts were included in the testing (see T37-T50 in Table 5.1.); each child was next tested for labelling of these 14 additional body part stimuli (again presented twice per body part, in a randomised order, with 28 trials per child in total).

Body-Part Labels: Comprehension Test. First, the experimenter explained to the child that they now needed to teach Teddy where the body parts are. Next, an example was given to the child; the experimenter asked, "Where's your nose?" If the child did not respond, the experimenter prompted the child by moving the child's hand to her or his own nose. This example was repeated and the prompt reduced until the child produced an independent response. If the child produced a correct response in the example trial, the experimenter provided praise. The example was presented at the start of the first session per day.

In the test trials that followed, the experimenter asked the child to touch the location of the body part that corresponded to the name she presented. At the start of each trial, she asked the child, "Where's your [body-part label]?" If the child produced a response (either correct or incorrect), the experimenter said, "OK!" and proceeded to the next trial. If the child performed no response, the experimenter prompted her or him to respond up to two more times by saying, "Show Teddy where your [body-part label] is". If the child still did not respond, the experimenter said, "OK" and delivered the next trial. Labels for the 36 body parts (see T1-T36 in Table 5.1.) were presented twice each in a pre-randomised order (there were 72 scheduled testing trials in total). Next, the additional set of 14 labels of body parts that were produced by some of the children in the labelling test (see T37-T50 in Table 5.1.) were presented following the same procedure (twice per body part, in a randomised order, with 28 trials per child in total).

After the end of the procedure, the experimenter administered the Griffiths' Mental Development Scales tests to 15 participants (the remaining 2 children left the nursery before this test could be administered). All parents received a brief summary of the findings (see Appendix C) and children were given small toys as gifts.

Measures

Coding of Children's Responses

Each body part label produced by a child in response to the experimenter's pointing (Labelling Test), and each body part location touched by a child in response to the experimenter's labelling (Comprehension Test) was coded as either correct or incorrect. In labelling tests, responses that were different from those listed in Table 5.1. were not counted as correct. This is because the acceptance of alternative labels (e.g., tummy for belly) in production trials would invalidate the comparisons with comprehension trials, where only one of these versions was presented. Instead, all child-generated "alternative" labels were noted and presented those as additional stimuli, in both types of tests, as described in the Procedure. Children's manual responses in label comprehension trials were coded as correct regardless of which hand was used, or the laterality of the target body part, but only small tolerance was used for target locations, to avoid overlaps in coding of adjacent body parts. Also recorded were the number of trials on which a child needed to be presented with the stimulus more than once to evoke a response, and whether multiple responses occurred in a trial (see for coding sheet Appendix D). On trials where children produced more than one response these were classified as either (i) self-correction, when the last response was correct while the previous response, within the same trial, was incorrect; (ii) correct to incorrect, when the last response was incorrect while the previous response, within the same trial, was correct; or (iii) no change, in which both the last and the previous responses within the same trial were either all correct, or all incorrect. Only the children's final responses were considered in all analyses.

Inter-observer Agreement

A second scorer, familiar with infant research but blind with respect to the aims of the present experiment, independently coded 35% of sessions, selected on a random basis across all the participants. Inter-observer agreement was calculated by dividing the number of agreements by the total number of coded response events. An agreement was noted whenever the two scorers coded the same response event (either correct or incorrect) on a trial. The agreement was 99% for the label production tests and 95% for the comprehension tests.

5.4 Results

Across the two phases, all children responded on a total of 200 trials each; half of the trials were presented in the label production test, and the other half in the comprehension test. All children responded promptly to the experimental stimuli on a majority of trials; more than one stimulus presentation had to be used on only 18% of the label production test trials (SD=16.8) and on 17% of the comprehension test trials (SD=13.0). In both test types, the number of such trials was negatively correlated with the children's age (for label production: Pearson's r=-.725; n=17; p<.001; for comprehension: r=-.728; n=17; p<.001). All children produced a single response on a majority of their trials. More than one response was produced on only 1% of the label production trials (SD=1.7) and on 4% of the comprehension trials (SD=3.2). Finally, the children failed to give a response on 19% of the label production trials (SD = 21.4) and on 14% of the comprehension trials (SD = 15.7). This shows that the participants were seldom distracted and were well motivated to respond to the experimenter's requests. There was no correlation between children's ages and the number of no-response trials. In the analyses presented next, these trials were treated as incorrect responses, rather than counted as missing trials, because the latter procedure would have produced inflated percentages of correct responses.

Correct Label Production and Comprehension Responses. The children's responses on each test trial were coded as either correct or incorrect in terms of the vocal responses they produced in the labelling test and the body part location they touched in the comprehension test. Figure 5.1. shows the percentage of trials on which correct responses were produced in the two experimental conditions for each of the 50 body parts. Considering the children's verbal production performances, only 12 of the 50 body parts presented in the tests were correctly labelled on more than 60% of the trials; a further 15 body parts were correctly labelled on more than 30% of the trials; another 5 body parts were correct on less than 10% of the trials; and no correct responses were recorded for the remaining 18 body parts. Considering the children's comprehension performances, the location of 21 body parts presented in the tests was correctly identified on more than 60% of the trials; an additional 7 body parts were correctly identified on more than 30% of the trials; for 12 body parts correct responses were produced on 10-30% of the trials; 7 body parts were identified on less than 10% of the trials; and no correct responses were recorded for the remaining 3 body parts.

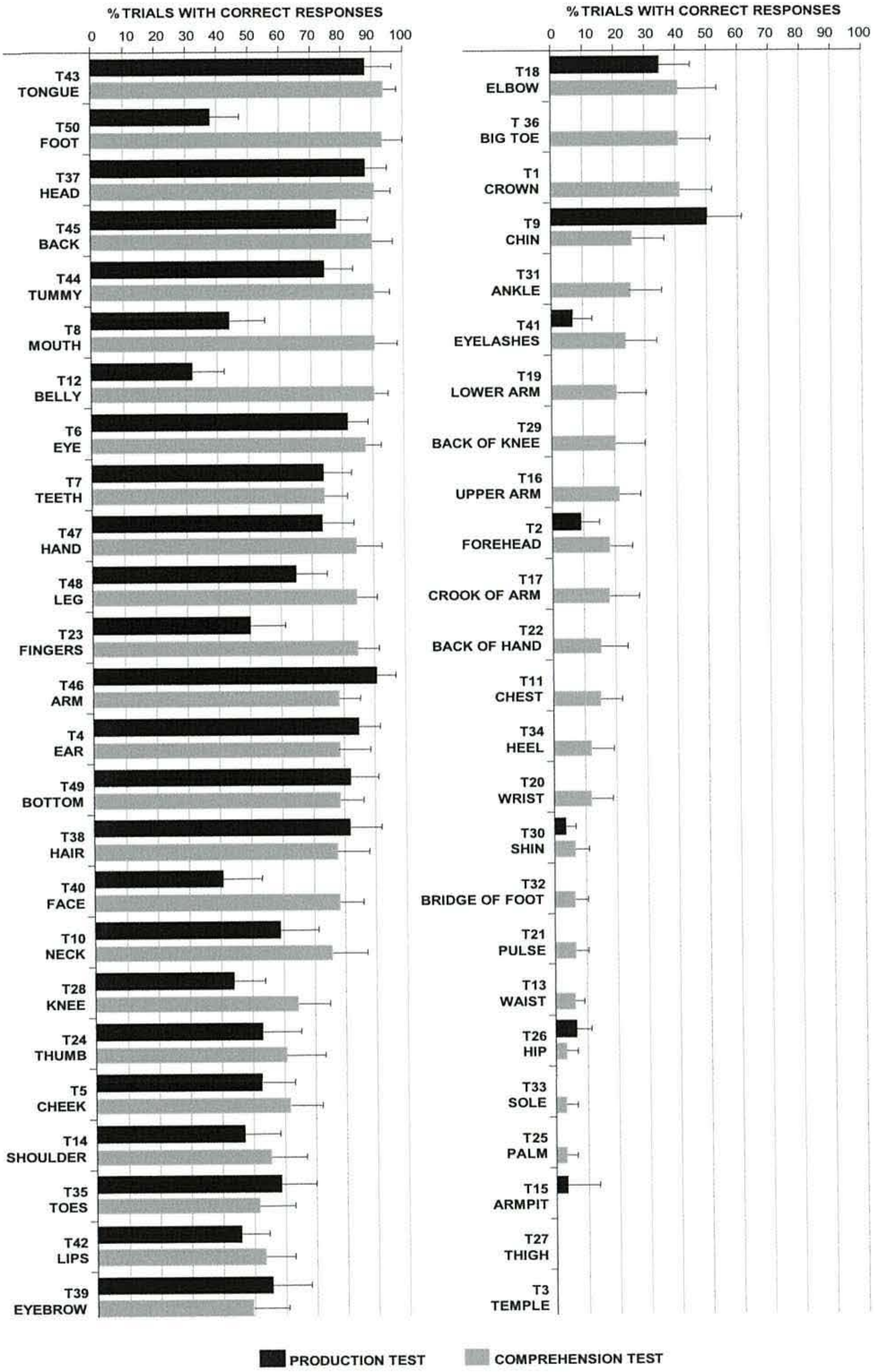

Figure 5.1. Percentage of trials on which children emitted correct body-part responses in the Production Test (black bars) and in the Comprehension Test (grey bars). The correct responses are plotted for each of the 50 target body parts, ordered by children's success on comprehension trials (best to poorest).

Comparing Label Production and Comprehension Responses.

Developmentally, children's verbal comprehension precedes their production ability; it was tested whether the same is true regarding their semantic body-part knowledge. Considering all 50 body parts, the percentage of labelling trials with correct responses (M=34.0, SD=33.50) was lower than the percentage of comprehension trials (M=46.5, SD=34.27); this difference was statistically significant ($t_{(41)}$=11.06; p<.0001) with a medium effect size (Cohen's d=.37; see Cohen, 1992). Children's individual repertoires were estimated by counting the stimuli to which at least one correct response was recorded. Children's individual labelling repertoires ranged from 6 to 26 body parts (median = 20) and their comprehension repertoires ranged between 15 and 33 body parts (median = 27) for the 50 stimuli presented. Across the whole sample (N=17), the comprehension repertoires were bigger than the production repertoires for each individual participant. There was a positive relationship between children's comprehension and production repertoires and their age (r=.630, p=.007 and r=.489, p=.047 respectively). The same was true for the correlations between their total correct scores (i.e., total number of correct responses across all body parts) and age for both comprehension (r=.596, p=.012) and production (r=.650, p=.005).

Is Children's Body-Part Knowledge Related to Cortical Representation? The proposition that sensory input and movement may be among the determinants of children's body knowledge was examined. First, if sensory input plays an important role in children's learning of body-part names, it would be expected the children to produce more correct responses to body parts that have a greater representation in the sensory cortex of the human brain. Based on Penfield and Rasmussen's work (1955), 28 of the 50 body parts used in the present study were ranked in order of the proportional percentage of responses elicited by brain stimulation in adults. The ordering of the stimuli, from most to least representation in the sensory cortex, was as follows: *Tongue, Hand, Arm, Thumb, Leg, Mouth, Lips, Fingers, Foot, Lower Arm, Teeth, Face, Head, Chin, Shoulder, Wrist, Eyes, Toes, Elbow, Knee, Neck, Thigh, Big Toe, Hip, Shin, Sole, Heel,* and *Ankle*. In both test types (body part labeling, and label comprehension), the percentages of children's correct responses were positively correlated with the amount of sensory representation in Penfield's sensory sequence (for label production: M=30.6, SD=35.20; Spearman's r=.650; n=28; p<.0001; for label comprehension: M=38.9, SD=37.34; r=.688; n=28; p<.0001).

Second, if movement contributes to how children learn body part names, it would be expected the children to produce more correct responses to body parts with a greater representation in the motor cortex. Based on Penfield and Rasmussen's work (1955), 19 body parts were ranked in order of proportional percentage of responses elicited by brain stimulation in adults. The ordering of the stimuli, from most to least represented, was as follows: *Lips, Hand, Elbow, Fingers, Wrist, Eyes, Shoulder, Thumb, Face, Tongue, Neck, Mouth, Eyebrow, Ankle, Knee, Eyelashes, Toes, Hip,* and *Big Toe*. In both test types, the correlation of the percentages of children's correct responses with Penfield's motor sequence was low, and did not reach statistical significance (for label production: M=39.3, SD=28.94; Spearman's r=.256; n=19; p= .291; for comprehension: M=53.9, SD=30.33; r=.266; n=19; p=.270).

Is Children's Knowledge Dependent on the Salience of Particular Locations and Features? It had been reported that children are able to point to facial features more readily than to other body parts, possibly because highly articulated facial features attract their attention from very early on and remain highly salient and interesting thereafter. Research has also shown that children's ability to locate articulated joints, which lack salience and require fine discriminations to be made, may be inferior to their knowledge of other broader areas of the body. For the same reason, broader body areas were considered to be easier to locate than other (smaller) body segments. Therefore, the present set of 50 stimuli were divided into four mutually exclusive categories and compared children's comprehension and production ability for body parts classified as being either (i) facial features; (ii) joints; (iii) broad; or (iv) other body segments. First, 12 body parts were included in the face group: *Cheek, Eye, Teeth, Mouth, Chin, Eyebrow, Eyelashes, Lips, Tongue, Forehead, Ears,* and *Face*. Second, 10 body parts were classified as joints: *Shoulder, Armpit, Crook of Arm, Elbow, Wrist, Pulse, Hip, Knee, Back of the Knee*, and *Ankle*. Next, 24 adults were asked to identify from the list of stimuli those they considered to be broad areas of the body. Only the body parts considered broad by more than 30% of these adults were included in this category (10 parts): *Chest, Belly, Tummy, Back, Head, Bottom, Waist, Thigh, Leg,* and *Arm.* Finally, the remaining 18 body parts were categorized as other body segments. Figure 5.2. shows the mean percentage of trials on which correct responses were produced in the Labelling and Comprehension Tests for the body parts in these four categories.

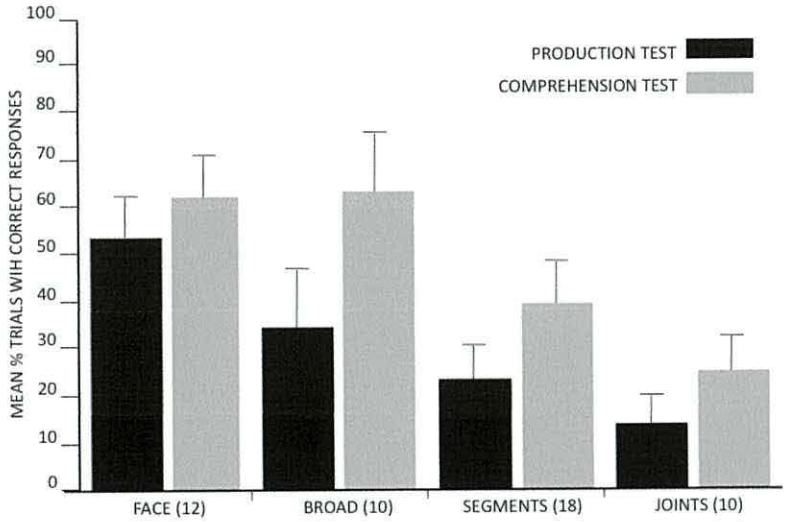

Figure 5.2. Mean percentage of trials on which children emitted correct body-part responses for facial features (Face; 12 body-parts), broad areas of body (Broad; 10 body-parts), other smaller body segments (Segments; 18 body-parts), and articulated joints (Joints; 10 body-parts), in Production Test (black bars) and in Comprehension Test (grey bars).

It was found that children's accuracy differed between the four stimulus groups for labelling ($F_{(3,46)}$=5.01, p=.004) and for comprehension ($F_{(3,46)}$=3.88, p=.015); in both cases, the effect sizes were large (Cohen's d=1.1 and d=1.0 respectively; see Brace, Kemp, & Sneglar, 2006). Next, the differences between each pair of categories were examined using conservative Bonferroni post-hoc comparisons; the degrees of freedom were adjusted whenever Levene's test of homogeneity of variance was violated. The post-hoc tests revealed that children's body-part label production was similar for Face and Broad areas ($t_{(16)}$=0.12, p=.905, d=0.06), and also for Joints and other body Segments ($t_{(25)}$=-1.00, p=.326, d=0.40). The remaining comparisons showed that children's labelling of facial features was significantly better than their labelling of joints and other segments of the body (Face vs Joints: $t_{(20)}$=3.82, p=.001, d=1.71; Face vs Segments: $t_{(28)}$=2.71, p=.011, d=1.02) and that their labelling of broad body areas was significantly better than that of joints or other body segments (Broad vs Joints: $t_{(14)}$=2.72, *p*=.017, *d*=1.51; and Broad vs Segments: $t_{(26)}$=2.09, *p*=.046, *d*=0.82).

Considering children's ability to localise their own body-parts in response to the experimenter's body part labels, the comprehension scores showed the same pattern of results as production: there were no differences between facial and broad parts ($t_{(20)}$=-0.03, *p*=.976, *d*=0.01), or between joints and other body segments ($t_{(25)}$=-1.23, *p*=.198, *d*=0.49). The children were more successful in locating facial features than joints or other body segments (Face vs Joints: $t_{(20)}$=3.44, *p*=.003, *d*=1.54; Face vs Segments: $t_{(28)}$=2.03, *p*=.052, *d*=0.77) and better at locating broad body areas than joints and other segments of the body (Broad vs Joints: $t_{(20)}$=-2.68, *p*=.018, *d*=1.43; Broad vs Segments: $t_{(26)}$=-1.73, *p*=.096, *d*=0.68). Although some of these comparisons did not reach statistical significance due to loss of power, the effect size indices show that the differences were real in all cases.

Comparing Children's Knowledge of Commonly Named and Uncommonly Named Body Parts. It was proposed that children's body knowledge would be expected to depend on the frequencies with which adults label and identify each body part in normal play and caregiving routines. To test this hypothesis, the present stimuli were sorted into one of two categories: those commonly named by the caregivers, and those not commonly named, for the children in the sample. The experimenter observed Nursery interactions and interviewed all nurses in order to obtain a direct and objective measure of which of the 50 body parts were commonly named, and which were not. The 26 body parts that were commonly used in the Nursery routines were: *Ear, Cheek, Eye, Teeth, Mouth, Chin, Neck, Belly, Shoulder, Fingers, Thumb, Knee, Toes, Big Toe, Head, Hair, Face, Lips, Tongue, Tummy, Back, Arm, Hand, Leg, Bottom,* and *Foot*. The remaining 24 body parts, which were not usually named for the children, included: *Crown, Forehead, Temple, Chest, Waist, Armpit, Upper Arm, Crook of Arm, Elbow, Lower Arm, Wrist, Pulse, Back of Hand,* *Palm, Hip, Thigh, Back of Knee, Shin, Ankle, Bridge of Foot, Sole, Heel, Eyebrow,* and *Eyelashes.* Figure 5.3. shows the mean percentage of trials on which correct responses were produced by the children in Labelling and Comprehension Tests for the body parts in these two categories. It was found that the children's responses were much more accurate for the commonly named body parts in both types of trials (for labelling: $t_{(41)}$=11.06, p=<.0001; for comprehension: $t_{(48)}$=13.21, p=<.0001), compared to the body parts that were not named in the Nursery. In both cases, the effect sizes were very large (d=3.45 and d=3.81, respectively).

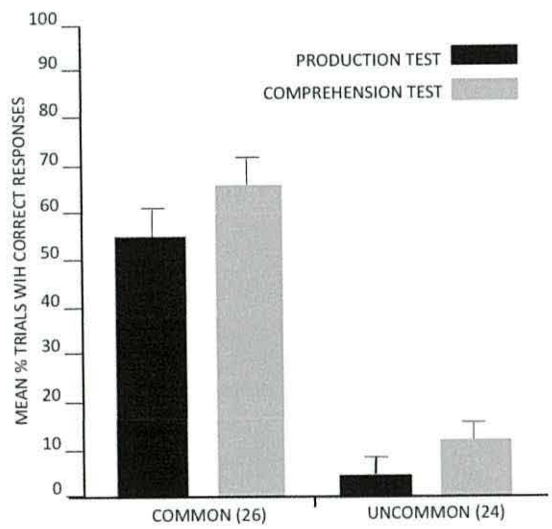

Figure 5.3. Mean percentage of trials on which children emitted correct body-part responses for body parts that are commonly named by caregivers (Common; 26 body-parts), and for body parts that are not commonly named by caregivers (Uncommon; 24 body-parts), in Production Test (black bars) and in Comprehension Test (grey bars).

5.5. Discussion

The results provide an extensive assessment of body-part knowledge in 2- to 3.5-year-old children. They complement and extend the existing literature by (i) providing a precise mapping of the body parts that young children are able to name and locate on their own bodies in response to body-part names; (ii) identifying categories of features which are well known at this age and those that are seldom named and located by children; (iii) identifying some of the determinants of lexical-semantic body knowledge. It was shown that children's ability to name different parts of body (production) lags behind their ability to locate body-parts named by an adult (comprehension), that both these repertoires increase with age in toddlerhood, and that they have similar determinants and characteristics.

The finding that children's comprehension of body-part names, develops earlier than production of body part names, is the first experimental comparison of this kind in the literature concerning children's body knowledge, but the same developmental pattern has been found in previous studies for a variety of verbal labels (e.g. Bates et al., 1995; Benedict, 1979; Fenson et al., 1994; Goldin-Meadow et al., 1976; Harris et al., 1995; Snyder et al., 1981).

Considerable individual variability in children's responses and several developmental changes across the range of ages in the sample were noted: (i) the younger children were more likely to require repeated presentations of the stimuli before responding than the older children; (ii) the younger children corrected their own responses more often than the older children; and (iii) the younger children had fewer correct responses overall for both types of tests, and had smaller comprehension and production repertoires than the older children. These results show that children's acquisition of lexical-semantic body knowledge is an ongoing process in 2- to 3.5-year-olds, and that it continues beyond the range of ages tested in the present study.

Employing a large set of 50 different body-part stimuli and a paradigm that allowed repeated testing over several sessions enabled us to estimate children's comprehension and production repertoires for the group and for each individual child. Considering all body parts to which at least one correct response was emitted, it was found that more than half of the children were able to label and comprehend labels for their ear, eye, cheek, teeth, mouth, chin, belly, neck, shoulder, elbow, finger, thumb, knee, toes, eyebrow, foot, face, bottom, leg, hand, arm, back, tummy, tongue, lips, hair, and head. However, these findings show that children younger than 3.5 years old were seldom able to label or comprehend the labels for waist, pulse, armpit, back of hand, palm, back of knee, hip, shin, ankle, heel, bridge of the foot, sole, forehead, and eyelashes. In addition, children often responded correctly to labels for crown, chest, wrist, lower arm, upper-arm, crook of arm, and big toe, but were most often unable to name those body parts. Only thigh and temple were never correctly named, or located in response to the labels "thigh" and "temple". Overall, these results—group scores and examination of individual participants' repertoires—show that toddlers were not able to locate or name many of the body parts targeted during the study. Therefore, future research should examine how this development continues in preschool age children.

It was shown that children's comprehension and production of body-part labels for facial and broad bodily features is superior to their comprehension and production of labels for articulated joints and other smaller segments of the body. These findings replicate and extend the existing published data. Similar to MacWhinney et al. (1987) and Witt et al. (1990), it was found in the present data that the children's knowledge of joints was comparably poor. The likely reason for this result is that accurate identification of joints requires children to make very precise discriminations of the boundaries between body parts (Schwoebel et al., 2004; Slaughter & Heron, 2004), which in turn may require extensive practice and repeated learning opportunities—more than this sample of toddlers had a chance to experience. A similar argument could be extended to children's poor knowledge of smaller body segments. By contrast, it was found that children's knowledge of broad body areas was very good, possibly because fine discriminations were not necessary to identify them. In agreement with previous reports (e.g., MacWhinney et al., 1987; Witt et al., 1990), children's knowledge was also comparably superior for body-parts located on the face. This result is interesting, because locations on a child's face are normally invisible to the child whereas many other body-parts that are identified far less readily have higher visibility. Therefore, this precedence in body knowledge development for the facial features cannot be attributed to increased visual input, suggested to be one of the determinants of early body knowledge by Slaughter and Heron (2004), because children cannot see their own facial features and yet know when they have successfully located their mouth, for example, in response to the experimenter's labelling of this body part. One explanation of the present data might be that facial features respond to sensory input more extensively than other parts of body; another possibility is related to children's interactions with their caregivers and the fact that during all verbal interactions children move and see moving nearly all features of the face area.

This study attempted to identify some of the determinants of children's body knowledge by examining the relationship between their comprehension and production test scores and the relative volume of representation of individual body-parts in the human sensory and motor cortices. A positive correlation was found between body knowledge and the extent of sensory cortical representation of body parts, but no such relationship existed with the motor cortex sequence of representation in the human brain. This result suggests that sensory input should be considered as a determinant of children's growing body awareness, but the present data do not allow us to make inferences regarding causality, not least because the knowledge of the relative representation in sensory and motor areas was derived from adult patient data (Penfield & Boldrey, 1937; Penfield & Rasmussen, 1955). At present, no comparable data sets exist in the developmental literature. Further research is clearly needed to explore the relative importance of input from different sensory modalities in the development of children's body knowledge.

It was possible to establish that a very strong relationship exists between the children's experiences of body-part naming routines with their caregivers, and their knowledge of individual body-parts demonstrated in both the comprehension and the production tests. In the current sample, the body-parts that commonly featured in social interactions with caregivers were known much better than the body-parts that were not commonly included in such early verbal and non-verbal daily interactions. This is consistent with previous findings which showed a similar relationship between toddlers' social experience of producing different hand-to-body gestures—similar to those required in the present study for the comprehension tests—in play, and their ability to imitate those gestures in response to adult modelling (Erjavec & Horne, 2008). Indeed, using the imitation paradigm, previous studies were able to demonstrate a causal relationship between social training and children's imitative success (Erjavec et al., 2009; Horne & Erjavec, 2007; Horne et al., 2009).

The present study offers a useful contribution to the existing literature, but also acknowledge the limitations of the present data. The results suggest that different social experiences may produce large differences in children's body knowledge. Thus the present sample, who attended a model Nursery affiliated with Bangor University, may have had a "richer" experience of body-part naming routines with their caregivers than would have been the case for other children—in which case the participants' repertoires may have been larger and more diverse than those of their peers growing up elsewhere. Clearly, only replication of the present tests with children from different backgrounds can determine whether these findings will generalise to other populations. However, the results are valid and reliable. The novel procedure employed provided a controlled yet highly engaging context in which each child willingly participated in hundreds of test trials (more data were collected subsequent to those reported here, in the same setting, with no problems or attrition). The results confirmed that this procedure was very effective in evoking reliable and prompt responses to the experimenter's requests in all tests. All children responded on virtually all of their trials; repeated requests seldom needed to be presented. Thus these data provide a more accurate assessment of 2- to 3-year-old toddlers' knowledge of body parts than would have been the case if the tests were administered in an unfamiliar setting, by an adult previously unknown to the participants, and over a comparably small number of trials (as is usually the case). Indeed, the response rates in the current study exceed those previously reported in the developmental literature on children's ability to focus and sustain attention, and to maintain concentration (e.g., see Levy, 1980; Ruff & Lawson, 1990). For example, a study by Levy (1980) showed that children's ability to complete a continuous performance test that required a high level of attention over time increased from 27% in the 3 year olds to 100% in the 4.5-year-old children. In the current study, 2- to 3.5-year-old children's response rates were close to 100% in most test sessions that contained up to 72 trials each. Therefore, the general experimental setup used in this study is commended to other researchers interested in measuring verbal and non-verbal responses in very young children.

To conclude. The data provided by this study contribute to the literature on the development of body knowledge in typically developing young children, providing statistics regarding the body parts that children can point to in response to labels and label themselves by the age of 3.5 years (Appendix E), and evidence regarding some determinants and correlates of this knowledge. These results may be useful in the detection of developmental delays in the areas of language, cognition, and body schema, or neuropsychological symptoms such as autotopagnosia (Goldenberg, 2003). As children's body knowledge is believed to underpin the development of their other abilities, the present data may be of wider interest to developmental psychologists, physiotherapists, and occupational therapists. Further research could, more systematically, look at the relation between the children's production and comprehension of body part names, the development of their fine and gross motor control, and their objective self-awareness. In addition, the present results may be relevant to the empirical literature on imitation in young children and the theoretical explanations of how children respond to adult modelling of gestures. For example, the accuracy of children's responses to hand-to-body gestures, often used in imitation tests, may be determined by their knowing (or not knowing) the specific body parts touched by the modeller (and see Bernardis & Gentilucci, 2006; Schwoebel et al., 2004). The body part discriminations established when children learn to produce and comprehend body-part labels are likely to provide body knowledge that enhances their performance on imitation tasks; indeed, as their verbal abilities increase, body part naming may come to play a pivotal role in the development of children's imitation repertoires (Horne & Lowe, 1996).

CHAPTER SIX: Patterns of Error in the Description and Performance of Empty-Handed Gestures by 2- to 3-Year-Old Children: Similarities with Gestural Imitation

6.1 Abstract

Young children's gestural and verbal repertoires develop together during social interactions with their caregivers, yet these abilities are seldom examined in conjunction. In the present study, 15 2- to 3-year-old children were first asked to produce verbal descriptions of 25 target gestures modelled by the experimenter. Next, they were asked to perform each gesture exactly as described by the experimenter (verbal comprehension). Overall, children's descriptions were less accurate than their instructed performances. They described the body parts touched by the model more readily than the limbs (effectors) moved to enact those touches, and seldom labeled limb movements (e.g., "across", "side") relative to the body. They were also more likely to label movements and effectors if the target actions did not terminate on a body part. Children's responses to the experimenter's performance instructions were likewise more accurate for body parts touched than for effectors, and showed a strong bias for ipsilateral responding. These errors resemble those found in gesture imitation studies, suggesting that common cognitive mechanisms may be involved in these seemingly different tasks. The common social origins of both repertoires, and the possibility that young children's verbal behaviour may influence their imitation of target gestures were considered.

6.2 Introduction

There is a consensus in the literature that speech and gesture complement each other in early child development (e.g., Nicoladis, Mayberry, & Genesse, 1999). Infants point to objects and events before they can name them, and development of both speech and gestures is influenced by children's social experiences with their caregivers (Carpendale & Lewis, 2004). However, with the exception of the earliest stages of language development, young children's vocal and gestural repertoires are typically studied separately. Whereas most language research has used tasks that require very simple gestures like pointing or reaching, more complex empty-handed gestures have frequently been used to study imitation (e.g., Bekkering, Wohlschläger, & Gattis, 2000; Erjavec, Horne, & Lovett, 2009; Gleissner, Meltzoff, & Bekkering, 2000). However, children's gestural performances in imitation tasks have not been examined in relation to their verbal abilities. Because these repertoires may be complementary, employing the same tasks to study them may improve our understanding of imitation, and more broadly of children's cognitive development.

Recent research points to the crucial role of social experiences in determining children's responses on imitation tasks: those gestures that are often practiced in dyadic interactions and nursery games are readily produced by children in imitation tests, but their counterparts that lack such history are not (Erjavec & Horne, 2008). Likewise, a very strong relationship exists between young children's verbal body knowledge and their histories of social interactions in which caregivers frequently label and point to some body parts, but not others (see Chapter 5). Games and social routines that provide ample practice for both these repertoires are often the same – they contain repeated modelling, naming, and prompts to perform a variety of gestures (e.g., 'Head and Shoulders, Knees and Toes'). Therefore, examining the kinds of errors children make when describing others' actions, and responding to others' performance instructions, may complement the study of children's imitative performances. If children respond similarly across these tasks, this may indicate that the same cognitive mechanisms underpin them; if there are marked differences, this would give credence to more 'specialist' accounts of imitation and language learning.

Most gestural imitation tests have employed modelling of touches to specific body parts – feet, knees, ears, shoulders, and so on – performed with a particular arm movement – either ipsilateral (same side of the body) or contralateral (crossing the body midline). These are the gestures employed in the present study. Instead of modelling actions and simply asking the children to copy them, this study aims to identify (i) which of the modelled actions and their components children can describe, and (ii) how accurately they can perform these behaviours in response to others' verbal descriptions of them.

It is expected that children's ability to perform gestures via verbal instruction would develop ahead of their ability to describe them, because it is well known that children generally learn to comprehend labels before they can produce them (Fenson et al., 1994; see also Chapter 5). As their vocabularies develop, young children learn nouns before verbs (e.g., Gentner, 1983); therefore, it is expected that participants name and touch body parts more readily than they describe and perform movements.

This research complied with British Psychological Society guidelines for research with children and was approved by the School of Psychology Ethics Committee.

6.3 Method

Participants

Fifteen children, 5 boys and 10 girls, aged between 26 months and 26 days and 41 months and 9 days at the start of the procedure (*M* = 35 months and 21 days), participated in this study. All children attended the University Nursery and Childcare Centre at least two days per week and were recruited by parental consent (see Appendix A). All participants were developing normally; their Griffiths' Mental Development Scores ranged from 103 to 139 (*M*=113; see Luiz et al., 2006).

Settings and Stimuli

Sessions were conducted in a quiet test room at the nursery. During each session, the child and the experimenter sat in an inflatable boat facing each other. A large teddy bear (Teddy) sat on the edge of the boat and had a backpack with toys and stickers, used for playtime after testing. Two wall-mounted digital video cameras and a microphone were used to record the sessions (see Appendix B).

Stimuli consisted of empty-handed gestures modelled and described by the experimenter. Target actions modelled by the experimenter in description tests, and corresponding instructions presented in performance tests, are listed in Table 6.1. Most of these actions have previously been used in imitation studies (e.g., Bekkering et al., 2000; Erjavec & Horne, 2008; Gleissner et al., 2000); their components were also included as additional targets.

Table 6.1.

Target actions modelled by the experimenter and corresponding instructions.

