DOCTOR OF PHILOSOPHY

Determinants of gestural imitation in young children

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DETERMINANTS OF GESTURAL IMITATION
IN YOUNG CHILDREN

Volume 2

Thesis submitted towards a Ph.D.

September, 2002
Contents

Volume 1

Forewords

CHAPTER 1 Introduction: Imitation, History and Definitions 1

CHAPTER 2 Non-Imitative Matching Processes: A Review of the Comparative Literature on Imitation 20

CHAPTER 3 Generalised Imitation: A Review of the Behaviour Analytic Literature 61

CHAPTER 4 Active Intermodal Mapping: A Review of the Developmental Literature on Imitation 99

CHAPTER 5 The Experimental Chapters: Introduction 142

CHAPTER 6 Experiment 1: Matching of Arbitrary Actions on Novel Objects in 9 – 15 Month Old Children 154

CHAPTER 7 Experiment 2: Matching of Gestures in 15 – 25 Month Old Children 221

Volume 2

CHAPTER 8 Experiment 3: Matching of Hand-to-Body Gestures in 24 – 42 Month Old Children 303

CHAPTER 9 Experiment 4: Do 17 – 21 Month Old Children Show Higher-Order Matching of Gestures? 389

CHAPTER 10 Experiment 5: Can 17 – 23 Month Old Children Match Gestures that are Frequent in Play but Not Trained as Matches? 450

CHAPTER 11 General Discussion 504

References 535

Appendix 559
Experiment 3: Matching of Hand-to-Body Gestures in 24 - 42 Month Old Children.

The experiment was designed to examine matching errors that two and three year old children make when presented with modelling of arbitrary hand-to-body gestures.

The procedure was essentially the same as in Experiment 2; the findings can be compared with those presented in the previous chapter for younger children (15 - 25 months). The experiment incorporated replication over 20 children; group results were intended to be comparable to results from cognitive developmental experiments with older children, published while Experiment 2 was in progress.

Two recent studies (Bekkering, Wohlschlager, & Gattis, 2000, and Gleissner, Meltzoff, & Bekkering, 2000) reported that children aged between 3 and 6 years produced consistent errors when asked to match hand touches to ear, to knee, and to a location on a table top. The authors of these studies offered a theoretical account of imitation in preschool children that aims to explain the observed errors and make predictions regarding children's matching responses to a variety of actions and gestures. The theoretical account of Bekkering and colleagues and of
Gleissner and colleagues will henceforth be referred to as the *goal theory of imitation* and the two studies as the *goal studies*.

As discussed in Chapter 1, the goal-directedness of imitative behaviour has been much debated within comparative psychology in the last decade; the goal theory of imitation grew out of this trend.¹

According to the goal theory of imitation, children exposed to modelling of actions and gestures engage in an active matching-to-goal process. Children perceive others' actions as semantic entities or goals; further, these goals are hierarchically organised. Young children's attempts to organise the goals of a seen action in this manner are, it is claimed, hampered by their limited (cognitive) processing capacities. As a result they produce characteristic matching errors; children's responses to modelled actions suggest that certain goals that are high in the hierarchy are preserved while others lower in the hierarchy are not.

¹ In brief, it was suggested that in the true, higher form of imitation (termed *program-level imitation*) an organism infers the goal structure of others' behaviour through observation, then it shows evidence of that understanding by reproducing the dominant goal(s) and necessary subgoals, improvising when it comes to fine details of execution. This was to be distinguished from "lower" forms of matching (termed *action-level imitation, blind imitation, or mimicry*) in which an organism reproduces exactly the action by which others' goals are realised, but without insight into what the latter may be (see e.g. Byrne & Russon, 1998; Tomasello, Kruger, & Ratner, 1993; Want & Harris, 2002). The goal theory of imitation assumes that preschool children engage in program-level imitation, albeit imperfectly.
Like the earlier active intermodal mapping theory of imitation (e.g. Meltzoff & Moore, 1992; see Chapter 4 for critique), the goal theory does not propose that matching repertoires learned in the course of early social experiences may influence children's experimental performances. Yet—as argued throughout the present thesis—clear predictions about which modelled behaviours will or will not be matched by young children can be made on the basis of the trained matching repertoires common to children of comparable age and social background.

In the following paragraphs, a critique of goal theory and a re-interpretation of the goal studies' data are offered; differences in design between the present experiment and the goal studies are outlined; and predictions of participants' matching performances made by the goal theory are compared with those based on the behaviour analytic hypothesis of generalisation of trained matching relations to novel behavioural models and contexts.

**Goal Theory Critique**

According to the goal theory, children are differentially responsive to the multiple goals that are said to be present in gestures. Particularly for young children, their matching performances are said to be constrained by goal processing limitations. The theory does not explain how "goal hierarchies" are established, and it is not based on evidence of either "goal hierarchies" or "processing limitations" that is independent from the observed errors in matching performances (which these two theoretical constructs are supposed to explain).
Goal theory, as presented by the authors, predicts that

- Children will show correct matching of gestures which are simple and do not contain multiple goals.
- Children will emit approximate matches for the more complex gestures where the omission of inferior goals nevertheless preserves feature(s) of the modelled gestures deemed to be the main goal(s) by coders.
- Children will never emit totally incorrect responses that do not reproduce any of the gestures' goals.

Although it appears that the goal theory accounts for a wide variety of responses, the authors offered no predictions a priori about which aspects of gestures may serve as goals, and how these goals are to be organised in a hierarchy. Children's responses were observed to contain some features of the modelled gestures; the authors—arguing back to causes—proposed that these features are the "dominant goals". Conversely, the features of the modelled gestures that were omitted in children's responses were labeled by the authors as "inferior goals".

According to goal theorists, gestures are commonly decomposed into the goals of "object" and "agent". The goal studies reported that children presented with contralateral gestural models, in which the moving hand(s) cross the body midline, often emitted ipsilateral responses, in which the hand(s) are moved on the same side of body and do not cross midline; the reverse errors (contralateral responses to ipsilateral gesture models) were seldom recorded. The authors argued that ipsilateral-for-contralateral errors were emitted because the goal of "object" (body part to be touched) was perceived by children to be dominant and was
therefore reproduced, while movement path, determined by the inferior
goal of "agent" (hand), was neglected.

The goal theory was tested solely on ipsilateral-for-contralateral errors. The authors reported that these errors were reduced for gestures that incorporated movement that did not involve touching of body parts or marks on a table-top, and also for bimanual gestures. The finding that children reproduced lower goals (hand selection and movement path) in cases where higher goals were absent or where lower goals were made more salient was considered to be consistent with the goal theory.

However, simpler explanations for ipsilateral-for-contralateral error effects are possible. Thus:

- Most conventional gestures in childhood matching games involve touching (often with naming) of body parts; the majority of these matching responses are performed ipsilaterally. When children are presented with models of contralateral hand-to-body gestures, they may therefore emit the well-established ipsilateral touches, and are unlikely to do the reverse. Further, the model's act of touching a particular body part may draw the observer's attention to that location; in this way socially enhanced stimulus control by the body part touched may be established (see Chapter 2 for a discussion of "social and stimulus enhancement"). Finally, children may use their dominant hand to touch the (covertly) named target body part nearest to that hand.

- Gestures that feature only hand movement are responded to with similar movements because (i) these responses have been directly trained as matches outside the experimental setting, or (ii) a child reaches
towards the model's hand and follows the seen movement as it occurs ("perceptual tethering"), or (iii) since there is no named body part to touch the gesture movement is named and the movement name guides the performance, or (iv) any combination of the above.

- Bimanual contralateral gestures may evoke fewer ipsilateral responses than the unimanual contralateral ones because bimanual models present an additional, hug-like stimulus that evokes well-established trained contralateral hug responses (which children may or may not integrate with touching of correct body parts).

To summarise. There are more parsimonious explanations than those provided by goal theory for children's ipsilateral-for-contralateral errors. Further, there is good reason to suppose that those are not the only matching errors that children are expected to make. Goal predictions were derived from, and have only been tested on, children's matching of ipsi- and contra-lateral gestures. In order to test the theory, to falsify or extend it, it is necessary to investigate children's matching of a wide range of complex (multiple-goal) gestures, and establish whether children's matching errors comply with the predictions derived from a priori goal analyses of such gestures.

**Generalisation of Trained Matching Hypothesis**

As discussed in Chapter 3, generalisation of trained matching may not be the only process that determines gestural matching responses in young children: higher-order matching (imitation) and naming would also be expected to influence their performances. However, in the previous
chapter it was reported that, for children up to two years of age, virtually all matching responses could be explained by generalisation of trained matching.\textsuperscript{2} Thus it is expected that this process exerts a considerable control in older children also; it may be a reliable predictor of matching performances over several more years.

According to the generalisation of trained matching hypothesis, it is their histories of reinforcement for matching that primarily determine children's responding to gestures; the discriminative functions of the physical components of each novel modelled gesture are also determined by prior training history. These trained matching repertoires are in principle observable and can be manipulated; likewise, limitations in children's matching repertoire learning at any one age or developmental level are amenable to empirical investigation.

Generalisation of trained matching to novel models and to novel contexts would predict that children's matching responses will show

- Good resemblance to the modelled gestures whenever all discriminative stimuli resemble those in previously trained matching relations, that is, across slight changes in physical characteristics of the person who models the gestures, or in the context in which modelling occurs.

\textsuperscript{2} As discussed in the previous chapter, it is impossible to establish whether children's naming, commonly taught alongside gestures in many matching games, is emitted covertly and is functional in children's matching of any one gestural model.
• Partial resemblance to the modelled gestures whenever some components of the modelled gestures provide discriminative stimuli for previously trained matching responses. Similarity between modelled gesture and the response(s) will depend on (i) how many discriminative stimuli are common across the novel and previously trained matching response(s), and (ii) whether multiple discriminative stimuli evoke trained responses that are complementary to or conflicting with each other. Multiple previously trained matching responses may be emitted, across or within trials, to novel models that contain multiple discriminative stimuli (see Experiment 2 for examples of such responding).

• No resemblance to the modelled gestures (or no response) whenever none of the components of the modelled gestures provide discriminative stimuli for previously trained matching responses.

In order to predict children's matching errors across a particular set of target behaviours, the experimenters need to become familiar with the relevant matching training to which their participants were likely to have been exposed. The target set of gestures used in the experiment presented next was designed to incorporate a mix of (i) common gestures that evoke well-practiced matching responses because they feature in games often played in the Nursery where our participants were recruited, and (ii) similar uncommon gestures for which no such evidence of prior matching training could be found.
Target Gestures and Matching Data

Goal studies have collected data on three related sets of gestures: hand-to-ear, hand-to-knee, and hand-to-table. Across experiments, target sets included uni- and bi-manual gestures, ipsilateral and contralateral gestures, touching body parts or movement toward body parts, and presence or absence of dots to be touched on a table top. Overall, the goal theory was based mainly on errors that children made with the hand-to-ear group of gestures. The studies employed large groups of children but collected only small numbers of responses to modelled gestures from each individual child: Bekkering and colleagues (2000) tested matching of as few as two gestures with three trials per gesture per child; Gleissner and colleagues (2000) collected children's responses to sets of ear and knee touches with a single trial per gesture per child.

The present experiment employed hand touches to ear, shoulder, and arm; matching response data were collected over six trials per target gesture per child: a total of 120 responses to 20 target gestures were recorded for each participant. Unlike the goal studies, individual participants' data were examined with respect to each effect that was found for the group.

Ear and shoulder gestures were designed to be directly comparable to the goal studies' data, and were performed uni- and bi-manually, with ipsilateral and contralateral movements. Thus the experimenter modelled these target gestures with her right hand, her left hand, and with both her hands; she touched her ear(s) and shoulder(s) on the same side of body with short upward movements that did not cross body midline (ipsilateral gestures) and with longer diagonal-upward movements that crossed
body midline (contralateral gestures). Somewhat longer movements were required for ear touches than for shoulder touches. Full descriptions and illustrations of six target touches to ear are presented in Table 8.3 and of six target touches to shoulder in Table 8.4 (see Method).

Target touches to arm were all modelled unimanually and contralaterally: the experimenter performed these touches with the moving hand (right or left) always crossing body midline. The experimenter's hand movement terminated on the top-of-arm surface or on the underside-of-arm surface, and on lower-arm or middle-arm locations. Thus:

1. Top-of-arm touches were modelled with a hand that moved in a slight downward arch across body midline, with palm down, terminating on the lower-arm (wrist) or on the middle-arm (crook of arm) location. The arm to be touched was always in a resting position, extended forward.

2. Underside-of-arm touches were modelled with a hand that moved in a slight upward arch across body midline, with palm up and facing the experimenter, terminating on the lower-arm (wrist) or the middle-arm (elbow) location. The arm to be touched was always lifted forwards and bent up at the elbow.

The top-of-arm touches were less complex than the underside-of-arm ones, because the latter contained an added component: the arm to be touched needed to be lifted or bent in order to perform underside-of-arm touches. Hand movement paths differed slightly between the two types of gestures, but neither was obviously more difficult than the other. All touches to
lower- and middle-arm locations involved hand movements of comparable lengths. Full descriptions and illustrations of four middle-arm target gestures are presented in Table 8.5, and of four lower-arm target gestures in Table 8.6 (see Method).

Several main predictions regarding children's responses to target gestures are presented next; many other features of children's matching that can differentiate between the generalisation of trained matching account and goal theory are presented in Results and Discussion.

**All Target Gestures**

General predictions across all target gestures are as follows:

- Children are expected to emit either correct or mirror responses on a substantial proportion of trials. In Experiment 2 it was found that children emitted correct and mirror responses, mostly to ipsilateral hand-to-body gestures, towards their second birthday; further, several target responses were chosen precisely because it was known that they feature in common nursery matching games.

- In Experiment 2 it was found that, across the majority of trials, three out of four children emitted right hand responses to the majority models, including left hand ones. It is possible that in two to three year old children this right hand bias may still be strong for most participants.
• Overall, it is expected that many of the participant's responses in the present study will be mirror ones. Earlier studies (see Baer and Deguchi, 1985) reported that adults' and older children's matching responses show a predominantly mirror relationship to the modelled gesture; the children in Experiment 2 started responding in this way towards the end of their testing. It is possible that, as children's matching repertoires increase to include responses performed with the non-prefered hand, social "local enhancement" (preference for acting in the same space as others, see Chapter 2) leads to increase in mirror responses. Such responses are likely to be reinforced by the caregivers as they are not obviously wrong. Further, as children learn higher-order matching, they should be expected to act in ways that maximize the similarity between the actions of others and their own behaviour, as seen from their perspective; mirror responses should achieve such similarity more readily than correct responses.

• Overall, older children are expected to show matching performances comparable to those of the three year old participants in Gleissner and colleagues' (2000) study; younger children may show lesser matching performances, comparable to those of the two year old participants in Experiment 2.

• All children are expected to emit multiple previously trained responses to comparably novel models. For example, a novel contralateral hand-to-body gesture performed bimanually may present two discriminative stimuli for previously trained gestures: hands touching the body parts, and arms crossed over midline. The younger group should be expected to have smaller trained repertoires (so that more of the target gestures
would be novel to them) and to be less likely to integrate two or more trained matching responses into novel configurations (as was found to be the case in Experiments 1 and 2). In the present example, they may first touch the body parts with both hands and then cross arms, but will not perform the two responses together in the appropriate sequence. The older children are expected to show fewer trials with more than one response than the younger ones.

**Ear and Shoulder Target Gestures**

Bimanual ipsilateral gestures that incorporate touching parts of the body (e.g. head, eyes, ears, shoulders, belly, knees) are established through common naming-and-matching games (see Experiment 2). These gestures are expected to be within the trained matching repertoires of two and three year old children; indeed, a set of four such gestures was chosen for baseline training (see Method and Table 8.2) because of the ease with which correct matching could be evoked and maintained in the experiment.