	Target Actions	Behaviour modelled by the experimenter in the description tests	Instruction given to the child in the performance tests
Conventional	A1 - Hands to eyes	Both hands covering eyes	Can you move hands up to touch eyes?
	A2 - Hands up	Both arms raised above head, stretching	Can you move hands up above head?
	A3 - Hands to head	Both hands placed on the top of the head	Can you move hands up to touch head?
	A4 - Hands to belly	Both hands tapping belly	Can you move hands to touch belly?
Contralateral arm	A5 - Hand to crook-of-arm	Left hand touching crook of right arm extended in front of the body	Can you move hand across to touch crook of arm?
	A6 - Hand to wrist	Left hand touching wrist of right arm extended in front of the body	Can you move hand across to touch wrist?
	A7- Hand to wrist with arm bent	Left hand touching wrist of bent and raised right arm	Can you bend arm up and move other hand across to touch wrist?
	A8 - Hand to elbow with arm bent	Left hand touching elbow of bent and raised right arm	Can you bend arm up and move other hand across to touch elbow?
Unimanual upper-body	A9 - Hand to ear	Left hand touching left ear (ipsilateral movement)	Can you move hand up to touch ear?
	A10 - Hand across to ear	Left hand touching right ear (contralateral movement)	Can you move hand up and across to touch other ear?
	A11- Hand to shoulder	Left hand touching left shoulder (ipsilateral movement)	Can you move hand up to touch shoulder?
	A12 - Hand across to shoulder	Left hand touching right shoulder (contralateral movement)	Can you move hand up and across to touch other shoulder?
Bimanual upper-body	A13 - Hands to ears	Both hands touching ipsilateral ears	Can you move hands up to touch ears?
	A14 - Hands across to ears	Arms crossed in front of the body, with both hands touching contralateral ears	Can you move hands up and cross arms to touch ears?
	A15 - Hands to shoulders	Both hands touching ipsilateral shoulders	Can you move hands up to touch shoulders?
	A16 - Hands across to shoulders	Arms crossed in front of the body, with both hands touching contralateral shoulders	Can you move hands up and cross arms to touch shoulders?
Bimanual lower-body	A17 - Hands to knees	Both hands apart touching ipsilateral knees	Can you move hands to touch knees?
	A18 - Hands across to knees	Both hands crossed touching contralateral knees	Can you cross arms to touch knees?
Component (no body-part touches)	A19 - Arms apart	Both arms extended in front of the body	Can you move arms to front and keep arms apart?
	A20 - Arms crossed	Both arms crossed in front, forearms overlapping	Can you move arms to front and cross arms?
	A21 - Arm bent	Left arm bent up in front of the body	Can you bend one arm up?
	A22 - Hand up	Left arm raised above head, stretching	Can you move one hand up?
	A23 - Legs crossed	Both legs crossed in front of the body, shins overlapping	Can you move legs to front and cross legs?
	A24 - Leg bent	Left leg bent in front of the body	Can you bend one leg up?
	A25 - Foot up	Left foot raised at chest level, stretching	Can you move one foot up?

Design and Procedure

The experimenter invited the child to sit in the boat and help her teach Teddy about things he needed to learn. Each child received the description test first, followed by the instructed performance test, in a repeated-measures design. This order was necessary to avoid false positives (i.e., children were not exposed to experimenter's descriptions before producing their own).

Action descriptions. The child was invited to teach Teddy what the experimenter was doing. As an example, the experimenter placed her hand on her own chin saying, "What am I doing?" If the child did not respond, the experimenter prompted, "Tell Teddy: Putting hand up to touch chin." This example was repeated and prompts faded until the child produced an independent verbal response (any description was accepted). In test trials, the experimenter asked the child, "What am I doing now?" every time she modelled an action. If the child produced a verbal response (either correct or incorrect), the experimenter said, "OK" and proceeded to the next trial. If no response was forthcoming, each prompt and action sequence was repeated up to two more times. There were two sessions per child with 50 testing trials in total, two for each modelled action, with randomised order of presentation. Hand-to-body actions were presented first, followed by component actions.

Instructed performances. First, the experimenter asked the child, "Can you put your hand up and touch chin?" If the child did not respond, the experimenter gently moved the child's hand to touch her or his chin. The request was repeated and prompts faded until the child responded independently. On subsequent test trials, the experimenter asked the child, "Can you…" then described the action scheduled for that trial (see Table 6.1.). If the child produced a gestural response (either correct or incorrect), the experimenter said, "OK" and proceeded to the next trial. If the child did not respond, the experimenter repeated this description up to two more times per trial. As in the description tests, hand-to-body actions were presented first, followed by component actions, with two trials per action (50 trials in total), and in randomised order.

The experimenter then administered GMDS tests to all participants, and gave them small presents (toys; see Appendix C).

Coding

Components of each response, vocal (description) or gestural (performance), were coded in terms of: (i) specific body part touched (ii) movement, and (iii) type and number of effectors involved. (See Appendix F for scoring matrix). Each component was coded as either present/correct, or present/incorrect, or absent/incorrect. For description tests, a component was scored as correct if the child mentioned it. For example, if a child stated, "Put hand on the ear" after being presented with A10 *Hand across to ear* gesture, the body part ("ear"), the effector ("hand"), and the number of effectors (one/singular) were counted as correct, but the movements "up" and "across" were coded as absent. Likewise, for instructed performance tests, a component was coded as correct if it featured in a child's gestural response (see coding sheet in Appendix D).

We also noted whether children attempted to copy the experimenter's movements in the description test or echo her descriptions in the instructed performance test. A second scorer, familiar with infant research but blind to the aims of the study, independently coded 30% of sessions, selected on a random basis across all the participants. Inter-observer agreement was calculated by dividing the number of agreements (same response events coded on a trial) by the total number of coded events. Agreement was 97% for each test.

6.4 Results

Each child (n=15) responded on a total of 100 trials, 50 per test. Failure to respond was recorded on only 3% of description trials (SD=7.3) and 1% of performance trials (SD=2.6). More than one stimulus presentation was required on only 17% of the description trials (SD=14.6) and 15% of the performance trials (SD=14.9). Repeat trials were negatively correlated with age; younger children were more likely to need more than one presentation (description: Pearson's r= -.513; p= .051; performance: r= -.535; p= .040).

Each response was analysed in terms of its constituent components (see Coding and Appendix F) and the results are reported according to this classification.

Children's Naming of and Touches to Body Parts

Action descriptions. Seventeen target actions terminated on a body part: either eye(s); head; belly; crook-of-arm; wrist; elbow; shoulder(s); or knee(s). Children correctly named a body part on 58% of the trials (SD= 35.0); on the remaining trials, they either named an incorrect body part (M=31%; SD=31.0) or did not mention any parts of body. Children's success on body part naming was not related to their age, r= 0.279, p= .314. Significant differences were found between correct scores for seven body parts, $F_{(8,\ 126)}$= 26.89, p<.0001. Tukey's post hoc tests showed that children named "eye" significantly more often than "crook-of-arm", and "wrist"; "head" significantly more often than "eye", "crook-of-arm", "wrist", "elbow", "shoulder", and "knee"; "belly" significantly more often than "eye", "crook-of-arm", "wrist", "elbow", and "knee"; "ear" significantly more often than "eye", "crook-of-arm", "wrist", "elbow", and "knee"; "shoulder" significantly more often than "crook-of-arm", "wrist", and "elbow"; and "knee" significantly more often than "crook-of-arm", and "wrist" ($p < .05$).

Instructed performances. Children touched a correct body part on 68% of the trials (SD= 32.2) and an incorrect body part on 27% of trials (SD= 30.0); no body parts were touched in remaining trials. Their correct scores were not related to their age, r= 0.437, p= .104. Incorrect responses typically terminated on body parts adjacent to targets; for example, children often touched their lower arm when instructed to "move hand across to touch wrist". Children touched some body parts correctly more readily than others, $F_{(8, 126)}$= 22.92, p<.0001: eye, head, belly, crook-of-arm, ear, shoulder, and knee were touched significantly more often that wrist, and elbow ($p < .05$).

Children's Naming and Use of Effector(s) and Number of Effectors

Action descriptions. Twenty-two target actions were performed with either arm(s) or hand(s); the remaining three were performed with foot or leg(s). Twelve of these actions had a single effector; the rest had two. Children named the effector(s) correctly on 28% of the trials (SD= 21.4) and their labels were incorrect on 6% of trials (SD= 9.7); they omitted these labels on the remaining trials. At the same time, children correctly identified the number of effectors (by appropriate use of singular or plural nouns) on 27% of all trials (SD=20.3). The percentages of correct naming were not related to children's age (effector: r= 0.481, p= .070; number: r= 0.441, p= .100). Overall, children were more likely to describe effectors correctly for gestures that did not terminate on a body part (M=52%; SD=28.8) than those that did (M=15%; SD=27.1), $t_{(14)}$= 3.596, p= .003.

Instructed performances. Children used the correct effector(s) on 88% of trials (SD= 19.9) and incorrect effector(s) on 11% of trials (SD= 17.2). The correct numbers of effectors were used on 68% of trials (SD= 13.6). The children's age was positively related to their correct effector scores, r= 0.550, p= .035, but not to their number scores, r= 0.278,

p= 0.315. Considering the instances where children did not employ the correct number of effectors, no difference was found between the use of two effectors instead of one or vice versa, $t_{(23)}$=0.71; p=.483.

Children's Naming and Use of Movements

Action descriptions. Target actions contained movements 'up', 'to front', 'bend', 'across', and 'apart' (see Appendix F). Thirteen actions modelled by the experimenter contained upward movements of the effector(s), but children named this action component correctly on only 10% of trials (SD= 17.4) and omitted it on the remaining trials. In 10 actions the experimenter moved her effector(s) to the front of her body; in 3 target actions the experimenter bent her arm, and in 1 she bent her leg. The children never named any of these movements. The experimenter modelled 11 contralateral actions in which the effector(s) crossed the body midline. The children produced an accepted label ("crossing") on only 5% of all trials (SD= 10.1). Only four children named this movement. In eight bimanual actions the experimenter moved her arms apart, but children never named this movement component. Overall, children were more likely to describe at least one movement correctly for gestures that did not terminate on a body part (M=21%; SD=13.9) than for those that did (M= 1%; SD=1.9), $t_{(14)}$= 6.013, p< .001. A significant positive correlation was found between the children's correct movement descriptions and their age, r= 0.658, p= .008.

Instructed performances. Children produced the upward movement on 92% of trials (SD= 6.9) across 13 target actions. The experimenter instructed the children to move their arms or legs to the front for 3 target actions; they did so correctly on 53% of trials (SD= 29.8). Children performed a bending movement on 49% of trials (SD= 28.2) across four target actions, and an apart movement on 56% of trials (SD= 37.2) for one action, when they were instructed to do so. For the 11 target actions where they were asked to move their effector(s) across, the children performed contralateral movements on only 32% of the trials (SD= 17.5); they performed ipsilateral (incorrect) movements on the remaining trials. Ipsilateral response bias was also evident across eight target actions where the experimenter did not explicitly tell the children whether to perform ipsi- or contra-lateral responses in order to touch the named body parts in the performance test (see Table 6.1.; e.g., in A9 trials they were told to "move hand up to touch ear" and in A17 trials to "move hands to touch knees"). Across these actions, the children's responses contained ipsilateral movements on 91% of trials (SD= 6.7). Their correct movement performances were positively related to their age, r= 0.648, p= .009.

Other Responses

Action descriptions. The children spontaneously imitated gestural responses on 25% of trials (SD=31.3); 85% of these responses matched the experimenter's actions. Their frequencies were not related to children's age, r= 0.292, p= .292.

Instructed performances. On 5% of test trials (SD=13.2), after the experimenter presented an action description, the children echoed a part of it. These responses were almost exclusively repetitions of the body part name and their frequencies were inversely related to children's age, r= -0.565, p= .028.

6.5 Discussion

Overall, children were more likely to produce the components of target actions in response to the experimenter's instructions, than to name those components in their own action descriptions. This lead of children's verbal comprehension over their corresponding production repertoires on the present tasks is consistent with the existing literature on the development of body knowledge (see Chapter 5) and language more generally (e.g., Fenson et al., 1994).

Children were most likely to name body parts. Observed variability in the accuracy of children's body part naming is in line with previous findings: broad features (e.g., head, belly) and parts most often named by caregivers (e.g., eye, shoulder) were described much more readily than joints (wrist, elbow; see Chapter 5). One could hypothesize that the body parts less frequently named by the children may be phonologically more complex (Gierut, 2007). However, this does not appear to be the case in the present sample: The body parts which contain phonological segments that occur more frequently in the English language (i.e., shoulder, wrist, crook-of-arm, belly and knee) were not more frequently named by the children than those body parts which contain phonological segments that occur less frequently in the English language (i.e., ear, head, elbow and eye; see Kucera & Francis, 1967; Vitevitch & Luce, 2004; and phonotactic probability calculator on: http://www.bncdnet.ku.edu/cgi-bin/DEEC/post_ppc.vi). Similarly, it is unlikely that children's ability to name body parts was simply a function of the frequency with which the labels for different body parts occur in the English language, because "eye", one of the most frequently used words in English (ranked 214th in the online frequency dictionary available at: http://www.insightin.com/esl/), was produced by children much less readily than the less frequent labels such as "head", "belly", or "ear". Nevertheless, future research could systematically examine whether children's body-part and movement-label knowledge may be affected by word frequency (both written and spoken; e.g., see Leech, Rayson, & Wilson, 2001) or by phonological complexity of these labels, and whether the results are similar across different cultures and languages.

Children seldom named the effectors (hand/arm or foot/leg) even though these are some of the first body parts learned by toddlers (see Chapter 5). Clearly, their lack of description was not due to inability to name these limbs. Indeed, children were much more likely to name effectors that did not terminate on a body part. A follow-up study could establish whether children would name this component more frequently if touches were performed with a wider range of effectors (finger, hand, elbow, foot and so on) each terminating on the same body part, or not touching body.

Children were least likely to label movements. The movement "up" was named occasionally, but the labels "in front", "bend", and "apart" were never produced and only a few participants named the movement "across". Overall, children's correct movement scores were positively correlated with their age. This accords with previous research showing that toddlers learn to name objects in their environment (nouns) before they can label events (verbs) or use qualifiers (adjectives, adverbs). As was the case for effectors, children were more likely to name movement if gestures did not terminate on a body part. It is possible that seeing touches to parts of a body draws young children's attention away from other gesture components – a process similar to *local stimulus enhancement* (see Horne, Erjavec, & Lovett, 2009; Zentall, 2006).

In their instructed target action performances, the children typically employed the appropriate and correct number of effector(s). They touched the correct body parts on most trials, but their performance was comparably poor for wrist and elbow, following the pattern observed in their descriptions and in previous research (see Chapter 5). The movement 'up' was performed correctly in most trials, but the children were much less likely to correctly produce the remaining movements: 'across' and 'bend' were the least performed, followed by 'in front' and 'apart' (their performance of movement was positively correlated with age). Overall, children's performances were similar to their descriptions, and children showed a very strong bias for ipsilateral responding.

A very similar pattern has been reported previously in gestural imitation studies (Bekkering et al., 2000; Erjavec & Horne, 2008). Children presented with modelling of ipsi- and contra-lateral hand-to-body gestures typically respond by touching the correct part of their body, but they often use incorrect movement – they favour ipsilateral responses on a majority of trials. However, children are more likely to reproduce movement correctly if target behaviours do not terminate on a body part. To explain this pattern of responses, some authors have argued that imitation is driven by a specialised perceptual-cognitive process whereby children perceive others' behaviours in terms of hierarchically organised goals (Bekkering et al., 2000; Gleissner et al., 2000). While some goals are seen as dominant and reproduced (body part or more generally end point of a gesture), others are neglected (type of movement), due to processing limitations. However, this account does not provide independent evidence of a mechanism that would establish such goal-hierarchies, or explain why children's action processing in imitation, but not in many other tasks, would be limited to a single dominant goal. The present results show that children's performances are similar across gestural imitation and verbal tasks, indicating that there is nothing 'special' about perceptual-cognitive mechanisms underlying imitation (and see Bird, Brindley, Leighton, & Heyes, Exp 3, 2007, for a similar demonstration with adults).

Alternative explanations of early imitative performances point to the social origin of imitation in games that young children play with their caregivers: gestures that are often practiced in dyadic interactions and nursery games are readily produced by children in imitation tests, but their counterparts that lack such history are not, regardless of their goal structure or apparent complexity (Erjavec & Horne, 2008; also see Heyes, 2005). In the games that toddlers play with their caregivers, ipsilateral responses are the norm. So is pointing at different parts of body.

Language is another constant feature of these early social interactions: gestural and verbal repertoires develop in parallel and are often practiced together. Although it is widely recognised that young children frequently use gestures to scaffold their immature speech and that their use of gestures may be a good measure of language ability while their vocal repertoires are still limited (Goldin-Meadow, 2004), the inverse relationship is seldom considered – that learning to speak may change children's gestural performances. As children learn to label the objects and events in their environment, this changes the way they respond on a variety of different tasks (Horne & Lowe, 1996). Naming can help children to direct and sustain their attention to some features that they see, influencing the way in which they respond to modelling. Thus children may selectively attend to frequently named body parts, and neglect other components of modelled gestures that are less often named, such as movement, unless these are the sole features of the actions they see performed. In the present study, children's echoing responses consisted almost exclusively of repeating the body part names, and their descriptions were far more accurate for body parts than for any other components. Naturally, to establish whether naming of some, but not other, components of gestures influences children's non-verbal imitative performances, future research should manipulate these variables directly. For example, would training children to name the movement 'across' result in better imitation of contralateral gestures?

Conclusion. The ability of 2- to 3-year old children to describe the components of empty-handed gestures performed by a model, and to perform these actions in response to verbal instructions, was tested using gestures that are typically employed in non-verbal matching tasks. The pattern of results was similar for children's descriptions, for their instructed performances, and for imitative performances recorded in the literature with children of a similar age, indicating that common cognitive mechanisms are likely to be involved in these disparate tasks. These findings suggest that children's responses in these verbal tests are best examined in relation to their history of interactions with caregivers, and that children's gestural performances may be influenced by their growing verbal (naming) repertoires.

CHAPTER SEVEN: The Impact of Body-Part Naming Training on the Accuracy of Children's Imitative Performances.

7.1 Abstract

A series of three experiments explored the relationship between 3-year-old children's ability to name target body parts and their untrained matching of target hand-to-body touches. Nine participants, 3 per experiment, were presented with repeated generalised imitation tests in a multiple-baseline procedure, interspersed with step-by-step training that enabled them to (i) tact the target locations on their own and the experimenter's bodies or (ii) respond accurately as listeners to the experimenter's tacts of the target locations. Prompts for on-task naming of target body parts were also provided later in the procedure. In Experiment 1, only tact training followed by listener probes were conducted; in Experiment 2, tacting was trained first and listener behaviour second whereas in Experiment 3 listener training preceded tact training. Both tact and listener training resulted in emergence of naming together with significant and large improvements in the children's matching performances; this was true for each child and across most target gestures. The present series of experiments provide evidence that naming – the most basic form of self-instructional behaviour – may be one means of establishing untrained matching as measured in generalised imitation tests. This demonstration has a bearing on the interpretation of imitation reported in the behaviour analytic, cognitive developmental, and comparative literature.

7.2 Introduction

Researchers of different theoretical persuasions agree that imitation is a key driver of development in infancy and childhood, and that its determinants deserve careful experimental investigation. Behaviour analysts distinguish between a directly trained repertoire of matching relations, established through discriminative reinforcement like any other operants (Skinner, 1953, pp. 119–120), and generalised imitation, a repertoire of emergent matching relations (Catania, 1998, p. 228). This latter kind of imitative repertoire, which could enable young children to learn new behaviours quickly and without the need for direct training, has been the focus of numerous experiments (e.g., Baer & Deguchi, 1985; Baer & Sherman, 1964; Erjavec et al., 2009; Horne & Erjavec, 2007; Kymissis & Poulson, 1994; Poulson & Kymmissis, 1988; Poulson et al., 2002; Poulson et al., 1991; Steinman, 1970; Waxler & Yarrow, 1970). Traditionally, the methodology for examining generalised imitation consists of the presentation of discrete trials on each of which the child observes a different modelled action to which he or she is asked to respond. Following some modelled actions, correct matching responses result in the delivery of reinforcers, but matching responses to the remaining models are not reinforced. It is the children's responses to the latter models that are of interest, as matching of unreinforced probes is considered to provide evidence of generalised imitation. If unreinforced matching is shown to be sensitive to changes in the contingencies provided for reinforced responses, this is considered to be evidence that generalised imitation had been established as a higher order class of behaviour (Catania, 1998). Thus evidence of generalised imitation has been reported in infants (e.g., Poulson et al., 1991, 2002), normally developing children (e.g., Baer & Sherman, 1964; Catania, 1998; Sherman et al., 1977), and children from special populations (e.g., Baer et al., 1967; Garcia et al., 1971; Peterson, 1968).

In the recent literature, additional necessary controls have been identified and incorporated into tests for generalised imitation. First, it has been shown that all such tests ought to employ pretests for novelty of the target actions presented as unreinforced probes. Second, researchers also need to ensure that parents and other caregivers remain unaware of the experimental procedures, particularly the modelled target behaviours, for the duration of the study. These steps safeguard against false positives – cases where target responses may be extra-experimentally established as trained matching relations either prior to or during the experiment (see Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007; for a more detailed discussion of these points and relevant data). Third, in tasks that model an action directed at a particular object, it has been shown that the action component may not be necessary to evoke the target response (see Zentall, 2006). For example, Horne and colleagues (2009) tested infants' imitation of a particular target behaviour. Depending on assigned condition, the infants were either shown a mitten falling from a puppet's arm (affordance demonstration control), or an experimenter pointing to a mitten on the puppet's arm (social enhancement control), or an experimenter removing the mitten from the puppet's arm (target behaviour modelling condition). This study demonstrated that infants in the affordance and social enhancement control conditions produced as many mitten removals in subsequent test trials as those who had seen the full target behaviour of the experimenter removing the mitten. Because object affordances and social enhancement are potential confounding sources of control when target behaviours are actions on objects, the authors concluded that, to provide a strong test of generalised imitation, future studies should employ novel, empty-handed gestures (i.e., those that do not involve touching or holding objects) as target behaviours (see Horne & Erjavec, 2007, for further discussion of this issue and relevant data).

Recent studies examining the determinants of imitation in infants and young children that have employed these experimental controls have failed to replicate the results of earlier studies. For example, neither extensive exposure to modelling nor multiple-exemplar matching training led to the emergence of novel untrained matching relations in infants (Erjavec et al., 2009; Horne & Erjavec, 2007). These results indicate that the imitative abilities of infants and young children may have been overestimated in the earlier behaviour analytic literature, and for similar reasons, also in cognitive-developmental studies (e.g., see Hurley & Chater, 2005). Clearly, more research is needed to identify the conditions under which young children may show emergent matching of novel behaviours.

One possibility is that children's growing verbal repertoires may alter the way in which they respond to behaviours modelled by others. Although experimenter-generated instructions have long been identified as one determinant of matching responses in school- and nursery-age children (see Baer & Deguchi, 1985, for a review), the effects of self-instructions on young children's imitative responses have not yet been examined directly. Horne and Lowe (1996, 1997; also see Lowe & Horne, 1996) propose that learning to name objects and events in their environment fundamentally changes the way in which children behave. They define naming as a higher order bidirectional relation, in which the speaker responds as a conventional listener to his or her own verbal responses. Via this intra-individual speaker-listener relation, when a child sees an object (e.g., a shoe) and tacts it ("shoe"), the child next responds as a listener to that tact by looking once again at the object, and so on. Naming is therefore the earliest form of self-instruction: This circular speaker-listener relation enables the child to maintain his or her attention on a particular object for as long as that particular cycle of speaking and listening continues. In addition, whenever the child names a particular object (e.g., the child's shoe), the listener response includes looking at other objects that he or she has learned to call by the same name.

Naming is therefore an important means of establishing category relations between objects (e.g., the child's shoe and the wide variety of adult's shoes). Indeed, common naming (but not common listener behaviour) has been shown to establish untrained categories in young children, even between objects that have no features in common (see Horne et al., 2006; Horne et al., 2007; Horne et al., 2004; Lowe et al., 2005; Lowe et al., 2002). Therefore, it is possible that when a child observes her mother touching her own foot, the child may tact what her mother has done by saying "touch foot" or simply "foot" and then respond in turn as a listener to that utterance by looking at her own foot and touching it. In this way, the self instructional effects embodied in the name relation may alter the way in which a child (or adult) responds on generalised imitation tests. Some recent findings suggest that this is indeed the case. For example, many empty-handed gestures used as target behaviours in imitation tests involve touching a specific body part – a shoulder, an elbow, a palm, a foot, and so on. It is well documented that infants and young children accurately match some of these models, but respond incorrectly to the remaining models by touching a different part of their own body, or using an incorrect movement (e.g., Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Erjavec et al., 2009; Gleissner et al., 2000; Horne & Erjavec, 2007). Erjavec and Horne (2008) have demonstrated that toddlers' responses to hand-to-body target gestures tend to be more accurate for those actions that frequently feature in naming and matching games that the children play with their caregivers (e.g., the nursery rhyme "Heads, shoulders, knees and toes") than for comparable actions that had no such training history (also see Chapter 5). However, the separate contributions of matching training, naming training, and listener training have not yet been assessed directly.

Let us consider in more detail how learning to name a target body part may change a child's performance in an imitation test. Figure 7.1. (left panel) illustrates the naming relation for Foot (adapted from Horne & Lowe, 1996, p. 201). A child, who has learned to name this part of the body, sees her foot, and then says "foot". This response automatically generates the auditory stimulus /foot/ to which the child responds as a listener by looking once again at her foot. This name relation can be evoked by seeing a foot or hearing /foot/; therefore, it can be re-evoked each time the foot is seen or through self-echoing. As caregivers train this relation, they are likely to point not only to the child's foot but also to other feet – their own and siblings' feet, feet on toys, pet animals, birds, and so on. This name relation will therefore come to include a variety of other stimuli that a child may name and, in so doing, categorize them as feet (this relation may also include a variety of conventional listener responses – looking at, pointing to, touching, kicking, putting on and pulling off socks or shoes, and so on, depending on the child's learning history). When, in an imitation context, the child sees an experimenter modelling a foot-touch, she may name the target body part as "foot", overtly or covertly, and respond to her own utterance by orienting to and touching her own foot (see Figure 7.1., right panel). This could happen even if the child has never been directly trained to produce a matching response to a model of a hand-to-foot target action. Thus an emergent matching response may be emitted in a generalised imitation test. However, if the child has not yet learned to name the target body part touched during a modelling demonstration, then naming cannot facilitate matching of the target behaviour.

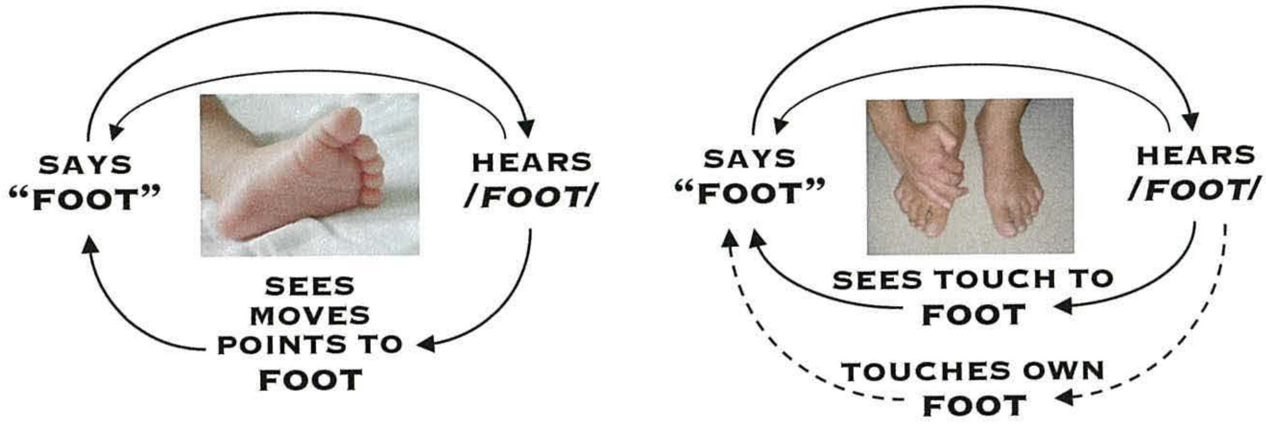

Figure 7.1. (adapted from Horne & Lowe, 1996, p. 201). Left Panel: A child, who has learned to name Foot, sees her foot, and then says "foot". Upon hearing this self-produced verbal stimulus /foot/, the child shows conventional listener behaviour; she orients to the foot, moves it, touches it, and so on. Thus naming can be evoked by seeing a foot or hearing /foot/; it can be re-evoked by seeing a foot again or through self-echoing. This illustrates the bidirectional relation between the tact, listener behaviour, and the object, or a class of objects or events. Right Panel: In an imitation task, seeing the experimenter touch her foot may evoke the child's naming of this body-part. Thus a child may covertly or overtly say "foot"; hearing her own utterance /foot/ may then direct the child's attention to her own foot, leading her to touch this location on her own body (listener behaviour). This illustrates how an apparently emergent matching response may come about as the result of naming.

In the present study, multiple baseline designs in three experiments were employed to explore the relationship between young children's ability to name target body parts and their untrained matching of target hand-to-body touches. Participants were presented with repeated generalised imitation tests in which models of four trained (baseline) hand-to-body touches were interspersed with four unreinforced (target) body touches; the novelty of all target behaviours was established at the outset for each individual child. The separate effects of training the children to (i) tact the target locations, and (ii) respond as listeners to the experimenter's tacts of the target locations, on their subsequent matching of the target body touches were next investigated. It was also examined whether prompts for on-task naming of target body parts enhanced the children's generalised matching performances.

This research complied with British Psychological Society guidelines for research with children and was approved by the School of Psychology Ethics Committee.

7.3 Experiment 1

7.3.1 Method

Participants

Three typically developing girls who attended the University Nursery and Childcare Centre Tir Na n'Og in Bangor at least two days a week were recruited by parental consent to participate in this experiment (see sample of consent form in Appendix A). Participants are referred to by short alternative names to preserve confidentiality. At the start of tact training they were aged 33 months (Emma), 34 months (Anna), and 35 months (Mol). Table 7.1. shows the total number of sessions administered to each child, their ages at the end of the procedure, and the General Quotient scores on the Griffiths Mental Developmental Scales (Luiz et al., 2006) obtained for 2 of the children (the remaining child left the nursery before this test could be administered).

Table 7.1.
Children's gender, target relations assigned to each participant, ages at start of naming intervention in Experiment 1, 2 or 3, total number of sessions administered in each experiment, and children's general quotient scores on the Griffiths Mental Developmental Scales (GMDS).

	Participant	Gender	Target relations	Age at start of training (months/days)	Total number of sessions administered	Age at end of testing (months/days)	GQ scores
Experiment 1	Emma	Female	T2, T5, T6, T8	33/00	70 sessions	35/11	117
	Anna	Female	T1, T4, T7, T8	34/14	57 sessions	36/08	___
	Mol	Female	T3, T5, T8, T9	35/29	113 sessions	38/16	120
Experiment 2	Jack	Male	T2, T4, T9, T14	31/17	79 sessions	35/16	132
	Gina	Female	T2, T7, T8, T10	31/24	85 sessions	36/01	120
	Mila	Female	T1, T4, T11, T14	33/24	80 sessions	37/24	120
Experiment 3	Fin	Male	T3, T7, T8, T9	28/03	44 sessions	30/10	110
	Carl	Male	T2, T3, T8, T9	32/04	51 sessions	35/14	116
	Fex	Male	T2, T8, T12, T13	34/07	83 sessions	38/22	113

Settings and Apparatus

Sessions were conducted in a specially designed quiet testing room at the Nursery. During the sessions, the child and the experimenter sat comfortably in an inflatable boat, on beanbags, facing each other. A large teddy bear toy (Teddy) was seated on the edge of the boat, facing the child. Age appropriate toys and stickers were used during play breaks between test trials and after testing. These items were kept hidden in a closed box and in Teddy's backpack between presentations. Two wall-mounted digital video cameras were employed to record the behaviour of the child and the experimenter. Audio and visual inputs from the two cameras and a hidden radio microphone were fed into a split-screen video recorder located in a separate audio-visual suite (see Appendix B). JVC SR-VS10

VHS/DV recorders, with stop- and slow-motion viewing facilities, were used for recording and coding.

The visual stimuli employed were manual gestures performed live by the experimenter (see Table 7.2.). These gestures consisted of touches to different parts of the body and were chosen based on the relative frequencies with which they appear in the naming (tact and listener) repertoires of 2- to 3-year-old children (see Chapter 5). Thus, the touches to body-parts that feature most frequently in children's naming repertoires were designated as baseline gestures; conversely, the touches to body-parts that seldom evoke correct tact and listener responses were employed as target gestures.

Procedure

A multiple-baseline procedure was employed; each child participated in all conditions of the experiment. Training was presented to the children in a staggered manner to demonstrate experimental control of any resulting changes in target behaviour. The flow of the procedure is illustrated in Figure 7.2. (left panel).

Table 7.2.
Description of movement modelled and accepted responses variations for each baseline gesture (B1-B4) and target gesture (T1-T15) used during training and testing. The experimenter always used her left hand for modelling hand-to-body touches but children could respond with either hand.

Baseline / Target gestures	Behaviour modelled by the experimenter	Accepted response variations
B1 Nose	Tips of fingers touching nose	Touching nose
B2 Ear	Tips of fingers touching right ear	Touching either ipsilateral or contralateral ear
B3 Neck	Tips of fingers touching neck (Adam's apple)	Touching anywhere on the neck
B4 Lips	Tips of fingers touching lips	Touching any area of the lips
T1 Temple	Tips of fingers touching right temple	Touching either ipsilateral or contralateral temple (excluding head/hair, forehead and ear)
T2 Bridge of foot	Tips of fingers touching bridge (arch) of right foot	Touching contralateral bridge of the foot (excluding top of foot, sole, toes and heel)
T3 Armpit	Tips of fingers touching right armpit	Touching contralateral armpit (excluding upper arm)
T4 Thigh	Tips of fingers touching middle of left thigh	Touching ipsilateral thigh (excluding knee and hip)
T5 Crook of arm	Tips of fingers touching crook of right arm	Touching crook of contralateral arm (excluding lower and upper arm)
T6 Crown	Tips of fingers touching middle of crown	Touching the top of the head (excluding forehead, back of the head, or temple)
T7 Ankle	Tips of fingers touching left ankle bone	Touching the area of either ankle (excluding shin, calf or any part of the foot)
T8 Wrist	Tips of fingers touching right wrist	Touching contralateral wrist (excluding lower arm and back of the hand)
T9 Upper arm	Tips of fingers touching middle of right upper arm	Touching contralateral upper arm (excluding crock of arm and shoulder)
T10 Lower arm	Tips of fingers touching middle of right lower arm	Touching contralateral lower arm (excluding crock of arm, elbow, wrist and pulse)
T11 Shin	Tips of fingers touching middle of left shin	Touching shin area of either leg (excluding ankle, top, side or back of the knee and calf)
T12 Calf	Tips of fingers touching middle of right calf	Touching calf area of either leg (excluding ankle, shin, and top, side or back of the knee)
T13 Thumb	Tip of index finger touching middle of right thumb	Touching or grabbing contralateral thumb (excluding other fingers)
T14 Hip	Tips of fingers touching middle of right hip bone	Touching hip area (excluding waist line or top of thigh)

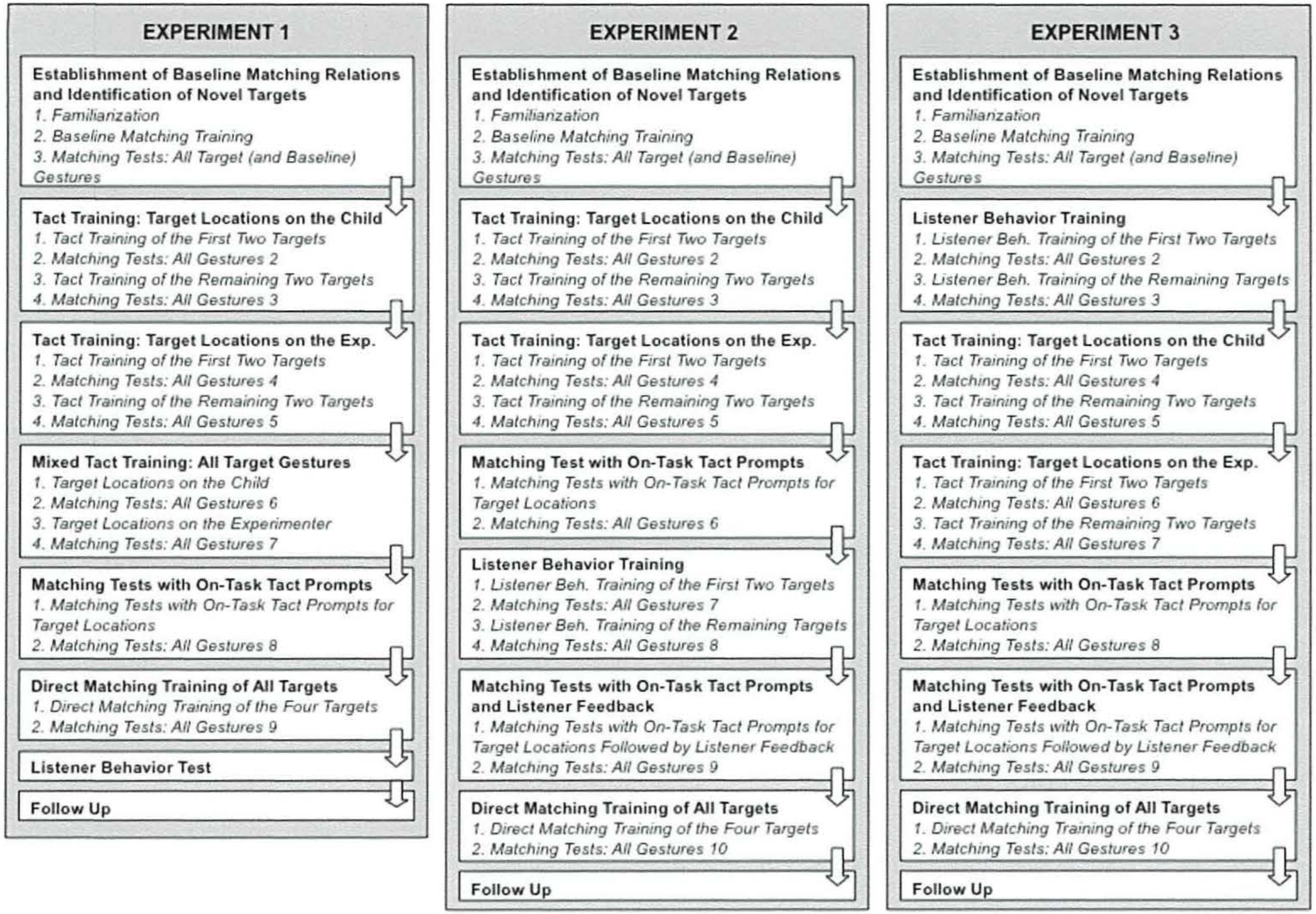

Figure 7.2. Flowcharts showing the stages of Experiment 1, Experiment 2, and Experiment 3.

Baseline Matching Training and Identification of Novel Targets

Familiarization. The experimenter established a good rapport with the children during unstructured daily play sessions in the nursery playroom before inviting each child to participate in one-to-one play with toys in the test room. The child was asked to show Teddy what the experimenter was doing by repeating the actions shown; the experimenter said, "Can you show Teddy how you do this?" before commencing the first trial. The experimenter modelled 8 different hand-to-body gestures twice per session and instructed the child to "Do this" before she presented each gesture. The body-parts touched by the experimenter on modelling trials were those that did not feature frequently in the naming repertoires of young children who attended the nursery (see Camões-Costa et al., 2010). At this early stage of the procedure, the experimenter determined which of the corresponding hand-to-body touches were not part of the individual children's trained matching repertoires and could therefore be employed as target gestures in the experiment (see Horne & Erjavec, 2007). If the child correctly matched a gesture more than once during the first two sessions of its presentation, this indicated that the gesture already featured in the child's trained matching repertoire, and consequently this target body-part touch was replaced with another; the replacement gestures were likewise tested over two sessions. This continued until four novel target gestures were identified for each child. No reinforcers were delivered following any of the children's responses (accurate matches or mismatches), but the children were allowed to play with Teddy's toys at the end of each session. In this and subsequent training conditions, children were tested at least three times a week. Each session lasted approximately 15-20 min.

Baseline matching training. This condition established reliable, prompt, and correct matching responding to the verbal request, "Do this," followed by modelling of a hand-to-body gesture on each trial. The details of this part of the procedure were presented in previous publications (see Erjavec et al., 2009; Horne & Erjavec, 2007) and only a summary is provided here: In each training session there were three modelling trials of each of the 4 baseline gestures (12 trials per session), with up to three presentations of the modelled gesture per trial (as necessary). The modelled gestures were presented in a predetermined randomized order, with the added constraint that no more than two trials of the same gesture could occur in succession. Matching of the four baseline gestures was trained under continuous reinforcement, to a criterion of 5 out of 6 correct responses per gesture, over two consecutive sessions. When matching performance met the 100% reinforcement criterion, reinforcement rate was reduced to 50% on a VR2 schedule. The intermittent reinforcement criterion was 11 out of 12 correct responses across three trials per gesture within a single session.

Matching tests: Target (and baseline) gestures. Next, the children were presented with 2 modelling trials of each untrained target gesture (4) and trained baseline gesture (4); target and baseline trials were delivered in a pre-randomized sequence (total of 16 trials per session). At the start of each session the experimenter asked, "Shall we play the game?" and before she modelled each gesture she prompted the child, "Can you do this?" Children's correct matching responses to baseline models were intermittently reinforced on a VR2 schedule, but their responses to the target models were never reinforced. In the first two sessions only, any target gestures to which more than one correct response was emitted were replaced, to ensure that none of the targets featured in the children's (extra-experimentally) trained matching repertoires. The criterion for performance of the baseline gestures was 13 out of 16 (81%) correct over two consecutive sessions. If the criterion was not met, the experimenter was required to re-train baseline responding before conducting the next test session – however, this was not necessary in this or any subsequent conditions of the study.

The number of test sessions was staggered across the participants; they received either 3, or 6, or 9 sessions before moving on to the next training condition. This allowed the effects of the subsequent interventions to be compared with those of repeated unreinforced presentations of the target gestures, and to control for non-experimental events that may occur over time.

Tact Training: Target Locations on the Child.

The aim of this training condition was to determine whether teaching the children to tact each of the four target locations *on their own body* would facilitate their matching of the modelled touches to those same locations *on the experimenter's body* on subsequent matching test trials. This tested the hypothesis that naming of target body locations can be instrumental in children's production of matching responses.

Tact training was administered in two stages for each child. First, the child was trained to accurately tact two of the four target body parts. The experimenter pointed to a target location on the child's body (e.g., *Thumb*) and said, "Look! Tell Teddy what this is called?" If the child responded correctly, the experimenter exclaimed enthusiastically, "Yes, it is the *Thumb*! Clever girl!" Occasionally (on 33% of trials) she also presented a toy for the child to play with as additional reinforcement. If the child produced an incorrect tact or no tact, the experimenter stated, "This is the *Thumb,*" before asking the child, "Can you say *Thumb*?" If the child failed to respond, the experimenter repeated presentation of the latter training sequence up to two more times on each trial before moving onto the next. Tact trials for each target location were alternated in the training sessions in a pre-randomised sequence. As tact responding became more proficient, the experimenter's prompt was abbreviated to, "What is this?" and the reinforcement rate was reduced to 25%. Finally, the child's tact responses were tested in extinction. The criterion was 7 out of 8 correct tact responses per target body location.

Following this, three test sessions for matching of target (and baseline) gestures were conducted, as described earlier (see *Matching tests: Target (and baseline) gestures*). In this and all subsequent test blocks, if the child matched each target gesture on at least 4 out of 6 trials over three test sessions – showing consistent matching of all target gestures – the remaining training and test conditions would not have been administered; instead, the child would have progressed to the final tests (*Listener Test* and *Follow Up*; see below).

The second stage of the tact training condition was administered next; the child was trained to tact the remaining two target body locations, exactly as described for the first two, followed by another three-session block of matching tests.

Tact Training: Target Locations on the Experimenter

The aim of this condition was to determine whether teaching the children to tact each of the four target locations *on the experimenter's body* would facilitate their matching of the modelled touches to those same locations on subsequent matching test trials.

Procedurally, this tact training condition was identical to the previous one, except that the experimenter pointed to the target locations on her own body, rather than on the child's body, while training the child to produce the target tacts. As in the previous training condition, tact training was first administered to criterion for two of the target body locations, followed by a three-session block of matching tests. This was followed by tact training of the remaining two target locations, and by three more sessions of matching tests.

Mixed Tact Training: All Target Gestures

The aim of this training condition was to ensure that the tact responses trained previously were maintained over time for all four target body locations, regardless of whether these were on the experimenter's or the child's body.

Target locations on the child. This training was also administered in two stages. First, one tact test trial was conducted for each of the four target locations. If the child responded correctly on all four trials, matching tests were re-administered. If any errors occurred on the tact test trials, mixed tact training was conducted at a progressively thinner reinforcement schedule until criterion was reached in extinction – the child produced at least 11 correct responses over 12 consecutive tact trials, across the four targets, with 3 trials per target body location. The matching tests were then administered, exactly as before, except that from this point onwards in the procedure the four tact responses to the child's body parts were probed once each before each test session to establish that tact responding to all target locations was maintained. If tact performance fell below criterion, mixed tact training was re-administered and criterion performance re-established before proceeding; if the child responded correctly to the four tact probes, one matching test was conducted. Probing for tact responses and matching tests were repeated until three test sessions were completed.

Target locations on the child and the experimenter. One tact test trial was conducted for each target location (4 per child and corresponding 4 per experimenter). If tact performance was errorless a matching test was conducted. If any errors were recorded, mixed tact training was administered to criterion (as described above). Thus at this point, prior to each matching test session, the child was required to show errorless tacting of all target locations that the experimenter pointed at on the child's body and on her own body.

In order to evaluate the effects of repeated matching tests over time on the accuracy of children's matching of target gestures, and to compare these with the effects of the next intervention, the number of matching test sessions was staggered across children; they completed either 3, or 6, or 9 sessions before proceeding to the next training condition.

Matching Tests with On-Task Tact Prompts for Target Locations

The aim of this training condition was to determine whether children's untrained matching would become more accurate if, on each matching trial, the experimenter touched a target location on her own body and maintained this gesture while she asked the child to tact that target location then prompted the child to touch the same location on her own body.

The children were once again invited to teach Teddy about body-parts. Tact performance was reviewed and if necessary retrained (as in *Mixed Tact Training: All Target Gestures*). After the child demonstrated errorless tact responding, a matching test session was conducted in the same way as for previous matching tests except that the experimenter provided tact prompts during modelling of the corresponding target gestures. There were three trials per target gesture (12 trials per session). On each trial, the experimenter first said, "What's this?" while pointing to a target location on herself. If the child did not respond within 3s, the experimenter prompted the child to do so by saying "Tell me!" up to two more times. If the child responded incorrectly, the experimenter provided corrective feedback as in previous tact training. When the child produced a correct tact, the modelling instruction was presented, up to three times, as needed; if the child still did not respond, the next trial was presented. As in previous matching tests, there were no scheduled consequences for any of the child's responses to the modelled target gestures. Each child completed three sessions.

Next, the children were presented with matching tests, without tact probes, as in the previous conditions; the number of sessions was once again staggered across the three children (either 3, or 6, or 9 were administered).

Direct Matching Training of All Target Gestures

The aim of this training condition was to establish whether children's responses to all target models in the matching tests could be further improved by matching training.

The matching training of target gestures was conducted in much the same way as for baseline gestures at the outset of the study (see *Baseline Matching Training*). Shaping and "putting-through" procedures were used when necessary. As each child's performance became more accurate, the experimenter gradually reduced the reinforcement rate. Matching training was complete when a child produced 11 out of 12 correct responses across the four target gestures, tested in extinction. This was followed by three matching test sessions.

Listener Behaviour Test

A listener behaviour test was conducted to determine whether the children's success on the matching task (i.e., before direct matching training) correlated with their listener responses to the named target locations on the child's body. One session was administered with four trials per target body location (16 trials in all) presented in a predetermined randomized order. On each trial, the experimenter asked the child to touch a named body location (e.g., "Can you touch your wrist?"). There were up to three prompts per trial, if necessary, and the children's listener responses were not reinforced or corrected.

Follow Up

One matching test session was administered every two to three weeks, until five sessions were conducted. This completed the experimental procedure.

Coding of Children's Responses

Each session was recorded on videotape and coded using pre-determined response criteria to identify, on each training and test trial, whether a child produced a correct response, an incorrect response, or failed to emit a response. The movement sequences considered as correct responses to each modelled gesture and listener prompts are listed in Table 7.2. For each target, the boundary with other targets was pre-set in a manner that enabled the coders to determine whether a child's response on a matching trial approximated the antecedent model as opposed to any other target or baseline model or none of these. The response criteria excluded behaviours that children naturally produce at this age, such as clapping, kicking, touching clothes or near objects, extending hands, mouthing fingers, rubbing eyes, and scratching any part of the body. If a child performed a correct response immediately after an incorrect response, it was coded as a "self-correction" and counted as correct in the final analyses. Conversely, an incorrect response emitted immediately after a correct response was coded as a "correct-to-incorrect" and counted as incorrect (see Erjavec & Horne, 2008; Horne & Erjavec, 2007). Such multiple responses were very infrequent. In matching test sessions, they occurred on 3% of baseline trials (range: 2–6%) and on 3% of target trials (range: 2–5%). Overall, self-corrections were scored eight times more frequently than correct-to-incorrect responses. Children's tact responses also needed to be entirely correct.

Also recorded was whether a reinforcer was delivered on a particular baseline gesture matching trial, the number of models (1, 2, or 3) per trial required to evoke a response, and the form of each incorrect response (see coding sheet in Appendix D).

Inter-Observer Agreement

A second scorer, familiar with infant research but blind to the aims of the present experiment, independently coded 25% of sessions selected on a random basis. Inter-observer agreement was calculated for each training and test phase by dividing the number of agreements by the total number of coded responses then multiplying the result by 100. An agreement was defined as two independent observers assigning the same response code on a given trial. Agreement per phase ranged from 98% to 100%.

7.3.2 Results and Discussion

Children's Matching of Baseline Gestures

The four trained matching relations for all children are listed in Table 7.2. (top panel). Each child completed training in three sessions (the minimum required by the mastery criteria, see Procedure). The children continued to respond correctly to baseline models throughout the procedure in all conditions (see Figures 7.3., 7.4., and 7.5.).

Children's Performance in Tact Training Sessions

Across 3 children and 12 target behaviours, the children learned to tact the relevant locations on their own bodies in an average of 26 trials (range: 5-78 trials). Much fewer trials were needed to subsequently train tact responses for the corresponding target locations on the experimenter's body (8 trials on average; range: 0-19 trials). This pattern of results was observed in each child's data (see Figures 7.3., 7.4., and 7.5.). Indeed, after tact training on the child's body, several of these tacts (3 for Anna and 3 for Emma) were in place at the outset of tact training on the experimenter's body; for these tacts, Anna and Emma did not require mixed tact training. Mol's tact relations were more fragile and all required extensive mixed training (see Figure 7.4.).

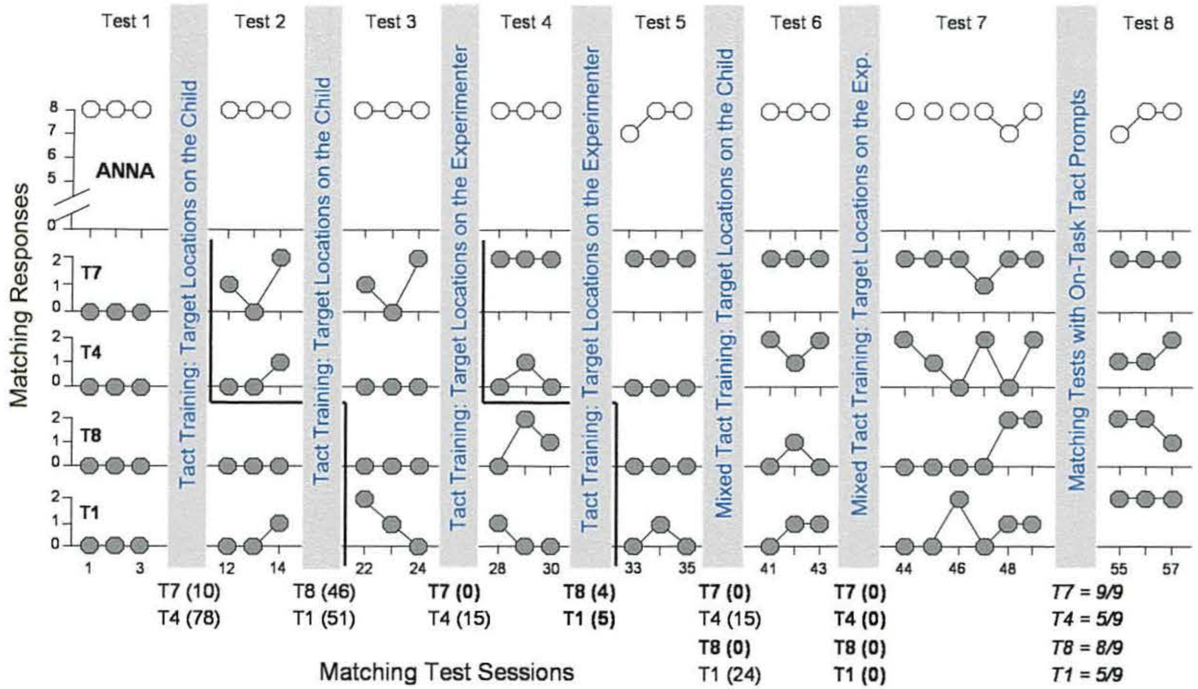

Figure 7.3. Correct matching responses emitted by Anna in the eight baseline trials (plotted together at the top of each figure and represented by open circles) and the eight target trials (plotted separately for the four target behaviours, with two trials per gesture, and represented by filled circles) presented during each session of the multiple baseline procedure in Experiment 1. Training and testing was administered in a staggered manner (see text) over five experimental training conditions. Each training phase is labelled and denoted by a shaded area; the bold lines indicate where training was applied in a staggered manner to pairs of target actions. Underneath, the number of training trials that needed to be administered before criterion performance was attained (T) and the proportion of trials on which a child responded correctly in probing sessions *(T)* are presented for each target gesture. Bold figures indicate the relations that were in place at the outset (i.e., only 0-5 trials were required to reach criterion performance)

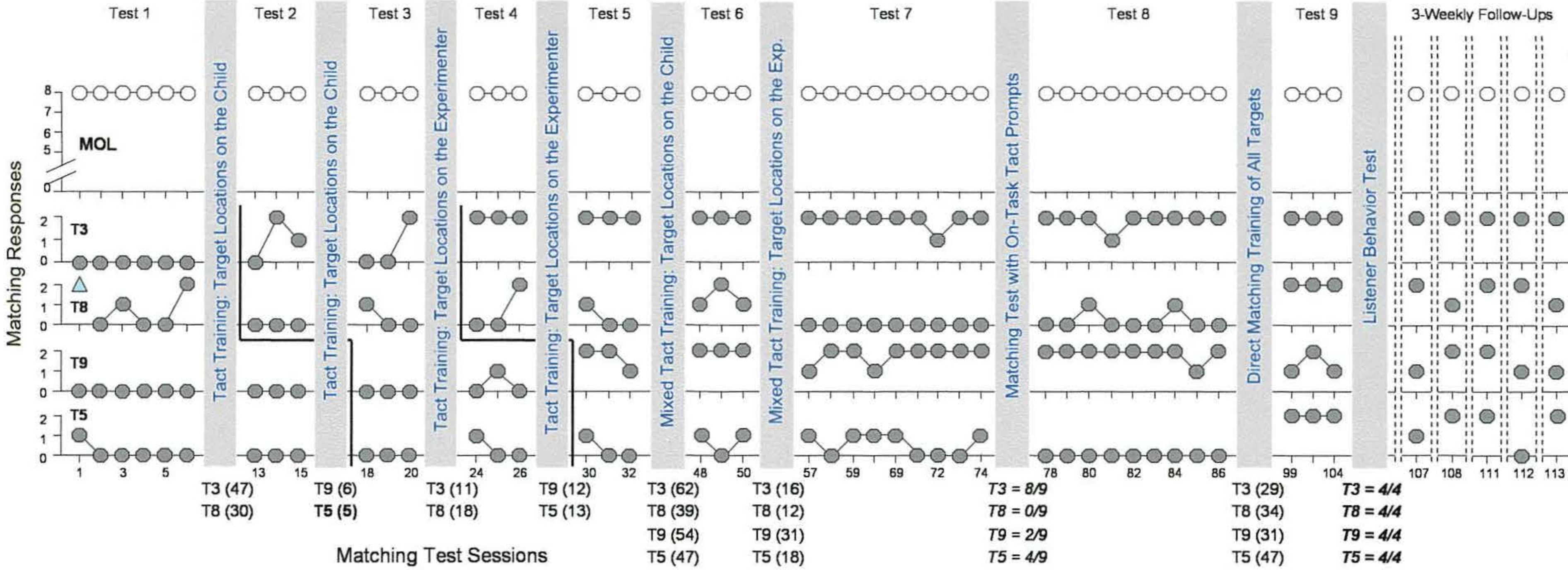

Figure 7.4. Data for Mol; otherwise as for Figure 7.3., except that the shaded triangles represent gestures that already featured in the Mol's trained matching repertoire which were replaced by novel gestures.

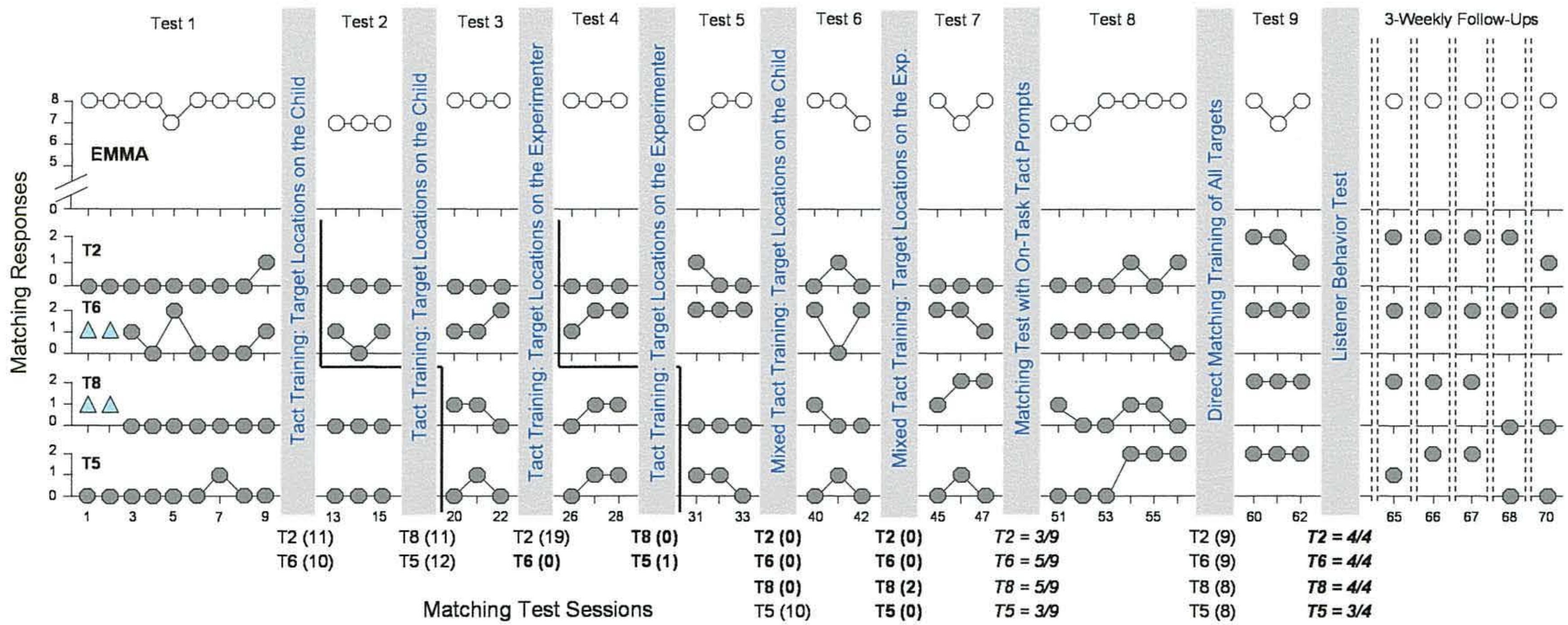

Figure 7.5. Data for Emma; otherwise as for Figure 7.4.

Overall, the results show that tact training often generalised from target locations on the child's body to the corresponding locations on the experimenter's body; this effect ranged from moderate savings in the number of training trials required to establish each tact to full emergence of tacts without training.

Children's Matching of Target Gestures

The sets of four gestures that were identified as targets for each child are listed in Table 7.1. and described in Table 7.2. (bottom panel). Children's matching of each target gesture in the test trials was classified as either (i) *consistent*, if correct on at least two-thirds (66-100%) of the trials; (ii) *intermittent* (33-66% correct trials); (iii) *infrequent* (1-32% correct trials); and (iv) *unmatched* (no matches). Note that for each child, the number of matching tests following each training condition may differ between targets, in accordance with the staggered and pair-wise introduction of the independent variables (e.g., tact training on the child's body) throughout the procedure. Therefore, in order to calculate % matching per phase for each target, matching responses were summed over *all* the matching tests that were conducted immediately after one training phase and before the beginning of the next.

In the matching tests that followed *baseline matching training* and prior to the first round of tact training (i.e., across Test 1 sessions for the first pair of targets, and Test 1 and Test 2 for the second pair of targets), out of a total of 12 untrained target gestures across all 3 children, 6 were infrequently matched, and the remaining 6 were not matched at all. These data show no evidence that repeated modelling of target gestures resulted in increased matching, which is consistent with previous findings (Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007).

After staggered *target tact training on the child's body*, the children's matching performances improved for some of the gestures, but no target was matched consistently. Looking at Test 2 and Test 3 scores for the pairs of target gestures trained first, and at Test 3 and Test 4 scores for the pairs of gestures that were trained second for each child, 5 out of 12 targets were now matched intermittently, 6 infrequently, and 1 target was not matched (see Figures 7.3., 7.4. & 7.5.). In the tests administered after staggered *target tact training on the experimenter's body*, but before the next round of training (i.e., across Test 4 and Test 5 for the first pair of targets, and in Test 5 for the second pair), the children matched 4 of their targets consistently, 1 intermittently, 5 infrequently, whereas 2 remaining targets were not matched. Next, following *mixed tact training of all target gestures on the child* (Test 6), the children matched 6 of the targets consistently, 2 intermittently, and 4 infrequently. Finally, following *mixed tact training of all target gestures on the experimenter* (Test 7), the children matched 5 of the targets consistently, 2 intermittently, and 5 infrequently. Clearly, tact training administered in the absence of modelling was effective in establishing and/or increasing matching of untrained target gestures in subsequent tests. However, after 20 (Emma), 25 (Anna), and 35 (Mia) tact training sessions, consistent matching – defined a priori as correct responding on at least two thirds of trials (see Procedure) – did not develop across all targets for any of the participants. The data show no evidence that training the children to tact the target locations on the experimenter's body resulted in larger improvements in their matching of the target gestures than when they were trained to tact these same locations on their own bodies.

The children were next taught to tact the location touched by the modeller before they responded to the "Do this" matching prompt on test trials. This intervention aimed to increase the incidence of (covert) naming of the target body locations during subsequent (unprompted) matching tests. In matching tests following this intervention (Test 8), the children matched 6 out of 12 target gestures consistently; 2 intermittently, 3 infrequently, and 1 target was not matched. However, this tact-prompt intervention was sufficient to establish consistent matching for one child, Anna, across all of her target gestures (see Figure 7.3.). The remaining two participants required direct matching training, administered next. As expected, direct matching training resulted in consistent matching of all target behaviours for these two children (see Test 9 for Mol, Figure 7.4. and Emma, Figure 7.5.); this outcome replicated previous findings (Erjavec et al., 2009; Horne & Erjavec, 2007).

Two children participated in the listener behaviour test. On 16 trials per child, responding was 100% for Mol and 94% for Emma, showing that listener responses, which were never directly trained, emerged as a result of tact training. This is consistent with the existing literature (e.g., Horne et al., 2007; Lowe et al., 2002, 2005) and predictions of the naming account of Horne and Lowe (1996). Due to her leaving the nursery, Anna did not take part in either *Listener* or *Follow Up* tests.

In the Follow Up, Emma and Mol were presented with one matching test session every two to three weeks until five sessions had been conducted. On average they matched 2 of their 8 targets at 100%, 3 consistently, and the remaining 3 intermittently. This shows that the majority of the target matches, when directly trained, were well maintained over the following 3 months in the absence of reinforcement or corrections. Children's incorrect responses on all matching test trials were noted and examined. These responses are reported in Appendix G. The children often touched, in response to the target model, the body parts adjacent to the target location, showing lack of discrimination between specific body locations. For example, in response to modelled touches to the armpit, Mol touched her tummy on 32%, her chest on 23% and her upper arm on 26% of trials. Theoretically at least, listener behaviour training, which includes manual correction following errors, might be expected to improve discrimination between body parts. This was investigated in the next two experiments.

7.4 Experiment 2

7.4.1 Method

Participants

Two typically developing girls, Gina (31 months) and Mila (33 months) and one boy, Jack (31 months) took part.

Settings, Apparatus, and Procedure

The setting and apparatus were as described in Experiment 1. The baseline and target behaviours allocated to each child are shown in Table 7.1. The flow of the experimental procedure is illustrated in Figure 7.2. (middle panel). The sequence of interventions was: (i) baseline matching training; (ii) tact training (locations on the child and experimenter); (iii) tact prompts during matching tests; (iv) listener training; and (v) tact prompts with naming feedback. As an addition to the procedure described for Experiment 1, it was planned to review previously trained tact and listener behaviour responses at the start of each matching test, and if necessary retrain them. However, this prolonged the procedure, reducing the children's willingness to participate; tact/listener reviews were therefore administered only prior to the first, fourth, and seventh matching test sessions presented after each intervention. These reviews were also administered prior to any new training/intervention, which made the mixed tact training sessions administered in Experiment 1 unnecessary.

Listener Behaviour Training

Listener behaviour training was administered in two stages for each child. First, the child was trained to respond accurately to the names for two of the four target body locations. The experimenter asked "Can you show Teddy where is your (target body-part name)?" then waited for the child to respond. If the child touched the correct location, the experimenter exclaimed enthusiastically, "Yes, that's right. Clever girl (or boy)!" and occasionally also gave the child a toy to play with. Otherwise, the experimenter said, "Here it is!" and moved the child's hand to touch the appropriate location, before asking the child again, "So, can you now touch your (repeat target body-part name)?" A correct touch was reinforced; if the child failed to respond, the latter training sequence was repeated up to two more times on each trial. Listener trials for each target location were alternated in each training session in a pre-randomized sequence. As the child became more proficient at correctly locating the named body-parts, the experimenter gradually faded the prompts, and reduced the reinforcement rate to 25%. Finally, the child's listener behaviour was tested in extinction. The criterion was 7 out of 8 correct trials per body part.

After listener training for the first two target locations was completed, three matching tests were conducted as described in *Matching tests: Target (and baseline) gestures*. Next, listener training was conducted for the remaining two target locations, followed by matching tests, staggered across children.

Matching Tests with On-Task Tact Prompts for Target Locations and Naming Feedback

The aim of this training condition was to determine whether the children's untrained matching would become more accurate if on each matching trial (i) the child first tacted accurately the target location, and (ii) following a correct matching response the experimenter provided feedback by saying, "Well done, you're touching your (target body-part)". Nine such trials were conducted for each target location, followed by another block of matching tests.

Finally, direct matching training and follow up tests were implemented as in Experiment 1.

Coding and Inter-Observer Agreement

Children's responses were coded according to the criteria described for Experiment 1. In the matching test sessions, multiple responses occurred on 4% of baseline trials (range: 3–5%) and on 4% of target trials (range: 3–5%). Overall, self-corrections were scored four times more frequently than correct-to-incorrect responses.