In the present experiment, children's performances are expected to reflect the effects of extra-experimental overtraining of bimanual ipsilateral touches to shoulder and ear in the following ways:

- Matching of bimanual ipsilateral target gestures ought to be better than matching of (less well trained) unimanual ipsilateral ones.
- Matching errors should contain more bimanual responses to unimanual models (bimanual-for-unimanual errors) than unimanual responses to bimanual models (unimanual-for-bimanual errors).
The goal theory, which considers hand choice to be an inferior goal, would probably predict no difference in matching of uni- and bi-manual gestures.

As discussed earlier, the generalisation of trained matching hypothesis predicts that (i) children's performances across all ipsilateral gestures ought to be better than those for contralateral gestures, (ii) comparably more trials with more than one response would be expected for contralateral models, and (iii) ipsilateral-for-contralateral errors are expected to be more frequent than contralateral-for-ipsilateral errors across all ear and shoulder target gestures.

**Middle- and Lower-Arm Target Gestures**

Middle- and lower-arm target gestures were modelled in two ways: as *top-of-arm* touches, and as *underside-of-arm* touches. Top-of-arm gestures terminated on the top surface of the arm that was slightly extended in front of the experimenter, resting on the table; either the middle-arm (crook of arm) or the lower-arm (wrist) were touched. Underside-of-arm gestures terminated on the underside surface of the arm that was raised above table, in front of the experimenter, and bent up at the elbow; either the middle-arm (elbow) or the lower-arm (wrist) were touched.

According to goal theory, *raising the arm-to-be-touched* in underside-of-arm target gestures introduces an additional goal to the display; this new goal would be perceived by children as inferior to the goal of *body part to-be-touched* and therefore should be neglected. Thus goal theory would predict inferior matching of all underside-of-arm target gestures as compared
to all top-of-arm gestures. Further, children would be predicted to emit top-of-arm responses to modelling of underside-of-arm gestures, but not vice versa—just as they are predicted to emit ipsilateral responses to contralateral models, but not vice versa—because children's matching errors are said to be caused solely by omission of inferior goals.

Overall, more complex gestures, such as underside-of-arm touches, are trained later than less complex gestures, such as top-of-arm touches; generalisation of trained matching would therefore usually result in better matching of less complex gestures. However, more specific predictions can be made regarding touches to the lower- and middle-arm.

**Middle-Arm Target Gestures**

Underside-of-arm touching or tapping of the middle-arm location (elbow) is an early trained matching response, established in games that teach children naming of body parts; it is expected that children in the present study have been trained to match this gesture. However, top-of-arm tapping of the middle-arm location (crook of arm) does not feature in such games and is expected to be an unfamiliar (comparably novel) configuration for many children. Thus, across middle-arm target gestures, the specific predictions are the opposite to the general ones for all arm touches. Children are expected to

1. Match middle-arm touch gestures better when these are modelled as underside-of-arm touches than as top-of-arm touches.

2. Emit (common) underside-of-arm responses to (uncommon) top-of-arm models more often than vice versa.
Lower-Arm Target Gestures

Top-of-arm touching or tapping of the lower-arm location (wrist or back of hand) is an early trained matching response, established in "pat-a-cake" and mock punishment routines; it is seen in children as young as 14 months (see Experiments 1, 2, 4, and 5). Underside-of-arm tapping of the lower-arm location, which requires the arm-to-be-touched being lifted or bent, however, is an unfamiliar (comparably novel) configuration for many children. Thus, across lower-arm target gestures, the specific predictions agree with the general ones for all arm touches. Children are expected to

1. Match lower-arm touch gestures better when these are modelled as top-of-arm touches than as underside-of-arm touches.

2. Emit (common) top-of-arm responses to (uncommon) underside-of-arm models more often than vice versa.

Generalisation of trained matching may result in yet more errors of substitution across lower- and middle-arm target trials. Thus:

- Across underside-of-arm target gestures, children would be expected to emit (common) middle-arm touches to (uncommon) lower-arm touch models more often than vice versa.

- Across top-of-arm target gestures, children would be expected to emit (common) lower-arm touches to (uncommon) middle-arm touch models.

Goal theory would predict no errors in touching correct body parts; this feature is said to be perceived by children as a dominant goal and
reproduced more readily than all other features of the modelling display.

METHOD

Participants

Two groups of children, aged between 24 - 30 months (younger group) and 36 - 42 months (older group), participated in the present experiment. There were 10 children in each group, with equal numbers of boys and girls. All children were attending the Nursery at least two days per week; all were recruited by parental consent. The Griffiths Mental Development Scales' scores, collected at the end of the experiment for 13 children, showed that they were developing normally. Children's Griffiths scores and their ages at the start and the end of experiment are presented in Table 8.1.

Materials and Apparatus

Materials and apparatus were identical to those used in Experiments 1 and 2, except for the seating arrangements.

In the present experiment, the testing room was equipped with a small child-sized chair in which participants were seated throughout
experimental sessions, a beanbag on which the experimenter sat facing the child, and a low table between the two.

**Table 8.1.** Means and ranges of general quotient (GQ) scores and age in months and days (m-d) at the start and the end of the experiment for two groups of participants.

<table>
<thead>
<tr>
<th></th>
<th>Younger Group (n = 10)</th>
<th>Older Group (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GQ score</strong> (n=13)</td>
<td>Mean 112</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Range 107 to 127</td>
<td>104 to 128</td>
</tr>
<tr>
<td><strong>Age at start</strong> (m-d)</td>
<td>Mean 27-07</td>
<td>37-02</td>
</tr>
<tr>
<td></td>
<td>Range 25-09 to 29-02</td>
<td>35-25 to 41-29</td>
</tr>
<tr>
<td><strong>Age at end</strong> (m-d)</td>
<td>Mean 28-19</td>
<td>38-14</td>
</tr>
<tr>
<td></td>
<td>Range 25-22 to 30-13</td>
<td>36-15 to 42-14</td>
</tr>
</tbody>
</table>

**Design**

A composite design that incorporated two independent (age) groups, repeated measures across target gestures, and single-participant methodology, was employed in the present experiment. The stages of the experiment are presented in Figure 8.1.
**Condition 1**

**Familiarisation**

Play in Nursery common room and one-to-one play in test room.

**Condition 2**

**Baseline Matching Training**

Train 4 chosen baseline matches under 100% and 50% reinforcement until reliable matching baseline is established.

**Condition 3**

**Probe Trials for Target Gestures**

Present baseline (trained) and new (target) models; provide 50% reinforcement for trained matches only.

<table>
<thead>
<tr>
<th>Target Set</th>
<th>Gestures</th>
<th>Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set 1</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Set 2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Set 3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Set 4</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

**Baseline Gestures** (set of 4)

**Figure 8.1.** The stages of Experiment 3.
In the first two conditions (Familiarisation and Baseline Matching Training) the experimenter familiarised with each participant on a one-to-one basis and established turn-taking play in the experimental room; she then presented modelling of four baseline gestures that were likely to be well-established within children's trained matching repertoires (see Table 8.2). The experimenter reinforced the child's correct matching responses to these gestures until reliable matching baselines were established; children's responding was maintained under intermittent reinforcement throughout subsequent probing sessions.

In the last condition of the experiment (Probe Trials for Target Gestures) the experimenter introduced modelling of 20 conventional target gestures (see Tables 8.3 - 8.6); she also continued providing intermittent reinforcement for children's correct matching of the trained baseline gestures. Target gestures were presented in four sets of five gestures; each set was modelled over three successive sessions (see Procedure). There were 12 probing sessions for each child; in each of these, the experimenter presented modelling of four trained baseline gestures and modelling of five target gestures, with two trials for each gesture, in a predetermined random order. Children's responses to target models were never reinforced or corrected; six responses per gesture per child for each of 20 target gestures were collected over the 12 probing sessions.

Single-participant methodology, similar to that employed in all other experiments in the present thesis, resulted in much more extensive data collection than is usually the case in group studies; this enabled the experimenter to establish whether trends corresponding to effects derived
from group comparisons were also present in individual participants' data.

Distribution-free (rank) tests were chosen for analyses between and within groups; these were deemed appropriate because (i) the children's matching data were categorical, and (ii) individual differences, expected across some of the measures, could produce outliers and distributions of scores that were not approximately normal (Howell, 1992).

**Procedure**

**Condition 1: Familiarisation**

The experimenter familiarised with each individual participant over several weeks, first in the playroom setting with other children and nurses present, second in the isolated test room. This continued until participants were happy, responsive, and comfortable with the experimenter and the new surroundings. The familiarisation play was age appropriate, with an emphasis on turn-taking games.

In all conditions of the experiment, a child was to be returned to the playroom if he or she showed discomfort during testing. This never happened, but a few sessions were terminated prematurely when the experimenter judged the participants to be unresponsive or unwell; the interrupted sessions were completed at the next testing opportunity. Children were tested daily, when they were available, alert, and happy to play, with unavoidable breaks for holidays and illnesses. A typical experimental session lasted just over 15 minutes; whenever
possible—especially with older children and in later probing sessions—more than one session was run in a single day.

**Condition 2: Baseline Matching Training**

Operant training was conducted in this condition to establish reliable and consistent correct responding to the verbal request, "Do this," followed by modelling. Sets of four baseline gestures (see Table 8.2) were presented, with three trials per gesture per session (12 trials in all), and with up to three models per trial. Baseline gestures were modelled in a predetermined randomised order, with an added constraint that no more than two trials of the same gesture be presented in succession.

The sessions initially started with warm-up play (this was unnecessary later on); the experimenter then removed the toys and invited the child to "play a game". Modelling trials commenced next. The experimenter made sure that the participant was attentive by calling his or her name or saying, "Look at me!" She then asked, "Can you [or child's name] do this?" before modelling a baseline gesture. Models were always clear and exaggerated (e.g. in the "hands up" gesture the experimenter stretched her arms as far as possible, looking up at her hands). After modelling a gesture the experimenter looked at the child expectantly; if the child did not respond immediately she prompted him or her to do so by saying, "You can do it!" or, "Show me!"

If the child did not respond to prompting, the experimenter modelled the same gesture again, up to three times per trial type. If no response was
emitted the experimenter gently moved the participant's hands so as to help him or her perform the matching response (putting through) and then promptly produced reinforcement.

Incorrect responses were corrected in similar manner, with a verbal command, "Not quite, this is how we do it!" and putting through followed by reinforcement. The correct matching responses were enthusiastically reinforced by the experimenter clapping, cheering, saying, "Yeah!" or, "Well done!" and allowing the child to play with toys and stickers. Usually, only a few trials of encouragement or putting through were necessary before children started responding promptly and correctly to all models in the baseline set.

All sessions ended with play; the training proceeded with a 100% reinforcement rate until the predetermined criterion of at least five out of six correct responses to each of the four baseline models, over two consecutive sessions, was reached. The reinforcement rate was then reduced to 50%, and when a child responded correctly on at least 11 out of 12 trials within a single session—across the four gestures—the training was considered complete. An illustrated list of gestures used in this condition is presented in Table 8.2.
Table 8.2. Illustrated set of four baseline gestures: their names, descriptions of models, and descriptions of responses coded as correct.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Responses Coded as Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peek-a-boo</td>
<td>Eyes covered with both hands; wide open eyes revealed while saying 'boo'.</td>
<td>Hands covering face.</td>
</tr>
<tr>
<td>Hands on middle</td>
<td>Hands touching or tapping belly or chest.</td>
<td>Hands touching middle of body.</td>
</tr>
<tr>
<td>Hands on head</td>
<td>Hands touching or tapping top of head.</td>
<td>Hands touching head.</td>
</tr>
<tr>
<td>Hands up</td>
<td>Hands lifted up as high as possible; looking up.</td>
<td>Hands lifted.</td>
</tr>
</tbody>
</table>

Condition 3: Probe Trials for Target Gestures

Twenty target gestures were presented in this condition. Sets of five target gestures were presented in each session, interspersed with the four baseline trained models; there were two trials per gesture per session (18 trials in all). Each set of five target gestures was presented over three consecutive sessions; there were four such sets for each child, who therefore completed 12 probe sessions in all. Target gestures were divided into sets quasi-randomly for each child; each set contained a unimanual ear gesture, a unimanual shoulder gesture, a bimanual shoulder or ear gesture, an elbow gesture, and a wrist gesture.

As in the previous condition, the experimenter asked, "Shall we play our game?" She then attracted the child's attention and asked, "Can you (name) do this?" before modelling a gesture. Correct matching responses to baseline models were reinforced intermittently, at 25% to 50%; there were no scheduled consequences for responses to target models. The experimenter smiled at all times when modelling and observing the children's responses, in both trained and target gesture trials. Thus children's responding in target gesture trials was not suppressed as might have been the case if such trials were selectively followed by a "still face" expression by the experimenter.

Complete illustrated lists of the target gestures with descriptions of models and responses coded as correct are presented in Tables 8.3 - 8.6.
Table 8.3. The descriptions of models and responses coded as correct for a set of six ear target gestures. These target gestures were modelled with the right hand (RH), the left hand (LH), or bimanually (2H), with ipsilateral (same) or contralateral (cross) movement.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Responses Coded as Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH ear same</td>
<td>Right hand touches or pulls right ear: right ear; also near hair or neck:</td>
<td>Right hand touches or pulls right ear; also near hair or neck:</td>
</tr>
<tr>
<td></td>
<td>- ipsilateral movement</td>
<td>- ipsilateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>RH ear cross</td>
<td>Right hand touches or pulls left ear: left ear; also near hair or neck:</td>
<td>Right hand touches or pulls left ear; also near hair or neck:</td>
</tr>
<tr>
<td></td>
<td>- contralateral movement</td>
<td>- contralateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>LH ear same</td>
<td>Left hand touches or pulls left ear: left ear; also near hair or neck:</td>
<td>Left hand touches or pulls left ear; also near hair or neck:</td>
</tr>
<tr>
<td></td>
<td>- ipsilateral movement</td>
<td>- ipsilateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>LH ear cross</td>
<td>Left hand touches or pulls right ear: right ear; also near hair or neck:</td>
<td>Left hand touches or pulls right ear; also near hair or neck:</td>
</tr>
<tr>
<td></td>
<td>- contralateral movement</td>
<td>- contralateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>2H ear same</td>
<td>Simultaneously, right hand pulls or touches right ear and left hand pulls or touches left ear: right ear; also near hair or neck:</td>
<td>Simultaneously, right hand pulls or touches right ear, hair, or near neck and left hand pulls or touches left ear, hair or neck:</td>
</tr>
<tr>
<td></td>
<td>- ipsilateral movement</td>
<td>- ipsilateral movement</td>
</tr>
<tr>
<td></td>
<td>- bimanual gesture</td>
<td>- bimanual gesture</td>
</tr>
<tr>
<td>2H ear cross</td>
<td>Simultaneously, right hand pulls or touches left ear and left hand pulls or touches right ear:</td>
<td>Simultaneously, right hand pulls or touches left ear, hair, or near neck and left hand pulls or touches right ear, hair or neck:</td>
</tr>
<tr>
<td></td>
<td>- contralateral movement</td>
<td>- contralateral movement</td>
</tr>
<tr>
<td></td>
<td>- bimanual gesture</td>
<td>- bimanual gesture</td>
</tr>
</tbody>
</table>
Table 8.4. The descriptions of models and responses coded as correct for a set of six shoulder target gestures. These target gestures were modelled with the right hand (RH), the left hand (LH), or bimanually (2H), with ipsilateral (same) or contralateral (cross) movement.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Responses Coded as Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH shoulder same</td>
<td>Right hand touches or taps right shoulder:</td>
<td>Right hand touches right shoulder; also upper right arm or near neck:</td>
</tr>
<tr>
<td></td>
<td>- ipsilateral movement</td>
<td>- ipsilateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>RH shoulder cross</td>
<td>Right hand touches or taps left shoulder:</td>
<td>Right hand touches left shoulder; also upper left arm or near neck:</td>
</tr>
<tr>
<td></td>
<td>- contralateral movement</td>
<td>- contralateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>LH shoulder same</td>
<td>Left hand touches or taps left shoulder:</td>
<td>Left hand touches left shoulder; also upper left arm or near neck:</td>
</tr>
<tr>
<td></td>
<td>- ipsilateral movement</td>
<td>- ipsilateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>LH shoulder cross</td>
<td>Left hand touches or taps right shoulder:</td>
<td>Left hand touches right shoulder; also upper right arm or near neck:</td>
</tr>
<tr>
<td></td>
<td>- contralateral movement</td>
<td>- contralateral movement</td>
</tr>
<tr>
<td></td>
<td>- unimanual gesture</td>
<td>- unimanual gesture</td>
</tr>
<tr>
<td>2H shoulder same</td>
<td>Simultaneously, right hand taps or touches right shoulder and left hand taps or touches left shoulder:</td>
<td>Simultaneously, right hand touches right shoulder, upper arm, or near neck and left hand touches left shoulder, upper arm or near neck:</td>
</tr>
<tr>
<td></td>
<td>- ipsilateral movement</td>
<td>- ipsilateral movement</td>
</tr>
<tr>
<td></td>
<td>- bimanual gesture</td>
<td>- bimanual gesture</td>
</tr>
<tr>
<td>2H shoulder cross</td>
<td>Simultaneously, right hand taps or touches left shoulder and left hand taps or touches right shoulder:</td>
<td>Simultaneously, right hand touches left shoulder, upper arm, or near neck and left hand touches right shoulder, upper arm or near neck:</td>
</tr>
<tr>
<td></td>
<td>- contralateral movement</td>
<td>- contralateral movement</td>
</tr>
<tr>
<td></td>
<td>- bimanual gesture</td>
<td>- bimanual gesture</td>
</tr>
</tbody>
</table>
Table 8.5. The descriptions of models and responses coded as correct for a set of four middle-arm target gestures. These target gestures were modelled with the right hand (RH) or the left hand (LH), and the movement terminated on the top-of-arm surface (top) or on the underside-of-arm surface (under).