A second scorer independently coded 32% of sessions selected on a random basis. Inter-observer agreement in each phase ranged from 95% to 100%.

7.4.2 Results and Discussion

Children's Matching of Baseline Gestures

The four gestures that were trained as baseline matching relations to all children were the same as in Experiment 1 (see Table 7.2., top panel). Each child completed matching training in the minimum three sessions. The children continued to respond correctly to baseline models in all tests (see Figures 7.6., 7.7., and 7.8.).

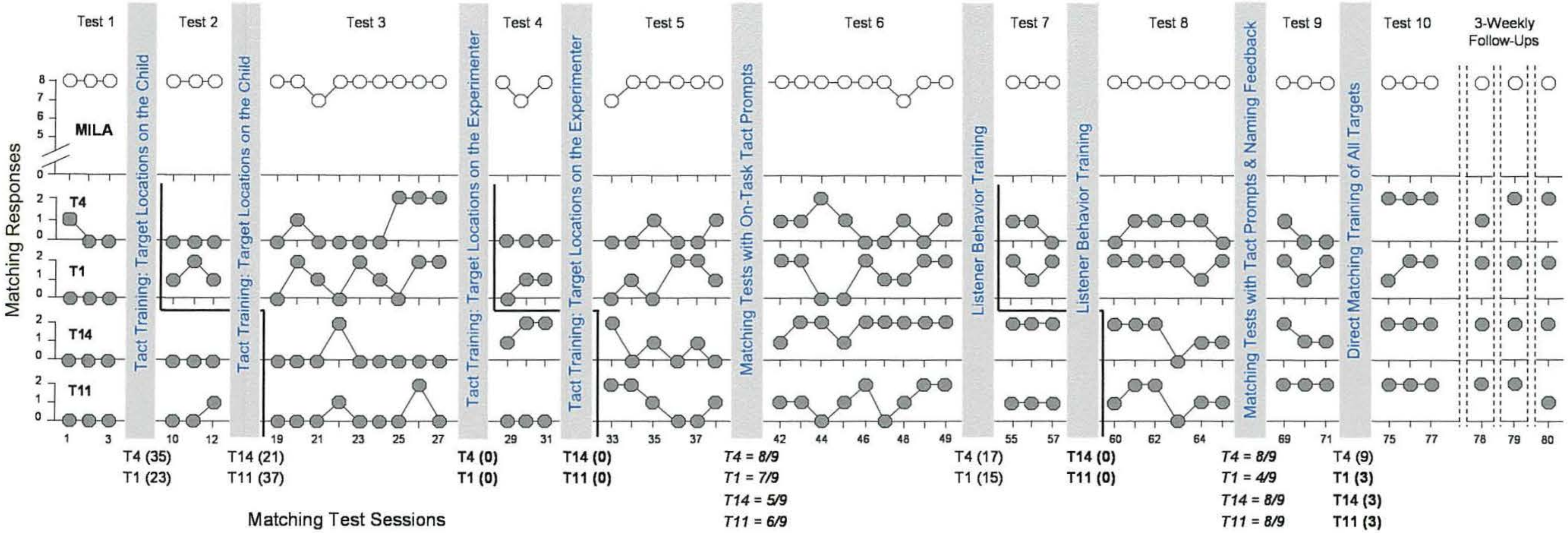

Figure 7.6. Data for Mila. Otherwise as for previous figures.

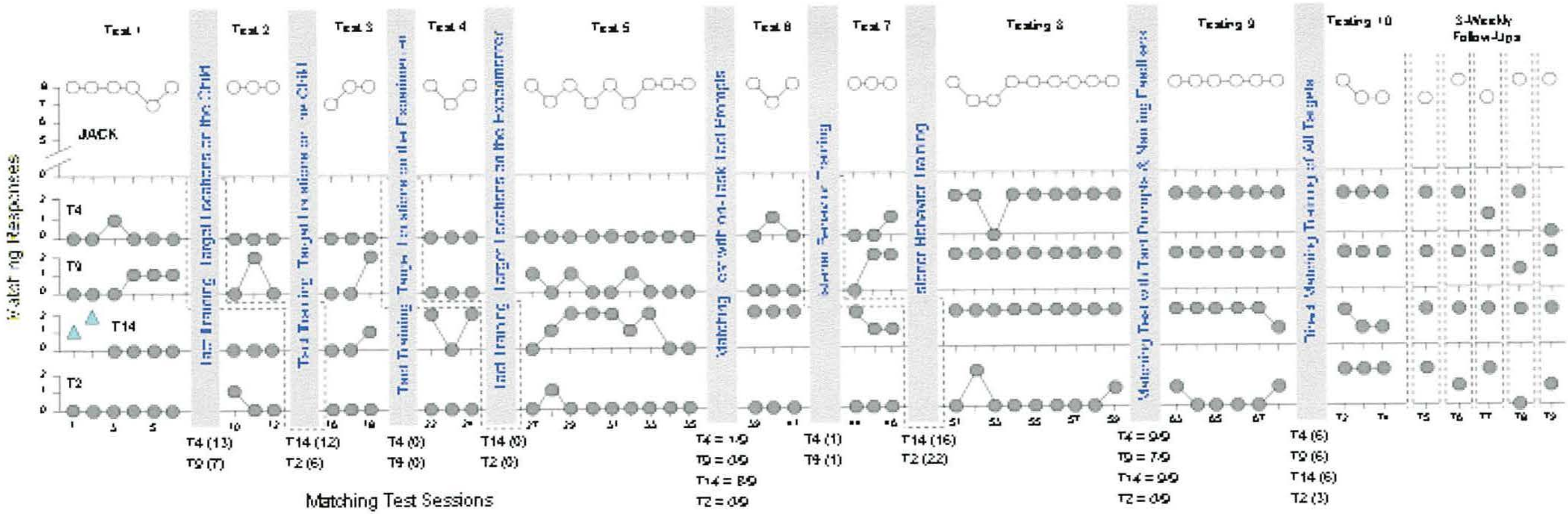

Figure 7.7. Data for Jack; otherwise as for previous figures.

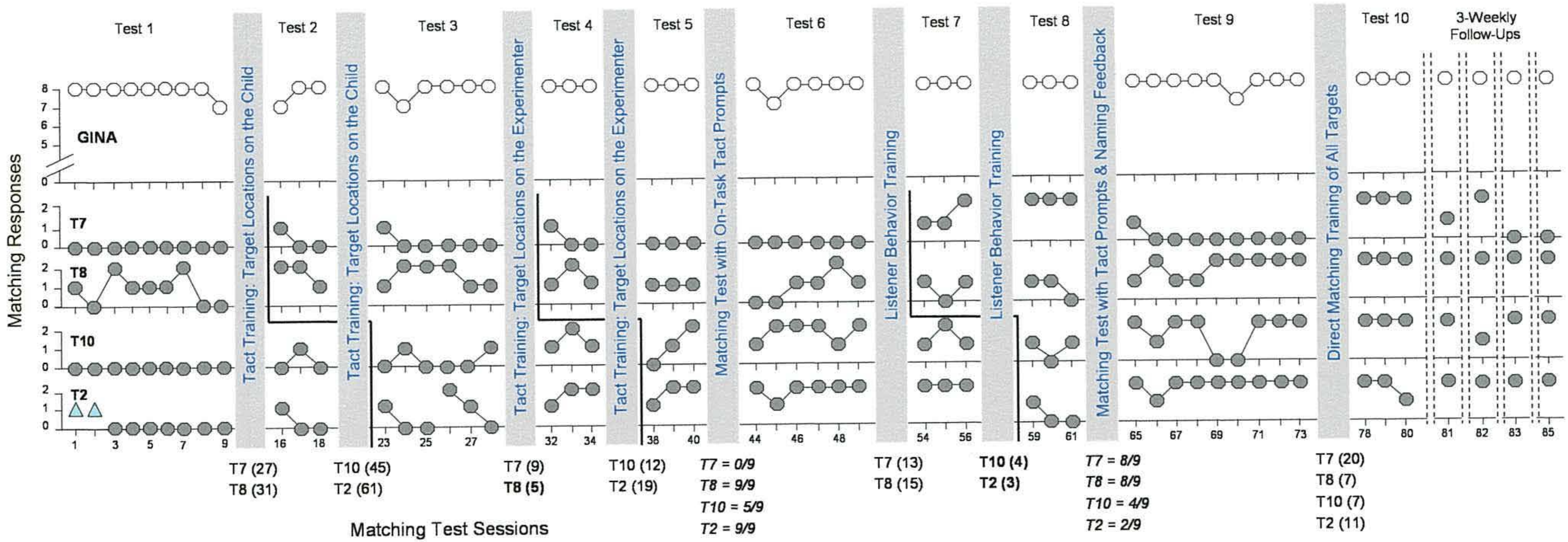

Figure 7.8. Data for Gina; otherwise as for previous figures.

Children's Performance in Tact and Listener Behaviour Training Sessions

Across 3 children and 12 target responses, the children learned to tact the target locations on their own bodies in an average of 27 trials (range: 6-61 trials). Replicating the results of Experiment 1, tacts trained on the child's body generalised to target locations on the experimenter's body. For Mila and Jack, all tacts were at criterion without training (see Figure 7.6. and 7.7., respectively), and the remaining child (Gina) required 5-19 trials to meet the criterion, considerably fewer than in the preceding target tact training on her own body (see Figure 7.8.).

It is well documented in the literature that tact training, administered to children of this age, establishes the whole naming relation; this is evident in the emergence of listener behaviour in tests that use well established, simple responses such as pointing to a whole object (e.g., Lowe et al., 2002; 2005). By contrast, correct listener responses in the present tests required children to make accurate discriminations between the adjacent body parts. Nevertheless, the data show that Mila and Jack emitted correct listener responses to half of their target locations on the first trial; the remaining listener responses required only 13 trials, on average, to reach criterion performance (range: 3-22 trials; see Figures 7.6., 7.7., and 7.8.).

Children's Matching of Target Gestures

In the tests following baseline matching training, out of a total of 12 target gestures (across all children), 1 target was matched intermittently, 7 infrequently, and 4 remaining targets were not matched at all. As in Experiment 1, there was no evidence that repeated presentation of modelling and response opportunities led to improvements in children's matching of target gestures.

Following tact training of target locations on the child's body, 1 target gesture was matched consistently, 3 intermittently, 6 infrequently, and 2 remaining targets were not matched. After tact training of target locations on the experimenter's body, the children matched 1 target gesture consistently, 6 intermittently, 4 infrequently, and the remaining gesture was not matched. These data replicate the results of Experiment 1 and show that training the children to tact target locations resulted in some correct matching of target gestures in subsequent tests. However, as in Experiment 1, none of the children showed consistent matching across all of their target body parts.

In the tests administered after the on-task tact prompts intervention, the children matched 5 targets consistently, 3 intermittently, 1 infrequently, and 3 were not matched. Although this intervention increased children's correct matching of some targets, it was not sufficient to establish consistent matching of all gestures for any of the children (see Figures 7.6., 7.7., and 7.8.). These results were similar to Experiment 1, in which only one participant consistently matched all target gestures at this point in the procedure.

Listener Behaviour Training was administered next. In the matching tests that followed, 6 out of 12 targets were matched consistently, 4 intermittently, and 2 infrequently. Although children's matching continued to improve, none of the children consistently matched all of their target gestures. They proceeded to the next stage of training where on each trial the experimenter first evoked the child's tacting of target body location, then presented the matching prompt "Do this", and finally provided naming feedback for any correct matching responses. In the subsequent matching tests, the children consistently matched 9 of their target gestures, but the remaining 3 were matched only infrequently. This intervention improved the children's performances considerably, but for each child one target gesture remained poorly matched (see Figures 7.6., 7.7., and 7.8.). Therefore, direct matching training was conducted next.

Direct matching training resulted in consistent matching of all target behaviours for all children (12 targets in total) in repeated tests administered in extinction, as in Experiment 1. In Follow Up, all children were given one matching test session every two to three weeks. Across all children, 11 target gestures continued to be matched consistently in the first 3 follow ups, but by the 4th follow up there was evidence of deterioration in matching of 2 of the 8 target gestures tested. At the 5th follow up, only 2 out of 4 targets tested were matched. This pattern of maintenance in extinction for some target matches, but decline in others is similar to that in Experiment 1.

Children's incorrect responses on all matching test trials are reported in Appendix G. These data show that, as in Experiment 1, children's errors mostly consisted of touches to body parts adjacent to the target locations. Listener behaviour training, which was intended to improve children's discriminations between adjacent target body-parts, was administered late in the procedure. By the end of listener training Jack matched 3 of his 4 targets at close to 100%, but showed no improvement for his remaining target. Gina showed transient improvement of matching for 1 target, but a decline in another; and there was no discernible effect of listener training on Mina's target matching. The next experiment was designed to investigate whether listener behaviour training may be more effective in improving children's matching of target gestures if administered earlier in the procedure. The next experiment, established whether the effect of tact training, which was demonstrated in Experiment 1 and Experiment 2, would be greater if the children underwent tact training *after* they had learned listener responses for each target body-part.

7.5 Experiment 3

7.5.1 Method

Participants

Three typically developing boys aged 28 months (Fin), 32 months (Carl), and 34 months (Fex) at the start of listener behaviour training participated in this experiment (see Table 7.1.).

Settings, Apparatus, and Procedure

The setting and apparatus was as described in Experiment 1. The baseline and target gestures allocated to each child are shown in Table 7.1. The experiment consisted of the same training conditions described in Experiment 2, but in the following order: (i) listener behaviour training; (ii) target tact training of the child's body and then on the experimenter's body; (iii) matching tests with on-task tact prompts for target locations; (iv) matching tests with on-task tact prompts for target locations and naming feedback; (v) direct matching training of all target gestures; and (vi) follow up sessions. The flow of the procedure is illustrated in Figure 7.2. (right panel). Testing and retraining (as needed) of tact and listener responses was conducted at the start of the matching test sessions as in Experiment 2.

Coding and Inter-Observer Agreement

Children's responses were coded as in the Experiment 1. In the matching test sessions, multiple responses occurred on 6% of baseline trials (range: 3–8%) and on 4% of target trials (range: 3–6%). Overall, self-corrections were scored two times more frequently than correct-to-incorrect responses.

A second scorer independently coded 33% of sessions selected on a random basis. Inter-observer agreement in each phase ranged from 99% to 100%.

7.5.2 Results and Discussion

Children's Matching of Baseline Gestures

Fex and Fin completed baseline matching training in three sessions (the minimum required to meet the criterion) and Carl needed four sessions to do so. Figures 7.9. and 7.10. show that the children continued to respond correctly to the baseline models in all tests.

Children's Performance in Listener Behaviour and Tact Training Sessions

In this experiment, listener behaviour training was administered first. Across 3 children and 12 target responses, training children to touch the correct body locations after hearing the experimenter's naming of these locations took 44 trials per target behaviour, on average (range: 11-86 trials). Compared to tact responses trained first in Experiments 1 and 2 (accomplished in *M*=26/27 trials), listener behaviour was clearly more difficult to establish. A comparison between the present results and those of Experiment 2, where listener behaviour training was administered late in the procedure, confirms that tact training had been effective in establishing and/or improving children's corresponding listener responses – 4 out of 12 were in place at the outset of Experiment 2 listener training, 2 required only 3 or 4 training trials, and the remainder took much fewer trials to train (*M*=13) than was the case in the present experiment (*M*=44).

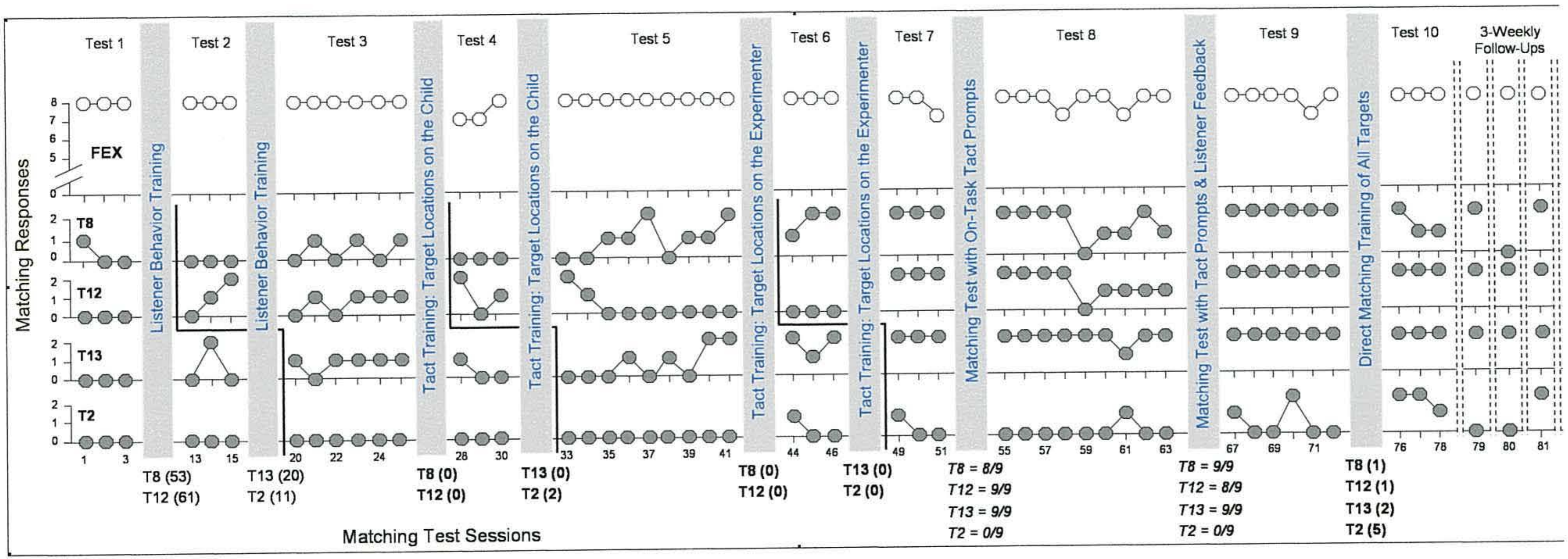

Figure 7.9. Data for Fex; otherwise as for previous figures.

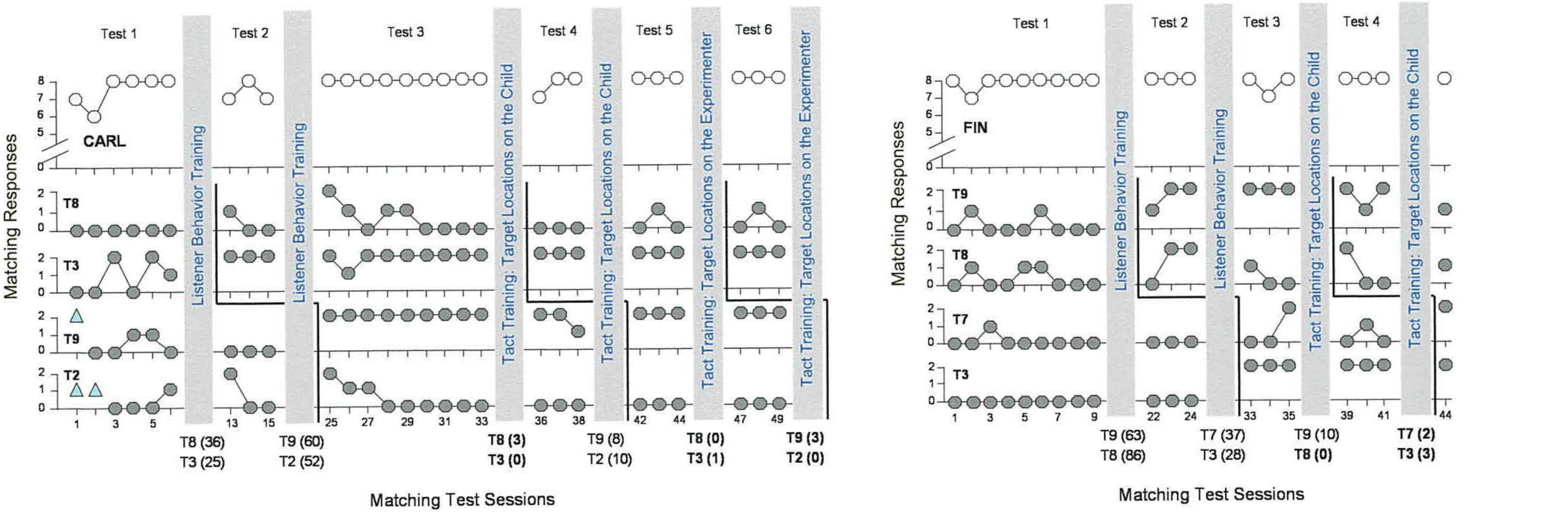

Figure 7.10. Data for Fin, and Carl; otherwise as for previous figures.

Likewise, the present data show that, once the children's listener responses were at criterion, in most cases the corresponding tact responses were either already in place or required very few trials to meet the set criterion (see Figures 7.9. and 7.10.). At the start of tact training for target locations on the child's body, all 4 tacts were in place for Fex, 3 for Fin, and 2 for Carl; the remaining 3 tacts took between 8 and 10 trials to reach criterion. For the 2 children who underwent tact training for target locations on the experimenter's body, all 8 tacts were in place at the outset. Overall, these data show that listener behaviour training sufficed to establish naming of most target body locations, and that the resulting name relations included corresponding locations on the child's and the experimenter's bodies.

This outcome differs from the findings of previous naming studies (Horne et al., 2004; 2006) in which listener training did not invariably result in the emergence of the corresponding tact relations.

Children's Matching of Target Gestures

The sets of four gestures that were identified as targets for each child are listed in Table 7.1. and described in Table 7.2. (bottom panel). In the generalised imitation tests conducted after baseline matching training, out of a total of 12 target gestures (across all children), 1 target was matched intermittently, 6 infrequently, and 5 were not matched at all. In the test sessions that followed listener behaviour training, the children matched 4 of their targets consistently, 3 intermittently, and 4 infrequently; the remaining target was not matched. These data show that listener training, conducted in the absence of modelling, was effective in establishing or increasing matching of target gestures in the subsequent matching tests.

In the matching tests administered after tact training for target locations on the child's body, 5 out of 12 targets were matched consistently, 3 intermittently, 3 infrequently, and 1 target was not matched. Fin participated in only one test session after tact training before dropping out of the study. Carl dropped out of the procedure after tact training of target locations on the experimenter's body was completed but before the subsequent matching test could be administered (see Figure 7.10.). After tact training for target locations on the experimenter's body was completed, out of a total of 6 target gestures, 3 were matched consistently, 1 intermittently, and 2 infrequently. This pattern is similar to the results of the previous experiments – at the end of the tact training intervention, all children matched some of their target gestures consistently, but no child did so across all their targets.

Only one child, Fex, participated in the matching tests with on-task tact prompts for target locations intervention. In the generalised matching tests that followed, he matched 3 of his 4 target gestures consistently, but the remaining target infrequently. His performance was similar to those of five out of six participants in Experiment 1 and Experiment 2, who by the end of this intervention consistently matched most – but not all – target gestures. After the next intervention, matching tests with on-task tact prompts for target locations with naming feedback was administered, Fex' matching was errorless for 3 of his targets, but the remaining gesture was still matched only infrequently. As in previous studies, the direct matching training that followed resulted in consistent matching of all targets for this child. Over his four Follow Up sessions, Fex matched 3 target gestures consistently, but the remaining gesture was once again matched only infrequently.

Children's incorrect responses on all matching test trials are reported in Appendix G; their pattern of errors was similar to those found in the previous two experiments.

Analysis of Children's Matching Responses Across All Experiments

Considering the results of Experiment 1, Experiment 2 and Experiment 3 together, there were 9 participants and 36 target behaviours. The percentages of children's correct matching responses to the experimenter's modelling of target gestures in repeated matching tests were analysed statistically to explore the effects of various types of training administered in these experiments. In all cases where data were available for at least 3 participants, the effect sizes were calculated as indices of change across conditions; repeated-measures t tests were also employed wherever the sample size was large enough (4 or more participants).

Effects of the Tact Training Interventions

Tact training administered before listener behaviour training. In Experiment 1 and Experiment 2, target tact training was administered on the child's body first, and then for the same locations on the experimenter's body. In Experiment 1, this was followed by a mixed tact training intervention.

Across the 6 children and 24 target gestures in Experiment 1 and Experiment 2, mean target matching in all generalised imitation test sessions administered before target tact training on the child's body was 8% (range: 6-13%). After this training, but before the next training commenced, matching was recorded on a mean of 27% of trials (range: 15-43%). Statistically, this difference was significant ($t_{(5)}$= -4.98, p = .004) with a very large effect size (Cohen's d=2.94; see Brace et al., 2006). Indeed, all children were more likely to match their target responses after this intervention. After target tact training on the experimenter's body, but before the next training commenced, target matching was recorded on a mean of 38% trials (range: 17-58%). The difference between the children's performances on the tests administered before and after this intervention was not statistically significant ($t_{(5)}$= -1.68, p = .152), but the effect size was large (Cohen's d=.90). All children were more likely to match their target responses after this intervention.

Across 3 children and 12 target gestures in Experiment 1, in the test sessions prior to mixed tact training, mean target matching was 44% (range: 36-58%). After mixed tact training, but before the next training commenced, correct target matches were recorded on a mean of 51% trials (range: 38-58%). The effect size was medium (d=.55); only 1 child was more likely to emit correct target responses after this intervention.

Overall, these tests confirm that the tact training interventions significantly increased children's matching of target gestures; tact training of target locations on the child's body, administered first, resulted in the biggest increases in target matching; the subsequent target tact training for the same locations on the experimenter's body, and mixed training, had smaller effects.

Tact training administered after listener behaviour training. In Experiment 3, the children were given tact training later in the procedure, after listener behaviour training. In their case, and across 12 target gestures, before target tact training on the child's body, mean target matching was 48% (range: 22-65%). After this tact training, correct target matches were recorded on a mean of 48% trials (range: 27-65%). The effect size was small (d=0.01); only 1 child was more likely to match the target responses after this intervention, which clearly did not add to the effects of the earlier listener behaviour intervention (see below). Only one participant, Fex, also underwent target tact training on the experimenter; in his case, this intervention improved the percentage of correct matching across the 4 target gestures from 27% to 67%.

Effects the Matching Tests with On-Task Tact Prompts for Target Locations

After tact training in all experiments, the children were presented with three sessions of matching tests with on-task tact prompts for target locations. All participants in Experiment 1 and Experiment 2, and one child in Experiment 3, took part. Across these 7 children and 28 target gestures, a mean of 45% (range: 17-67%) of target trials were matched in the test sessions conducted prior to the on-task naming prompts for matching intervention. After this intervention, but before the next, target matches were recorded on a mean of 55% trials (range: 31-88%). Statistically, this difference was not significant ($t_{(6)}$= -1.59, $p = .164$). Only a medium effect size was obtained (d=.57) because only 4 children were more likely to emit correct target responses after this intervention.

Effects of the Listener Behaviour Training Interventions

Listener behaviour training administered before tact training. In Experiment 3, listener behaviour training was administered to 3 children, across 12 target behaviours. Prior to this intervention, the children responded correctly on 9% of the generalised imitation test trials (range: 3-17%). Following the intervention, but before the next training commenced, the children emitted correct matching responses on 48% of the trials (range: 22-65%). The effect size was very large (d=2.60). Indeed, all children were more likely to match targets after the listener intervention.

Listener behaviour training administered after tact training. In Experiment 2, across 3 children and 12 target gestures, mean target matching responses in the test sessions conducted prior to listener behaviour training was 52% (range: 31-64%). Following listener training, but before the next training commenced, mean target matching increased to 59% (range: 47-71%). The effect size was small (d=.47) and only one child was more likely to emit correct target responses after the listener intervention.

Overall, listener behaviour training, when administered first (Experiment 3), was very effective in increasing children's matching of target gestures in the subsequent tests; however, this training had no effect when administered later in the procedure (Experiment 2).

Effects of the On-Task Tact Prompts for Target Locations and Naming Feedback Intervention

In Experiment 2 and Experiment 3, after both listener behaviour training and tact training were completed, the children were presented with three sessions of matching tests with on-task tact prompts for target locations followed by naming feedback. All participants in Experiment 2 and 1 child in Experiment 3 took part. Across these 4 children and 16 target gestures, mean target matching in the test sessions conducted prior to this intervention was 59% (range: 47-71%). After this intervention was administered, but before the next training commenced, target matches were recorded on a mean of 72% trials (range: 64-81%). Statistically, this difference was significant ($t_{(3)}$= -3.82, p = .032) with a large effect size (d=1.48). Indeed, all children were more likely to emit target responses after this intervention.

Joint Effects of All Naming Interventions

Considering all naming training that was administered to the participants in the three experiments – tact training and prompts in Experiment 1 and tact and listener training and prompts in Experiment 2 and Experiment 3 – there were 7 participants who completed the experimental procedures. The 2 children who left the Nursery before all scheduled interventions could be administered also completed a part of this training. Therefore, it was possible to compare the accuracy of 9 children's performances, across 36 target gestures, to estimate the overall effectiveness of name training.

Mean target matching in all generalised imitation test sessions prior to any intervention was 8% (range: 3-17%). After all naming interventions, but prior to the start of direct matching training, target matches were recorded on a mean of 65% test trials (range: 33-88%). Statistically, this difference was significant ($t_{(8)}$= -9.18, $p < .001$) and the effect size was extremely large (d=5.40); the effect was present for each child and across most of the target gestures.

The Effects of Direct Matching Training

Although all children's matching of target gestures showed large and significant increases following the naming interventions, only one child in Experiment 1 (Anna) developed consistent matching of *all* her target gestures as the result of tact training. To achieve this criterion, the remaining children needed to undergo direct matching training. Two children in Experiment 1, 3 children in Experiment 2, and 1 child in Experiment 3 participated in this intervention. Across these 6 children and 24 target gestures, mean target matching in all matching test sessions administered prior to direct matching training was 62% (range: 33-81%). After matching training, matching occurred on a mean of 93% test trials (range: 88-96%). Statistically, this difference was significant ($t_{(5)}$= -3.86, $p = .012$) and the effect size was very large (d=2.96); the effect was present for each child.

7.6 General Discussion

The present study aimed to investigate whether training young children to name four target body parts would be sufficient for the children to match, for the first time, an adult's touches to those locations during a generalised imitation test. The series of three experiments reported were designed to test this naming hypothesis by comparing imitation of novel target gestures by children who either (i) had learned to name them or (ii) only responded as listeners to those names. If untrained imitation emerged only in children who had learned to name the target stimuli this would provide evidence that target naming is sufficient whereas the corresponding listener behaviour is not. However, the data show that all 9 children acquired both the tact and listener components regardless of whether they were ostensibly trained the tacts (Experiment 1 and Experiment 2) or corresponding listener relations (Experiment 3) at the outset. Consequently, it can be assumed that both the tact and listener training established naming and the analysis of whether naming can in turn establish matching of novel targets when these are presented in the context of a generalised imitation task must rest on whether there is a significant change in the level of target matching after target naming was established during the experiments.

The Effects of All Naming Interventions on Novel Target Matching

The effects of the naming interventions so defined were analysed statistically for the combined data from all 9 children who participated in the three experiments, thereby encompassing potential untrained matching of 36 novel target behaviours. The analyses showed that before the naming interventions were introduced, mean target behaviour matching was only 8% in the generalised imitation tests. This initial low level of target matching, here over as many as 12 successive generalised imitation tests, replicates the findings reported in earlier studies on generalised imitation (Erjavec et al., 2009; Horne & Erjavec, 2007). However, in the generalised imitation tests conducted after all the naming interventions had been implemented, target-matching responses had increased to a mean of 65%. This is a very significant change with an extremely large effect size – and the increase in target matching occurred in all children. Behaviour change of this order is impressive given that target matching was always tested under extinction.

Limitations on the Effects of Naming Interventions

Although the above data suggest that target naming had a large and significant effect on the development of children's untrained matching of the novel target behaviours, with 1 child, Anna (Experiment 1) showing near perfect matching following the naming interventions, the untrained matching performances of the remaining children were more variable. This variability, however, is to be expected. The naming account predicts that self-instructional effects will occur *if* the child produces the relevant name on-task. This Skinnerian approach considers outcomes in probabilistic rather than mechanistic terms and recognises that task performance is always a function of multiple sources of control; particularly in young children, other influences on task performance are likely if the probability of the main independent variable under study, here on-task naming, is not fully controlled. For example, the studies by Horne et al. (2004, 2006, 2007) and Lowe et al. (2002, 2005) show that emergent name-based category sorting of arbitrary stimuli occurred reliably only when the experimenter evoked the child's on-task naming by first pointing to the sample stimulus, and asking "What's this?" before indicating the mixed array of stimuli and saying to the child "Can you give me the others?" When the children were only asked to *look* at the sample before sorting the stimuli, many failed to sort the arbitrary comparisons along common name lines, even though they had all previously learned to name the stimuli appropriately, and had passed tact review trials immediately before the sorting test was conducted. In the present study, although the children took part in an intervention that comprised a tact-prompt version of the generalised matching task (with no consequences for correct target matches) they were *never* prompted to tact the target stimulus in any of the generalised imitation tests employed throughout each experiment: the main independent variable, target naming, was therefore left uncontrolled in the repeated tests that measured emergence of untrained target matching. Although a strong test of the self-instructional effects of naming was not performed in the present experiments, future studies can address this shortcoming.

The Effects of Instructional Context

Another explanation of performance variability is that the self-instructional effects of naming pertain to looking rather than touching behaviours. Naming may therefore generate looking at a target location on the child's and modeller's body, but additional on-task instructions may be required to determine whether the child also touches the body part that he or she names. The instruction "Do this" given on each generalised imitation test trial may not have been sufficient in this regard. This instruction is essentially ambiguous: should the child touch the named body part on the experimenter's body or on her own body? In contrast, the sorting instruction employed in the naming and categorisation studies has no such ambiguity: "Zag" (sample name produced by child) plus "Where are the others?" (experimenter instruction) directs the child's behaviour quite clearly from the sample to the comparisons. The possibility that on-task instructions might facilitate the effects of target naming in the imitation test context should be investigated further.

Discrimination Between Target Body Locations

Although the naming interventions resulted in untrained matching of target behaviours, the children did not learn to match all their targets reliably until they took part in direct matching training. Prior to this, their most frequent errors consisted of touching body parts adjacent to the targets. This is surprising given that the novel target responses all terminated on body parts that are visible (see Table 7.2.) and, throughout tact training, the experimenter touched each target body location while she asked the child "What's this?" Likewise, during listener training, the experimenter corrected errors by moving the child's arm and hand to enable him or her to touch the location specified by a given listener stimulus, gradually fading this "putting through" procedure as the child learned to respond correctly. In both tact and listener training the child was therefore provided tactual and visual stimulation to help him or her discriminate one target location from another. It appears that this bimodal stimulation per se was not sufficient to constrain variability in the children's otherwise untrained matching of the target behaviours. In contrast, the four trained baseline matches required the children to differentiate between their nose, ear, lips or neck—very fine discriminations indeed, and ones that rely exclusively on touch (see Table 7.2.). Nevertheless, these matches were reliable and veridical under intermittent reinforcement throughout the procedures employed in the three experiments and, once established at the start, never required correction. Children of this age as well as infants are easily able to learn fine discrimination of body part locations, and match them, when the relevant matching relations are established under contingent reinforcement.

Parity and Cross-Body Mapping

One hypothetical constraint on children's matching of target locations modelled on an experimenter's body is that body structure and size is very different when comparing a 3-year-old child with an adult. This might be expected to limit children's discrimination of varying degrees of parity between the modelled behaviour and their own responses. However, this study provides good evidence that children's tacts for target locations on their own bodies often generalised without training to the corresponding locations of the adult's body. This outcome suggests that cross-body mapping may not be a serious limitation on young children's target matching (see Baer & Deguchi, 1985).

Direct Matching Training and Maintenance

The impact of direct matching training for all matching relations is demonstrated clearly by the large and significant increases to a mean of 93% in target matching when "putting through" and contingent reinforcement were finally employed. This second large change in level clearly supports the findings of earlier studies on the determinants of matching in infants and young children and reaffirms that repeated presentation of genuinely novel target behaviours in the context of trained and intermittently reinforced matching relations does not of itself result in generalised imitation in infants and young children. That said, direct matching training did not guarantee reliable matching of all the novel targets in the long-term follow up tests. Target matching averaged 80% over the follow up data in all three experiments, but for some targets fell to baseline levels under the extinction conditions of these long-term tests. This suggests that intermittent reinforcement, as was provided for the baseline matching relations throughout the procedures in the present and previous studies, may be necessary to maintain even directly trained matching relations. This accords fully with a Skinnerian account of how matching is established and maintained.

Conclusion

The failure to identify children who learned only listener behaviour in the course of the listener training conducted at the outset in Experiment 3 limits the consideration of the findings to the naming account, which is the main theoretical driver of the present study. However, replication of Experiment 3 with a larger number of participants should increase chances of identifying children who only learn listener behaviour (see Horne et al., 2004; 2006) and would enable to investigate whether this relation on its own results in an increase in novel target matching in young children's performances on generalised imitation tasks, in which case these findings could be reinterpreted in terms of simpler behavioural relations. Nevertheless, this first study to investigate the relationship between naming and imitation in very young children found large and significant increases in matching responses following the introduction of the naming interventions. It appears that target naming raises the probability of target matching in most cases to levels that would enable caregivers to fine tune the relevant matching relations in the day to day social environment by providing occasional social reinforcement contingent on a good match to target. This provides support for the hypothesis that naming, and indeed other kinds of verbal self-instruction, may be an important means of accelerating the development of imitation, a repertoire that plays an important role in human learning throughout the lifespan.

CHAPTER EIGHT: Can naming of arm movements improve imitation accuracy in 2- to 3-year-old children?

8.1 Abstract

This study explored the relationship between 2- to 3-year-old children's ability to name target arm movements and their untrained matching of target hand-to-body touches. Three participants were presented with repeated generalised imitation tests in a multiple-baseline procedure, interspersed with tact training of labels "Across" for contralateral gestures and "To the side" for ipsilateral gestures. Tact training was administered in three stages; children were presented with (i) ipsilateral and contralateral gestures that contained component movements of target and baseline actions but – unlike the latter – did not terminate on any parts of body; (ii) ipsilateral baseline and contralateral target actions that terminated on a body-part and were performed bimanually; and (iii) ipsilateral baseline and contralateral target body-part touches performed unimanually. Tact training resulted in the emergence of consistent matching of all target gestures for the oldest participant, but it had little effect on matching performances of the remaining two children, who required direct matching training before they too matched all their targets in subsequent imitation tests. It is considered how learning to name the components of gestures such as body parts touched and movements performed by the modeler – the most basic form of self-instructional behaviour – may affect young children's performances in imitation tests.

8.2 Introduction

It is widely agreed that imitation drives psychological development in infancy and childhood, and that the determinants of this repertoire require careful study. Behaviour analysts are careful to distinguish between a trained repertoire of matching relations that is established through discriminative reinforcement like any other operant (Skinner, 1953, pp. 119–120) and generalised imitation – a repertoire of emergent matching relations that enables young children to learn new behaviours quickly and without the need for direct training (Catania, 1998, p. 228).

The environmental contingencies that may facilitate generalised imitation have been explored in many studies (e.g., Baer & Deguchi, 1985; Baer & Sherman, 1964; Erjavec et al, 2009; Horne & Erjavec, 2007; Kymissis & Poulson, 1994; Poulson & Kymmissis, 1988; Poulson et al., 2002; Poulson et al., 1991; Steinman, 1970a, 1970b; Waxler & Yarow, 1970). Typically, in each experiment, participants are presented with repeated modelling of several different actions. Whereas reinforcers are delivered following participants' correct matching responses to some modelled actions, the remaining behaviours are designated as targets (or probes) and no consequences are presented for matching them. Nonetheless, children frequently emit correct matching responses to these models. While this was taken as evidence of generalised imitation, more recent studies have employed controls for the influence of alternative learning mechanisms and participants' learning history on their imitative performances (see Erjavec, 2002; Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007). It is now recognized that generalised imitation tests ought to employ pretests for novelty of the target actions presented as unreinforced probes, and that children's caregivers need to remain unaware of the modelled target behaviours and experimental procedures, to avoid extra-experimental matching training of target actions. It has also been shown that variables other than models of the target actions may evoke target responses: Demonstration of objects' affordances and local social enhancement of target-relevant object parts are likely to present confounding sources of control when target behaviours are actions on objects (Horne et al., 2009; also see Zentall, 2006). Therefore, to provide strong tests of generalised imitation, studies should employ novel empty-handed gestures as target behaviours.

Only a few of studies to date have employed all these necessary controls. These studies have shown that the imitative repertoires of 1- to 2-year old infants consist entirely of trained matches, and found no evidence of generalised imitation in this group (Erjavec et al., 2009; Horne & Erjavec, 2007). Clearly, more research is needed to establish the age at which the latter repertoire can be reliably demonstrated in normally developing children, and to carefully explore its determinants.

Empty-handed gestures have been used in several recent cognitive-developmental experiments, albeit without the controls necessary for elucidating the determinants of children's responses (e.g., Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Gleissner et al., 2000). Nevertheless, their results are informative. Most tests employed modelling of touches to specific body parts – feet, knees, ears, and so on – performed with a particular arm movement – either ipsilateral (same side of the body) or contralateral (crossing the body midline). These tests showed that young children accurately match some of these models, but respond incorrectly to the remaining models, most often by touching the correct part of the body using an incorrect arm movement, such as performing ipsilateral responses to contralateral models. A similar pattern of arm movement errors has also been observed in the behaviour analytic literature (see Erjavec & Horne, 2008;

Erjavec et al., 2009; Horne & Erjavec, 2007). Cognitive accounts attribute these errors to children's tendency to focus on the main 'goal' of a modelled behaviour (e.g., touching the ears) and to neglect the movement performed by the experimenter to achieve this goal (e.g., crossing the arms to touch contralateral ears). However, Erjavec and Horne (2008) have demonstrated that learning history is likely to be a critical determinant of whether or not children match a modelled behaviour. They showed that 2- to 3-year old children's responses to hand-to-body target gestures tend to be much more accurate for gestures that frequently feature in naming and matching games that they play with their caregivers (e.g., the nursery rhyme 'Heads and shoulders, knees and toes') compared to gestures that are not commonly trained in early interactions; this is the case regardless of 'goal' structure, presence of contralateral movements, or apparent complexity of target behaviours. However, the children's trained matching relations and their naming repertoires were not manipulated directly in that study.

In their naming account, Horne and Lowe (1996, 1997; also see Lowe & Horne, 1996) have argued that control of behaviour is fundamentally altered in children who are able to name objects and events in their environment. Thus children's growing verbal repertoires may change the way in which they respond to behaviours modelled by others. Horne and Lowe define naming as a higher order bidirectional relation in which the speaker responds as a conventional listener to her own verbal responses; it is the most basic form of self-instructional behaviour. When a child learns to name an object, she learns a circular speaker-listener relation that enables her to see the object, name it (or tact it), respond as a listener to that utterance by looking once again at the object, and maintain her attention on the object for as long as she continues to name it. In addition, through naming, the child also learns to establish category relations between objects (e.g., a dog and the wide variety of dogs). Therefore, whenever the child utters the name for a particular object (e.g., the dog), when responding as a listener to her utterance ("dog") she will look also for other objects that she has learned to call by the same name. Numerous studies have shown that common naming (but not common listener behaviour) is therefore an important means of establishing untrained categories in young children, even between objects that are physically very different (see Horne et al., 2006; Horne et al., 2007; Horne et al., 2004; Lowe et al., 2005; Lowe et al., 2002).

Generally, children learn to name actions much later than they learn to name objects (Bates, Bretherton, & Snyder, 1988; Bates et al., 1994; Caselli et al., 1995; Tomasello, Akhtar, Dodson, & Rekau, 1997). This is perhaps not surprising given that naming of actions is in some ways different from naming of objects; this is because a child may see her own performance of an action as topographically different from the same action modelled by another person. It cannot be assumed therefore that a child who learns to name as "hug" the actions of two people she sees hugging, will generalize that name by saying "hug" when *she* hugs someone. Conversely, if the child is seated and is taught to name her own sitting behaviour she may not extend that name to others who are also engaging in the same behaviour. This difference in topography, and therefore discriminative stimuli, when observing rather than performing a particular action oneself is characterized as the cross-body mapping problem in studies of imitation (e.g., Baer & Deguchi, 1987), but clearly also applies to action naming.

With these limitations in mind, it is nevertheless possible that modelling of hand-to-body gestures employed in previous imitation studies (e.g., Bekkering et al., 2000; Erjavec & Horne, 2008; Gleissner et al., 2000) may have evoked children's naming of one or more target action components, which in turn could have influenced their gestural responses. Modelling of hand-to-body actions presents multiple stimuli that include the sight of the body part touched (object) and the movement performed by the modeller (action). Young children are more likely to name the former than the latter (see Chapter 6). In order to see how this selective naming may affect a child's performance in a matching task, let us consider the sequence of behaviours in a naming episode. Figure 8.1. (left panel) illustrates this relation for *foot*, following the naming account of Horne and Lowe (1996, p. 201). A child, who has learned to name this part of the body, sees her foot, and then says "foot". Upon hearing this self-produced verbal stimulus /foot/, the child shows listener behaviour; she orients to the foot. Thus naming can be evoked by seeing a foot or hearing /foot/; it can be re-evoked by seeing a foot again or through self-echoing. When this child is presented, in a matching task, with an experimenter's modelling of an ipsilateral foot-touch, she may name this body part "foot" overtly or covertly, and respond to her own utterance by orienting to and touching her own foot (see Figure 8.1., middle panel). This touch is likely to be accomplished with an ipsilateral response, because children's early repertoires acquired in naming and matching games with their caregivers seldom contain contralateral actions (see Erjavec & Horne, 2008; see also Chapter 5). Therefore, in this instance, naming of the body part evokes a listener response that is an accurate match of the modelled hand-to-body gesture. However, on another trial, this child may be presented with an experimenter's modelling of a contralateral foot touch. If she names the body part touched "foot" she is again likely to respond by touching her own foot – but is unlikely to do so by crossing her body midline (see Figure 8.1., right panel). Thus the observed pattern of correct matching responses of ipsilateral hand-to-body models, but incorrect (i.e., ipsilateral) responses to contralateral models, may be in part the result of a limitation in children's early action naming repertoires, rather than their inability to perform contralateral target actions, or attend to multiple 'goals' presented during modelling of target behaviours.

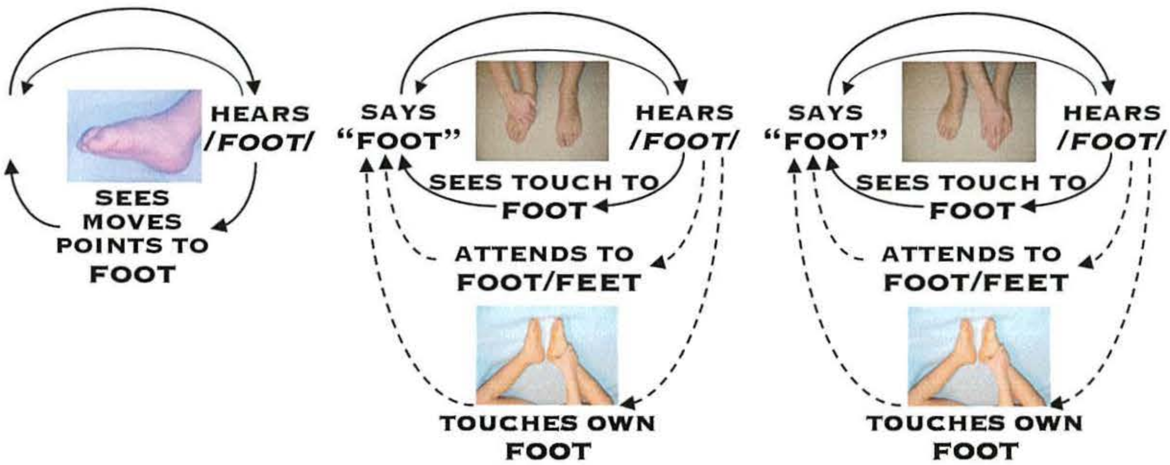

Figure 8.1. (adapted from Horne & Lowe, 1996, p. 201). ***Left Panel:*** **A child, who has learned to name Foot, sees her foot, and then says "foot". Upon hearing this self-produced verbal stimulus /foot/, the child shows conventional listener behaviour; she orients to the foot, moves it, touches it, and so on. Thus naming can be evoked by seeing a foot or hearing /foot/; it can be re-evoked by seeing a foot again or through self-echoing. This illustrates the bidirectional relation between the tact, listener behaviour, and the object, or a class of objects or events.** ***Central Panel:*** **In an imitation task, seeing the experimenter perform an ipsilateral foot-touch may evoke the child's naming of this body-part. Thus a child may covertly or overtly say "foot"; hearing her own utterance /foot/ may then direct the child's attention to her own foot, leading her to touch this location on her own body using a commonly trained ipsilateral movement (listener behaviour). This illustrates how an accurate matching response may come about as the result of body-part naming.** ***Right Panel:*** **In another imitation task, seeing the experimenter perform a contralateral foot-touch may again evoke the child's naming of "foot"; as before, hearing her own utterance /foot/ may then direct the child's attention to her own foot, leading her to touch this location on her own body (listener behaviour), again using a commonly trained ipsilateral movement. This illustrates how an inaccurate matching response may come about if a child's repertoire contains a correct body-name but not a name for the movement ("across") that was used by the experimenter to perform a target gesture.**

If this account is correct, one can predict that (i) young children are unlikely to accurately name the movements an experimenter uses to model ipsilateral and contralateral hand-to-body touches, and that (ii) training a child to label these movements may lead to emergence of correct matching performances in the absence of direct matching training. Thus generalised imitation of hand-to-body matches would be predicted to result from teaching the child to name the relevant movements, providing that a child has the appropriate responses (i.e., crossing body midline to touch parts of her body) already established as a part of her common listener repertoire.

In the present study, a multiple baseline design was employed to explore the relationship between young children's ability to name the movement featuring in modelling of hand-to-body actions and their untrained matching of target hand-to-body touches. Participants were presented with repeated generalised imitation tests in which models of four trained (baseline) hand-to-body touches were interspersed with four unreinforced (target) body touches; the novelty of all target behaviours was established at the outset for each individual child. Each child was trained to tact the ipsilateral and contralateral arm movements (i.e., to say "to the side" and "across", respectively) that were performed (i) bimanually, and did not terminate on a body part; (ii) bimanually, terminating on target body parts; and (iii) unimanually, terminating on target body parts.

This research complied with British Psychological Society guidelines for research with children and was approved by the School of Psychology Ethics Committee.

8.3 Method

Participants

Three typically developing children (two girls and one boy) who attended the University Nursery and Childcare Centre Tir Na n'Og in Bangor at least two days a week were recruited by parental consent to participate in this experiment (see sample of consent form in Appendix A). Participants are referred to by alternative names to preserve confidentiality. At the start of tact training they were aged 33 months (Sara), 31 months (Ola), and 29 months (Gareth). Table 8.1. shows the baseline and target relations assigned to each child, the total number of sessions administered to each child, their ages at the end of the procedure, and the General Quotient scores on the Griffiths Mental Developmental Scales (Luiz et al., 2006) obtained for all children.

Table 8.1.
Children's gender, baseline and target relations assigned to each participant, ages at start of naming intervention, total number of sessions administered, and children's general quotient scores on the Griffiths Mental Developmental Scales (GMDS).

Participant	Gender	Baseline and target relations	Age at start of training (months/days)	Total number of sessions administered	Age at end of testing (months/days)	GQ scores
Sara	Female	B1(B), B2(B), B1(U), B2(U)	33/10	53	35/19	117
		T1(B), T2(B), T1(U), T2(U)				
Ola	Female	B1(B), B3(B), B1(U), B3(U)	31/15	141	36/05	116
		T1(B), T3(B), T1(U), T3(U)				
Gareth	Male	B1(B), B3(B), B1(U), B3(U)	29/24	92	33/21	110
		T1(B), T3(B), T1(U), T3(U)				

Settings and Apparatus

Sessions were conducted in a specially designed quiet testing room at the Nursery. During the sessions, the child and the experimenter sat comfortably in an inflatable boat, on beanbags, facing each other. A large teddy bear toy (Teddy) was seated on the edge of the boat, facing the child. Age appropriate toys and stickers were used during play breaks between test trials and after testing; they were kept hidden in a closed box and in Teddy's backpack between presentations. Two wall-mounted digital video cameras were employed to record the behaviour of the child and the experimenter. Audio and visual inputs from the two cameras and a hidden radio microphone were fed into a split-screen video recorder located in a separate audio-visual suite (see Appendix B). JVC SR-VS10 VHS/DV recorders, with stop- and slow-motion viewing facilities, were used for recording and coding.

Stimuli

The visual stimuli employed were manual gestures performed live by the experimenter (see Table 8.2.). Target and baseline gestures terminated on ear(s), knee(s), or foot (feet). These body parts were chosen because previous research established that 2-to-3 years old children readily tact them (59 – 94% of children) and respond as listeners to the experimenter's naming of these parts (76 – 94% of children; see Chapter 5). The experimental gestures consisted of unimanual and bimanual hand-to-body touches that were performed ipsilaterally and contralaterally. Baseline models were performed with ipsilateral movements, and target gestures were performed with contralateral movements.

The experimental stimuli presented to individual children consisted of 8 hand-to-body touches to two body parts (4 target gestures with contralateral touches to 2 target body parts performed bimanually and unimanually, and 4 baseline gestures with corresponding ipsilateral touches to the same body locations). Novelty of target gestures was established at the outset for each child. Two additional stimuli were used in naming training for each child – the experimenter modelled bimanual arm movements that were either contralateral or ipsilateral, but did not terminate on any parts of body. All stimuli are illustrated in Figure 8.2.

Table 8.2.

Description of movement modelled by the experimenter and accepted responses variations for each (i) baseline gesture [bimanual: B1(B), B2(B), and B3(B); unimanual: B1(U), B2(U), and B3(U)], (ii) target gesture [bimanual: T1(B), T2(B), and T3(B); unimanual: T1(U), T2(U), and T3(U)], and (iii) component movement training gesture [A1(B) and A2(B)]. The experimenter always used her left hand for modelling one-hand-to-body touches but children could respond with either hand.

Baseline / Target gestures	Behaviour modelled by the experimenter	Accepted response variation
B1(B) – Hands apart to ears	Both hands touching ipsilateral ears	Hands touching ipsilateral ears
B2(B) – Hands apart to knees	Both hands touching ipsilateral knees	Hands touching ipsilateral knees or upper legs
B3(B) – Hands apart to feet	Both hands touching ipsilateral toes	Hands touching ipsilateral toes, feet area or ankles
B1(U) – Hand to same ear	Left hand touching ipsilateral ear	Hand touching ipsilateral ear
B2(U) – Hand to same knee	Left hand touching ipsilateral knee	Hand touching ipsilateral knee or upper leg
B3(U) – Hand to same foot	Left hand touching ipsilateral toes	Hand touching ipsilateral toes, foot area or ankle
T1(B) – Hands across to ears	Both hands touching contralateral ears	Hands touching contralateral ears
T2(B) – Hands across to knees	Both hands touching contralateral knees	Hands touching contralateral knees or upper legs
T3(B) – Hands across to feet	Both hands touching contralateral toes	Hands touching contralateral toes, feet area or ankles
T1(U) – Hand cross to ear	Left hand touching contralateral ear	Hand touching contralateral ear
T2(U) – Hand cross to knee	Left hand touching contralateral knee	Hand touching contralateral knee or upper leg
T3(U) – Hand cross to foot	Left hand touching contralateral toes	Hand touching contralateral toes, foot area or ankle
A1(B) – Arms apart	Arms raised to chest level apart in front of the body, forearms parallel to each other, hands fisted	Arms clearly raised in front with forearms or wrists parallel to each other
A2(B) – Arms crossed	Arms crossed in front of the body, forearms overlapping, hands fisted	Arms clearly crossed with forearms or wrists overlapping

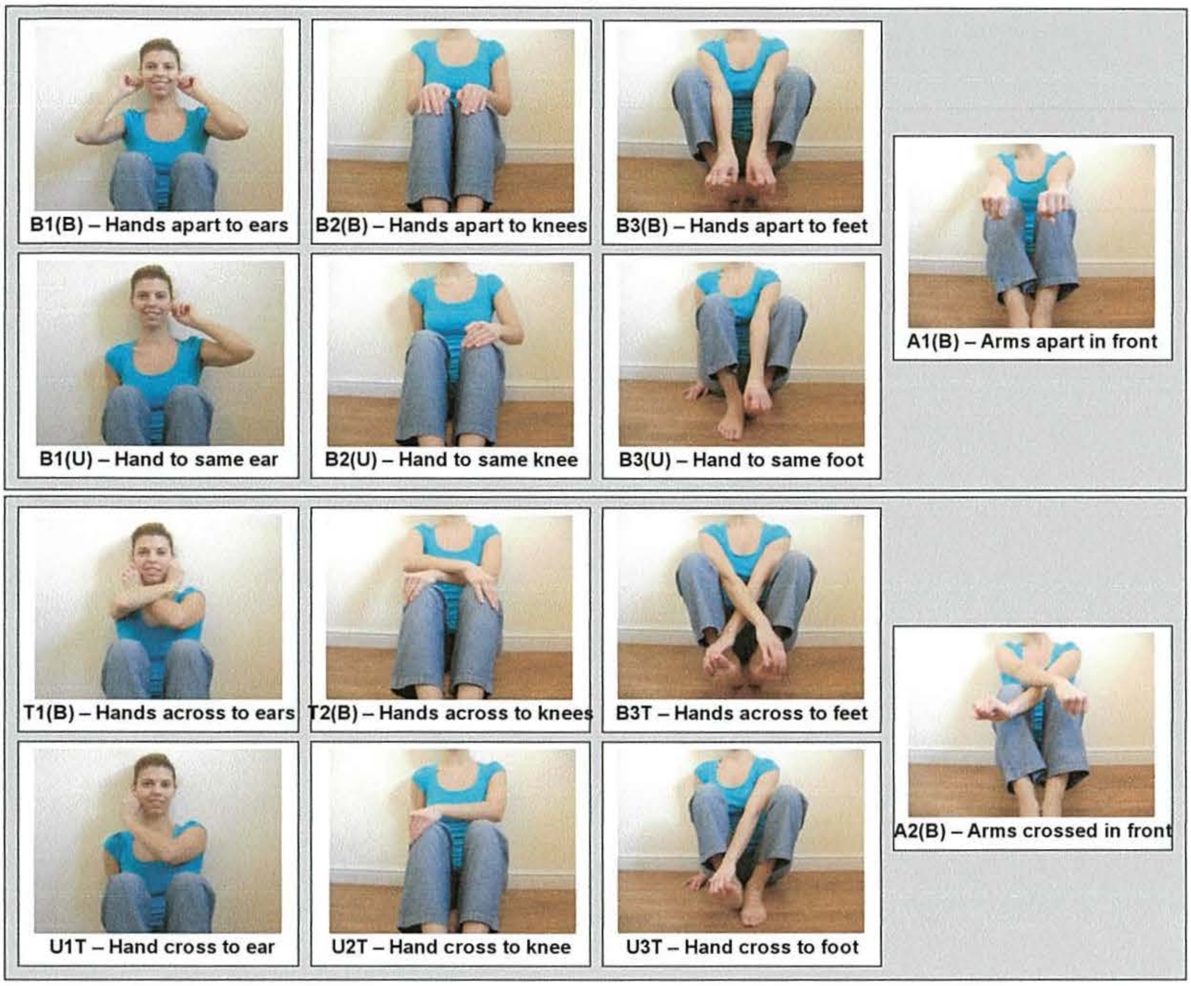

Figure 8.2. Images of baseline, target, and component gestures. Baseline and target gestures terminated on ear(s), knee(s) or foot/feet; they were performed either bimanually (B) or unimanually (U). Baseline gestures contained ipsilateral and targets contralateral movements. Each child was presented with (i) two bimanual touches [B1(B), B2(B) or B3(B)] and two corresponding unimanual touches [B1(U), B2(U) or B3(U)] as baseline gestures; and with (ii) two bimanual touches [T1(B), T2(B) or T3(B)] and two corresponding unimanual touches [T1(U), T2(U) or T3(U)] as target gestures. Component movement gestures were performed bimanually in front of body and did not terminate on any part of the body: for A1(B) the experimenter's hands were extended and held apart, and for A2(B) they were crossed.

Procedure

A multiple-baseline procedure was employed; each child participated in all conditions of the experiment. Training was presented to the children in a staggered manner to demonstrate experimental control of any resulting changes in target behaviour. The flow of the procedure is illustrated in Figure 8.3.

Baseline Matching Training and Identification of Novel Targets

Familiarization. The experimenter established a good rapport with the children during unstructured daily play sessions in the nursery playroom before inviting each child to participate in one-to-one play with toys in the test room. The child was asked to teach Teddy what the experimenter was doing by repeating the actions shown; the experimenter said, "Can you show Teddy how you do this?" before commencing the first trial. The experimenter modelled different contralateral hand-to-body gestures twice per session and instructed the child to "Do this" before she presented each gesture. At this early stage of the procedure, the experimenter determined which of the contralateral hand-to-body touches were not part of the individual children's trained matching repertoires and could therefore be employed as target gestures in the experiment (Erjavec et al., 2009; Horne & Erjavec, 2007).

If the child correctly matched a gesture more than once during the first two sessions of its presentation, this indicated that the gesture already featured in the child's trained matching repertoire, and consequently this target body-part touch was replaced with another; the replacement gestures were likewise tested over two sessions. This continued until 4 novel target gestures were identified for each child. Reinforcement was never provided for any children's responses (accurate matches or mismatches), but the children were allowed to play with Teddy's toys at the end of each session. In this and subsequent training conditions, children were tested at least three times a week. Each session lasted approximately 15-20 min.

Figure 8.3. Flowchart showing the stages of Experiment.

Baseline matching training. This condition established reliable, prompt, and correct matching responding to the verbal request, "Do this," followed by modelling of an ipsilateral hand-to-body gesture on each trial. In each training session there were three modelling trials of each of the 4 baseline gestures (12 trials per session), with up to three presentations of the modelled gesture per trial (as necessary). The modelled gestures were presented in a predetermined randomized order, with the added constraint that no more than two trials of the same gesture could occur in succession. Matching of the four baseline gestures was trained under continuous reinforcement, to a criterion of 5 out of 6 correct responses per gesture, over two consecutive sessions. When matching performance met the 100% reinforcement criterion, reinforcement rate was reduced to 50% on a VR2 schedule. The intermittent reinforcement criterion was 11 out of 12 correct responses across all baseline gestures within a single session.

Matching tests: Target (and baseline) gestures. Next, the children were presented with 2 modelling trials of each untrained target gesture (4) and trained baseline gesture (4) in each session; target and baseline trials were delivered in a pre-randomized sequence (16 trials in total). At the start of each session the experimenter asked, "Shall we play the game?" and before she modelled each gesture she prompted the child, "Can you do this?" Children's correct matching responses to baseline models were intermittently reinforced on a VR 2 schedule, but their responses to the target models were never reinforced. The criterion for performance of the baseline gestures was 13 out of 16 (81%) correct over two consecutive sessions. If the criterion was not met, the experimenter was required to re-train baseline responding before conducting the next test session.

The number of test sessions was staggered across the participants; they received either 3, or 6, or 9 sessions before moving on to the next training condition. This allowed the effects of the subsequent interventions to be compared with those of repeated unreinforced presentations of the target gestures, and to control for the passage of time.

Tact Training

The aim of these training conditions was to determine whether teaching the children to tact two component arm movements – ipsilateral ("*to the side*") and contralateral ("*across*") – would result in better matching of target gestures on subsequent matching test trials. In all stages of training, the experimenter taught the children to accurately tact her arm movements; the children were not taught to perform these movements as matches.

Tact training 1: Ipsilateral and contralateral arm movements performed bimanually, in front of body. In half of the training trials, the experimenter crossed her arms in front of her body [A2(B); see Figure 8.2.] and said, "Look! Tell Teddy how am I putting my arms: Are they *across* or *to the side*?" If the child responded correctly, the experimenter exclaimed enthusiastically, "Yes, they are *across*! Clever girl!" Occasionally (on 33% of trials) she also presented a toy for the child to play with as additional reinforcement. If the child produced an incorrect tact or no tact, the experimenter stated, "They are *across*," before asking the child, "Can you say *across*?" If the child failed to respond, the experimenter repeated presentation of the latter training sequence up to two more times on each trial before moving onto the next. In the remaining half of the trials, the experimenter extended her arms in front of her body and prompted the child to tact this gesture [A1(B); see Figure 8.2.] in the manner described above.

Tact trials for each arm movement were alternated in the training sessions in a pre-randomized sequence. As tact responding became more proficient, the experimenter's prompt was abbreviated to, "How am I putting my arms?" and the reinforcement rate was reduced to 25%. Finally, the child's tact responses were tested in extinction. The criterion was 7 out of 8 correct tact responses per target action. Following this, test sessions for matching of target (and baseline) gestures were conducted, as described earlier (see *Matching tests*). In this and all subsequent test blocks, if the child matched each target gesture on at least 4 out of 6 trials over three test sessions – showing consistent matching of all target gestures – the remaining training and test conditions would not have been administered; instead, the child would have progressed to the final *Follow Up* tests (see below).

To ensure maintenance of accurate tact responses, tact reviews were administered prior to the first, fourth, and seventh matching test sessions presented after each intervention and prior to any new training. If a child's tact performance fell below criterion, training was re-administered and criterion performance re-established before proceeding. In order to evaluate the effects of repeated matching tests over time on the accuracy of children's matching of target gestures, and to compare these with the effects of the next intervention, the number of matching test sessions was staggered across children; they completed either 3, or 6, or 9 sessions before proceeding to the next training condition.

Tact training 2: Ipsilateral and contralateral arm movements performed bimanually as part of target and baseline gestures. The experimenter presented the child with modelling of two bimanual baseline gestures and two bimanual target gestures; she prompted the child to tact the component movement in each gesture (*across* for target gestures and *to the side* for baseline gestures). The training procedure was the same as in *Tact training 1*. This training stage was complete when a child produced 11 out of 12 correct responses across all four bimanual gestures, tested in extinction. This was followed by another staggered block of matching tests.

Tact training 3: Ipsilateral and contralateral arm movements performed unimanually as part of target and baseline gestures. The experimenter presented the child with modelling of two unimanual baseline gestures and two unimanual target gestures; she again trained the child to tact the component movement in each gesture (*across* for target gestures and *to the side* for baseline gestures). The procedure was the same as in *Tact training 1* and *Tact training 2*; the training was complete when a child produced 11 out of 12 correct responses across all four unimanual gestures, tested in extinction. This was followed by another staggered block of matching tests.

Direct Matching Training

The aim of these training conditions was to establish whether children's responses to all target models in the matching tests could be further improved by matching training. This training was administered in two stages for each child.

Direct matching training of a bimanual contralateral component action. It was considered that children's matching of contralateral target hand-to-body actions may improve following matching training of the arms crossed in front of body gesture [A2(B); see Table 8.2.]. The experimenter asked the child "Can you do this?" followed by modelling of A2(B). Shaping and 'putting-through' procedures were used when necessary, and training proceeded as described for *Baseline matching training*. Matching training of this gesture was completed when a child produced 7 out of 8 correct responses in extinction. This was followed by staggered matching test sessions.

Direct matching training of target gestures. The matching training of target gestures was conducted in much the same way as for baseline gestures at the outset of the study (see *Baseline Matching Training*); it was complete when a child produced 11 out of

12 correct responses across the four target gestures, tested in extinction. This was followed by staggered matching test sessions.

Follow Up

One matching test session was administered every two to three weeks, until a total of two (Ola), three (Sarah), or four (Gareth) sessions had been conducted. This completed the experimental procedure.

Coding of Children's Responses

Each session was recorded on videotape and coded using pre-determined response criteria to identify, on each training and test trial, whether a child produced a correct response, an incorrect response, or failed to emit a response. The movement sequences considered as correct responses to each gesture are listed in Table 8.2. The response criteria excluded behaviours that the children naturally produce at this age, such as clapping, kicking, touching clothes or near objects, extending hands, mouthing fingers, rubbing eyes, and scratching any part of the body. Children's tact responses needed to be clear and audible; abbreviations "cross" and "side" were accepted as correct tact responses for "across" and "to the side" respectively.