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Responses Coded as Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH to mid-arm, top</td>
<td>Right hand tapping or touching middle of left arm (crook of arm), which is slightly extended and resting: top-of-arm movement</td>
<td>Right hand touching middle of left arm (crook of arm), or touching left lower or upper arm: top-of-arm movement</td>
</tr>
<tr>
<td>RH to mid-arm, under</td>
<td>Right hand tapping or touching middle of left arm (elbow), which is bent and lifted up: underside-of-arm movement</td>
<td>Right hand tapping or touching middle of left arm (elbow), or touching lower or upper part of left arm; left arm is bent or lifted: underside-of-arm movement</td>
</tr>
<tr>
<td>LH to mid-arm, top</td>
<td>Left hand tapping or touching middle of right arm (crook of arm), which is slightly extended and resting: top-of-arm movement</td>
<td>Left hand touching middle of right arm (crook of arm), or touching right lower or upper arm: top-of-arm movement</td>
</tr>
<tr>
<td>LH to mid-arm, under</td>
<td>Left hand tapping or touching middle of right arm (elbow), which is bent and lifted up: underside-of-arm movement</td>
<td>Left hand tapping or touching middle of right arm (elbow), or touching lower or upper part of right arm; right arm is bent or lifted: underside-of-arm movement</td>
</tr>
</tbody>
</table>
Table 8.6. The descriptions of models and responses coded as correct for a set of four lower-arm target gestures. These target gestures were modelled with the right hand (RH) or the left hand (LH) hand, and the movement terminated on the top-of-arm surface (top) or on the underside-of-arm surface (under).

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Responses Coded as Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH to low-arm, top</td>
<td>Right hand tapping or touching left lower-arm (wrist); left arm is slightly extended and resting: - top-of-arm movement</td>
<td>Right hand tapping or touching left lower arm (wrist), or back of left hand: - top-of-arm movement</td>
</tr>
<tr>
<td>RH to low-arm, under</td>
<td>Right hand tapping or touching left lower-arm (wrist); left arm is bent and lifted up: - underside-of-arm movement</td>
<td>Right hand tapping or touching left lower arm (wrist), or back of left hand; left arm is bent or lifted: - underside-of-arm movement</td>
</tr>
<tr>
<td>LH to low-arm, top</td>
<td>Left hand tapping or touching right lower-arm (wrist); right arm is slightly extended and resting: - top-of-arm movement</td>
<td>Left hand tapping or touching right lower arm (wrist), or back of right hand: - top-of-arm movement</td>
</tr>
<tr>
<td>LH to low-arm, under</td>
<td>Left hand tapping or touching right lower arm (wrist); right arm is bent and lifted up: - underside-of-arm movement</td>
<td>Left hand tapping or touching right lower arm (wrist), or back of right hand; right arm is bent or lifted: - underside-of-arm movement</td>
</tr>
</tbody>
</table>
At the end of the experiment, a trained member of the Nursery and University staff tested the children on the Griffiths Mental Development Scales (Griffiths, 1954). This was done in the familiar test room, and the experimenter was present as a familiar adult to encourage the participants to complete all the tasks. Some of the scores on the social development scale of the latter test were assigned by questioning those Nursery staff who were most familiar with the individual children.

Debriefing letters, the Griffiths' reports, and videotapes containing representative recordings of testing were then presented to parents. A toy was given to each child.

**Coding**

Children's responses to baseline and target models were classified into four main categories:

1. **Correct**: Tables 8.2 - 8.6 show exact criteria for each gesture.
2. **Mirror**: the same configuration as correct, but performed with the left hand to right hand models and with right hand to left hand models.
3. **Incorrect**: all responses that were not coded as correct or mirror were included in this category; exact descriptions were noted.
4. **No response**.

Incorrect responses were further classified as follows:
Ipsilateral responses to contralateral models or contralateral responses to ipsilateral models, across ear and shoulder target gestures.

Bimanual responses to unimanual models or unimanual responses to bimanual models, across ear and shoulder target gestures.

Top-of-arm responses to underside-of-arm models or underside-of-arm responses to top-of-arm models, across all arm target gestures.

Middle-arm responses to lower-arm models or lower-arm responses to middle-arm models, across all arm target gestures.

Whenever children emitted more than one response to any of the models, all responses were noted. On all measures reported in the Results, only the last responses were included in the data. In addition to this, separate analyses of trials with more than one response were performed.

For all matching trials the following were also noted:

- The number of models (1-3) needed to evoke a response.
- Whether reinforcement was given (for the baseline trained set only).

**Intra- and Inter- Observer Reliability**

Preliminary coding was done after each experimental session in order to monitor the experimenter's performance and the children's responsiveness to modelling. All data were then coded at the end of the experiment by examining the video recordings; slow- and stop-motion facilities were used; each response was viewed as many times as necessary. These codes were used for the data analyses presented in Results.
The experimenter coded 20% of the data (matching responses for four children) twice; the second coding was done without reference to the first codes. Intra-observer agreement across the four main categories of correct, mirror, incorrect, and no response was

- 100.0% for trained responses in Condition 2 baseline, across 131 trials
- 99.7% for trained responses in Condition 3 probing, across 384 trials
- 97.1% for target responses in Condition 3 probing, across 480 trials

A pair of undergraduate students, with experience in working with preschool children, were presented with coding criteria and asked to jointly code 30% of all data (matching responses for six children); they were not informed about the experimental predictions. Inter-observer agreement between the experimenter's and students' codes across the four main categories of correct, mirror, incorrect, and no response was

- 98.0% for trained responses in Condition 2 baseline, across 252 trials
- 98.3% for trained responses in Condition 3 probing, across 576 trials
- 96.3% for target responses in Condition 3 probing, across 720 trials
RESULTS

Unless stated otherwise, data are reported as the percentages of trials in which a measured variable occurred; this facilitates comparison between (i) target groups that contain unequal numbers of gestures (there are six target gestures each for ear and shoulder, and four target gestures each for middle- and lower-arm), and (ii) unequal numbers of unimanual (four) and bimanual (two) target gestures within ear and shoulder groups.

Group results are reported as means, ranges are presented as measures of variability, and counts of trends in individual data that correspond to group effects are reported when appropriate. Effects for all measures are reported across 20 children whenever trends are the same for younger and older groups. Important effects are presented in bar charts; all of these are plotted on the same scale (0-100% along the y axis).

Baseline (Trained) Gestures

A minimum of three sessions was required to establish trained matching of baseline gestures to the predetermined criteria of (i) 5 out of 6 correct for each gesture over two consecutive sessions under 100% reinforcement, followed by (ii) 11 out of 12 correct across all four gestures within a single session under 50% reinforcement. Eleven children completed Condition 2 baseline training within three sessions, 6 children had four sessions each, 2 children had five sessions each, and 1 child completed training in six
sessions. Overall, correct matching of baseline gestures was established quickly for both age groups; the younger children did not take longer to train than the older ones.

Table 8.7 shows that children's responding to baseline models remained correct on over 90% of Condition 3 probe trials for each child. All children also responded promptly in this condition: baseline gestures had to be modelled more than once on less than 10% of trials for each individual child.

Correct responses to baseline (trained) gestures were intermittently reinforced in Condition 3 probe sessions; up to 50% reinforcement could be presented, but good matching performances were maintained under 25% reinforcement for most children.

Table 8.7. Means and ranges of percentages of trials with correct responses, and trials where more than one model was presented, for baseline (trained) gestures in Condition 3 probe sessions, for younger and older groups of children.

<table>
<thead>
<tr>
<th></th>
<th>Correct responses (%)</th>
<th>More than one model (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
</tr>
<tr>
<td>Younger group (n=10)</td>
<td>98</td>
<td>91 - 99</td>
</tr>
<tr>
<td>Older group (n=10)</td>
<td>96</td>
<td>93 - 100</td>
</tr>
</tbody>
</table>
In the following paragraphs, results are grouped and analysed for (i) all target gestures, (ii) ear and shoulder target gestures, and (iii) middle- and lower-arm target gestures.

**All Target Gestures**

All children responded promptly and reliably to target gestures modelled in Condition 3 probe sessions. No responses were recorded on only four target trials, two each for 1 older and 1 younger child. More than one model was required to evoke a response on only 2% of target trials for younger children (range: 0 - 12%) and on 4% of target trials for older children (range: 0 - 11%).

**Correct and Mirror Responses**

Correct and mirror responses, both of which contain correct gesture configurations, were added to obtain a joint measure of children's good matching performances in several analyses presented for all target gestures, ear and shoulder gestures, and middle- and lower-arm gestures. Across unimanual target gestures, correct and mirror responses were visually separated in all graphs; correct responses were represented in bars of solid colour, and mirror responses were represented in striped bars. These bars were stacked in graphs that presented the joint measure of correct and mirror responses.
Across all target gestures, children emitted correct and mirror responses on 53% of all trials. There were marked differences between individual data; however, on average, the two groups performed equally well: younger children emitted correct and mirror responses on 51% of trials (range: 38 to 63%), and older children emitted correct and mirror responses on 54% of trials (range: 35 - 67%). Thus incorrect responses were recorded on just under half of all target trials, on average, for both groups.

Mean percentages of trials in which correct and mirror responses were recorded for each target gesture group are presented in Figure 8.2. Friedman's Rank Test for related samples showed that, overall, differences in participants' correct and mirror scores between four target groups were not statistically significant ($\chi^2=0.945$, $df=3$, $p>0.05$).

![Figure 8.2. Mean percentages of trials on which correct and mirror responses were emitted for ear, shoulder, middle-arm, and lower-arm target gestures, across all children.](image)
Correct and mirror responses are plotted separately in Figure 8.3 for unimanual ear and shoulder and all middle- and lower-arm target gestures. Figure 8.3 shows that children responded to modelling of all target groups with mirror matches more often than with correct matches; this was also true for each individual participant.

![Graph showing mean percentages of trials with correct (solid red bars) and mirror (striped red bars) responses, for unimanual ear and shoulder gestures, and for all middle- and lower-arm gestures, across all children.]

**Figure 8.3.** Mean percentages of trials with correct (solid red bars) and mirror (striped red bars) responses, for unimanual ear and shoulder gestures, and for all middle- and lower-arm gestures, across all children.

**Hand Preferences**

All unimanual target gestures were modelled with the right and left hand an equal numbers of times. Children's right and left hand responses (correct, mirror, and incorrect) were counted across all trials; marked differences between numbers of right and left hand responses would
indicate that children's hand preferences were among the determinants of their matching performances.

Overall, children responded with right hand gestures on 55% of all trials (range: 21 - 77%), with left hand gestures on 31% of all trials (range: 0 - 75%), and bimanually on the remaining trials. The Wilcoxon’s Matched Pairs Test for related samples confirmed that right hand responses were, across children, significantly more frequent than the left hand ones ($T=28$, $\alpha<0.005$). Figure 8.4 shows that this trend was present in both age groups. The individual data show that, in keeping with the group trend, 15 out of 20 participants responded predominantly with the right hand. Half of all children emitted 2 to 10 times more right hand than left hand responses, 1 child showed a strong left hand bias, and the remaining children showed little or no preferences for either hand.

![Figure 8.4](image.png)

**Figure 8.4.** Mean percentages of trials with right hand (red bars) and left hand (blue bars) responses across 16 unimanual target gestures, for younger and older groups of children.
**Trials with more than one response**

Generalisation of trained matching would be expected to result in multiple responses to modelling of comparably novel and/or complex gestures. Thus multiple responding may be used as an index of gesture complexity and of children's matching ability. Overall, children emitted more than one response on 18% of trials across all target gestures.

A mean of 22% of trials with more than one response (range: 16 - 32%) were recorded for the younger group, and a mean of 15% of trials (range: 6 - 22%) were recorded for the older group. The Wilcoxon's Rank Sum Test for independent groups confirmed that the older children responded more than once on significantly fewer trials than the younger ones, across all target gestures ($W=74$, $p<0.01$).

**Consistency of children's matching within and between trials**

The consistency of children's matching was examined within trials that contained more than one response and across the six trials that were presented for each individual target gesture. As discussed in the previous chapter, self-correction within and especially between trials can be interpreted as an index of children's higher-order matching abilities.

Children's performances on trials with more than one response were classified as
1. **Improving.** This was whenever the last response was correct or mirror while the first response was incorrect; it was also whenever the last response was a better approximation to the modelled target gesture than the first one (e.g. when a child, presented with an unimanual contralateral ear touch, first produced a bimanual ipsilateral ear gesture and then responded with an unimanual ipsilateral ear gesture).

2. **Getting worse.** This was whenever the last response was incorrect while the first response was correct or a mirror; it was also whenever the last response was a lesser approximation to the modelled target gesture than the first one (e.g. when a child, presented with a underside-of-arm middle-arm touch responded first with a top-of-arm middle-arm touch and then with a top-of-arm lower-arm touch).

3. **Being consistent (neither improving nor getting worse).** This was whenever both the first and the last responses were either correct/mirror, or incorrect; it was also whenever the responses were equally good approximations to the modelled target gesture (e.g. when a child, presented with a bimanual contralateral shoulder touch, first produced a bimanual ipsilateral shoulder response and then responded with a big hug).

Overall, children improved on 56% of trials where more than one response was recorded (range: 18 - 81%), they got worse on 27% of these trials (range: 9 - 50%), and performed consistently over the remaining trials. The Wilcoxon's Matched Pairs Test confirmed that, across children, there was significantly more improvement than worsening of matching in trials with more than one response ($T=17.5, \alpha<0.005$). Although there were
marked differences between individual data, in keeping with the group effect, 9 out of 10 younger and 8 out of 10 older children improved more often than they got worse.

As reported in the Method section, each target response was modelled over six trials for each individual child. Children's performances across trials were examined for each individual target gesture by comparing the (final) responses emitted in the first three modelling trials to those from the last three modelling trials; children's matching was then classified as

1. **Improving.** This was whenever more correct and mirror responses were emitted in the last three trials than in the first three trials; it was also whenever the last three trials contained better approximations to the modelled target gesture than the first three trials.

2. **Getting worse.** This was whenever fewer correct and mirror responses were emitted in the last three trials than in the first three trials; it was also whenever the last three trials contained lesser approximations to the modelled target gesture than the first three trials.