If a child performed a correct response immediately after an incorrect response, it was coded as a 'self-correction' and counted as correct in the final analyses. Conversely, an incorrect response emitted immediately after a correct response was coded as a 'correct-to-incorrect' and counted as incorrect (see Erjavec & Horne, 2008; Horne & Erjavec, 2007; see also Chapter 7). Such multiple responses were very infrequent. In the matching test sessions, they occurred on 7% of baseline trials (range: 4–9%) and on 9% of target trials (range: 8–12%). Overall, self-corrections were scored six times more frequently than correct-to-incorrect responses.

Also recorded was whether a reinforcer was delivered in a particular baseline gesture matching trial, the number of models (1, 2, or 3) per trial required to evoke a response, and the form of each incorrect response (see Appendix D).

Inter-Observer Agreement

A second scorer, familiar with child research but blind to the aims of the present experiment, independently coded 29% of sessions selected on a random basis. Inter-observer agreement was calculated by dividing the number of agreements by the total number of coded responses then multiplying the result by 100. An agreement was defined as two independent observers assigning the same response code on a given trial. Across all training and testing sessions, there was 100% agreement for matching training trials, 98% for matching test trials, 98% for tact training trials, and 100% for tact test trials.

8.4 Results

Children's Matching of Baseline Gestures

The four gestures that were trained as baseline matching relations for each child are listed in Table 8.1. and described in Table 8.2. (top panel). Sara completed baseline training in 4 sessions, Ola in 3 sessions (the minimum required by criteria, see Procedure), and Gareth in 12 sessions. All children responded promptly to the experimenter's modelling upon the first presentation on almost every trial (repeated presentations of baseline gestures were required on only seven trials across all children) and they continued doing so throughout the subsequent tests. Children's correct responses in all matching test sessions presented throughout the procedure are shown in Figure 8.4. for Sara, Figure 8.5. for Ola, and Figure 8.6. for Gareth. These figures show that Sara emitted correct responses on 94% of baseline trials, Ola on 93% of trials, and Gareth on 89% of trials.

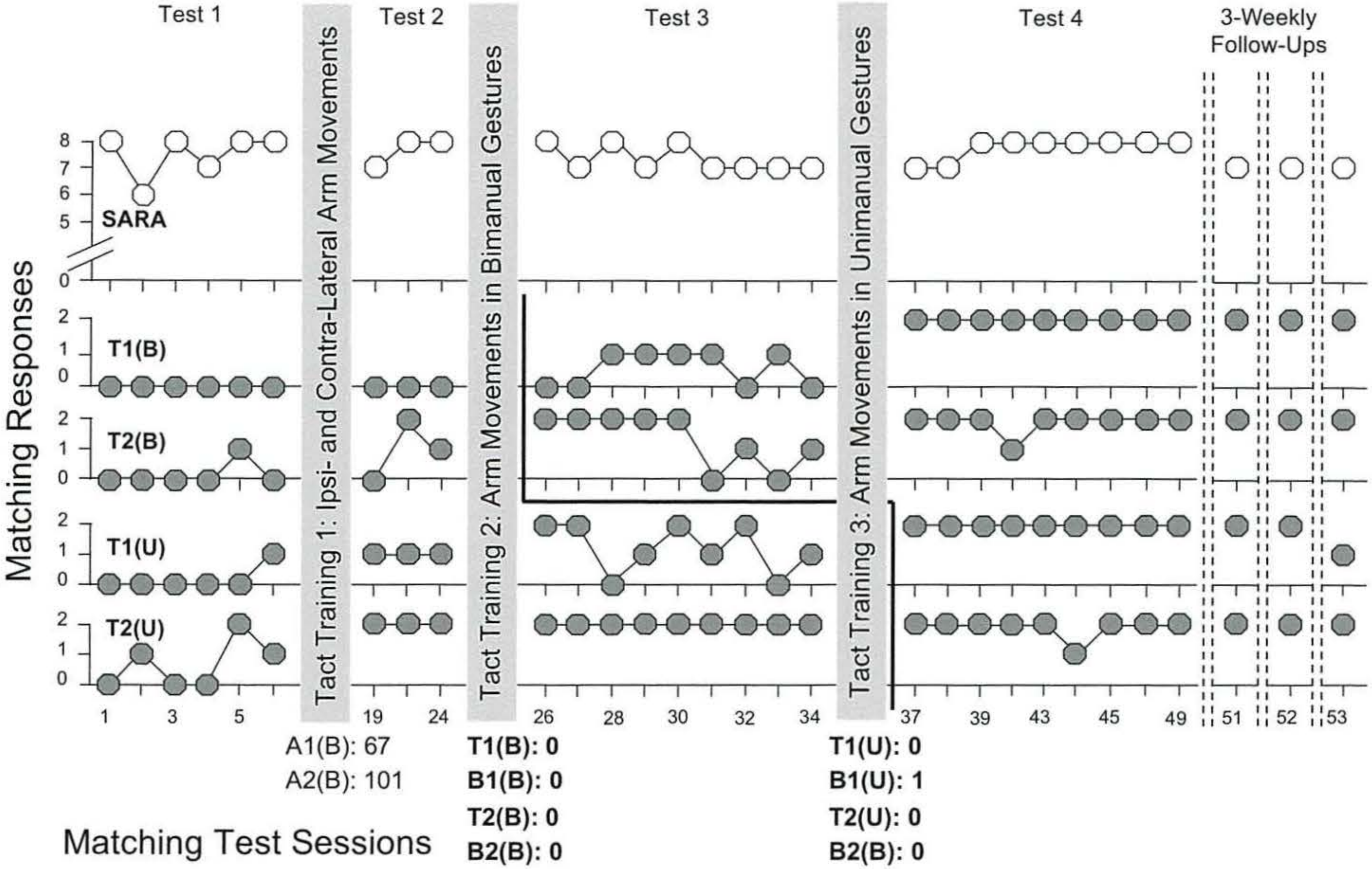

Figure 8.4. Correct matching responses emitted by Sara in the eight baseline trials (plotted together at the top of figure and represented by open circles) and the eight target trials (plotted separately for the four target behaviours, with two trials per session per gesture, and represented by filled circles) presented during each session of the multiple baseline procedure. Training and testing was administered in a staggered manner across the participants (see text). Each training round is denoted by a shaded area accompanied by a description; the bold lines indicate where training was applied in a staggered manner to pairs of target actions and the correspondent baseline actions. Underneath, the number of training trials that needed to be administered before criterion performance was attained is presented for each target gesture. Bold figures indicate the relations that were in place at the outset.

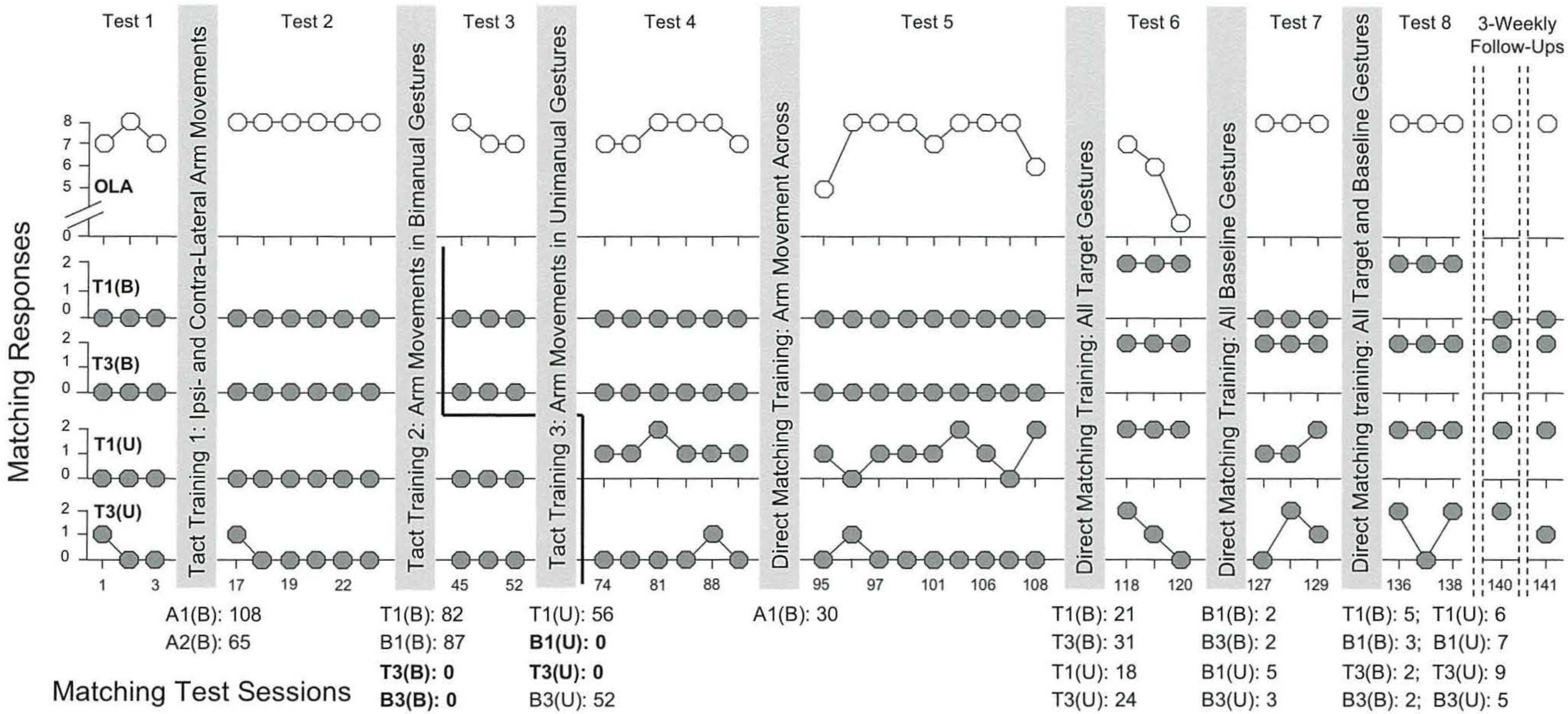

Figure 8.5. Data for Ola; otherwise as Figure 8.4.

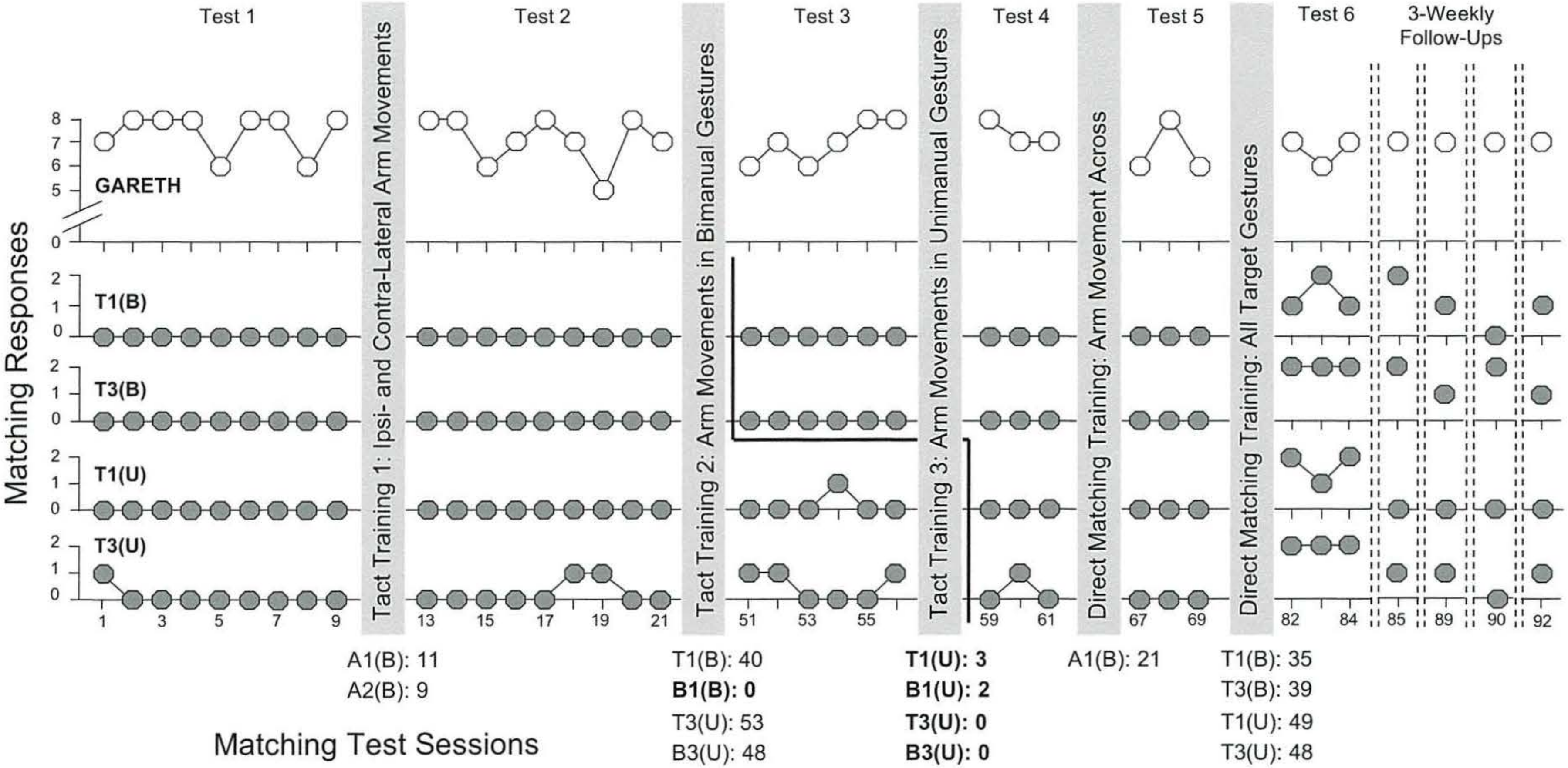

Figure 8.6. Data for Gareth; otherwise as Figure 8.4.

Children's Matching of Target Gestures

The Effects of Tact Training

Sara learned to tact "to the side" in 67 trials and "across" in 101 trials when she was presented with component gestures that did not terminate on a body part (*Tact training 1*; see Figure 8.4.). These labels generalised to movement in bimanual baseline and target gestures (in *Tact training 2*) and in unimanual gestures (in *Tact training 3*), which Sara was able to tact accurately without further training. Prior to tact training, in *Matching test 1*, she emitted correct matches on only 13% of her target trials, but following *Tact training 1* she correctly matched 50% of her targets; after *Tact training 2*, she did so for 64% of targets, and after *Tact training 3* she correctly matched all but two models across 72 target trials (97% correct in *Matching test 4*). Clearly, tact training of movement sufficed to produce near-errorless matching of all target gestures for Sara – and her performance remained excellent in *Follow-up*, where only one error was recorded on 24 target test trials administered over next two months (96% correct). In her *Matching test 4*, Sara frequently tacted movements modelled by the experimenter (she said "cross" on 8 trials and "side" on 2 trials) before performing correct matching responses to target and baseline gestures.

Ola learned to tact "to the side" in 108 trials and "across" in 65 trials when she was presented with component gestures that did not terminate on a body part in *Tact training 1* (see Figure 8.5.). Ola did not match her target gestures before this training (4% correct in *Matching test 1*), or after it was administered (2% correct in *Matching test 2*). Following this, she was presented with tact training of movement in bimanual baseline and target gestures (*Tact training 2*). She was able to tact movements for two of her gestures without further training, but required 87 trials before she could accurately tact "to the side" and 82 trials for "across" when presented with the remaining pair of gestures. This training had no effect on her subsequent matching performances (0% correct in *Matching test 3*). Finally, Ola was presented with tact training of movement in unimanual baseline and target gestures (*Tact training 3*). Again, tacting generalised for two of her gestures, but the remaining pair required 52 trials for "to the side" and 56 trials for "across" before criterion performance was reached. In the following *Matching test 4*, Ola started to match one of her target gestures, T1(U), and did so on 58% of trials, whereas the remaining three targets remained unmatched (3% of trials).

Data for the remaining child, Gareth, show that he did not match his target models at the outset (1% correct in *Matching test 1*; see Figure 8.6.). *Tact training 1* was completed very quickly; he learned to tact "to the side" in only 11 trials and "across" in 9 trials. However, this training had no effect on Gareth's matching in subsequent *Matching test 2*, where only 3% of responses were correct. He was next trained to tact the movement component in bimanual baseline and target gestures; *Tact training 2* required 93 trials to train "across" for two targets, and 48 trials to train "to the side" to one of baseline gestures, whereas the remaining baseline gesture evoked this tact with no further training. Again, this training had no effect on Gareth's matching (8% correct in *Matching test 3*). Finally, he was presented with tact training of movement in the unimanual baseline and target gestures (*Tact training 3*), which took only a few trials to complete; but his matching remained incorrect in the following *Matching test 4* (only 4% correct).

The Effects of Direct Matching Training

Having matched all her targets correctly as the result of tact training, Sara did not require direct matching training. The remaining 2 children did.

It took 30 trials to train Ola to produce the component movement "across" to criterion, but her performance did not improve in the following *Matching test 5* – only one of her gestures, T1(U), continued to be matched intermittently (50% correct), whereas the remaining targets remained unmatched (2% correct). Next, it took 90 trials to train Ola to produce all target gestures to criterion. In the subsequent *Matching test 6*, she emitted correct matches to all her targets on most trials (88% correct), but her matching of baseline gestures deteriorated, and fell below the criterion. Therefore, baseline gesture training was administered next, over 12 trials; this resulted in errorless matching of baseline gestures in the following *Matching test 7*, but in this test Ola's matching of target gestures fell to 54% correct. Mixed direct training of all baseline and target gestures was administered next; 12 trials were needed for baseline, and 27 trials for target gestures, to reach criterion performances. Following this, in *Matching test 8*, Ola's matching of baseline models remained errorless, and her matching of targets became excellent (92% correct). In *Follow-up*, over two sessions, Ola's matching of targets fell again to 67% correct.

It took 21 trials to train Gareth to produce the component movement "across" to criterion, but his performance did not improve in the following *Matching test 5* (0% correct). Next, Gareth received direct matching training of all his target gestures, which took between 35 and 49 trials per gesture (171 trials in total) to complete to criterion. Following this, in *Matching test 6*, Gareth matched his targets on 88% of trials. However, *Follow-up* shows that his performance did not remain as high over the next three months – he emitted correct matches on 41% of these trials.

Children's incorrect responses on all matching test trials were noted and examined. These responses are reported in Appendix H. In most cases, the children touched a correct part of the body using an incorrect, ipsilateral movement – thus producing baseline responses to target models. This replicated the earlier findings from the behaviour analytic and cognitive developmental literature (e.g., Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Erjavec et al., 2009; Gleissner et al., 2000; Horne & Erjavec, 2007).

8.5 Discussion

None of the children were able to tact movements "to the side" and "across" at the outset of the present study. This is in line with a previous finding that young children, presented with modelling of empty-handed gestures, seldom name limb movements (see Chapter 6). However, once the children were trained to tact movements in component gestures A1(B) and A2(B), this training generalised to the corresponding movements in bimanual hand-to-body gestures (7/12 were in place); for unimanual hand-to-body gestures, trained last, most tact relations were found to be in place at the outset (10/12).

Following tact training, Sara's performance improved until her matching of untrained target gestures was as accurate as her matching of trained baseline gestures. Sara's generalised imitation of target gestures could not be attributed to extra-experimental training, as her targets were shown to be novel at the outset, and her caregivers were unaware of the experimental task. Her increased accuracy was unlikely to be the result of repeated modelling, which was shown to be ineffective across a number of previous studies (Erjavec & Horne, 2008; Erjavec et al., 2009; Horne & Erjavec, 2007; see also Chapter 7), and which did not effect changes in performances of the remaining 2 children in the present study.

Training children to tact two movements aided their discrimination between baseline and target gestures, and it could be argued that the improvement in Sara's matching was indeed due to discrimination training. This is not likely: The existing literature shows that discrimination training alone – even if it consists of training the children to produce each target response in the absence of modelling – is not sufficient to evoke correct matching in generalised imitation tests (see Erjavec et al., 2009; Horne & Erjavec, 2007). Consistent with this, training children to match the A2(B) arms crossed gesture in the present study – which was easily accomplished, demonstrating that contralateral responses are not very difficult for toddlers to perform – did not evoke correct matching of contralateral target gestures for Ola and Gareth.

The results suggest that Sara's accurate matching of novel targets in the absence of direct training was the result of her learning to name the component movements of the target and baseline gestures. Whenever the experimenter modelled a contralateral target response, Sara was now able to name the movement she witnessed, and to respond as a listener to her own utterance "across" by extending her hand across her body midline to touch the appropriate body part. Indeed, examination of the matching test sessions that followed last tact training revealed that Sara overtly named the movement "across" eight times, and did so for the movement "to the side" twice, as she emitted her gestural responses. On other trials, such naming responses could have been emitted covertly (see Horne & Lowe, 1996). However, the same outcome was not recorded with the remaining 2 children: Tact training enabled Ola to match only one of her novel targets, and Gareth did not match any of his targets at the end of this training. Neither of these children overtly labelled component movements in their matching test trials. Clearly, tact training did not lead to accurate matching in all cases.

The pattern of results is, however, in line with the predictions derived from the naming account of Horne and Lowe (1996). It is well documented that tact training establishes naming in young children (e.g., Horne et al., 2004; 2006). However, the self-instructional effects of naming are most reliable when children produce the relevant name on task. For example, in the study of naming and categorization conducted by Lowe et al., (2002), children who failed to produce the expected effects of naming in initial tests of emergent categorization, went on to pass those tests when prompted to produce the relevant name out loud at the start of the test trials. Interestingly, in the present study, only Sarah spontaneously named the action components of the target actions and only she matched them. Future studies should investigate whether prompting children to name the action component as Sarah did will result in more reliable name-based matching of modelled movements.

The present study, however, highlights another limitation that is more likely to apply in action naming than in naming of objects. Once the children had learned to tact and name the across and to the side movements, they were expected to attend to these features of the gestures. However, given the cross-body mapping problem inherent in all matching studies, their responses to those tacts will have depended on their existing listener repertoires: Those children who were already able to respond as listeners to others' "side" and "across" tacts by performing the named movement themselves may have been expected do so in response to their own utterances, but children whose listener repertoires were limited to looking at the named event could only re-orient to the movement modelled by the experimenter after they named it. Therefore, another explanation for the pattern of results observed in the present study is that Sara's listener repertoire already contained crossing the arms and body midline, but this was not the case for the remaining 2 children. Indeed, Sarah was the oldest and it is likely that her naming repertoire was the most developed. Future research should address this proposition directly and measure individual children's listener repertoires at the outset. For example, if a child is able to choose a correct picture showing the action named by the experimenter [e.g., A2(B) rather than A1(B) after the experiment asks, "Can you show me arms crossed?"], this would indicate that her common listener repertoire includes orienting to the gesture(s) that contain the described movement. If a child is also able to perform the required gestures when presented with the same prompt, this would demonstrate that her listener repertoire is more developed and includes the performance of a named target action. The naming account would predict that tact training would lead to generalised imitation only in the latter case. For those children whose listener repertoires only contain orienting to named movements, and whose matching performances fail to improve as the result of tact training, the experimenter could proceed to train target movements as listener responses, in absence of modelling, before again testing for generalised imitation.

Ola and Gareth were able to match the unreinforced targets in matching tests after they received direct matching training; this replicated findings previously reported in the literature (e.g., Erjavec et al., 2009; Horne & Erjavec, 2007). However, their matching of targets was unstable for some of the gestures – it declined over time in follow-up sessions. Sara's matching, established via tact training, was much more stable over time. Future research should investigate whether generalised imitation established through naming may be more robust that directly trained matching repertoires.

The multiple baseline design used here (see also Chapter 7) allows the experimenter to control for effects such as exposure to multiple trials and passage of time; it demonstrates the effect of an intervention by showing changes across separate behaviours, when, and only when, a treatment intervention is introduced. However, in some cases presented in this and the previous series of experiments, it was observed that the effect of the intervention (in this case naming training) on the children's matching behaviour did not follow immediately or it apparently emerged before the intervention was put in place. Thus the conclusions drawn from the results need to be interpreted with some caution. The present pattern of results is likely due to the gradual effects that different aspects of training may have had on the children's production of body part and movement labels in the subsequent matching trials: The more naming relations children are taught, the more those relations are likely to be evoked on task. Because of this, the effects of naming training on matching may, in some cases, appear to be continuous rather than discrete (i.e., shown only when certain gestures were targeted in naming intervention). An alternative explanation could be that the improvements in children's performances were unrelated to naming training, and were instead a result of a gradual convergence towards more accurate matches, indicative of reinforcement by parity that such responses achieved. However, this is unlikely, because for most children and gestures, in these and in previous related studies with children of similar age (Horne & Erjavec, 2007; Erjavec et al., 2009), there is no evidence of generalised imitation being demonstrated over very many response opportunities, in the absence of either naming training or, more commonly, direct matching training of target responses.

Alternatively, other sources of control could be considered. Rather than continuous stimulus control relations being in effect in the matching task, a multiplicity of stimuli in the experimental environment may acquire controlling properties (Bickel & Etzel, 1985) and be inadvertently measured along with the control exerted by the specified stimulus, here naming. This quantal interpretation is supported by the fact that children's responding often fluctuated from trial to trial, which may have been a result of unspecified or masked sources of stimulus control. For example, tact training can indeed be one route of establishing the critical discrimination. Similarly to naming, discrimination effects are not an all-or-none phenomenon, such that discriminations shown on one task would necessarily imply their occurrence on another task. Therefore, discrimination training cannot be completely ruled out as a determinant of the behaviour change observed here, as it is also expected that only if a child produces the relevant discrimination on-task the effect would be observed in the response. The matching task particularly is always a function of multiple sources of control, in which on-task discrimination for example is not fully controlled.

To summarise. The present study replicated the earlier findings by showing no evidence of spontaneous generalised imitation of cross-body gestures in 2- to 3-year-old children. It also extended these results by showing that learning to name the constituent movements of hand-to-body gestures can, in some cases, lead to accurate matching of these gestures in subsequent imitation tests.

A limitation of this study is the absence of clear evidence that the participant who showed positive results was reliably tacting target models during testing (although she did so overtly on several occasions, all of which were followed by correct matching responses) or that she was responding to her tacts as a listener. Conversely, stronger evidence for the naming hypothesis would have been provided if it had been shown that failure to imitate by the other two participants was associated with absence of the speaker and/or listener components of naming, at least during testing. Therefore, future studies ought to employ at least two additional experimental manipulations that would clarify the conditions under which children do, and do not, emit correct matching responses following tact training.

First, the experimenters should evaluate directly whether tact training led to full naming by testing for corresponding listener behaviour. If listener responses that include performing the actions (and not just orienting or pointing to it) are absent at this point, they can be trained directly and the effect of this training on matching performances evaluated again. Second, children's overt naming can be prompted in matching tests. For example, in previous categorisation studies (Horne et al., 2004, 2006, 2007; and Lowe et al., 2002, 2005), participants were asked to tact the sample prior to selecting the comparison to ensuring that naming was brought to bear on the selection task. A similar procedure was also used in the Experiments 2 and 3 reported in Chapter 7. In a replication of the present study, the participants could respond to a question such as, "What am I doing?" prior to responding to the experimenter's modelling and the auditory stimulus, "Do this".

Overall, considering the findings from all generalised imitation studies to date that have employed all the necessary controls for children's extra-experimental learning histories and non-imitative learning mechanisms, it is apparent that generalised imitation in infants and toddlers had only been observed after these children were presented with naming training.

Clearly, on-task naming can be sufficient to establish generalised imitation – but is this the only means through which children's matching can extend to behaviours that have not been directly trained as matches? More research is needed to explore determinants of matching in infants and young children, and especially the relationship between children's verbal abilities and their imitative performances.

CHAPTER NINE: Learning to Name Arm Movements Improves Imitation Accuracy in Preschool Children[1]

9.1 Abstract

The present study investigated the relationship between preschool children's imitation accuracy and their ability to name the components of hand-to-body gestures presented in the imitation test. Sixty-two children participated in one of three conditions: They were either trained to name two arm movements featuring in the modelling of 12 hand-to-body gestures ("across" for contralateral movements and "to the side" for ipsilateral movements); or two body parts touched in the modelling of these gestures ("shoulder" and "knee"); or pictures in a book, unrelated to arm movements or body parts. Next, all children were presented with modelling and imitation test of the same hand-to-body gestures. The children trained to name the arm movements produced significantly fewer matching errors then the remaining groups. These results are incompatible with the specialist accounts of imitation that attribute young children's matching errors to immature cognitive processing and goal-selection, but they support the generalist accounts of imitation, providing evidence that early imitation is determined by children's ongoing learning experiences. It is concluded that children's imitative performances need to be interpreted with reference to their verbal repertoires, and that determinants of imitation may change over the course of development.

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[1] I would like to acknowledge and thank all the undergraduate project students that participated in the collection of the data reported in this Chapter.

9.2 Introduction

It is widely agreed that imitation is established early in human development and that it facilitates the acquisition of other important behavioural repertoires exclusive to humans. However, there is less agreement about the cognitive processes involved in this early skill.

Several authors have proposed that matching an action entails a specialised process that starts with decomposition of observed motor patterns into their constituent components and then involves (re)construction of the action pattern that the observer performs (see Bekkering et al., 2000; Gattis et al., 2002; Gleissner et al., 2000; Meltzoff & Moore, 1997; Wohlschläger et al., 2003). In this process, children are said to be hampered by processing limitations; they attend to dominant goals of the observed actions, but neglect those lower in the hierarchy. Consequently, their imitative responses contain the motor program most strongly associated with the achievement of the main goal (ideomotor principle). Whenever children are presented with modelling of complex actions that contain multiple goals, this is predicted to result in imitation errors. Consistent with this account, errors have been observed in a number of studies that employed modelling of empty-handed gestures to infants, toddlers, and preschool children (e.g., Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Erjavec & Horne, 2008; Erjavec et al., 2009; Gleissner et al., 2000; Horne & Erjavec, 2007). In these studies, children had been presented with touches to feet, knees, ears, shoulders and so on, performed with either ipsilateral (same side of the body) or contralateral (crossing the body midline) arm movements. Children accurately matched some of these models, but responded incorrectly on the remaining trials, most often by touching the correct part of the body but using ipsilateral movements in response to contralateral models. Proponents of the specialist goal theory of imitation have attributed these errors to children's focus on the main goal of a modelled behaviour (end-point of the action; in this case body part touched) and their neglect of the inferior goals (movement performed by the experimenter) – a consequence of their processing limitations (Gleissner, et al., 2000; Wohlschläger, et al., 2003; also see Byrne & Russon, 1998).

Others have argued that children's correct matching responses and their commonly produced errors can be explained without evoking specialised cognitive processes. In a recent review, Ray and Heyes (2011) have proposed that imitation develops from children's interactions with their sociocultural environment in which seeing an action is frequently accompanied by doing an action; these early imitogenic experiences (such as direct or mirror self-observation, or being imitated by adults) are likely to be instrumental in the emergence of matching repertoires in young children. According to their Associative Sequence Learning (ASL) model, imitation is said to involve bidirectional links between the sensory (mainly visual) representations of the observed movements and their motor representations, established via general learning processes (see Brass & Heyes, 2005; Byrne, 2003; Heyes, 2001; Heyes, 2005; Heyes & Ray, 2000). Erjavec and Horne (2008) have also argued that there is nothing special about imitation, which is learned in the same way as other behaviours in the course of children's social interactions with their caregivers. They have demonstrated that 2- to 3-year old children's matching responses tend to be much more accurate for gestures that frequently feature in naming and matching games that they play with their caregivers (e.g., the nursery rhyme 'Heads and shoulders, knees and toes'), compared to gestures that are not commonly practiced in this way, regardless of their goal structure, presence of contralateral movements, or apparent complexity of these behaviours (also see Erjavec et al., 2009). Ray and Heyes (2011) also suggested that children's ongoing vocabulary development may become an important determinant of their imitative performances, because same labels are frequently used when children see an action performed by others and when they perform an equivalent action (see also Hall, 1994; and Heyes & Ray, 2000). This is in agreement with the earlier account of Horne and Lowe (1996), who propose that learning to name objects and events in their environment may alter the way in which children respond on imitation tests. Thus children's matching may become more accurate for those gestures or their features that children have learned to name, and vice versa. The observed pattern of correct responses and errors on hand-to-body imitation tasks is consistent with these proposals: Children's matching tends to be accurate for body parts touched, which young children learn to name early in their interactions with caregivers (see Chapter 5), but their matching is less accurate for movements, consistent with the findings that verbs are typically learned later than nouns (e.g., Gentner, 1983; Horne & Lowe, 1996) and that contralateral responses are seldom used by young children (Erjavec et al., 2009; see also Chapter 5).

The present study was designed to explore the relationship between children's ability to name the components of actions presented in imitation tests, and the accuracy of their matching responses. Given that there is sufficient evidence in the literature to show that young children are much more practiced at naming parts of body than movements (see Chapter 6), the emphasis was placed on the latter: Will training the children to accurately name contralateral and ipsilateral arm movements improve the accuracy of their matching performances?

Different accounts of early imitation generate different predictions about the likely effects of this training. If children's imitation is determined by their learning history, training them to name the movement components of modelled actions – to say "across" when presented with contralateral actions, and to say "to the side" when they see the experimenter modelling ipsilateral actions – is expected to improve their discrimination of these hand-to-body gestures, and to direct their attention to the movement. As a result, their matching responses in the subsequent imitation tests should become more accurate. This is because, according to generalist accounts, children's matching accuracy is constrained by their experiences, rather than any inherent limitations in their processing of the observed actions or their ability to (re)produce them. By contrast, according to the specialist goal theory of imitation, children's imitation accuracy is determined by hierarchical goal selection and their processing limitations. While errors can be reduced through simplifying the goal structure (complexity) of the modelled actions (see Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Gleissner et al., 2000), training children to label and attend to movement component of the modelled behaviours may change the pattern of their errors, but would not be expected to yield better performances overall. If training the children to label movements "across" and "to the side" suffices to establish this component of the modelled behaviours as a dominant goal, this account predicts that children would proceed to accurately match the movement, but they would be expected to make errors in reproducing the remaining goals, such as touching correct parts of body. Alternatively, if the goal structure is not very flexible and cannot be altered by this (brief) training, no change in the error rates or patterns would be predicted.