3. **Being consistent (neither improving nor getting worse).** This was whenever there were equal numbers of correct and mirror responses in the last and the first three trials; it was also whenever approximations to the modelled target gestures were equal in the first and the last three trials.

Children's matching improved across trials for 25% of target gestures (range: 5 - 60%), got worse for 27% of target gestures (range: 10 - 45%), and remained consistent for the remaining gestures. The
Wilcoxon's Matched Pairs Test confirmed that improvements and getting worse were recorded for equal proportions of gestures, across all children ($T=77, \alpha>0.05$).

Mean proportions of trials in which children improved, got worse, and remained consistent, within trials with more than one response and across trials for each target gesture, are presented in Figure 8.5.

![Figure 8.5](image-url)  
**Figure 8.5.** Mean proportions of trials on which children's responding improved (red bars), got worse (blue bars), and remained consistent (yellow bars), within trials with more than one response and across trials for each target gesture.

The individual data show that, across trials: 6 out of 10 younger children improved more often than got worse, while 4 showed the opposite trend; 4 out of 10 older children improved more often than got worse, 4 showed the opposite trend, and the remaining 2 improved and got worse on the same numbers of target gestures. Overall, the differences between improving and getting worse were small for most children. However, six children
(one younger and five older) showed more extreme scores: two children improved two to four times more often than they got worse, and four children got worse two to nine times more often than they improved.

**Ear and Shoulder Target Gestures**

**Correct and mirror responses**

Younger children emitted correct and mirror responses to ear and shoulder models on 45% of trials (range: 31 - 58%), while older children emitted correct and mirror responses to ear and shoulder models on 57% of trials (range: 42 - 78%). The Wilcoxon's Rank Sum Test confirmed that, overall, older children performed significantly better than the younger ones on this measure ($W=81.5$, $p<0.05$). Figure 8.6 shows that this trend was stronger for shoulder than for ear target gestures. Overall, incorrect responses were emitted in about half of all trials for ear and shoulder target gestures.

Children's correct and mirror responses were analysed separately for ipsilateral and contralateral gestures. Across ipsilateral ear and shoulder trials, 74% of responses were correct or mirror (range: 33 - 100%). Children's performances were much poorer for contralateral trials, where only 22% of responses (range: 0 - 69%) were correct or mirror.
The percentages of trials with correct and mirror responses for *ipsilateral* ear and shoulder target gestures are presented in Figure 8.7; the figure shows that children emitted more correct and mirror responses to bimanual models than to unimanual ones. Indeed, 14 out of 20 children never emitted an incorrect response to bimanual ear models, and 17 out of 20 children never emitted an incorrect response to bimanual shoulder models. By contrast, only 5 children showed errorless performances for unimanual ear gestures, and 2 children showed errorless performances for unimanual shoulder gestures.

The Wilcoxon's Matched Pairs Test confirmed that—across ipsilateral ear gestures—children's matching of bimanual target models was significantly better than that of unimanual ones ($T=6$, $\alpha<0.005$). This was true of 19 out of 20 children (only 1 younger child showed a slight opposite
trend). The same test confirmed that—across ipsilateral shoulder gestures—children's matching of bimanual target models was significantly better than that of unimanual ones \((T=10, \alpha<0.005)\). This was true of 14 out of 20 children (only 1 child showed a slight opposite trend, and 5 children showed no effect either way).

![Graph showing percentages of trials with correct and mirror responses for ipsilateral ear and shoulder target gestures, for bimanual (red bars) and unimanual (blue bars) gestures, across all children. For unimanual gestures, correct responses are presented in lower (solid blue) bars, and mirror responses are presented in top (striped blue) bars.]

**Figure 8.7.** Percentages of trials with correct and mirror responses for ipsilateral ear and shoulder target gestures, for bimanual (red bars) and unimanual (blue bars) gestures, across all children. For unimanual gestures, correct responses are presented in lower (solid blue) bars, and mirror responses are presented in top (striped blue) bars.

A reverse trend was recorded for contralateral ear and shoulder target gestures, as can be seen from Figure 8.8. There was no significant difference between children's correct and mirror responses to unimanual and bimanual ear gestures (Wilcoxon's Matched Pairs test, \(T_{(10)}=26.5, \alpha>0.05\)). Children emitted more correct and mirror responses to
unimanual models than to bimanual models for shoulder gestures (Wilcoxon's Matched Pairs Test, $T(16)=27$, $\alpha<0.025$); this was true of 12 out of 20 children (4 children showed a slight opposite trend, and 4 children showed no effect either way).

To summarise. Children responded markedly better overall to ipsilateral than to contralateral modelled gestures. They responded better to bimanual models than to unimanual models when presented with ipsilateral ear and shoulder models. However, when shown contralateral models, responding was better for unimanual than for bimanual shoulder gestures and approximately the same for unimanual and bimanual ear
gestures. Across all unimanual trials, mirror responses were far more numerous than correct responses.

**Ipsilateral Responses to Contralateral Models (Ipsi-For-Contra Errors)**

Across ear and shoulder target gestures, children responded with ipsilateral gestures to contralateral models on 67% of (contralateral) trials. The younger group showed ipsi-for-contra errors on 80% of trials (range: 50 - 100%), while older children showed ipsi-for-contra errors on 53% of trials (range: 22 - 86%). The Wilcoxon's Rank Sum Test confirmed that, on average, older children had significantly fewer ipsi-for-contra errors than the younger ones ($W=69, p<0.005$). Figure 8.9 shows that this trend was present for unimanual and bimanual gestures, and across ear and shoulder target groups.

Children's ipsilateral responses to contralateral models were compared between unimanual and bimanual gestures: ipsi-for-contra errors were recorded on 68% of trials with unimanual models (range: 8 - 100%), and on 50% of trials with bimanual models (range: 0 - 100%). Thus there were significantly fewer ipsi-for-contra errors for bimanual than for unimanual ear and shoulder target gestures (Wilcoxon's Matched Pairs Test, $T=51, \alpha<0.025$). Figure 8.9 shows that this trend was present for ear and shoulder gestures across younger children, and for ear gestures across older children. Individual data were quite variable: most children had more ipsi-for-contra errors for unimanual than bimanual gestures (13), 5 children showed an opposite trend, and 2 children showed no trend.
Figure 8.9. Mean percentages of trials with ipsi-for-contra errors for younger and older children, for ear and shoulder target gestures, and for unimanual (red bars) and bimanual (blue bars) models.

Children's ipsilateral responses to contralateral models were compared between ear and shoulder target gestures: ipsi-for-contra errors were recorded on 80% of trials with ear models (range: 39 - 100%), and on 47% of trials with shoulder models (range: 6 - 89%). Thus there were significantly fewer ipsi-for-contra errors for shoulder than for ear target gestures (Wilcoxon's Matched Pairs Test, $T=2.5$, $\alpha<0.005$). In keeping with the group results, individual data showed that 8 out of 10 younger and all older children had more ipsi-for-contra errors for ear than for shoulder gestures.
Children emitted contralateral responses to ipsilateral models on only 6% of ear and shoulder (ipsilateral) trials. Younger children committed contra-for-ipsi errors on 3% of trials (range: 0 - 17%), and the older children committed contra-for-ipsi errors on 9% of trials (range: 0 - 19%). The Wilcoxon's Rank Sum test confirmed that the younger group had significantly fewer contra-for-ipsi errors than the older group ($W=72$, $p<0.01$). Figure 8.10 shows that this trend was present only for unimanual target gestures; across bimanual trials, there were only three contra-for-ipsi errors for ear (3 children committed one error each), and no contra-for-ipsi errors for shoulder gestures.

The Wilcoxon's Matched Pairs Test confirmed that—across all children—there were significantly more contra-for-ipsi errors for shoulder than for ear gestures ($T=13$, $\alpha<0.005$). In keeping with the group results, 12 children committed more contra-for-ipsi errors for shoulder than for ear gestures, 2 showed the reverse trend, and 6 showed no trend.
Figure 8.10. Mean percentages of trials with contra-for-ipsi errors for younger and older children, ear and shoulder target gestures, and unimanual (red bars) and bimanual (blue bars) models.

Bimanual Responses to Unimanual Models (Bimanual-For-Unimanual Errors) and Unimanual Responses to Bimanual Models (Unimanual-For-Bimanual Errors)

Children emitted bimanual responses to unimanual models (bimanual-for-unimanual errors) and unimanual responses to bimanual models (unimanual-for-bimanual errors) on 15% of all trials across ear and shoulder target gestures.

Younger children committed bimanual-for-unimanual errors on 23% of unimanual ear and shoulder trials (range: 0 - 67%), and older
children committed bimanual-for-unimanual errors on 19% of trials (range: 2 - 67%). Both groups had very few unimanual-for-bimanual errors: younger children emitted these on 3% of bimanual trials (range: 0 - 8%), and the older ones on 1% of trials (range: 0 - 4%). Figure 8.11 shows that bimanual-for-unimanual errors were much more frequent than unimanual-for-bimanual errors across ear and shoulder models and for both groups of children. Although individual error data were variable, this general trend was present for each child across target gestures.

![Figure 8.11](image)

**Figure 8.11.** Mean percentages of trials with bimanual responses to unimanual models (bimanual-for-unimanual errors, red bars) and unimanual responses to bimanual models (unimanual-for-bimanual errors, blue bars) for younger and older children, across ear and shoulder target gestures.

Figure 8.12 shows comparisons, across all children, between bimanual-for-unimanual errors for ipsilateral and contralateral ear and shoulder gestures. The Wilcoxon's Matched Pairs Test revealed that there was no
significant difference between bimanual-for-unimanual errors for ipsilateral and contralateral ear gestures ($T=51, \alpha>0.05$). However, across shoulder gestures, there were significantly more bimanual-for-unimanual errors for ipsilateral models than for contralateral ones (Wilcoxon's Matched Pairs Test, $T=10$, $\alpha<0.005$). This trend was also present in most individual children's data: 7 out of 10 younger, and 9 out of 10 older children had more bimanual-for-unimanual errors for ipsilateral models than for contralateral ones.

**Figure 8.12.** Mean percentages of trials with bimanual-for-unimanual errors for unimanual ear and shoulder gestures, for ipsilateral (red bars) and contralateral (blue bars) models.
Trials with More Than One Response

Across all ear and shoulder target gestures, children emitted more than one response on 19% of trials. The Wilcoxon's Matched Pairs Test ($T=17.5$, $\alpha<0.005$) revealed that there were significantly fewer trials with more than one response for ipsilateral gestures (mean: 14%, range: 8 - 44%) that for contralateral gestures (mean: 23%, range: 0 - 39%). Figure 8.13 shows that this trend was present for both ear and shoulder gestures, and for both groups of children.

![Figure 8.13](image)

Figure 8.13. Mean percentages of trials with more than one response for ear and shoulder target gestures, for contralateral (red bars) and ipsilateral (blue bars) models, and for younger and older groups of children.
In keeping with the group results, individual data show that for 9 out of 10 younger, and 7 out of 10 older children, trials with more than one response were more numerous for contralateral than for ipsilateral models across ear and shoulder gestures.

**Other Errors**

*Hugs and hug-like crossed arms gestures*, in which children's arms were crossed in front but were not reaching up and touching correct body parts (ears or shoulders), were produced solely to contralateral bimanual models. These (commonly trained) incorrect responses were emitted on 6% of contralateral bimanual ear trials (range: 0 - 34%), and on 27% of contralateral bimanual shoulder trials (range: 0 - 100%). Not all children emitted hugs and hug-like responses; the individual data show that (i) 3 younger and 1 older child produced these responses to the ear models, and (ii) 6 younger and 6 older children produced these responses to the shoulder models.

*Responses where both arms touched one correct body part*, and in which one arm performed an ipsilateral movement while the other arm performed a contralateral movement, were produced solely to contralateral bimanual ear and shoulder models. Children emitted these incorrect responses on 8% of contralateral bimanual ear trials (range: 0 - 83%), and on 3% of contralateral bimanual shoulder trials (range: 0 - 67%). Only 7 children produced this type of error (i) 3 younger and 4 older to ear models, and (ii) 1 younger and 1 older to shoulder models.
Errors in which hand(s) touched incorrect body parts consisted mostly of well-trained gestures such as bimanual ipsilateral touches to head and eyes, clapping, and tapping back of hand. These errors were recorded on 4% of all ear and shoulder trials (range: 0 - 13%). Seventeen out of 20 children emitted such errors at least once.

**Middle- and Lower-Arm Target Gestures**

**Correct and Mirror Responses**

Across middle- and lower-arm target gestures, children emitted correct and mirror responses on 56% of all trials. The younger group emitted correct and mirror responses on 61% of trials (range: 44 - 77%), and the older group on 50% of trials (range: 25 - 77%). The Wilcoxon's Rank Sum Test revealed that the difference between the two groups for correct and mirror responding was not statistically significant ($W=89.5, p>0.05$).

Correct and mirror responses were compared between top-of-arm trials (modelled with the arm-to-be-touched forward and resting) and underside-of-arm trials (modelled with the arm-to-be-touched bent and raised) across all middle- and lower-arm target gestures. Children emitted correct and mirror responses on 61% of top-of-arm trials (range: 0 - 92%) and on 49% of underside-of-arm trials (range: 4 - 88%). The Wilcoxon's Matched Pairs test confirmed that children performed significantly better on top-of-arm than on underside-of-arm trials ($T=45.5, \alpha<0.025$). This effect is illustrated in Figure 8.14, which also shows that mirror responses were much more frequent than correct responses.
Figure 8.14. Mean percentages of trials with correct (solid bars) and mirror (striped bars) responses for top-of-arm and underside-of-arm models, across all children.

Figure 8.15 shows the percentages of correct and mirror responses that children in both groups emitted to top-of-arm and underside-of-arm models of middle- and lower-arm target gestures. The figure shows that both groups of children performed more correct and mirror responses to underside-of-arm models than to top-of-arm models for middle-arm gestures; however, they responded better to top-of-arm models than to underside-of-arm models for lower-arm gestures.

The Wilcoxon's Matched Pairs Test ($T=34, \alpha<0.025$) confirmed that, across all children and for middle-arm gestures, correct and mirror responses were more frequent for underside-of-arm models (mean: 69%, range: 0 - 100%) than for top-of-arm models (mean: 52%, range: 0 - 100%). Although individual data were very variable, the same trend was present for 15 out of 20 children.
Across all children and for lower-arm gestures, correct and mirror responses were much more frequent for top-of-arm models (mean: 72%, range: 17 - 100%) than for underside-of-arm models (mean: 28%, range: 0 - 75%); the Wilcoxon’s Matched Pairs Test confirmed that this difference was statistically significant ($T=9$, $\alpha<0.005$). Although individual data were very variable, the same trend was present for 17 out of 20 children.

**Figure 8.15.** Mean percentages of trials with correct and mirror responses for middle- and lower-arm target gestures, for top-of-arm (red bars) and underside-of-arm (blue bars) models, and for two groups of children.
Top-Of-Arm Responses to Underside-Of-Arm Models (Top-For-Underside Errors) and Underside-Of-Arm Responses to Top-Of-Arm Models (Underside-For-Top Errors)

Across middle- and lower-arm target gestures, children emitted top-of-arm responses to underside-of-arm models (top-for-underside errors) on 36% of trials (range: 0 - 79%). Children emitted underside-of-arm responses to top-of-arm models (underside-for-top errors) on 10% of trials (range: 0 - 63%). The Wilcoxon’s Matched Pairs Test confirmed that top-for-underside errors were significantly more frequent than underside-for-top errors across all middle- and lower-arm gestures ($T=16$, $\alpha<0.005$).

As discussed earlier in the present chapter, generalisation of trained matching would be expected to result in (i) comparably fewer errors for a pair of common and likely to be trained gestures (underside-of-arm touches to middle-arm, and top-of-arm touches to lower-arm), and (ii) comparably more errors for a pair of uncommon and unlikely to be trained gestures (top-of-arm touches to middle-arm, and underside-of-arm touches to lower-arm). Thus children’s top-for-underside errors and underside-for-top errors were analysed separately for these two sets of common and uncommon target gestures, each of which contained equal numbers of top-of-arm and underside-of-arm target gestures.

Children emitted top-for-underside and underside-for-top errors on 12% of trials for the common target gestures (range: 0 - 75%) and on 34% of trials for the uncommon target gestures (range: 4 - 71%). The Wilcoxon’s Matched Pairs test confirmed that, over all children, significantly fewer top-for-underside and underside-for-top errors were recorded for
the common target gestures than for the uncommon ones ($T=1, \alpha<0.005$).

The percentages of trials in which top-for-underside and underside-for-top errors were emitted across the common and the uncommon target gestures are shown in Figure 8.16 for younger and older group. The difference in errors was present for both groups, but was more extreme in older children, who seldom made any top-for-underside and underside-for-top errors to common models. Although there was much variability in the individual data, the group results were reflected in individual trends for 18 out of 20 children.

**Figure 8.16.** Mean percentages of trials where top-for-underside and underside-for-top errors were emitted in response to common target models (underside-of-arm touches to middle-arm, and top-of-arm touches to lower-arm) and to uncommon target models (top-of-arm touches to middle-arm, and underside-of-arm touches to lower-arm), for younger and older groups of children.
Middle-Arm Responses to Lower-Arm Models (Middle-For-Lower Errors) and Lower-Arm Responses to Middle-Arm Models (Lower-For-Middle Errors)

Middle-arm responses to lower-arm models (middle-for-lower errors) and lower-arm responses to middle-arm models (lower-for-middle errors) were recorded on 20% of all arm target trials. Children emitted lower-for-middle errors on 20% of trials (range: 0 – 58%); they emitted middle-for-lower errors on 19% of trials (range: 0 – 83%). The Wilcoxon's Matched Pairs Test confirmed that these two types of errors were equally frequent across all gestures and children ($T=75, \alpha>0.05$). Figure 8.17 shows distribution of lower-for-middle errors and middle-for-lower errors across top-of-arm and underside-of-arm models.

Figure 8.17. Mean percentages of trials with lower-for-middle errors and middle-for-lower errors across top-of-arm models (red bars) and underside-of-arm models (blue bars), across all children.
Figure 8.17 shows that the lower-for-middle errors were comparably more frequent for top-of-arm models, while the middle-for-lower errors were comparably more frequent for underside-of-arm models.

The Wilcoxon's Matched Pairs Test confirmed that there were significantly more lower-for-middle errors for top-of-arm models than for underside-of-arm models ($T=24.5$, $\alpha<0.005$). The individual data were very variable: the group results were reflected in individual trends for 14 out of 20 children, 4 children had opposite trends, and 2 children showed no trend. The Wilcoxon's Matched Pairs Test showed that there were significantly more middle-for-lower errors for underside-of-arm models than for top-of-arm models ($T=27$, $\alpha<0.05$). The individual data were very variable: the group results were reflected in individual trends for 11 out of 20 children, 4 children had opposite trends, and 5 children showed no trend.

**Trials with More Than One Response**

Across all arm target gestures, children emitted more than one response on 19% of all trials. They responded more than once to top-of-arm models on 20% of trials (range: 0 -33%), and to underside-of-arm models on 18% of trials (range: 4 - 38%). As can be seen from Figure 8.18, older children had fewer trials with more than one response than the younger group, across all arm target gestures. However, within age groups, children had similar proportions of trials with more than one response across middle- and lower-arm gestures, and across top- and underside-of-arm models.
Chapter 8

Table 8.18. Mean percentages of trials with more than one response for younger children (red bars) and older children (blue bars), for middle- and lower-arm gestures, and for top- and underside-of-arm models.

The Wilcoxon’s Matched Pairs Test confirmed that there was no significant difference between proportions of trials with more than one response for top- and underside-of-arm models ($T=74, \alpha>0.05$).

Other Errors

Incorrect responses where hand(s) touched body parts other than locations along arms consisted mostly of well-trained gestures such as bimanual ipsilateral touches to head and eyes, clapping, unimanual touches to shoulder, and hugs. These errors were recorded on 8% of all middle- and lower-arm trials (range: 0 - 40%). The individual data show much variability, but these errors accounted for less than 10% of responses for most children; 19 out of 20 children emitted them at least once.
DISCUSSION

In the present experiment, evidence to support the view that generalisation of trained matching may be a major determinant of matching was found in the performances of two to three year old children. Children's matching of common gestures (likely to be well-established matching responses because they feature in games often played in the nursery where our participants were recruited) was superior to their matching of uncommon gestures (similar gestures for which there was no evidence for such a training history) within all target gesture groups. Further, children's matching errors showed that their responses to uncommon models were similar to those they frequently produced to common models.

The results were inconsistent with the goal theory of imitation across a multitude of measures and for all gesture groups; these are discussed individually in the following paragraphs.

All Target Gestures

Overall Error Rates

Just under half of all responses to target gestures were incorrect in the present experiment (49% for the younger group, and 46% for the older group); these error rates were about twice as high as those reported in
the goal studies of Bekkering and colleagues (24.5% or less) and of Gleissner and colleagues (27%) (see Bekkering, Woschlager, & Gattis, 2000; Gleissner, Meltzoff, & Bekkering, 2000).

The procedural differences between the goal studies and the present experiment that may have resulted in error rate differences were as follows:

- Bekkering and colleagues tested children as old as six years; these older children would be expected to have (i) larger trained matching repertoires, (ii) better established higher-order matching abilities, and (iii) better naming of gestures and movements that could contribute to the control of their gestural responses to modelling. Therefore, Bekkering and colleagues' participants would be expected to produce fewer matching errors than the two to three year old children who participated in the present experiment.

- Bekkering and colleagues reported that all children's responses were followed by "encouragement". It is possible that "encouragement" of children's responding was selective (i.e. more enthusiastic for correct responses), thus effectively training correct matching. It is also possible that on-line cueing (e.g. selective smiling, nodding, eye contact, urging children to "play properly" etc.) promoted children's response correction in many trials; only final arm configurations were coded for each response, so on-line cueing could have resulted in an apparent increase in correct matching.
• Gleissner and colleagues' participants were of comparable age to those in the present study. However, parents were present in the testing but their behaviour was not recorded; the experimenter's actions were also excluded from the coding tapes. Thus on-line cueing by parents and the experimenter was possible.

• Gleissner and colleagues' coding of children's gestures was imprecise: a coder was asked to record whether children performed a movement towards either ear or knee, which hand they used to do so, and whether their body mid-line was crossed. The exact details of movements were not noted: all movements toward the top half of body were all scored as ear touches, and all movements toward the lower half of body were scored as knee touches. Many incorrect responses may have been coded as correct; for example, children in the present study often responded to modelling of bimanual contralateral touches with hugs that produced crossed arms configurations, but did not contain touches to correct body parts; Gleissner and colleagues would have coded such responses as correct. These authors justified their coding by stating that children's fine motor skills, required for touching of correct body parts, were not in themselves a subject of investigation. In the present study some variability and imprecision in responses were allowed: for example, ear touches were coded as correct whenever children touched ear, neck, or hair; shoulder touches were coded as correct whenever children touched shoulder, neck, upper arm, or chest locations (and see Tables 8.3 - 8.6.) Any coding that is more lenient than that employed in the present study excludes the possibility of testing whether correct body parts were touched at all—it effectively removes this aspect of children's performances from the analyses. Thus Gleissner and colleagues' theory (their claims that
children perceive the body part to be touched as the dominant goal in modelled gestures and reproduce it more faithfully than any other goal) was belied by their choice of coding (which assumes that touching correct body parts is difficult for young children).

- Gleissner and colleagues' procedure did not specify what was coded on trials where children responded more than once; presumably if a correct response (or indeed a poor approximation, see above) was emitted at any point, the trial was coded as correct and all other responses were ignored. In the present study it was found that children emitted multiple responses on a substantial proportion of trials (19%); further, they often "got worse" and emitted incorrect responses immediately after the correct ones. Gleissner and colleagues' coding may have overestimated the correct response rates by selectively ignoring certain of the multiple responses.

The comparably higher error rates in the present experiment were not due to children's boredom with the procedure, which, unlike the goal studies, included testing in 15 or more consecutive sessions. Consider:

- The results showed that children's responses to target models remained consistent over trials.

- All children responded promptly to modelling of target gestures; more than one model had to be presented on only 3% of all trials.

- Out of 20 children, 18 responded to all 120 models that were presented to them; no response was noted only on two trials each for 2 children.
Children's responses to the trained (baseline) models, presented in all probing sessions, remained excellent throughout; over 90% of all trained models were matched correctly by each child.

Correct and Mirror Responses

Correct and mirror responses, both of which contained correct gesture configurations, were emitted on just over half of all target gesture trials. On average, younger and older children performed equally well (although there were differences in the kinds of errors that they made within target gesture groups, as discussed later). Mirror responses were far more frequent than correct responses across all (unimanual) target gestures and for all individual participants. Thus 24 - 42 months old children showed much more mirroring than did 15 - 25 months old children in Experiment 2.

As noted in introduction, the predominance of mirror responding is consistent with “social/local enhancement” (a tendency to respond in the same spatial location as the person who presents modelling), “perceptual tethering” (a tendency to reach for and follow the movement of the person who presents modelling), and with higher-order matching ability. However, mirror responding is not consistent with the predictions derived from the active intermodal mapping account of imitation (e.g. Meltzoff and Moore, 1992) which states that children map their own (proprioceptively perceived) movements and other’s (visually perceived) movements onto the same cognitive schema. As discussed in Chapter 4, active intermodal cognitive mapping of organ relations is said to result in the taking of
others' perspective which should result in correct—not mirror—matching.3

In the present experiment it was found that, on average, children emitted more right hand responses than the left hand ones, although in the modelling both hands were used on equal proportions of trials. Most children showed a marked right-hand bias, and some responded up to 10 times more often with the right hand than with the left hand; only 1 child showed a strong left-hand bias, and 4 children used both hands equally often. In Experiment 2 it was found that three out of four children showed marked right hand preferences; that one of these children responded almost exclusively with his right hand, and that the remaining child had no hand preferences. The results from Experiments 2 and 3 thus indicate that hand preferences influence matching of most children aged between 15 and 42 months.

3 Gleissner and colleagues (2000) argued that the active intermodal mapping account and the goal theory of imitation are complementary in portraying children's matching as active processes at different stages in childhood. However, the two theories are not continuous: the active intermodal mapping theory claims that children perceive and code other's movements in terms of organ relations, and reproduce these correctly by taking the others' perspective; in the goal account, the correct (goals of) body parts and hands are assumed either to be the mirror ones (see Bekkering et al., 2000), or both mirror and correct ones, although this is not discussed in detail. The goal theorists did not explain how or when the transition from intermodal mapping to goal-hierarchical matching would occur in childhood.
As discussed earlier, self-correction within and especially across trials can be interpreted as an index of children's higher-order matching abilities. In the present experiment, children's performances across trials remained consistent on about half of the target gestures, and improved or got worse on equal proportions of the remaining target gestures. There was variability in individual data but most children did not show either extreme improvements or getting worse; this was true for both age groups.

The younger group had, on average, more trials with multiple responses than the older group. Within the trials where more than one response was emitted (22% for the younger group, and 15% for the older group; the individual differences within the age groups were not very large for this measure) children's responses improved more often than they got worse; this was true of 17 out of 20 children.

Given the large proportion of trials on which incorrect responses were emitted, the present results suggest that higher-order matching was not a major determinant of children's performances: children who had learned higher-order matching would be expected to improve over time—across and within trials—and not get worse (however, the present experiment was not designed to directly test children's higher-order matching abilities; see later discussion).

The results were also inconsistent with the active intermodal mapping theory, which would predict (i) much better overall matching of body-touches—because organ relations that ought to have been mapped from
birth and presumably perfected by three years of age were modelled (see Chapter 4)—and (ii) improvement across trials for any comparably novel organ relations that may have been previously unmapped but were repeatedly modelled in the probing sessions.

As discussed earlier, the present results show that multiple responses ought to be considered in the coding of matching data. Analysing only the first responses in each trial would produce the highest error rates, as children's responses within trials improved more often than they got worse. Conversely, the lowest error rates would be scored whenever the experimenters simply noted whether correct responses were produced or not. Such was the case for most developmental studies (see Chapter 4); all trials in which a correct response occurred along with incorrect ones were nevertheless scored as correct, irrespective of where in a sequence of responses the correct response occurred.

**Ear and Shoulder Target Gestures**

Overall, children emitted correct and mirror responses on about half of ear and shoulder target trials; across unimanual target gestures mirror responses were over five times more frequent than the correct ones on average; all individual children emitted mirror responses much more frequently than the correct ones.
Ipsilateral Vs. Contralateral Gestures

The majority of responses trained in the conventional matching-and-naming games are performed ipsilaterally; thus children's matching of ipsilateral (common) models was predicted to be superior to their matching of contralateral (uncommon) models. Indeed, the results showed that children emitted correct and mirror responses, on average, more than three times more often to the ipsilateral models (74% of trials) than to the contralateral ones (22% of trials). Although there was much individual variability in the data, this trend was recorded for all individual children.

All contralateral gestures contained at least two components that could evoke trained (and competing) incorrect responses. Thus:

1. Experimenter's touching of ear(s) or shoulder(s) resembled discriminative stimuli for common ipsilateral hand-to-body gestures; the act of touching could have resulted in socially enhanced stimulus control by the body part(s) touched.

2. Experimenter's hand(s) crossed the body midline; this resembled discriminative stimuli for common contralateral and bimanual "hug" gestures. The resemblance was good for bimanual models but minimal for unimanual models; further, the shoulder touches, modelled with arm(s) that crossed on chest, resembled the common "hug" models more than the ear touches, modelled with arm(s) that crossed higher up (under chin).

Children seldom emitted correct and mirror responses to the uncommon contralateral models: errors were recorded on 78% of all trials.
Children's errors reflected their trained matching histories in the following ways:

- Multiple responses were emitted less often to ipsilateral models than to contralateral ones across both ear and shoulder target groups; this was true for 16 out of 20 children.

- Overall, children emitted ipsilateral responses to contralateral models eleven times more often than vice versa (ipsi-for-contra and contra-for-ipsi errors were recorded on 67 and 6% of trials, respectively).

- Children's ipsi-for-contra errors were, on average, more frequent across unimanual gestures (68% of trials) than across bimanual gestures (50% of trials). In addition, children emitted hug-like responses where arms were crossed in front but without touching correct body parts solely to bimanual contralateral models (on 17% of trials). Thus, across unimanual contralateral trials, children's errors mainly consisted of common ipsilateral touches; across bimanual contralateral trials, common ipsilateral touches were still predominant, but common contralateral hug-like gestures were also emitted. In the goal theory terminology, children who emitted hug-like incorrect responses reproduced the supposedly inferior goals of hand choice and movement path but neglected the supposedly dominant goal of touching the correct body parts; such errors would not be predicted by the goal theory. Yet children also emitted other incorrect body touches (e.g. to head, eyes) on a further 4% of all ear and shoulder trials. Although such errors were not frequent, 17 out of 20 children emitted them at least once.
Children emitted more ipsi-for-contra errors to ear models (80% of trials) than to shoulder models (47% of trials); this was true of 18 out of 20 children. This was not because children found the ear models more difficult to match: the correct and mirror rates were comparable across the two target gesture groups (and the pattern was reversed across contra-for-ipsi errors). Children emitted hug-like responses to ear models less frequently (6% of bimanual trials) than to shoulder models (27% of bimanual trials). Thus, across ear trials, children's errors mainly consisted of common ipsilateral touches with few hug-like contralateral gestures; across shoulder trials, common ipsilateral touches were dominant but comparably fewer, while common contralateral hug-like gestures were emitted comparably more often. Overall, children's error patterns differed between ear and shoulder gestures; the goal theory would consider the two target gesture groups to be equivalent and would predict no such differences.