The present study employed hand-to-body actions most frequently used in previous imitation studies – touches to knees and shoulders, performed bimanually and umimanually, containing ipsilateral and contralateral movements. Each participant was first exposed to one of three training conditions: they were asked to name either the movements performed by the experimenter (movement naming condition), or the body parts touched (body part naming condition), or the pictures in a book that contained neither movements nor body parts (picture naming condition). Following this, all children were presented with the same imitation test.

This research complied with British Psychological Society guidelines for research with children and was approved by the School of Psychology Ethics Committee.

9.3 Method

Participants

Sixty-two children, 30 boys and 32 girls, aged between 36 months and 19 days and 57 months and 0 days (M = 44 months and 6 days), participated in this study and completed the procedure. The children were recruited by parental consent (see sample of consent for in Appendix A) and tested in the nursery or school they attended. Twelve nurseries and three primary schools in the north and west regions of Wales participated in this study. No special inclusion or exclusion criterion was employed, except that the children needed to be fluent English speakers. At the end of the experimental session, each child was given a sticker bracelet and a certificate for their participation, and a debrief letter was sent to the parents (see sample to debrief letter in Appendix C). The data for additional 4 children that took part in the experiment were omitted from the final set (1 child suffered from speech impairment and 3 children did not complete the procedure).

Settings and Apparatus

Sessions were conducted in a designated quiet space at the nursery or school. During the session, the experimenter and the child sat on beanbags inside an inflatable boat, facing each other. A teddy bear toy (Teddy) sat on the edge of the boat, wearing a backpack full of stickers. A portable digital video camera with microphone was set up in the testing area and DV tapes were used for recording the sessions. These recordings were imported into an external hard drive so that stop- and slow-motion viewing and coding could be done on a computer.

Stimuli

The visual stimuli employed were 12 manual gestures performed live by the experimenter; these are shown and described in Figure 9.1.

Design and Procedure

Each child was randomly allocated to one of three independent conditions. In each condition, the children were presented with naming training followed by imitation test. First, the experimenter invited each child to sit with her in the boat and help her teach Teddy – a large stuffed bear toy – about things he needed to learn. When the child accepted this invitation, training commenced. Training was different across conditions, but testing was the same for all children.

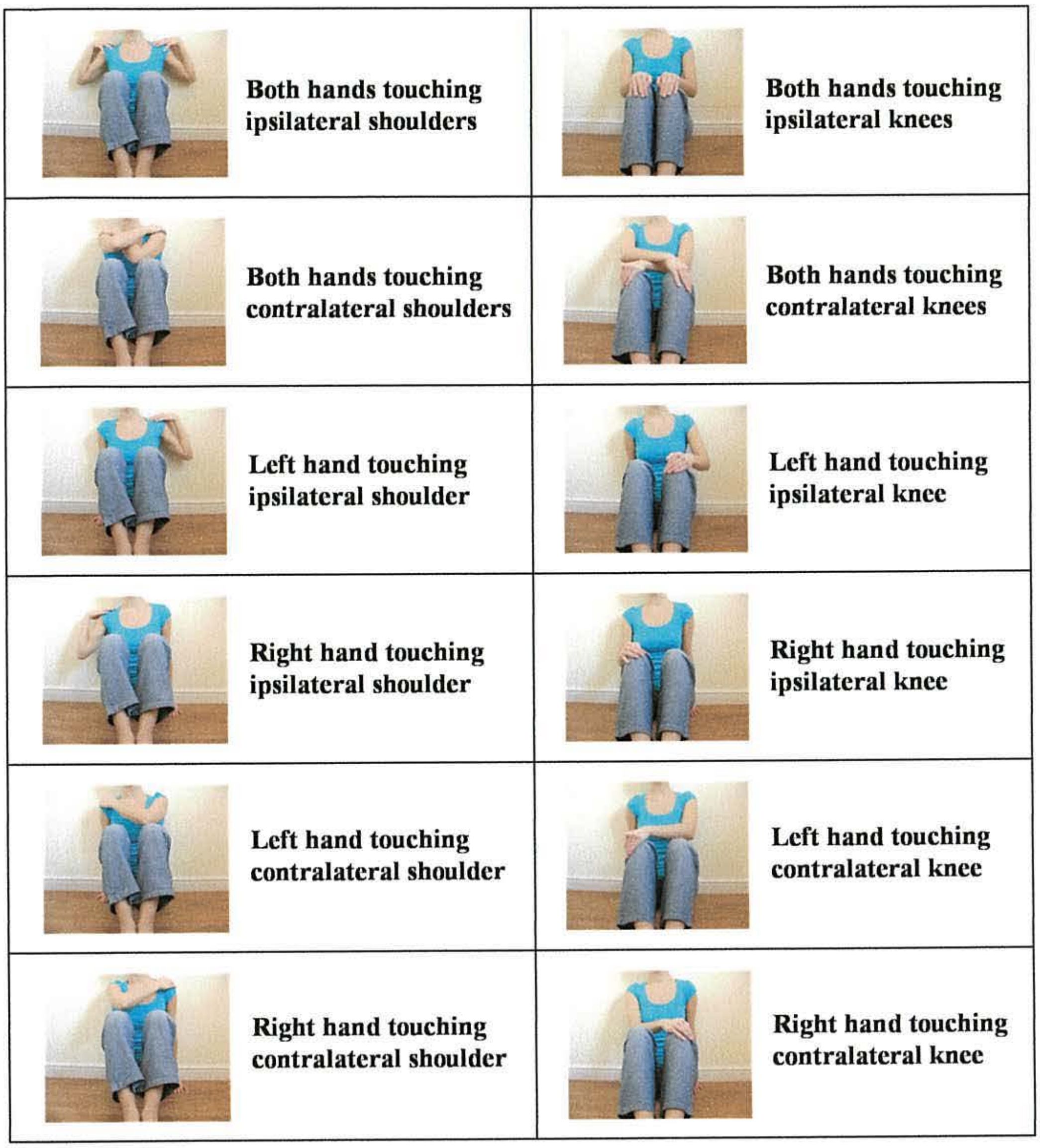

Figure 9.1. Gestures modelled by the experimenter.

Movement Naming Training

In the movement naming condition, children were trained to accurately name two arm movements, "across" (contralateral) and "to the side" (ipsilateral), involved in the behaviours performed by the experimenter. The child was invited to teach Teddy how the experimenter was putting her arms. The experimenter first produced the four bimanual gestures, one at the time, in a pre-randomized order (see Figure 9.1.). She drew the child's attention to the movement by saying, "Look, how am I putting my arms – are they across or to the side?" Children's correct responses were praised, and their incorrect responses received correction; up to three prompts were presented on each trial, as needed. As each child became more proficient at naming the arm movements, the experimenter abbreviated her prompt to, "Across or to the side?" Naming training of bimanual gestures was considered complete when the child responded correctly on four consecutive trials. The same training was then employed on the eight unimanual gestures; this training ended when the child was able to name eight consecutive movements correctly, with no more that one error.

To maintain children's interest in the tasks, a time limit was placed on training in this and the remaining conditions. If a child failed to reach the training criteria in eight minutes, the training stopped and imitation test was administered next. Sixteen children reached the training criteria and correctly named the two movements, but another 10 children did not. These latter children formed another comparison group; their data were analysed separately and are presented in the Results.

Body Part Naming Training

In the body part naming condition, children were trained to accurately name body parts, "knee(s)" and "shoulder(s)", involved in the behaviours performed by the experimenter. The child was invited to teach Teddy what the experimenter was touching. The experimenter modelled the gestures and drew the child's attention to the body parts by saying, "Look, what am I touching – knee(s) or shoulder(s)?" This prompt was later abbreviated to, "Knee(s) or shoulder(s)?" Training procedure and criteria were exactly as described for the movement condition. Seventeen children completed this training within the allocated eight minutes; no child failed to reach the correct naming criteria for body parts.

Picture Naming Training

In the picture naming condition, children were asked to name pictures in a book. These pictures did not represent gestures, movements or parts of body (e.g., they showed a tiger, ice-cream, apple, car, and so on). Training was presented prior to imitation test simply as a control for warm-up play that involved naming training. On each trial, the experimenter pointed to one picture in the book and asked the child "What's this?" She praised or corrected each response, as appropriate. Training was considered complete when a child, presented with twelve consecutive trials, named each picture correctly with no more than one error. Nineteen children completed the training, and none failed to reach the correct naming criteria within eight minutes.

Imitation Test

Imitation test was administered to all children immediately after training. Twelve models were presented twice each in a pre-randomized order (a total of 24 trials per child). Before modelling the first gesture, the experimenter told the child, "Shall we play a different game? Can you copy me?" On each trial, the experimenter prompted the child, "Can you do this?" and modelled one of the gestures; modelling and prompts were presented up to three times per trial, as needed, to elicit a gestural response. Children's responses were never praised or corrected, but the experimenter smiled throughout to ensure that responding was not suppressed, as may have been the case if the responses were followed by a 'still face' expression by the experimenter (Striano & Lizkowski, 2005).

Coding of Children's Responses

In training, children's verbal responses needed to be correct and audible; "cross" and "side" were accepted as correct responses in movement naming condition. In imitation tests, the last response on each trail was considered in the analyses (in cases of multiple responses, which are not very frequent in children of this age, self-corrections are typically recorded much more often than correct-to-incorrect responses; e.g., see Erjavec & Horne, 2008). Touches to upper leg were accepted as correct responses to knee models, and touches to front or side of shoulder were accepted as correct responses to shoulder models. Mirror responses to unimanual models, in which a child responded in the same hemispace as the modeller, but correctly reproduced topography of the response, were accepted as correct. The form of each incorrect response was recorded (see coding sheet in Appendix D) in order to analyse the type and percentage of matching errors observed in each condition.

Inter-Observer Agreement

A second scorer independently coded 34% of sessions selected on a random basis across participants. Inter-observer agreement was calculated by dividing the number of agreements by the total number of coded response events. An agreement was defined as two independent observers coding the same response event on a trial. Across all experimental conditions, the agreement was 100% for naming responses in training, and 96% for matching responses in imitation test.

9.4 Results

Table 9.1. shows the number of participants, their mean age, and number of trials administered in training across four independent experimental groups. Children's ages were well matched across these four groups (no significant differences, $F_{(3,58)}=.922$, $p=.436$). Across the three groups that completed naming training, there was no significant difference between the number of training trials administered to children, $F_{(2,49)}=.527$, $p=.594$, but significantly more training trials were presented to children who failed to reach the movement naming criteria within the eight-minute time limit (p range .004 to .016 for comparisons with the remaining three groups).

Table 9.1.

Children's ages and number of training trials administered in each experimental condition.

		Age (Months/Days)		Number of Training Trials	
Experimental Condition	**N**	**M**	**SD**	**M**	**SD**
Movement Naming	**16**	**46/29**	**04/13**	**32.9**	**17.00**
Body Part Naming	**17**	**44/12**	**06/21**	**27.9**	**23.96**
Picture Naming	**19**	**45/05**	**05/24**	**27.7**	**3.43**
Movement (criteria not reached)	**10**	**43/01**	**04/20**	**52.8**	**19.55**

The percentage trials on which the children emitted correct matching responses in imitation test are shown in Figure 9.2. The accuracy of children's matching was different across the four experimental groups, $F_{(3,58)}=8.04$, $p<.001$, and the effect size was large (Cohen's $d=1.29$; see Cohen, 1992). Conservative Games-Howell post-hoc comparisons (with degrees of freedom adjusted whenever Levene's tests of homogeneity of variance were violated) revealed that children's correct responses were significantly higher in the movement naming condition compared to the body part naming condition, $t_{(31)}$=4.62, p<.001, d=1.66; compared to the picture naming condition, $t_{(33)}$=3.59, p=.001, d=1.20; and also in comparison with the group of children who did not reach training criteria in the movement naming condition, $t_{(24)}$=4.12, p<.001, d=1.68.

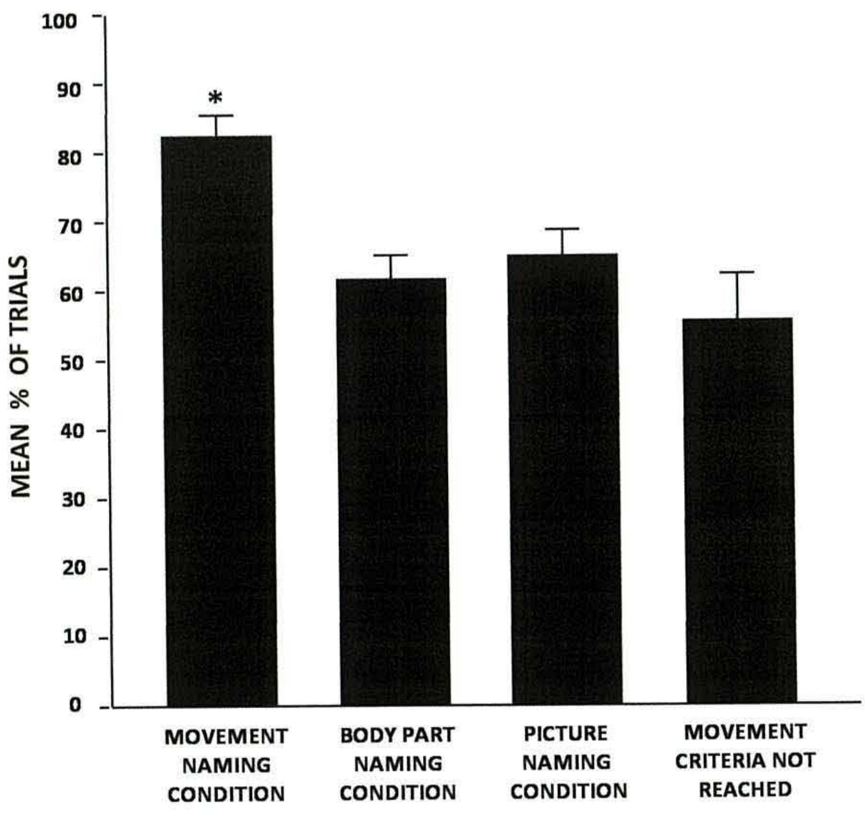

Figure 9.2. Mean percentages of trials on which the children emitted correct matching responses in imitation test, across the four experimental groups.

Children's incorrect responses were analysed next. The most frequent matching errors were the responses in which children touched a correct body part, but used an incorrect movement to accomplish the touch. Figure 9.3. shows the percentages of trials on which the children in each group emitted such movement errors. The percentages of ipsilateral-for-contralateral errors differed across the four groups, $F_{(3,58)}$=8.25, p<.001, with a large effect size, d=1.31. Games-Howell post-hoc comparisons showed that these errors were significantly lower in the movement naming condition compared to the body part naming condition, $t_{(27.69)}$=5.56, p<.001, d=2.11; to the picture naming condition, $t_{(33)}$=3.07, p=.004, d=1.07; and to the group of children that did not reach training criteria in the movement condition, $t_{(12.95)}$=3.96, p=.002, d=2.20. The percentages of contralateral-for-ipsilateral errors, which were emitted much less frequently overall, also differed across the four groups, $F_{(3,58)}$=2.89, p=.043, with a medium effect size, d=.77. The children in the movement naming condition produced significantly fewer errors than those in the picture naming condition, $t_{(20.09)}$=3.03, p=.007, d=1.35, but the remaining two comparisons were not statistically significant.

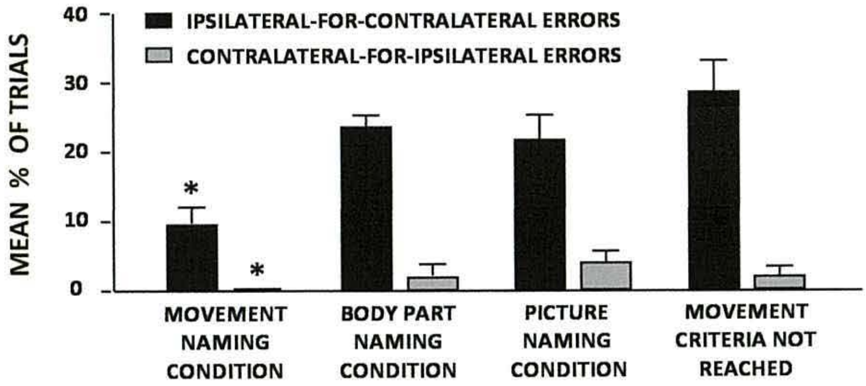

Figure 9.3. Mean percentages of trials with ipsilateral-for-contralateral errors, and vice versa, across the four experimental groups.

Children seldom emitted body part errors in any group. The percentages of trials on which they performed a correct movement but touched an incorrect part of body were not significantly different across the groups, $F_{(3,58)}$=0.42, p=.737. On a small proportion of their trials, children emitted bimanual responses to unimanual responses, and vice versa. These hand number errors were present on a similar proportion of trials in each group, $F_{(3,58)}$=1.93, p=.135. Finally, children's remaining errors consisted of entirely incorrect responses and trials where no response was emitted; these error rates were also not different between the groups, $F_{(3,58)}$=1.01, p=.393. Figure 9.4. shows the percentages of trials on which children emitted body part errors, hand number errors, and other incorrect / no responses.

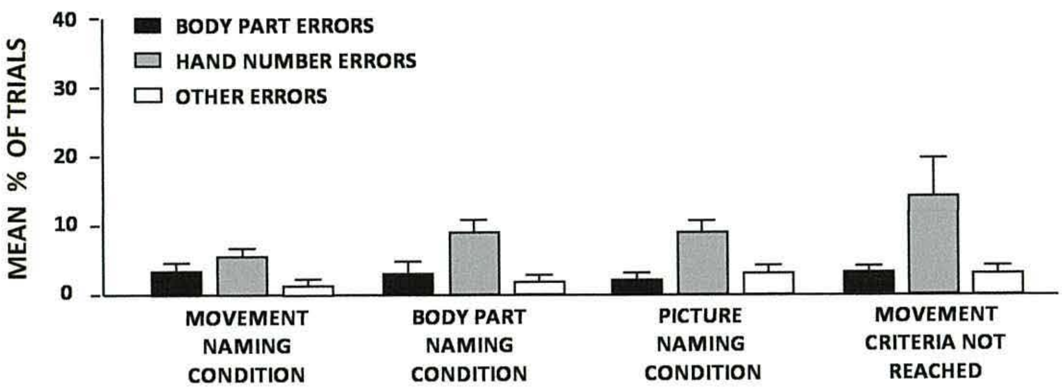

Figure 9.4. Mean percentages of trials with body part errors, hand number errors, and other errors (entirely incorrect responses and trials with no response), across the four experimental groups.

9.5 Discussion

The results show that training the children to correctly name movement components of modelled hand-to-body gestures significantly increased their imitation accuracy. Compared to the children who were trained to name two parts of body touched in the modelled gestures or pictures in a book that were unrelated to gestures, and those children who failed to learn to name the two movements in eight minutes of training, the children who could accurately name movements “across” and “to the side” emitted significantly fewer movement errors in their imitation test trials. At the same time, their other errors – including touches to incorrect parts of body – remained comparable to the remaining groups. This result is not consistent with the predictions derived from the goal account of imitation (Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Gattis et al., 2002; Gleissner et al., 2000), which states that children’s matching errors are a consequence of their immature cognitive processing of actions, whereby only the dominant goals and motor responses strongly associated with their achievement are (re)produced by young children.

Children in the picture naming control condition responded correctly on over half of their trials. They typically touched the same body part as the experimenter, but often used ipsilateral movements in response to contralateral models. This replicated the pattern of responses reported in the imitation literature (Bekkering & Wohlschläger, 2002; Bekkering et al., 2000; Erjavec & Horne, 2008; Gleissner et al., 2000) and showed that the current procedure – presenting the children with naming training prior to imitation tests – did not in itself alter their matching performances. Indeed, the effect of training was specific to naming of movement: those children trained to name parts of the body performed exactly the same as the control group, as did the children who did not reach training criteria in the movement training condition.

Horne and Lowe (1996, 1997; also see Lowe & Horne, 1996) explain how selective naming may affect children's imitative performance. Naming training administered by their caregivers enables the children to direct and sustain their attention to the components of actions that they see others perform and which the children are able to name. Each naming relation also contains conventional listener responses – the actions that children learn to perform when they hear others, or themselves, produce a verbal label for objects, actions, or other events in their environment. To start with, children's listener responses may be simple looking or orienting to the named events, but ongoing social interactions and practice will eventually extend these repertoires to include performance of conventional actions, such as crossing the body midline in response to the label "across". Let us now consider an imitation test trial in which the experimenter models a contralateral touch to a knee. If a child only named the body part, overtly or covertly, she would attend to this component of the modelled gesture and proceed to touch her own knee, but she would be unlikely to do so using a contralateral movement, which is not a frequent response in young children. However, if this child had been trained to name the movement "across" prior to the imitation test, she would also attend to this component of the modelled gesture and become more likely to respond accurately, by crossing her body midline to touch her knee. Of course, her ability to do the latter would depend on the extent of her previously learned listener repertoire (i.e., whether she has sufficient experience of producing contralateral hand-to-body movements).

The present results are entirely consistent with the predictions derived from the naming account, and more generally with generalist accounts of imitation which consider children's learning histories as a key determinant of their imitative performances (Erjavec & Horne, 2008; Heyes, 2001; Heyes, 2005; Ray & Heyes, 2011). They also complement the earlier findings that show how training infants and toddlers to perform contralateral gestures as matching responses increases their accuracy in imitation tests (Horne & Erjavec, 2007; Erjavec et al., 2009).

Clearly, the present results do not show that naming training is a necessary prerequisite for correct matching of hand-to-body gestures, but the data indicates that children's verbal repertoires need to be taken into account in the interpretation of their imitative performances. More broadly, these findings allow to consider that determinants of imitation are likely to change during the course of development, and that they may vary across tasks. For example, different learning experiences may influence children's matching responses in instrumental imitation tests, where their attention can be drawn to task-relevant object features through social stimulus enhancement or demonstration of the objects' affordances (see Horne et al., 2009; Thompson & Russell, 2004; Zentall, 2006).

Instead of omitting some components of the target actions, as is the case for empty-handed gestures used in the present study, young children often faithfully reproduce non-functional and obviously redundant components of complex instrumental tasks (this is referred to as overimitation: see Whiten, McGuigan, Marshall-Pescini & Hopper, 2009). Taken together, these findings point to the multiple influences and processes that can operate in imitation tests. The stimuli presented in an imitation episode may evoke competing responses: well-established movements that children have been practicing with their caregivers and peers in matching games, verbal responses to the sight of the modeller's actions (such as naming the whole action, or one or more of its components), children's tendency to attend to parts of objects or body that they see an adult touch, exploration of objects' affordances, and so on. Thus it is concluded that a complete explanation of children's matching performances necessitates understanding of the multiple determinants of this complex behaviour. Researchers aiming to explain the pattern of responding on a particular imitation test ought to consider varied learning histories of their participants, their social experiences, and their verbal repertoire.

CHAPTER TEN: General Discussion

The present thesis follows the format in which each experimental chapter presents a paper that has been submitted for publication to either a mainstream developmental journal (Chapter 5, Chapter 6, and Chapter 9) or a behaviour analytic journal (Chapter 7 and Chapter 8). Therefore, thorough discussion of the findings, including their theoretical and practical implications, is presented at the end of each experimental chapter. In order to minimise repetition, only brief summaries are presented here. However, ideas that have not been discussed in previous chapters are presented in more detail.

10.1 Research Summary

The present research programme was designed to explore the relationship between young children's ability to name different components of novel target gestures when presented to them in a modelling context, and their matching accuracy.

In order to identify target behaviours suitable for experimental manipulation, the first two studies mapped toddlers' ability to name a wide range of gestures, and their component behaviours, that were modelled by the experimenter, and their ability to respond to the descriptions of these same behaviours presented by the experimenter. The studies presented in Chapter 5 and Chapter 6 have shown that the children's performance of gestures that were verbally described by the experimenter (verbal comprehension) was better than their descriptions of the same gestures when the experimenter performed them (verbal production); this is in line with previous findings that verbal comprehension develops ahead of verbal production during young children's language learning. The children were more likely to name the body parts that the experimenter touched than the effectors or movements that she used to accomplish these touches. Considering the body parts under study, children's naming was better for facial and broad features than for joints and smaller body segments. The likely determinants of children's ability to name some parts of the body, but not others, include their past experience of naming games and routines used by their caregivers, the sensory input that each body part receives, and how easy it is to discriminate each part from the adjacent areas. Considering movements, the children's ability to name them, and perform them in response to instruction, was related to their age; overall, across the sample studied, few movement labels were ever emitted. The results of these two preliminary studies confirmed that children could not name the gesture features that were reported as poorly matched in previous imitation studies (e.g., Bekkering et al., 2000; Erjavec & Horne, 2008), and that the children's pattern of naming errors reported in Chapter 5 and Chapter 6 of this thesis resembled the pattern of imitation errors reported in those studies; this suggests that children's verbal and imitation repertoires may be in some way functionally related.

In the next three experimental chapters, children were trained to name body parts (Chapter 7) and movements (Chapter 8 and Chapter 9) that were novel to them at the outset, in order to establish whether this training would improve the accuracy of their imitative performances. In the three experiments presented in Chapter 7, children were first trained to match four baseline relations; next, four novel (untrained) target relations were identified for each child and presented as unreinforced probes in repeated generalised imitation tests, interspersed with intermittently reinforced baseline gestures. These novel targets comprised touches to body parts that are seldom named by toddlers, such as temple, armpit, shin, calf, thumb, and so on. After repeated modelling failed to evoke correct matching of novel targets, the children received tact or listener behaviour training for the previously unnamed target body parts. Both procedures established naming and, subsequent to this, children's matching of touches to target body parts greatly improved. Thus it was shown that learning to name the key components of the target gestures is a potent determinant of children's imitative success. This finding was confirmed when, in the following experiments presented in Chapter 8 and Chapter 9, training the children to name the movement components of target and baseline gestures (i.e., to say either "across" or "to the side" when presented with contralateral and ipsilateral gestures, respectively) resulted in marked improvements in their imitative performances. These findings present the first experimental demonstration that shows, conclusively, that children's verbal repertoires can determine their performance on apparently non-verbal imitation tests. These findings bear on the evaluation of the key theories and accounts of imitation, presented in Chapter 2 and Chapter 3 of this thesis.

10.2 Theoretical Implications of the Present Findings

Key Theories and Accounts of Imitation Revisited

Although Piaget (1962) considered that full imitation requires full representation and the ability to symbolically represent events in the world, he did not consider that language might be directly involved in children's imitative performances. The finding that children in their third year of life could not accurately imitate fairly simple hand-to-body touches that terminated on visible locations (e.g., thumb or wrist) prior to receiving naming training or direct matching training also contradicts the predictions of Piaget's account.

The active intermodal mapping (AIM) theory of Meltzoff and Moore (1992, 1997) considers that imitation is an innate ability, driven by cross-modal mapping processes. The present findings, which confirm that repeated modelling of fairly simple hand-to-body gestures is not sufficient to evoke correct matching responses in toddlers, are not compatible with the predictions derived from this theory. According to Meltzoff and Moore, children should vary their responses until they match the modelled gesture because the innate mechanism compares the sensory input and proprioceptive feedback. Contrary to this prediction, there is no indication in the present data that children's responses converged on more accurate matching configurations over repeated modelling trials in the absence of further interventions and training. However, AIM theory is concerned with neonatal and early infant performances, so the possible role of language has never been considered.

The evidence presented in this thesis confirms that children's pre-existing matching experiences determine which actions and their features are produced in response to modelling, and that children's verbal repertoires of body part and movement names are likewise determined by their history of interactions with their caregivers. The associative sequence learning (ASL) model of Heyes and colleagues (e.g., Heyes, 2001, 2005; Brass & Heyes, 2005) and various mirror neuron system (MNS) accounts (see Lepage & Théoret, 2007) accept that experiences change the way in which children respond to seeing others' actions. They propose that imitation is mediated via associations made during what they term "imitogenic social experiences", and that language can provide a link between seeing an action being performed and performing the equivalent action. Therefore, the present data are broadly in agreement with the predictions derived from the ASL model. Nevertheless, there are subtle differences between the predictions derived from the ASL model and the behaviour analytic accounts of Skinner (1953) and Horne and Lowe (1996); these are discussed later in this chapter.

The present results are incompatible with the predictions of the goal-directed theory of imitation (GOADI) of Bekkering and colleagues (e.g., Bekkering, et al., 2000; Gleissner, et al., 2000; Wohlschläger, et al., 2003). This account was discussed in detail in Chapter 9, which also presents a direct empirical test of the GOADI predictions that will not be repeated here.

The present data confirm that direct matching training is a key determinant of young children's success on generalised imitation tests, which is in line with Skinner's (1953) explanation of imitation as a directly trained operant repertoire.

However, the experiments conducted in this thesis do not support the conditioned reinforcement hypothesis of Baer and Deguchi (1985). This account predicts that increasingly better approximations to target modelled behaviour would develop over repeated response opportunities due to the reinforcing properties of similarity or parity that such responses could achieve. A steady improvement in children's matching over trials was not observed in any of the experimental tests reported in this thesis. Additionally, the present findings are inconsistent with the results of Poulson and colleagues (Poulson & Kymmissis, 1988; Poulson et al., 1991; Poulson et al., 2002), which suggested that generalised imitation across behaviours within the same topographical boundaries emerges during infancy. In the experiments reported in Chapter 7 and Chapter 8, when matching of some novel targets emerged, other targets within the same topographical boundaries were still incorrectly matched.

Naming and Imitation

The results of the research presented in this thesis were entirely consistent with the predictions of the naming account of Horne and Lowe (1996), described in detail in Chapter 3, Chapter 6, and Chapter 7. Overall, these results show that children's learning history of naming influences their matching performance in imitation tests. The self-instruction quality of naming may facilitate or restrict the accuracy of their matching behaviour, depending of the choice of target responses and the extent of the child's verbal repertoire. As children's verbal ability develops, modelling may evoke their learned naming repertoires that, in turn, may serve to guide their matching performance – this can happen covertly and remain unnoticed by the experimenter. Therefore, children's naming repertoires should always be considered when establishing experimental controls for confounding variables in the study of imitation.

The present data do not suggest that naming is necessary for accurate matching; only that it is one of the multiple determinants of imitation. These and previous studies (e.g., Horne & Erjavec, 2007; Erjavec et al., 2009) have shown that matching of target gestures can be easily established in infants and toddlers through direct matching training, for which naming skills are not required. The current findings also show that, unless prompted, naming is not consistently evoked during matching. Only when naming occurs can it reliably exert control over children's matching behaviour.

It could be argued that naming only served to establish simple discrimination between target gestures, and to direct children's attention towards relevant gesture features, which in turn aided the accuracy of their imitative performances. However, this seems unlikely. One line of evidence against the argument that simple discrimination instead of naming could be the main facilitator of an untrained behaviour (here imitation) is the outcome of the early studies on naming and categorisation (see Horne et al., 2006; Horne et al., 2007; Horne et al., 2004; Lowe et al., 2002; Lowe et al., 2005). These studies show that establishing common listener behaviour with respect to arbitrary stimuli does not establish untrained categorisation of those stimuli (whether categorisation is measured via a matching-to-sample sorting task or transfer of novel behaviours). On the other hand, establishing names for the stimuli generates these emergent category relations. Listener training ensures the child attends to and discriminates between each arbitrary stimulus as readily as tact (name) training does, so attention/discrimination training on its own cannot explain the emergent categorisation effects of naming.

Future research could provide a similar test regarding the effects of listener training on children's matching. The replication of Experiment 3 in Chapter 7 and the study reported in Chapter 8 with the proposed modifications and a larger number of participants, should increase chances of identifying children who only learn listener behaviour (see Horne et al., 2004; 2006) rather than full naming relation. A comparison between the former and latter groups of children would provide a direct test of the naming interpretation adopted in this Thesis: If it was found that listener behaviour alone suffices to establish accurate matching of novel targets, this would show that the present results could be interpreted as an effect of enhanced attention or discrimination of perceptual cues, rather than naming.

More generally, the present findings show that all accounts of imitation should take into consideration that the determinants of this repertoire change over the course of childhood. Depending on major developmental milestones (such as the acquisition of language, the acquisition of particular fine and gross motor skills, and the acquisition of specific social and emotional competencies), the determinants of imitative performance in pre-verbal infants and toddlers will be different from those in older children and even adults. Different social and cultural learning experiences are also likely to account for intra- and inter-individual variability in imitative performances; these should be considered in the study on this complex and multiply-determined, learnt repertoire.

10.3 Methodological Considerations

The sample of children that participated in the first six studies reported in this thesis attended a model Nursery affiliated with Bangor University. It is possible that these children have a richer experience of body part naming routines with their caregivers, and consequently their body part naming repertoires may be larger and more diverse when compared to those of other children. However, the participants of the last study reported in Chapter 9 attended different local nurseries of the North West region of Wales, which provided more diverse and mixed levels of early experiences with caregivers. Nevertheless, the results obtained in the last study were in line with what was predicted and derived from the experiments conducted with children from the University nursery. Ideally, to determine whether the present findings generalise to other populations, replication with children from different backgrounds is desirable.

A second methodological consideration is that, in the single case design experiments reported, which involved daily sessions with each child during a period of 4 to 6 months (see Chapter 7 and Chapter 8), it was necessary to maintain a high level of interest and responding. Therefore, a brief reinforcer preference assessment was frequently conducted prior to commencing each session. In this quick assessment, a selection of toys were presented to the child prior to any experimental trial and the child would choose the ones she or he would like to play with after

Teddy had had his lesson or during break times throughout the session (as needed). These toys and praise would also serve to reinforce responding to some baseline models. The toys in Teddy's box included a variety of story and music books, jigsaws, games, stickers, plastic figures, and bubbles, and were replaced with new ones on a regular basis. This ensured that Teddy's box kept its novelty and reinforcement value throughout the research. The steadiness of the baseline responses at most stages of the single-case experiments, and the children's constant motivation to play with the experimenter and Teddy, indicates that the reinforcement value of the experimental situation was well maintained. Indeed, the levels of engagement and responding were very high in the group studies as well (see Chapter 5, Chapter 6, and Chapter 9), which commends the present experimental setup to developmental psychologists.

10.4 Implications for Clinical Practice

Chapter 5 and Chapter 6 present the results of an extensive assessment of verbal knowledge of body parts and movements in normally developing children. These data may be useful in the detection of developmental delays in the areas of language, cognition, and body schema, or neuropsychological symptoms such as autotopagnosia (Goldenberg, 2003), and enable developmentally delayed children to receive intervention programmes at younger ages. Therefore, these data may be of wider interest to developmental psychologists, physiotherapists, occupational therapists, and applied behaviour analysts, given that children's body knowledge and imitation repertoires are likely to underpin the development of other abilities.

Research on the determinants of imitation in typically developing children, presented in Chapter 7, Chapter 8, and Chapter 9, may be used to enrich the interventions currently employed in the applied setting. For example, children with autism manifest severe disruption of the normal developmental processes in the first two years of life. Autism tends to be correlated with impaired language, poor imitation skills, and consequently, impaired cognitive, and social and adaptive functioning. As a result, autistic children's development in these key domains tends to fall further behind that of their peers as they grow older (Baron-Cohen, 1989; Frith, 1989). These children often show the inability to understand simple verbal and non-verbal communication, impairments in social interaction, repetitive and restricted patterns of behaviour (Cohen & Volkmar, 1997), and difficulty in imitating others' actions (e.g., Rogers, 1999; Smith & Bryson, 1994). The literature suggests that their imitative impairment can often have a devastating impact on related repertoires, such as language and social development, depending on when the imitation deficit occurs and its severity (Rogers, Hepburn, Stackhouse, & Wehner, 2003).

Stone, Ousley and Littleford (1997) reported motor imitation deficits in very young children with autism, and raised the possibility that this reflects a delayed, rather than a distorted pattern of acquisition (see also, Baron-Cohen, 1989; and Whiten & Brown, 1999). Stone et al. argued that despite delayed development of their imitation repertoire, children with autism could acquire early imitation skills in an identical pattern and sequence to that of typically developing children (see also, Williams, Whitten & Singh, 2004). This indicates that the determinants of imitation identified for normally developing children may also apply to other populations.

A recent fMRI study has demonstrated that children with autism spectrum disorders have lower mirror neuron system activity during social mirroring compared with typically developing children (Dapretto et al., 2006). However, recent evidence shows that the mirror neuron system has sufficient plasticity to accommodate new learning; this means that its level of functioning can gradually change (Calvo-Merino, Glaser, Grèzes, Passingham, & Haggard, 2005; Catmur, Walsh, & Heyes, 2007; Haslinger, Erhard, Altenmüller, Schroeder, Boecker, & Ceballos-Baumann, 2005). Imitation training has been put forward as an effective form of treatment for autism, as a way of training and activating the mirror neuron system (Escalona, Field, Nadel, & Lundy, 2002; Field, Sanders, & Nadel, 2001). Therefore, research concerning treatment approaches for improving imitation skills is highly relevant.

Applied behaviour analysis programs on imitation already incorporate many basic research findings. The latest improvements in applied interventions that target the development of imitation and language are worthy of note here (e.g., Ingersoll & Schreibman, 2006; Ingersoll, Schreibman, & Tran, 2003; Piaget, 1962; Rogers, Bennette, McEvay, & Penninton, 1996; Sundberg & Michael, 2001; Sundberg & Partington, 1998). For example, established verbal operants are often used to develop other verbal operants. The use of stimulus control transfer procedures have been extremely helpful in establishing the use of a word across different verbal operants and are widely used in verbal behaviour intervention programs (e.g., Sundberg & Michael, 2001; Sundberg & Partington, 1998). From a naming perspective, stimulus control transfer procedures facilitate the link between the listener, echoic and tact repertoires and therefore promote the emergence of combined speaker-listener behaviour (this was also the rationale behind the on-task naming prompt conditions employed in the series of experiments reported in Chapter 7).

Further investigating the possible mediating role of naming in the development of other non-verbal skills is exciting to both theorists and practitioners of behaviour analysis and developmental psychology. For example, understanding the relation between gestural imitation and naming in typically developing young children may contribute to the advancement of applied behaviour programs for children with autism. It may be that accurate matching of novel behaviours would be established quicker if naming training were employed concurrently with matching training. Future research could investigate the effectiveness of integrating relevant naming training in early imitation training programs for children with delayed imitative repertoires. One way to measure the effectiveness of such procedures could be to compare the amount of matching training necessary to establish novel matching when matching training is administered in parallel with related naming training *versus* on its own, using age-matched groups of young children.

10.5 Conclusions and Suggestions for Future Research

Generalised Imitation and Naming

Considering the evidence of all behaviour analytic studies to date that have employed the necessary controls for non-imitative matching mechanisms (see Chapter 4) and the present findings, it is clear that generalised imitation (as defined in this thesis; see Chapter 1) has only been demonstrated in the latter research, and only as a result of the naming interventions. Therefore, at present, we know that young children can accurately match empty handed gestures in the absence of external reinforcement or corrections in two ways: (i) if these gestures have been established as trained matching relations, or (ii) if the children have been trained to name the key components which they previously could not match (body parts or movements). More research is clearly needed to establish whether generalised imitation of novel behaviours can be established without the mediating influence of naming.

To facilitate accurate interpretation of the results, target behaviors needed to be operationally defined and distinguished as much as possible from each other and from each of the baseline gestures in terms of the trajectory of the arm movement and the body location touched (see Chapter 2). However, it could be argued that the coding criteria adopted in the present research were too stringent for young children to demonstrate their generalised imitation ability. This is not likely. First, although children often emitted responses to near-body areas, the results of this and previous research show that incorrect responses did not typically consist of inaccurate matches or near-misses. For many children, different target behaviors evoked the same kinds of incorrect responses: for example, some children tapped the back of their hands in response to almost every target gesture presented to them (see Horne & Erjavec, 2007) and others tapped their arm in response to more than one target model (see Erjavec et al., 2009, and the present research). Responding in the same way to different modeled gestures cannot be considered to be instances of inaccurate generalised imitation. Second, in all these studies children were presented with multiple response opportunities – in many cases hundreds of consecutive trials – on which to demonstrate the emergence of correct responding or the convergence towards more accurate matching responses. However, even when children occasionally emitted better approximations to target models or even entirely correct responses, these did not subsequently increase in frequency as would have been expected if parity acted as a conditional reinforcer and poor accuracy was simply a consequence of the participants' young age and their limited behavioural repertoires. Therefore, the most parsimonious explanation of children's performances is that they had not yet acquired generalised imitation (unless they were aided by naming) – rather than that they showed spontaneous generalised imitation that was lacking in accuracy.

The children's performances in imitation tests reported in this thesis are consistent with the Skinnerian account of early imitation as a gradually learned repertoire of discrete responses (Skinner, 1953), established and maintained like all other operants. However, a direct test of Skinner's notion of a minimal imitation repertoire leading to gradually more complex forms of imitative behaviour has not yet been performed; future studies should address this question directly.

The procedures employed in the present experiments allow only limited inferences about the lasting effect of the naming interventions. In the experiment presented in Chapter 8, one child's generalised imitation of target gestures established via movement naming training proved to be very stable over follow-up tests – more so than the matching performances of her two peers who were subjected to direct matching training. The long-term effects of the two types of training need to be more systematically evaluated in the future.

The present results indicate that, out of the two verbal repertoires manipulated in these experiments, body part naming is more readily evoked than movement naming as children observe modelling of hand-to-body gestures. Future research could look at the role of naming in matching behaviour while employing different target behaviours, training of other naming repertoires, or imposing a delay before testing.

Differentiating Between Generalist Theories of Imitation

The behaviour analytic account of imitation and cognitive ASL model of imitation both state that the children's matching repertoires develop as a result of their social experiences with caregivers, where children are presented with many instances of seeing and performing equivalent actions. However, the two accounts do not agree on details of the process by which new matching responses can be established in a child's repertoire.

According to ASL, contiguously seeing an action modelled by others and performing an equivalent action establishes and strengthens vertical associations between sensory and motor representations (Heyes, 2001, 2005; Brass & Heyes, 2005). As the result of these experiences, children become able to match the actions that they see. This process is mediated by the mirror neuron system. In contrast, according to Skinner (1953), operant training establishes matching responses to novel behaviours. In learning to match a new behaviour, a reinforcer is delivered when a child's response resembles a model of that behaviour; this increases the probability of the same response on subsequent occasions in the presence of similar models. Caregivers are said to gradually shape matching responses by providing reinforcement for successively better approximations.

These two accounts generate subtly different predictions that can be put to empirical test. This test could employ methodology similar to that used in the single-case experiments presented in this thesis. After novel target actions are identified at the outset and it is established that children cannot match them in repeated imitation tests, the target behaviours can be evoked under alternative stimulus control, such as placing stickers on unnamed body parts (see Erjavec et al., 2010; Horne and Erjavec, 2007). After each action is evoked in this way, the experimenter could match it, taking care that her own performance does not overlap with the child's, for example by waiting for the child to stop gesturing and providing distractions immediately after her own action to avoid repetition of the responses. ASL would predict that matching of target actions should develop as the result of this procedure, in which associations are made between performing an action (motor representation activation) and seeing a similar action being performed (sensory representation activation) in quick succession. However, behaviour analytic predictions would be different, because contiguity of responses is not considered sufficient to establish new operant responses. Instead, matching training, such as that described in Chapter 7 and Chapter 8 is needed.

Indeed, a closer examination of the data obtained in the present thesis and in previous research (Erjavec et al., 2010; Horne and Erjavec, 2007) shows that the ASL predictions have not been fulfilled: On many occasions, the children emitted correct matching responses to target models, but this did not serve to increase the likelihood of their correct matching of these behaviours in the subsequent trials in the absence of direct matching training or naming intervention.

The ASL model also predicts that learning to name actions could provide a link between seeing these actions done and performing them. However, this account does not specify exactly how this may happen. According to the ASL account, verbal responses may enter into equivalence relations together with sensory and motor representations of actions (similar to those described by Sidman and discussed in Chapter 3). By contrast, the naming theory of Horne and Lowe (1996) specifies the conditions under which training the children to tact the relevant features of target behaviours may influence their imitative responses.

Future research could also aim to test the predictions of the naming account further. For example, the naming account predicts that teaching a child to respond as a listener to the experimenter's naming of a target body part would lead to better matching of a target touch to that body part *only* if this training served to establish full naming relations. In the present thesis, this happened in all cases (see Chapter 7, Experiment 3), but future research can test this proposition with a larger sample of young children, where it would be expected that listener training would not suffice to establish full naming in all the participants.

The final suggestion for future research concerns the study of mirror neuron activation, which is presently a common interest amongst researchers from developmental, learning, comparative, and cognitive perspectives. Having demonstrated that learning to name the key components of the previously unmatched actions can lead to imitation, it would be interesting to learn whether such naming training would also alter the pattern of MNS activation. This would provide an insight into neural correlates of both repertoires, and their links.

Summary: Developmental Course of Imitative Responding

The latest research shows that there is no evidence of imitation at birth (Anisfeld et al., 2001; Jones, 2009) or generalised imitation (as defined in Chapter 1) during infancy up to 36 months of age (Horne & Erjavec, 2007; Erjavec et al., 2009). As babies develop into toddlerhood, they acquire imitative behaviour through direct training. This repertoire is not generalised and is better for gestures that entail manipulation of objects than for empty-handed gestures (Horne &

Erjavec, 2007; Horne et al, 2009; Erjavec & Horne, 2008; Erjavec et al., 2009), mainly because the manipulation of objects evokes other social learning mechanisms (such as affordances and stimulus enhancement). When toddlers and young children are presented with modelling of empty-handed gestures, their performances are far from perfect. As children acquire language and start learning to name objects and events in social contexts, this behaviour directs their attention and aids their discriminations, and through the mechanism of self-instruction, facilitates their imitative behaviour. During childhood, imitation develops into a prevalent social game where, instead of omitting some components of the target actions, young children often faithfully reproduce non-functional and obviously redundant components of complex instrumental tasks (e.g., Kenward, Karlsson, & Persson, 2010; McGuigan, Makinson, & Whiten, 2011; Nielsen and Blank, 2011). This is called over-imitation, and demonstrates that copying of the modeller's behaviour is more reinforcing to children than attaining the tangible reinforcers provided during the instrumental tasks. This phenomenon increases with age. As children develop into adulthood, they become increasingly more imitative, and able to imitate with high levels of selectivity and fidelity to the model. In children and adults, imitative behaviour may often serve social and cultural, rather than other functional purposes (McGuigan et al., 2011).

Overall, the findings reported in this thesis contribute to our knowledge and understanding of processes that can operate in imitation learning and testing. They show how naming – the earliest form of self-instructional behaviour – can determine children's responses in imitation contexts. As their verbal abilities develop, children's imitative performances may come under control of ever more complex rules, whether self-generated or provided by others. It is possible that self-instruction as a result of naming in young children may also be a powerful tool in assisting their learning of other non-verbal skills. It is hoped that the work conducted in the present thesis has contributed to generating further research and applied ideas.

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Appendix A.

A sample consent form and information sheet[2]

Dear Parent(s) or Guardian(s),

The Learning, Language, and Development research group at the School of Psychology, University of Wales Bangor, is conducting a new study on the early stages of learning in young children. We are investigating the steps involved in learning to produce various actions and gestures, and how young children come to respond appropriately. The study will be conducted by myself, Vera Costa, a postgraduate member of our team, and directed by Dr. Pauline Horne and Dr. Mihela Erjavec. Between us, the team have considerable experience of working and conducting research with infants and young children. We have a website that can tell you more about our group and our varied research: www.psychology.bangor.ac.uk/playlab/.

We wish to recruit children between the ages of 28 and 42 months for a medium-scale study. With your permission, your child will be seen by our researcher and shown many varied actions, some of which may be familiar and others novel, as a part of a "Simon Says" type game. We are not really interested in measuring how much your child already knows, instead, we are trying to learn more about the way that children's abilities and responses change over time and in response to new play experiences. Although it is difficult to estimate exactly how long it will take to complete the procedure with any individual child, we estimate that the study will take about three months to complete. Each session will be conducted at a specially equipped test room in the Nursery, and should take about 15 minutes. The sessions will be run, dependant on your child's

[2] All letters and forms were translated into Welsh.

willingness, each day your child attends the nursery. We fully expect that your child, like so many others we worked and played with before, will enjoy these sessions because of the fun one-to-one interactions and learning opportunities that they provide. We will videotape each session so that we can analyse responses afterwards, but we will not identify participants by name in any publication or report so that your child's anonymity is maintained.

When you consent to the study, we will keep you informed about its progression. Please feel free to arrange a time that suits you when we can meet and answer any further questions you may have about our work. We will provide you with a summary of the results of the study upon its completion, a participation certificate and a small gift for your child by way of thanks for your child's involvement.

Please let us know whether or not you agree for your child to participate in this study as soon as you can. This should be done by filling in the details on the attached consent form, and leaving it with the Nursery Manager, Sue Kennedy. If you are undecided and need to get more information before consenting please let us know either by asking Sue or by phoning on 01248 382 039, or by emailing me at v.costa@bangor.ac.uk. Naturally, participation in this study is entirely voluntary; even after you have given your consent to the study, you are free to withdraw your child at any time—just let us know.

We aim to make all our research enjoyable for both you and your child. However, should you be unhappy with any aspect of this research, please direct your complains to the Head of the School, Dr. Oliver Turnbull, School of Psychology, Brigantia, Penrallt Rd., Bangor, Gwynedd LL57 2AS.

Thank you for your time

Yours Sincerely

Vera Costa

Consent form

Date: ____________

Parent's name(s): ______________________________________

Please tick one of the statements below:

I have read and understood the information accompanying this form and –

<u>I consent</u> to the participation of my child in the study [ ]

<u>I do not consent</u> to the participation of my child in the study [ ]

Parent's signature: _____________________________________

Child's name: ____

Child's date of birth: ___________________________________

Griffiths Developmental Assessment consent form and information sheet

Dear Parent(s) or Guardian(s),

Thank you for consenting for your child to take part in our present study on the early stages of learning in young children. The study is still continuing and your child's collaboration has been very appreciated.

In the course of the study we wish to obtain an objective measure of the participants development, by administering the Griffiths Mental Developmental Scales. The Scales measure trends of development in the domains of language, cognition, and motor and social performances. The apparatus consists of a number of common objects carefully standardized and packed into a small carrying case.

I will be conducting the assessment (I am already familiar to the children given that I am also running the study sessions), which should not take more that one or two sessions; each session will be conducted in the Nursery test room, and should take about 30 minutes. We fully expect that your child, like so many others we have worked and played with before, will enjoy these sessions because of the fun one-to-one interactions and learning opportunities that they provide. We will videotape each session so that we can analyse responses afterwards, but we will not identify participants by name in any publication or report so that your child's anonymity is maintained.

When you consent to the assessment we will provide you with a summary of the results of the assessment upon its completion. Please feel free to arrange a time that suits you when we can meet and answer any further questions you may have about our work. Please let us know whether or not you agree for your child to participate in this assessment as soon as you can. This should be done by filling in the details on the attached consent form, and leaving it with the Nursery Manager, Sue Kennedy.

We are grateful for your continued support and we will inform you when we have concluded the study. If you are undecided and need to get more information before consenting please let us know either by asking Sue or by telephoning or texting Mihela on 077 5757 5182, or by emailing her at m.erjavec@bangor.ac.uk. Naturally, participation in this assessment is entirely voluntary; even after you have given your consent to the study, you are free to withdraw your child at any time—just let us know.

We aim to make all our research enjoyable for both you and your child. However, should you be unhappy with any aspect of this research, please direct your complains to the Head of the School, Dr. Oliver Turnbull, School of Psychology, Brigantia, Penrallt Rd., Bangor, Gwynedd LL57 2AS.

Thank you for your time,

Yours faithfully,

Vera Costa

Consent form

Date: ____________

Parent's name(s): ______________________________

Please tick one of the statements below:

I have read and understood the information accompanying this form and –

<u>I consent</u> to the participation of my child in the assessment [ ]

<u>I do not consent</u> to the participation of my child in the assessment [ ]

Parent's signature: ______________________________

Child's name: ______________________________

Child's date of birth: ______________________________

Appendix B.

Picture of the testing room and camera angles

Picture of the audiovisual suite

Appendix C.

A sample debrief and thank you letter

Dear Parent / Guardian,

Thank you very much for letting us play with your child! In the present study we are aiming to investigate how do children between 24 and 42 months of age name body parts and actions. Your child helped us in this venture, and we very much appreciate it.

An inflatable boat and a teddy bear on his way to school were the scenario in which the experiment took place. Your child enjoyed showing Teddy how things are called and where they can be found! In our sessions, your child was asked to produce the name for a range of body parts and actions, such as nose, teeth, touching chin, or peek-a-boo, and to identify a named body part or produce an action. The same selection of body parts and actions were used for the comprehension and production phases.

We hypothesize that younger children will name body parts by giving names of and touching general sections of the body (e.g., leg), while older children are able to be more specific (e.g., correctly name and point to toes as different from heel). Children's knowledge about body parts and actions is culturally driven and changes as they develop. We aim to map these changes in some detail, and to continue this line of research. For example, we will soon be looking into studying the role of the children's knowledge of body parts and actions in their imitative behaviour.

Please accept the enclosed toy as a token of our gratitude and appreciation. Please do not hesitate to get in touch with us if you have any further questions about our work. We hope that you will continue to support our research, which depends entirely on goodwill of parents like yourself. Best regards.

Appendix D.

CODING SHEET USED IN STUDIES REPORTED IN CHAPTER 5 AND CHAPTER 6

Child: __________ Session Number: ____________ Phase: _______

Date: _______________Start @_______ End @ _______ Length: __________

Trial	Gesture	Number of Models	Response	Correct?	Putting Thru?	Imit?	Echo?	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

CODING SHEET USED IN STUDIES REPORTED IN CHAPTER 7 AND CHAPTER 8

Child: __________ Session Number: ____________ Phase: ______

Date: _______________ Start @______ End @_______ Length: __________

Trial	Gesture	Number of Models	Response	Correct?	Putting Thru?	Reinf?	Any comments…
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							

CODING SHEET USED IN STUDY REPORTED IN CHAPTER 9

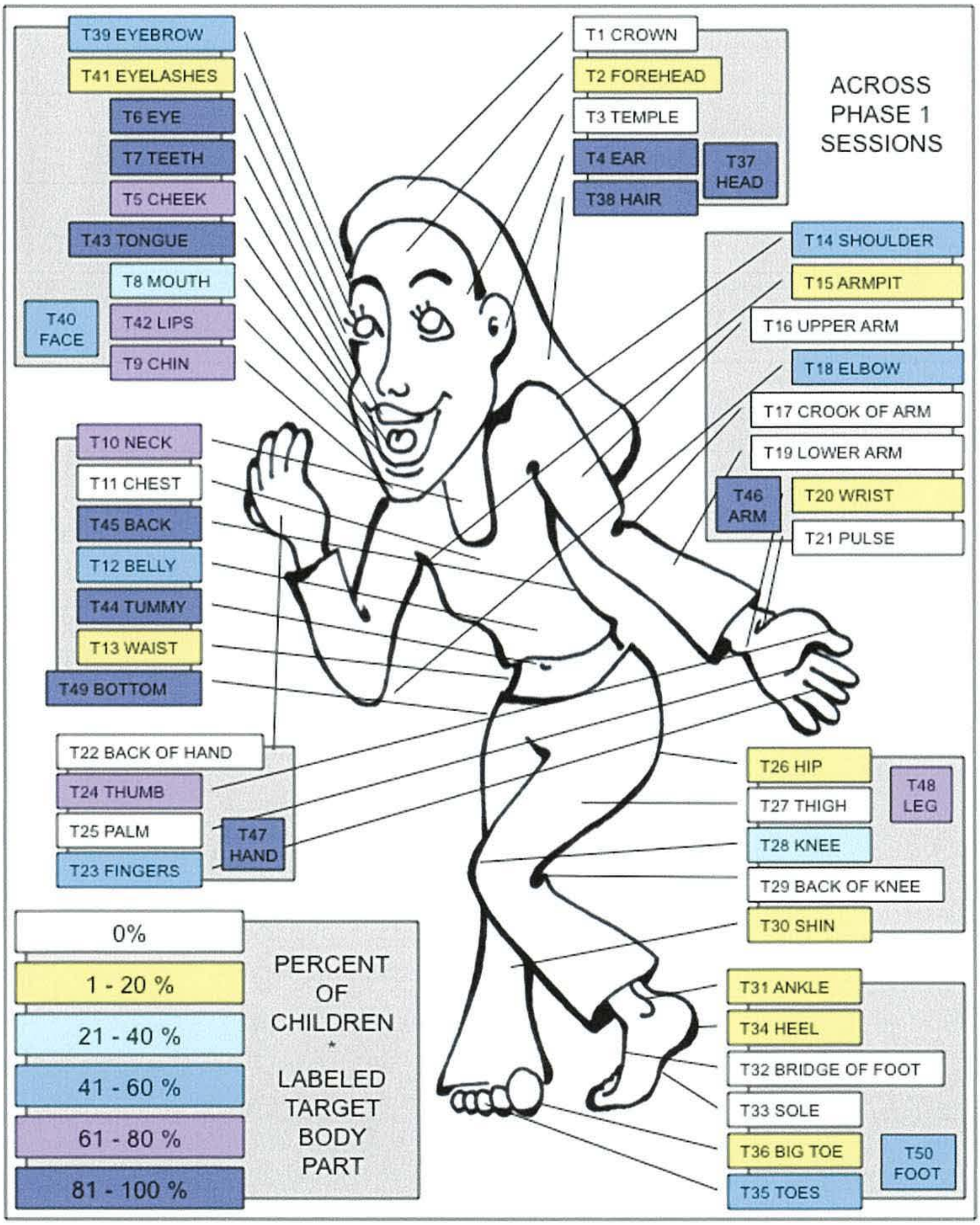
Child: __________ CONDITION: ____________ Phase: ______

Date: _______________Start @______ End @ _______ Length: __________

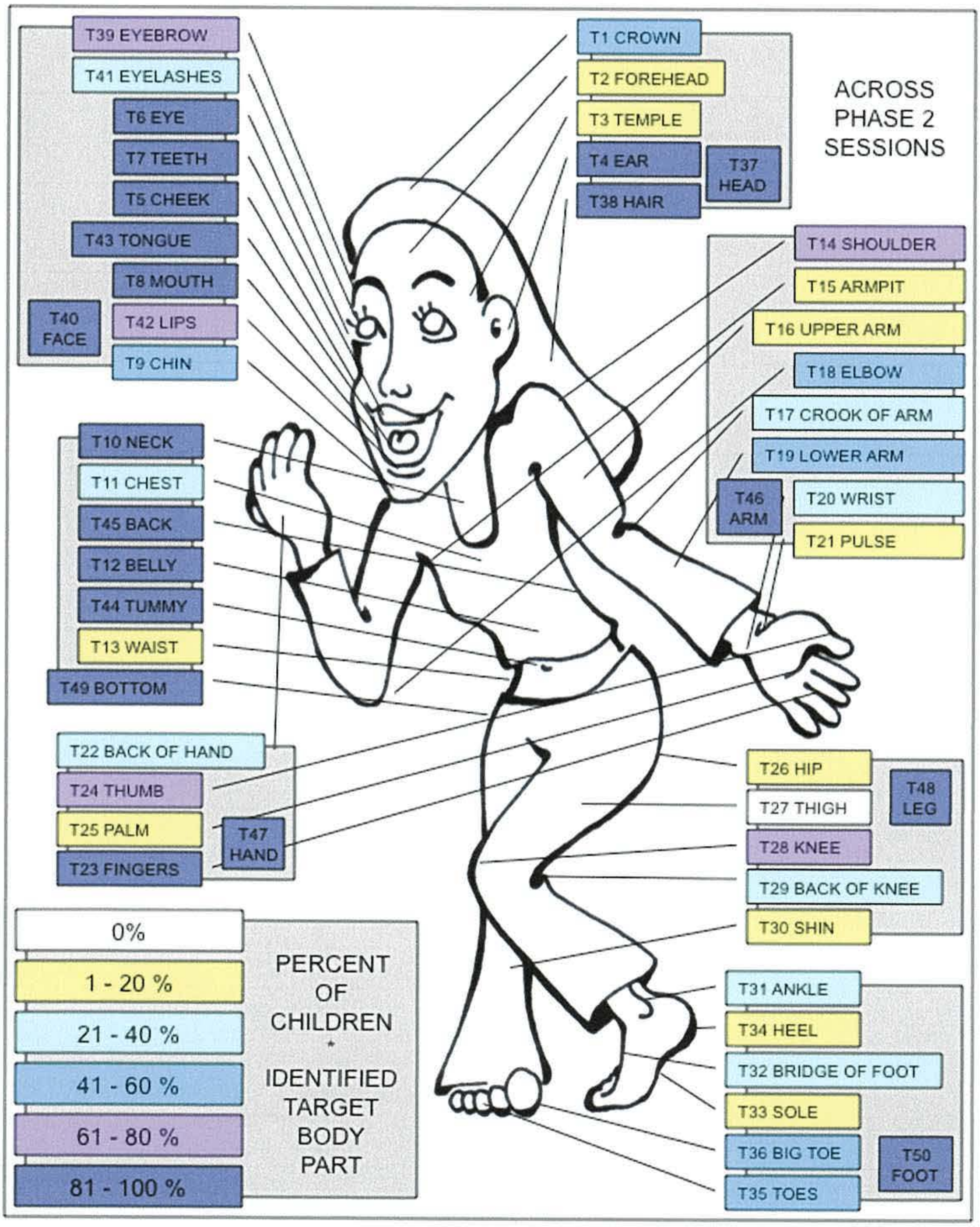
Trial	Gesture	Number of Models	Response	Error?	Correction	Any comments…
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Appendix E.

Human body representation of children's response frequencies in comprehension of body-part labels



Human body representation of children's response frequencies in production of body-part labels



Appendix F.

Scoring Matrix: Constituent components of each target action that were explicitly stated in experimenter's instructions (in performance tests) and shown in the experimenter's modelling (in description tests).

rget Action	Body-part(s) touched	Movement(s) performed					Effector(s)	Number of effectors
		Up	Front	Bent	Across	Apart		
1 - Hands to eyes	Eye(s)	√				*	Hand(s)	2 (plural)
2 - Hands up		√				*	Hand(s)	2
3 - Hands to head	Head/hair	√				*	Hand(s)	2
4 - Hands to belly	Belly/tummy		*			*	Hand(s)	2
5 - Hand to crook--arm	Crook-of-arm		*		√		Hand	1 (singular)
6 - Hand to wrist	Wrist		*		√		Hand	1
7- Hand to wrist th arm bent	Wrist		*	√	√		Arm / hand	1
8 - Hand to elbow th arm bent	Elbow		*	√	√		Arm / hand	1
9 - Hand to ear	Ear	√					Hand	1
10 - Hand across ear	Ear	√			√		Hand	1
11- Hand to oulder	Shoulder	√					Hand	1
12 - Hand across shoulder	Shoulder	√			√		Hand	1
13 – Hands to rs	Ear(s)	√				*	Hand(s)	2
14 – Hands across ears	Ear(s)	√			√		Hand(s)	2
15 – Hands to oulders	Shoulder(s)	√				*	Hand(s)	2
16 – Hands across shoulders	Shoulder(s)	√			√		Hand(s)	2
17 – Hands to ees	Knee(s)		*			*	Hand(s)	2
18 – Hands across knees	Knee(s)		*		√		Hand(s)	2
19 - Arms apart			√			√	Arm(s)	2
20 - Arms crossed			√		√		Arm(s)	2
21 - Arm bent				√			Arm	1
22 - Hand up		√					Hand	1
23 - Legs crossed			√		√		Leg(s)	2
24 - Leg bent				√			Leg	1
25 - Foot up		√					Foot	1

*** Stars denote modelled components of bimanual actions that were not explicitly named.**

Appendix G.

Children's incorrect touches in response to matching trials (ordered by percentage from highest to lowest) of each target gesture across all Experiments (Chapter 7).

Target gestures	Children's incorrect touches (ordered by percentage from highest to lowest)
T1 Temple	55% (Anna) to eyebrow, 43% (Mila) to wrist, 25% (Anna) and 16% (Mila) to ear, and 24% (Mila) to the side of the head.
T2 Bridge of foot	87% (Jack), 86% (Carl), 85% (Fex), 20% (Emma), and 17% (Gina) to the outer side of the foot, 51% (Emma) and 34% (Gina) to the sole of the foot, 18% (Emma) to toes, 14% (Gina) to ankle, and 11% (Gina) to the top of the foot.
T3 Armpit	38% (Fin) and 26% (Mol) to upper arm, 38% (Carl) to the back of the head, 33% (Fin) to lower arm, 32% (Mol) to tummy, 25% (Carl) to elbow, 23% (Mol) to chest, and 21% (Fin) to the crook of the arm.
T4 Thigh	99% (Mila), 79% (Anna), and 37% (Jack) to knee, 58% (Jack) and 19% (Anna) to shin.
T5 Crook of arm	53% (Mol) to upper arm, 49% (Emma) and 15% (Mol) to lower arm, 19% (Emma) to the back of the hand, and 16% (Emma) and 13% (Mol) to wrist.
T6 Crown	47% (Emma) to forehead, and 13% (Emma) to the side of the head.
T7 Ankle	77% (Gina) and 75% (Fin) to the arch of the foot, 43% (Anna) to heel, 14% (Anna) to the sole of the foot, and 13% (Fin) to the top of the foot.
T8 Wrist	93% (Fin), 88% (Emma), 79% (Mol), 78% (Anna), 70% (Gina), 67% (Carl), and 42% (Fex) to the back of the hand, 53% (Fex) to pulse, 25% (Carl) and 24% (Gina) to lower arm, and 20% (Anna) and 17% (Mol) to fingers.
T9 Upper arm	61% (Jack), 53% (Carl), 42% (Fin), and 24% (Mol) to lower arm, 39% (Mol) to wrist, 33% (Fin), 26% (Jack), 20% (Carl), and 12% (Mol) to the crook of the arm, 13% (Carl) to ear, 11% (Fin) to elbow, and 11% (Fin) to the back of the hand.
T10 Lower arm	53% (Gina) to wrist, and 22% (Gina) to the back of the hand.
T11 Shin	64% (Mila) to knee, and 23% (Mila) to thigh.
T12 Calf	78% (Fex) to the back of the knee, and 15% (Fex) to the back of the thigh.
T13 Thumb	72% (Fex) to the index finger, and 22% (Fex) to fingers.
T14 Hip	76% (Mila) and 26% (Jack) to waist, 35% (Jack) to thigh, 16% (Mila) to ribs, and 12% (Jack) to knee.

Appendix H.

Children's incorrect responses across all matching test trials (Chapter 8).

Target gestures	Children's incorrect (non-matching) responses ordered by percentage from highest to lowest
T1(B) Hands across to ears	97% (Gareth), and 68% (Sara) touching both ears using an ipsilateral movement (B1B); 47% (Ola) touching chin with both hands; 23% (Sara) touching one ear with both hands; 15% (Ola) touching face with both hands using an ipsilateral movement.
T2(B) Hands across to knees	45% (Sara) touching both knees using an ipsilateral movement (B2B); 27% (Sara) touching one knee with both hands; 23% (Sara) touching one knee using a contralateral movement (U2T).
T3(B) Hands across to feet	85% (Gareth), and 80% (Ola) touching both feet using an ipsilateral movement (B3B); 17% (Ola) touching one foot with both hands.
T1(U) Hand across to ear	95% (Sara), 85% (Ola), and 72% (Gareth) touching one ear using an ipsilateral movement (U1B); 26% (Gareth) touching both ears using an ipsilateral movement (B1B).
T2(U) Hand across to knee	44% (Sara) touching one knee using an ipsilateral movement (U2B); 33% (Sara) touching both knees using an ipsilateral movement (B2B).
T3(U) Hand across to foot	79% (Gareth), and 78% (Ola) touching one foot using an ipsilateral movement (U3B); 14% (Gareth) touching both feet using an ipsilateral movement (B3B); 10% (Ola) touching one foot with both hands.