Responses where both arms touched one (correct) body part were emitted solely to bimanual contralateral models; overall these errors were few (6% of trials) and recorded for 7 out of 20 children, who emitted them more frequently to ear models than to shoulder models. These responses could have resulted from simultaneous performance of two trained gestures that were not entirely integrated.

**Bimanual Vs. Unimanual Gestures**

The two target gestures that feature most prominently in common matching games were bimanual ipsilateral touches to ears and
shoulders. It was predicted that children's matching performances would reflect their extra-experimental overtraining of these gestures. The results were consistent with this prediction. Thus:

- Children's matching of bimanual ipsilateral ear and shoulder target gestures was superior to that of all other gestures. Fourteen out of 20 children always responded correctly to bimanual ipsilateral ear models while only 5 showed errorless matching of unimanual ipsilateral ear models. Seventeen out of 20 children responded errorlessly to bimanual ipsilateral shoulder models, but only 2 children emitted no errors to unimanual ipsilateral shoulder models. No child showed errorless matching of any contralateral ear and shoulder models. The goal theory makes a distinction between contralateral and ipsilateral gestures, but the authors do not offer different predictions for unimanual and bimanual ipsilateral gestures.

- Children's superior matching of bimanual ipsilateral ear and shoulder models was not due to their general preference for bimanual responding: across contralateral models the trend was reversed; children emitted correct and mirror responses on equal proportions of bimanual and unimanual ear trials, and performed better on unimanual shoulder gestures than on bimanual ones.

- Children emitted bimanual responses to unimanual models ten times more often than they emitted unimanual responses to bimanual models (21 and 2% of trials, respectively). This was true across both ear and shoulder target gesture groups and for all individual children. As noted
above, the goal theory would not predict bimanual responding to unimanual models.

- Bimanual-for-unimanual errors were more frequently emitted to ipsilateral models (which resemble the common and presumably trained bimanual responses more) than to contralateral models (which resemble the common bimanual responses less) across shoulder gestures; a much smaller trend in the same direction was recorded for ear gestures.

**Age (Group) Differences**

The older children were expected to have, on average, larger trained matching repertoires, and better higher-order matching and naming abilities; thus they were expected to show better matching performances than children in the younger group. However, the differences between the two groups were overall very small, although the trends that reached statistical significance were consistent with the predictions. Thus:

- The younger children emitted fewer correct and mirror responses to ear and shoulder target models (45% of trials) than the older group (57% of trials).

- The younger group produced, on average, more ipsilateral responses to contralateral models than the older group (80 and 53% of trials, respectively). Thus the younger group emitted common incorrect responses to uncommon models more frequently than did the older group.
Contralateral responses to ipsilateral models were infrequent overall, but the pattern was reversed here: the older group produced, on average, more contralateral responses to ipsilateral models than did the younger group (9 and 3% of trials, respectively). The larger matching repertoires of the older children may have included more contralateral responses than those of the younger group; these contralateral gestures were emitted comparably more often overall, including as errors. One such gesture was a game played in the Nursery where children were asked to sit with their arms crossed and "pat themselves on the back". According to the goal theory, children's matching errors result from their cognitive processing limitations which are presumably greater for younger children—who would be predicted to show more, not fewer, errors (across all measures) than the older children.

**Middle- and Lower-Arm Target Gestures**

Children emitted correct and mirror responses to middle- and lower-arm gestures on 56% of trials. The two groups performed equally well overall; the error rates were lower for the younger children than for the older ones (39 and 50% of trials, respectively) but the individual variability was large and this difference did not reach statistical significance.

All arm target gestures were performed contralaterally while half of ear and shoulder gestures were performed ipsilaterally; yet children's overall correct and mirror response rates were as high (or even slightly higher) for the arm touches as compared with the ear and shoulder touches. This
indicated that crossing body midline was not, in itself, difficult for two to three year old children.

**Top-Of-Arm Gestures Vs. Underside-Of-Arm Gestures**

The arm gestures in which touches were performed on top-of-arm locations were comparably less complex than those in which touches were performed on underside-of-arm locations, because in the former the arm-to-be-touched was resting, whereas in the latter it had to be raised or bent. Children's matching performances were, overall, better for top-of-arm gestures than for underside-of-arm gestures. Thus:

- Correct and mirror responses were emitted on 61% of top-of-arm trials and on 49% of all underside-of-arm trials. Mirror responses were, on average, about three times more frequent than correct responses; the individual variability in the data was high overall.

- Children emitted top-of-arm responses to underside-of-arm models more frequently than vice versa: top-for-underside errors were recorded on 36% of trials and underside-for-top errors were recorded on 10% of trials.

**Trained Vs. Uncommon Arm Target Gestures**

Within all arm target touches, half of target gestures were common (presumed to be well-established matching responses because they feature in common games); the other half of gestures were uncommon (and had no such training history).
Thus:

- Within the top-of-arm target group, touches to lower-arm location were common [e.g. ], while the touches to middle-arm location were uncommon [e.g. ].

- The pattern was reversed for underside-of-arm target group, where touches to lower-arm were uncommon [e.g. ], while the touches to middle-arm location were common [e.g. ].

It was predicted that children would show superior matching of common models as compared to the uncommon ones across all target arm touches.

The results showed that
Across lower-arm target gestures, children emitted more correct and mirror responses to common, top-of-arm models (72% of trials) than to uncommon, underside-of-arm models (28% of trials); this was true for 17 out of 20 individual children.

The pattern was reversed for middle-arm models, where children's matching was better for common underside-of-arm models (69% of trials) than for uncommon top-of-arm models (52% of trials); this was true for 15 out of 20 children.

Overall, children's correct and mirror responses to common target models were almost twice as frequent as their correct and mirror responses to uncommon models. This result is inconsistent with the goal theory of imitation, which would predict different matching between top-of-arm models and underside-of-arm models on grounds of goal complexity but would not predict different performances within these target sets.

The uncommon models each contained at least two components that could evoke common incorrect responses. Thus:

- When modelling the uncommon middle-arm touches performed on top-of-arm location, the experimenter touched the top of her arm, which resembled a discriminative stimulus for common lower-arm touches. Whenever children emitted these common but incorrect responses, lower-for-middle errors were recorded.

- When modelling the uncommon middle-arm touches performed on top-of-arm location, the experimenter touched her middle-arm location;
Chapter 8

Experiment 3

this resembled a discriminative stimulus for common underside-of-arm touches. Whenever children emitted these common but incorrect responses, underside-for-top errors were recorded.

- When modelling the uncommon lower-arm touches performed on underside-of-arm location, the experimenter touched the underside of her arm, which resembled a discriminative stimulus for common middle-arm touches. Whenever children emitted these common but incorrect responses, middle-for-lower errors were recorded.

- When modelling the uncommon lower-arm touches performed on underside-of-arm location, the experimenter touched her lower-arm location; this resembled a discriminative stimulus for common top-of-arm touches. Whenever children emitted these common but incorrect responses, top-for-underside errors were recorded.

Overall, children were predicted to emit common responses to uncommon models much more frequently than vice versa. The analyses of errors showed that

- Top-for-underside and underside-for-top errors were almost three times as frequent, on average, for uncommon gestures than for the common ones (these errors were recorded on 34% of trials for uncommon arm touches and on 12% of trials for trained arm touches, respectively). This was true for 18 out of 20 individual children. The error differences were inconsistent with the goal theory of imitation: this theory would predict equal error rates across the sets of common and uncommon gestures, that
contained equal numbers of top-of-arm and underside-of-arm touches.

- Middle-arm responses to lower-arm models (middle-for-lower errors) and lower-arm responses to middle-arm models (lower-for-middle errors) were equally frequent overall; these errors were emitted on 19 and 20% of trials respectively. However, lower-for-middle errors were comparably more frequent for top-of-arm models, while the middle-for-lower errors were comparably more frequent for underside-of-arm models. Thus children emitted common but incorrect responses to uncommon models more than twice as often than vice versa; they touched incorrect body parts when presented with modelling of uncommon gestures on 27% of trials, and committed this error when presented with modelling of common gestures on 12% of trials. This was true across wrist-for-elbow and elbow-for-wrist errors, and for most individual children, although the variability in the individual data was high for this measure. In goal theory terminology, children who touched middle-arm locations in response to modelling of lower-arm touches and vice versa neglected the supposedly dominant goal of touching the correct body parts. Such errors would not be predicted; if any occurred, the goal theory would not differentiate between common and uncommon arm touches. In addition to this—and contrary to the goal theory predictions—children emitted other incorrect body touches (e.g. to head, eyes, shoulder) on a further 8% of all arm target trials; 19 out of 20 children committed these errors.
**Age (Group) Differences:**

The differences between the two age groups were overall small, as they were for the ear and shoulder target groups; the trends that reached statistical significance were consistent with the generalisation of trained matching predictions. Thus:

- Older children had, on average, fewer trials with multiple responses (15% of trials) than the younger group (23% of trials) across all arm target gestures.

- As discussed earlier, children emitted more top-for-underside and underside-for-top errors to uncommon models than to trained ones. The effect was statistically significant for both groups, but was more extreme for the older group of children, who seldom emitted any errors of this kind to the trained arm models (2% of trials, as compared with 31% of trials to uncommon models).

**Summary**

According to the goal theory of imitation, children should be expected to reproduce the dominant goal of modelled gestures—touch correct body part(s)—but to neglect the inferior goals (other aspects of the modelled target gestures). The theory predicts children's omission of inferior goals to result in better matching of ipsilateral models than of contralateral ones, and in ipsilateral responding to contralateral models (ipsi-for-contra errors) for ear and shoulder target gestures; the theory predicts, across
the arm target gestures, children to show better matching of top-of-arm gestures than of underside-of-arm gestures, and to emit top-of-arm responses to underside-of-arm models (top-for-underside errors). Overall results were in line with these very general predictions—which were also made, on more parsimonious grounds, by the generalisation of trained matching hypothesis. However, all additional comparisons produced results that strongly contradicted the goal theory predictions. Thus:

- Children's errors contained a substantial proportion of touches to incorrect body parts, or omission of supposedly dominant goals, across all gesture groups (e.g. hug-like responses to bimanual contralateral shoulder and ear touches, middle-for-lower and lower-for-middle errors for arm touches, and other trained incorrect body touches for all gestures).

- Children performed better on common gestures than on uncommon ones, even when these gestures did not differ in terms of goal structure (e.g. bimanual vs. unimanual touches within ipsilateral ear and shoulder gestures, middle- vs. lower-arm touches within underside-of-arm and top-of-arm gesture groups).

- Children emitted common responses to uncommon models far more often than vice versa; often such errors did not contain inferior goal omissions (e.g. bimanual-for-unimanual errors for ear and shoulder gestures) and across some gestures the erroneous responses contained additional goals (e.g. underside-of-arm responses to top-of-arm models across arm gestures).
The present experiment demonstrated that gestural matching of two to three year old children cannot be explained by the goal account of imitation; as noted earlier, the present data are also incompatible with the active intermodal mapping account of imitation (see Chapter 4).

Children's matching of ear, shoulder, and arm target gestures was consistent with the predictions derived from the generalisation of the trained matching hypothesis. However, the present experiment was not designed to exclude the other possible sources of control; higher-order matching and verbally controlled matching could also have determined children's responses to modelling.

At least one child consistently (overtly) named one group of models: when the experimenter touched ear(s), whether unimanually or bimanually, crossing body midline or not, this participant often said, "My ears," and performed a bimanual ipsilateral ear touch herself. In these episodes, the experimenter's touching of ear(s) apparently evoked a well-trained verbal response, which in turn evoked a well-established gestural performance (that was usually incorrect). All participants were able to name many body parts (this was revealed in the Griffiths' testing and in play interactions with the experimenter), and some of the older children may have also been capable of naming movements. Children occasionally offered comments; for example, one older girl informed the experimenter, "I don't want to do belly again!" Overall, overt naming of body parts was rare; naturally, the extent of children's covert verbalisations, and their possible influence on gesturing, was not known.
There were very few differences in matching performances between the two (age) groups of children. It is possible that the choice of participants and of target gestures minimised the possible age differences in the present experiment. The children who participated attended the same nursery several days each week; they were part of the same group and exposed to the same teaching and play activities. Thus the histories of trained matching—in the nursery if not at home—were comparable for younger and older children (except that the younger group had less exposure to these common games than the older group).

The individual participants' histories of trained matching were not known to the experimenter, who relied on her knowledge of common nursery matching-and-naming games to designate some of the target gestures as "common". The remaining gestures were referred to as "uncommon" and were presumed to be untrained; however, some of these could have been trained as matches, outside the nursery, for at least some of the participants. As reported earlier, children showed some correct and mirror matching of uncommon gestures; however, attributing these performances to children's higher-order matching abilities would be unparsimonious.

There were some indications that a few of the older children had learned higher-order matching or showed rule-governed behaviour; for example, one girl responded to modelling of a contralateral bimanual ear touch, on an early trial, by hugging (not touching ears), then with an ipsilateral bimanual gesture (touching ears); then she performed a hug again, then (still holding this configuration) moved one hand slowly up until it reached one ear, then (holding this configuration) she moved the other
hand up until the other ear was touched as well; at this point the gesture was correct. In the following trials she performed this response much faster, thus showing good evidence of improvement both within and across trials. Such impressive displays were rare, and although children, on average, improved more often than they got worse within trials where multiple responses were emitted, they did not, on average, improve across trials.

In Experiment 2 it was reported that generalisation of trained matching could account for all correct and approximate matching of a large number of hand and body gestures, many of which were uncommon, in three out of four children up to 25 months old; some evidence of higher-order matching was found with the remaining participant, but the data were not conclusive. In the present study, matching of hand-to-body gestures was consistent with the predictions derived from the generalisation of trained matching hypothesis, across 20 children aged between 24 and 42 months. Higher-order matching could have played a part for some of these children, but did not appear to be—for most children—a major variable.

Experiments 1, 2, and 3 were not designed to directly test higher-order matching: children's training histories were inferred but not examined or manipulated directly for individual participants. The following chapters present the results of two studies, Experiments 4 and 5, that were designed to do just that.
Experiment 4: Do 17 - 21 Month Old Children Show Higher-Order Matching of Gestures?

The aim of Experiment 4 was to establish whether children under two years of age would match gestures that are within their behavioural repertoires, but that had not yet been directly trained as matches.

There were five conditions in the experiment: Familiarisation, Training Baseline Matching Relations, Probing for Untrained (Target) Matching Relations, Training Target Responses Without Modelling, and Testing Untrained (Target) Matching Relations. The first three conditions were identical to those employed in Experiments 2 and 3; the remaining two were added to provide a conclusive test of higher-order matching.

In the first two conditions the experimenter identified, by modelling a range of conventional gestures, four trained matching relations already in children’s repertoires; she then reinforced correct matching until reliable baselines were established. Trained matching baselines were maintained under intermittent reinforcement throughout subsequent probing and testing conditions.
In Condition 3 the experimenter introduced modelling of new sets of conventional gestures, responses to which were never reinforced or corrected; she also continued providing intermittent reinforcement for the trained (baseline) matching relations. The aim was to identify four modelled gestures to which the children reliably failed to produce correct matching target responses.¹

In Condition 4, children were trained, mostly through play with stickers and by putting through, to produce the four target responses in the absence of the corresponding modelled gestures. Each target response was evoked at least once.

Failure to produce matching responses to the four target models in Condition 3 may have been due to children’s level of motor development: they may have lacked the sufficient operant motor control to enable them to produce the target responses. The aim of the intervention employed in Condition 4 was to train performances of the target responses but not under discriminative control of the corresponding models. Successful

¹ Without knowledge of the complete training histories of all participants, it is impossible to rule out the possibility that apparently emergent correct matching in an experiment is a result of direct operant training elsewhere. However, when incorrect, non-matching responses are consistently emitted to a set of models, in a context where only correct matching (of a trained set) is ever reinforced; it is reasonable to conclude that these gestures were never directly trained as matches, in any setting.
training demonstrated that motor development was not a limiting factor in the children's production of target responses.

In Conditions 3 and 4 of the experiment, the four target gestures were shown to be within the participants' behavioural repertoires, but not to be within their trained matching behaviour repertoires. Thus it was known that the children could perform the target responses in play; it remained to be seen whether they would emit them as matching responses to the corresponding models.

In Condition 5, the target gestures were again modelled interspersed with the baseline trained matches trials; while correct matching responses to the trained gestures were intermittently reinforced, the responses to target models were never reinforced or corrected.

Higher-order matching would be demonstrated if the children, following motor training of the target responses, produced each of the latter in response to the corresponding target models, in the absence of external reinforcement for doing so. Conversely, participants' failure to match gestures that they have learned to produce in Condition 4, but under alternative stimulus control, would suggest that extension of their matching repertoires still required direct matching training for each new matching relation.
METHOD

Participants

Two girls and four boys, aged between 8 and 19 months at the start of the experiment, and 17 to 21 months at the end, participated in this experiment. All children were attending the Nursery at least three days per week, and were recruited by parental consent. The Griffiths Mental Development Scales' scores (Griffiths, 1954), obtained at the end of the experiment for five children, showed that they were developing normally (see Table 9.1).

Table 9.1. The participants' general quotient (GQ) scores, gender, and age in months and days (m-d).

<table>
<thead>
<tr>
<th>Child</th>
<th>GQ score</th>
<th>Gender</th>
<th>Age at start (m-d)</th>
<th>Age at end (m-d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhys</td>
<td>109</td>
<td>male</td>
<td>08-20</td>
<td>17-17</td>
</tr>
<tr>
<td>Cal</td>
<td>119</td>
<td>male</td>
<td>12-14</td>
<td>20-18</td>
</tr>
<tr>
<td>Lora</td>
<td>*</td>
<td>female</td>
<td>14-11</td>
<td>19-06</td>
</tr>
<tr>
<td>Tony</td>
<td>107</td>
<td>male</td>
<td>14-12</td>
<td>20-12</td>
</tr>
<tr>
<td>Mia</td>
<td>115</td>
<td>female</td>
<td>16-14</td>
<td>19-11</td>
</tr>
<tr>
<td>Dan</td>
<td>105</td>
<td>male</td>
<td>18-21</td>
<td>20-27</td>
</tr>
</tbody>
</table>

* Participant Lora left the Nursery before this test could be administered.
Three children came from monolingual (English speaking) families, two were exposed to both English and Welsh, and one came from a family in which English and Arabic were used. Griffiths comprehension scores showed that all were competent English listeners.

**Materials and Apparatus**

The materials and apparatus were identical to those used in Experiment 2.

**Design**

In order to investigate higher-order matching it is important to identify a set of target modelled behaviours that any given child cannot yet match, and then proceed to determine the variables that may result in that child subsequently producing appropriate matching responses to these target models. A single-participant design, appropriate for investigating individual children's matching repertoires, and for manipulating individuals' behavioural repertoires, was therefore employed in the present experiment.

Replication across six participants was included as a control for generalisibility and reliability of the findings.

An essentially ABA design was used. Target gestures were modelled under 0% reinforcement in Condition 3 probing (for untrained
matching relations) and Condition 5 testing (untrained matching relations); the corresponding target responses were trained, without modelling, in Condition 4 (intervention). The data were presented in graphs and tables; these were analysed visually. Statistical analyses were not used.²

The design is illustrated in Figure 9.1.

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² Obtaining zero correct responding to target sets before an intervention is effective in ruling out prior learning (matching training) as a determinant of subsequent appropriate matching responses, which may develop as a result of an intervention. In this type of design, statistical comparisons are often not needed to evaluate the main effects (if any) of the intervention, which are qualitative rather than quantitative (e.g. no target responses vs. some target responses, emitted to the appropriate models in Conditions 3 and 5 respectively). When needed, however, non-parametric (binomial) statistics can be employed to analyse the results (e.g. to compare relative frequencies of individual target responses emitted to each of the target gestures).
**Figure 9.1.** An illustration of Design in Experiment 4.
Procedure

**Condition 1: Familiarisation**

The experimenter played with each child for several weeks—first in the playroom setting with other children and nurses present, second in the isolated test room. This continued until the participants were happy, responsive, and comfortable with the experimenter and the new surroundings. The familiarisation play was age appropriate, with an emphasis on turn-taking and give-and-take games with toys.³

In the second part of this condition, the experimenter started modelling, as part of play, conventional gestures which were known from the earlier studies (see Experiment 3) to be generally within the trained matching repertoires of children in this age group. Informal matching repertoire mapping ended when the experimenter identified four gestures to which a child responded correctly at least some of the time.

³ Throughout the months in which the experiment was conducted, the experimenter spent many additional hours with the participants in common rooms, taking part daily in the Nursery routines. She was treated by children and staff as one of the nurses, albeit more likely than most to engage in one-to-one play. However, she never took part in matching games outside the test room.
In all conditions of the experiment, a child was to be returned to the playroom if he cried or showed discomfort during testing. This never happened, but a few sessions were terminated prematurely when the experimenter judged the participants to be feeling unwell. The interrupted sessions were completed at the next testing opportunity.

Children were tested daily, when they were available, alert, and happy to play, with unavoidable breaks for holidays and illnesses. A typical experimental session lasted just over 10 minutes. Occasionally, when a participant was exceptionally happy and responsive, more than one session was run in a single day.

**Condition 2: Trained Matching Relations Baseline**

Conventional gestures to which at least occasional correct matching responses were emitted were identified for each child in the familiarisation sessions. Operant training was conducted in this condition to establish reliable and consistent correct responding to the verbal request, "Do this," followed by modelling of these gestures. Each training session contained three trials of each of the four chosen gestures (12 trials per session), with up to three models per trial. The gestures were modelled in a predetermined randomised order, with an added constraint that no more than two trials of the same gesture were presented in succession.

The sessions usually started with warm-up play; the experimenter then removed the toys and asked, "Shall we play our game?"
Modelling trials commenced next. The experimenter made sure that the participant was attentive by touching his or her feet, calling his or her name, or saying, "Look at me!" She then asked, "Can you [name] do this?" before modelling a baseline gesture. Models were always clear and exaggerated; for example, in the "hands up" gesture the experimenter stretched her arms upwards as far as possible, looking up at her hands. After modelling a gesture the experimenter looked at the child expectantly; if the child did not respond immediately she prompted him or her to do so by saying, "You do it!" or "Show me!" If the child did not respond to prompting, the experimenter modelled the same gesture again, up to three times per trial type. If no response was emitted, the experimenter used putting through to gently move a participant's hands into a matching response configuration and promptly produced reinforcement. Non-matching (incorrect) responses were corrected in a similar manner, with a verbal command, "Not quite; this is how we do it!" and putting through followed by reinforcement. The correct matching responses were enthusiastically reinforced by clapping, exclaiming, "Yeah!" or "Well done!" and play with toys and stickers.

All sessions ended with play. The training proceeded with a 100% reinforcement rate until the predetermined criterion of at least five out of six correct responses to each of the four baseline models, over two consecutive sessions, was reached. The reinforcement rate was then reduced to 50%; when a child responded correctly on at least 11 out of 12 trials within a single session—across gestures—the training was complete. A list of gestures used in this condition is presented in Table 9.2.
Table 9.2. Trained baseline matching relations: descriptions of modelled gestures and corresponding correct matching responses.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Correct Responses</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>HANDS ON HEAD (2 hands)</td>
<td>Both hands on top of head, once or tapping.</td>
<td>Both hands on head, touching hair.</td>
<td>Rhys, Cal</td>
</tr>
<tr>
<td>PEEK - A-BOO (2 hands)</td>
<td>Both hands covering eyes, opening wide with a sound 'boo'.</td>
<td>Both hands on face.</td>
<td>Rhys, Dan, Mia, Tony, Lora</td>
</tr>
<tr>
<td>HANDS UP (2 hands)</td>
<td>Both hands over head, stretching, looking up.</td>
<td>Both hands at head level or above.</td>
<td>Rhys, Tony, Lora, Mia, Cal</td>
</tr>
<tr>
<td>PALM POINT (right hand)</td>
<td>Index of right hand touching or tapping up-turned palm of left hand.</td>
<td>Index of right hand touching left palm.</td>
<td>Lora</td>
</tr>
<tr>
<td>HAND TO BACKHAND (left hand)</td>
<td>Left hand tapping back of right hand.</td>
<td>Left hand touching back of right hand or wrist.</td>
<td>Dan</td>
</tr>
<tr>
<td>HANDS ON BELLY (2 hands)</td>
<td>Both hands tapping middle of body (belly/chest).</td>
<td>Both hands touching middle of body.</td>
<td>Tony, Mia</td>
</tr>
<tr>
<td>HAND TO MOUTH - AHH (right hand)</td>
<td>Palm of right hand tapping open mouth to produce sound 'ahh'.</td>
<td>Right hand touching mouth.</td>
<td>Rhys, Tony, Lora, Mia, Cal</td>
</tr>
<tr>
<td>HANDS ON FRAME (2 hands)</td>
<td>Both hands tapping infant chair frame.</td>
<td>Both hands tapping chair frame.</td>
<td>Rhys, Cal, Dan</td>
</tr>
<tr>
<td>NOSE POINT (right hand)</td>
<td>Index of right hand touching or tapping tip of nose.</td>
<td>Index of right hand touching nose.</td>
<td>Dan</td>
</tr>
<tr>
<td>TONGUE OUT</td>
<td>Tongue extended out in front.</td>
<td>Tongue shown.</td>
<td>Lora</td>
</tr>
</tbody>
</table>

Condition 3: Probing for Untrained (Target) Matching Relations

New gestures, chosen from among those shown in the earlier studies (see Experiment 2) as unlikely to be matched correctly by children in
this age group, were presented in this condition. Four target models were interspersed with the four baseline trained models, and there were two trials per gesture per session (16 trials in all).

As in the previous condition, the experimenter asked, "Shall we play our game?" She then attracted the child's attention and asked, "Can you (name) do this?" before modelling a gesture. Correct responses to trained baseline models were reinforced intermittently; there were no scheduled consequences (reinforcement or correction) for responses to target models. The experimenter smiled at all times while modelling and observing the children's responses, in both trained and target gesture trials. Smiling was presented unconditionally in order to ensure that responding in target gesture trials was not suppressed as might have been the case if such trials were selectively followed by a "still face" expression by the experimenter.

The target models used for all children at the start of the procedure were as follows: a hand cross to shoulder (touching contralateral shoulder with right or left hand), a hand cross to elbow (touching contralateral elbow with right or left hand), a palms up bowl (cupped palms turned up and extended), and crossed arms (arms clearly crossed in front of body). If a child responded correctly to one of the target models, this gesture was replaced with another target gesture in the next session. Probing continued with each participant until consistent incorrect responding was
recorded for each of the four probe gestures over a minimum of 10 trials (five consecutive sessions).  

A complete list of the target gestures and descriptions of the responses, coded as correct, mirror, and incorrect in the probing, training, and testing sessions, is presented in Table 9.3.

**Condition 4: Training Target Responses Without Modelling**

The sessions in this condition were less structured than those in baseline and probing, and consisted of play with stickers, stamps, bubbles, and other toys. During play, the experimenter attempted to evoke and shape approximations to the target gestures in various ways. For example, touching the opposite shoulder (hand cross to shoulder gesture) was often easily occasioned by placing stickers on one shoulder and initially holding the child's ipsilateral hand. After several trials the child would reach for the sticker with the target, contralateral hand—and perhaps later touch the shoulder without the sticker—at which point training for this gesture stopped.

During these training sessions the experimenter never modelled the probe gestures. Further, she took care to avoid any resemblance in the arm and

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4 There was one exception: six probe trials (over three sessions) were recorded for one of Amy's gestures (hand cross to wrist).
hand movements she employed in putting through training and any of
the corresponding target gestures.

For example, during putting through training of the arms crossed target
gesture, a less vigilant experimenter could have crossed her own arms as
she crossed the child's. In so doing the experimenter would have
unwittingly provided the sight of her own crossed arms as an antecedent
discriminative stimulus to the child's crossing of his own arms; thus the
relation to be tested in the next experimental condition would have been
inadvertently trained.

The reinforcers for correctly performing the target responses, or
successively better approximations to them, were the same as in the other
conditions: clapping, praise, and play. In addition, gestures that were
performed by the child as actions to retrieve stickers, placed by the
experimenter at various locations on the child's body, were immediately
reinforced by the acquisition of those stickers.

Training was deemed complete when a participant performed each of the
four probe gestures correctly, without help, at least once. The criteria for
coding responses as correct, mirror, and incorrect are given in Table 9.3.
Descriptions of various ways in which gestures were evoked in this
condition are provided in Coding, below.
Table 9.3. Target gestures: modelled gestures and responses coded as correct, mirror, and incorrect in the probing, training, and testing sessions.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model</th>
<th>Correct Response Criteria</th>
<th>Child</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARMS CROSSED IN FRONT</td>
<td>Arms crossed in front, forearms overlapping, hands fisted.</td>
<td>YES: Arms clearly crossed, forearms or wrists overlapping.</td>
<td>Rhys, Dan, Tony, Cal, Lora, Mia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO: Arms slightly crossed while grabbing opposite arm/hand; all other gestures.</td>
<td></td>
</tr>
<tr>
<td>PALMS UP BOWL</td>
<td>Palms turned up, joined to form a bowl, extended to front.</td>
<td>YES: Both palms up in front, joined (coded closed) or slightly apart (coded open).</td>
<td>Rhys, Tony, Lora, Mia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO: Hands in front with palms down or to side; hands spread wide (to side) with palms up; all other gestures.</td>
<td></td>
</tr>
<tr>
<td>HAND CROSS TO SHOULDER</td>
<td>Hand touching or tapping top of contralateral shoulder.</td>
<td>YES: Hand touching top, side, or front of contralateral shoulder.</td>
<td>Right hand: Lora, Cal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch.</td>
<td>Left hand: Rhys, Tony</td>
</tr>
<tr>
<td>HAND CROSS TO ELBOW</td>
<td>Hand touching or tapping bottom of contralateral elbow, other arm bent.</td>
<td>YES: Hand touching bottom, front, or side of contralateral elbow, with other arm bent at elbow.</td>
<td>Right hand: Rhys, Dan, Tony</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch.</td>
<td>Left hand: Lora, Mia, Cal</td>
</tr>
<tr>
<td>HAND CROSS TO WRIST</td>
<td>Hand grabbing or tapping contralateral wrist, with other arm bent.</td>
<td>YES: Hand touching front or side of contralateral wrist, with other arm bent at elbow.</td>
<td>Right hand: Mia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch.</td>
<td></td>
</tr>
<tr>
<td>HAND CROSS TO KNEE</td>
<td>Hand touching or tapping contralateral knee.</td>
<td>YES: Hand touching contralateral knee.</td>
<td>Right hand: Cal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch.</td>
<td>Left hand: Dan</td>
</tr>
<tr>
<td>HAND CROSS TO FOOT</td>
<td>Hand touching or tapping tip of contralateral foot (shoe).</td>
<td>YES: Hand touching tip, side, or top of contralateral foot (shoe).</td>
<td>Right hand: Dan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NO: All other gestures.</td>
<td></td>
</tr>
</tbody>
</table>
Chapter 9

Experiment 4

**Condition 5: Testing Untrained (Target) Matching Relations**

The procedure in this condition was the same as that of probing for untrained (target) matching relations (Condition 3). The experimenter modelled the four baseline gestures that the children were trained to match in Condition 2, and the four target gestures that the children had not been trained to match—although in Condition 4 it was demonstrated that the children were able to perform these target behaviours under alternative stimulus control (i.e. other than sight of the corresponding target models).

The order of presentation was randomised, with two trials per gesture per session (16 trials in all), and an added constraint that no more than two trained (baseline) gestures or two target gestures could be presented in succession. Correct matching of the trained (baseline) models was intermittently reinforced; responses to probe models were not corrected nor did they receive reinforcement. At least four sessions (eight probes per gesture) were completed with each participant.

At the end of the experiment a trained member of the Nursery and University staff tested the children on the Griffiths Mental Development Scales (Griffiths, 1954). This was done in the familiar test room, and the experimenter was present as a familiar adult to encourage the participants to complete all the tasks. Some of the scores on the social development scale were assigned by questioning those Nursery staff who were most familiar with the individual children.
Finally, videotapes containing representative recordings of testing were presented to parents, who were encouraged to ask questions and comment on what they had seen. Letters with comprehensive explanation of the procedures and results of the study, the Griffiths' reports, and a toy present for each child were also given.

Coding

**Condition 2 Baseline, Condition 3 Probing, and Condition 5 Testing Trials**

The experimenter modelled each gesture up to three times on each trial, until the child emitted a response. The following were not counted as responses in baseline, probing, and testing trials:

- Turning away.
- Pointing at something.
- Vocalising.
- Trying to stand up.
- Rocking or swaying.
- Kicking the footrest.
- Holding onto the chair.
- Touching or pulling clothes.
- Touching the safety belt or buckle.
Chapter 9

- Touching the wooden screen.
- Putting fingers into mouth or nose.
- Extending arms to experimenter (to be picked up).
- Rubbing eyes or yawning.

In baseline sessions, while matches were being trained, clapping did not count as a response. The experimenter clapped as part of reinforcement, and most children started clapping after, between, and sometimes before responding; this was usually transient. In later probing and testing sessions, clapping was coded as a response whenever it was emitted to either trained models or probes.

Occasionally, more than one response was emitted to modelled gestures in the baseline, probing, and testing trials. An incorrect response promptly followed by a correct response was counted as correct and was marked in coding as "self-correction"; for example, touching the head with one hand but then repeating the gesture with both hands was coded as a correct "hands on head" when emitted to the appropriate model; it received reinforcement when scheduled. Conversely, a correct response promptly followed by an incorrect response was counted as incorrect and was marked in coding as "correct to wrong"; for example, a child tapping the
chair frame in response to the corresponding model but then placing his hands on eyes was coded as incorrect.\(^5\)

**Correct Response Criteria for Condition 4 Training**

As noted in Procedure, the four target gestures were trained in play until at least one correct response (i.e. a response that would be judged to correspond to the target model gesture) was recorded for each. For a response to be coded as correct, no physical manipulation of the child's body parts (full- or part-putting through) could have been performed by the experimenter while the gesture was being completed—a child had to complete each gesture on his or her own.\(^6\)

The target responses were evoked in several ways, differing within and between gestures and children. The following types of responses were coded as correct:

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\(^5\) When children emitted more than one response to a probe (untrained) model in probing and testing trials, all responses were noted; although “correct to wrong” responses were not counted as correct and plotted, they are discussed in results.

\(^6\) The only exception was occasional gentle pushing or holding of one of the child's arms to the front, done to aid coding of arm crosses (the crosses performed to the side of body were not clearly visible to the experimenter—and on records—because of the chair frame). A child then had to cross with the other arm to complete the gesture.
• Target responses performed spontaneously; for example, if a child looked at his or her hands, and at one point turned both his or her palms up (this was coded as a correct palms up bowl).

• Target responses performed in response to putting through; for example, if the experimenter held a child's hand and placed it on his or her contralateral shoulder, and the child repeated the movement immediately afterwards (this was coded as a correct hand cross to shoulder).

• Target responding in form of peeling off a sticker which the experimenter had placed on a child's body; for example, if a child peeled a sticker from his or her knee using contralateral hand (this was coded as a correct hand cross to knee).

• Target responses performed in response to the experimenter's touch; for example, if the experimenter touched a child's elbow as if placing a sticker, and the child then touched the same elbow with his or her contralateral hand (other arm bent) searching for a sticker (this was coded as a correct hand cross to elbow).

• Target responses performed in anticipation of touch, toys, or stickers; for example, where a child extended both hands, palms up, for a toy to be placed on them (this was coded as a correct palms up bowl).
• Target responses performed as placing of stickers on parts of body; for example, where a child was given a sticker and placed it on his or her contralateral foot (this was coded as a correct hand cross to foot).

• Target responses performed in response to a verbal request, but never naming of the body parts to be touched or actions to be performed; for example, when the experimenter asked, "Where shall we put this sticker?" and the child touched his or her contralateral shoulder (this was coded as a correct hand cross to shoulder).

• Target responses performed in the response to the sticker(s) and a verbal request; for example, where the experimenter placed two stickers on the child's arms and asked, "Can you make them kiss?" and the child placed the stickers on top of each other by crossing arms (coded as correct arms crossing).

• Target responses performed in response to touch and a verbal request; for example, where the experimenter touched a child's shoulder and asked, "Where's the sticker?" and the child searched for it with his contralateral hand (coded as a correct hand cross to shoulder).

• Target responses performed in anticipation and to a verbal request; for example, where the experimenter held two stickers and asked, "Where shall we put these?" and the child extended his or her hands palms up (this was coded as a correct palms up bowl).
• Target responses performed in response to sticker(s), touch, and a verbal request; for example, where the experimenter placed a sticker on the child's knee, then touched it and asked, "Where's the sticker?" and the child searched for it with his or her contralateral hand (this was coded as a correct hand cross to knee).

**Intra- and Inter-Observer Reliability**

Coding of responses was performed by the experimenter immediately after each session, and again at the end of the experiment; this was done by examining the video recordings. Slow- and stop-motion facilities were used; each response was viewed as many times as necessary.

The main coding categories for responses emitted in each baseline, probe, training, and testing trial were

1. Correct.
2. Mirror.
3. Incorrect.
4. No response.

For baseline, probing, and testing trials (Conditions 2, 3, and 5) the following were also noted:

• The number of models (1-3) needed to evoke a response.

• The form of each incorrect gesture.
Chapter 9

Experiment 4

• Whether reinforcement was given.

A total of 2373 trials were coded for baseline, probe, training, and testing sessions across 6 participants. Out of these, 94% of the trials (2230) were coded immediately after testing and at the end of the experiment; the remaining 6% of trials (143) were coded only at the end. Intra-observer agreement was almost perfect, with 98% of the trials (2193 out of 2230) coded the same, with respect to the four main coding categories, on both occasions; second coding was done without reference to the first codes.

Finally, data for two children were coded independently by a postgraduate researcher with experience in working with children under two years old. The second observer coded 33% of all data (786 trials in baseline, probing, training, and testing conditions). Inter-observer agreement was 95%, with 745 out of 786 responses coded the same across the four categories of correct, incorrect, mirror, and no responses. The two observers never disagreed with respect to children's responses to target models in probing and testing. The few disagreements were clarified through viewing of tapes and discussion. The majority of differences were on responses in training without modelling: the second observer tended to code the responses which had received a little help from the experimenter as correct (e.g. the experimenter pushing a child's hands slightly while applying stickers, the child then producing a palms up bowl target response). The first observer (experimenter) disregarded such responses and counted only independently produced ones as correct. Overall, the more stringent coding was used in the final analyses.
RESULTS

Table 9.4 shows, for each participant, the age in months and days at start and end of the experiment, the number of sessions in each experimental condition, and the total number of sessions conducted.

Table 9.4. Participants' ages in months and days (m-d) at the start and end of the experiment, number of sessions conducted in each experimental condition, and total number of sessions.

<table>
<thead>
<tr>
<th>Child</th>
<th>Age at start (m-d)</th>
<th>Age at end (m-d)</th>
<th>Familiarisation (c1)</th>
<th>Baseline Sessions (c2)</th>
<th>Probing Sessions (c3)</th>
<th>Training Sessions (c4)</th>
<th>Testing Sessions (c5)</th>
<th>Total Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhys</td>
<td>08-20</td>
<td>17-17</td>
<td>13</td>
<td>11</td>
<td>5</td>
<td>3</td>
<td>10</td>
<td>42</td>
</tr>
<tr>
<td>Cal</td>
<td>12-14</td>
<td>20-18</td>
<td>25</td>
<td>9</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>53</td>
</tr>
<tr>
<td>Lora</td>
<td>14-11</td>
<td>19-06</td>
<td>3</td>
<td>11</td>
<td>7</td>
<td>15</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>Tony</td>
<td>14-12</td>
<td>20-12</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>Mia</td>
<td>16-14</td>
<td>19-11</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>10</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>Dan</td>
<td>18-21</td>
<td>20-27</td>
<td>6</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>6</td>
<td>27</td>
</tr>
</tbody>
</table>
Conditions 1 and 2: Familiarisation and Training Baseline Matching Relations

The number of sessions required to establish consistent correct matching of the four baseline gestures differed greatly between children. As noted in Procedure, the experimenter modelled a range of easy gestures, waiting for some correct matching to be shown, and then trained these baseline matching relations until they were emitted reliably, rather than shaping entirely new matches (see Experiment 2). Not surprisingly, the two children who were the oldest at the start of the procedure (Dan and Mia) emitted correct matches the most readily and met the criteria the most quickly; conversely, the two children who were the youngest at the start (Rhys and Cal) took the most trials to train.

There were long (1 - 3 months) breaks in the procedure for three children (Tony, Cal, and Lora), due to their holidays and illness; their baseline matching had to be re-trained after these breaks. For two children (Rhys and Lora) one of the baseline gestures was changed in the middle of training because the responding became less reliable than for the other gestures.

Correct matching in Condition 2 baseline sessions, for individual participants, is plotted in Figures 9.2 - 9.7. It can be seen from these graphs that correct matching, initially trained with continuous reinforcement, remained stable when reinforcement rates were reduced to 50% towards the end of Condition 2 training.
Figure 9.2. Four trained (baseline) matching relations for Participant Dan. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across five baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions.
Figure 9.3. Four trained (baseline) matching relations for Participant Mia. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across five baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions.
Figure 9.4. Four trained (baseline) matching relations for Participant Cal. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across nine baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions. The break in the graph indicates the point at which the matching relations had to be re-trained after a two month long break in training.
Figure 9.5. Four trained (baseline) matching relations for Participant Tony. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across eight baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions. A break in the graph indicates the point at which there was a four week break in training.
Figure 9.6. Trained (baseline) matching relations for Participant Rhys. Gesture “hands on head” was replaced by “peek-a-boo” in later trials. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across 11 baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions.
Figure 9.7. Trained (baseline) matching relations for Participant Lora. Gesture “tongue out” was replaced by “hand to mouth” in later trials. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across 11 baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions.
Chapter 9

Condition 3: Probing for Untrained (Target) Matching Relations

In this condition of the experiment the trained (baseline) gestures continued to be modelled. Correct trained matching was reinforced at about 50% on average; the rates varied between children and sessions.7

As noted in Procedure, similar sets of four target models were used at the start of this condition for all children: a hand cross to shoulder (with either right or left hand), a hand cross to elbow (with other hand than for shoulder), a palms up bowl, and crossed arms. Three children (Rhys, Tony, and Lora) never responded correctly to these models. The target gestures to which correct responses were emitted were replaced for the remaining children. Cal emitted palms up bowl approximations (open

7 The experimenter sometimes produced extra reinforcers if responding seemed hesitant, especially in early probing sessions; she also reduced rates when children seemed especially happy playing the matching game so as to keep the flow uninterrupted (matching and turn-taking was in itself reinforcing for many children—see discussion of Experiment 3). Reinforcers differed widely between children, as they found different kinds of play reinforcing; for example, the experimenter may have presented fewer reinforcers consisting of longer bursts of play, or more reinforcers of short give-and-take, handling of toys. Play also happened at the end of each session, and there were play-breaks in between trials when children seemed less than enthusiastic. At all times baselines and responding to targets were monitored; correct trained matching and (incorrect) responding to targets remained high for all the children.
palms up) and this target gesture was replaced with a hand cross to knee. Mia produced hand crosses to shoulder and this target gesture was replaced by a hand cross to wrist gesture. Dan emitted hand crosses to shoulder and palms up bowl approximations; these target gestures were replaced by hand crosses to knee and foot.

Responses to target gestures were never reinforced or corrected. However, all participants responded consistently—albeit incorrectly—to these models: no responses were recorded on only 4.6% of the trials in this condition. Responding to trained (baseline) models also remained high: no responses were recorded on only 2.6% of the trials.

**Condition 4: Training Target Responses Without Modelling**

Table 9.4 shows that it took between 3 and 15 sessions to evoke or shape the target responses in play with individual children. A minimum of one correct response for each target gesture was required, but many more were usually recorded for all the children.

A list of target responses performed by the participants in this condition, the antecedents of these responses, and the total numbers of correct responses, are presented in Tables 9.5.a and 9.5.b.
Table 9.5.a. Target responses, their antecedents, and total number of correct responses emitted in Condition 4 training for Rhys, Cal, and Lora.

<table>
<thead>
<tr>
<th>Child</th>
<th>Gesture</th>
<th>Antecedent Events</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHYS</td>
<td>Left hand cross to shoulder</td>
<td>2 with stickers; 1 to touch &amp; verbal request</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to elbow</td>
<td>3 with stickers; 2 to touch &amp; verbal request</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>2 open spontaneous; 1 open in anticipation; 1 open to touch; 1 with stickers; 2 in anticipation</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>3 to stickers &amp; verbal request; 1 spontaneous</td>
<td>4</td>
</tr>
<tr>
<td>CAL</td>
<td>Right hand cross to shoulder</td>
<td>2 with stickers; 1 placing sticker on verbal request</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to elbow</td>
<td>2 with stickers</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to knee</td>
<td>3 with stickers</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>1 to stickers &amp; verbal request; 2 to stickers</td>
<td>3</td>
</tr>
<tr>
<td>LORA</td>
<td>Right hand cross to shoulder</td>
<td>1 to putting through and verbal request; 5 with stickers; 3 to stickers &amp; verbal request; 9 to touch; 1 to touch &amp; verbal request; 1 spontaneous; 1 to verbal request; 2 mirror to stickers; 3 mirror to touch &amp; verbal request</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to elbow</td>
<td>3 to stickers &amp; verbal request; 1 placing stickers, 1 mirror spontaneous; 4 with stickers; 3 to touch; 5 to touch &amp; verbal request; 4 mirror to touch &amp; verbal request</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>3 open spontaneous; 1 open to verbal request; 4 with stickers; 4 open in anticipation</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>2 to stickers &amp; verbal request</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 9.5.b. Target responses, their antecedents, and total number of correct responses emitted in Condition 4 training for Tony, Mia, and Dan.

<table>
<thead>
<tr>
<th>Child</th>
<th>Gesture</th>
<th>Antecedent Events</th>
<th>Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>TONY</td>
<td>Left hand cross to shoulder</td>
<td>1 spontaneous; 3 mirror spontaneous</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to elbow</td>
<td>1 to touch; 1 with stickers; 4 mirror to stickers; 2 mirror to touch</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>7 open spontaneous; 1 with stickers</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>4 to stickers &amp; verbal request</td>
<td>4</td>
</tr>
<tr>
<td>MIA</td>
<td>Left hand cross to elbow</td>
<td>8 with stickers; 3 to touch; 1 to touch &amp; verbal request; 1 mirror to stickers; 1 mirror to touch</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to wrist</td>
<td>3 mirror to stickers; 7 with stickers; 2 to touch; 1 to putting through; 1 mirror to touch</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>1 open with stickers &amp; putting through; 1 with stickers &amp; putting through; 1 with putting through; 2 with stickers</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>1 to stickers &amp; verbal request</td>
<td>1</td>
</tr>
<tr>
<td>DAN</td>
<td>Right hand cross to elbow</td>
<td>5 with stickers, 1 to touch</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to knee</td>
<td>3 with stickers</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to foot</td>
<td>3 with stickers</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>2 to stickers &amp; verbal request</td>
<td>2</td>
</tr>
</tbody>
</table>

The data in Tables 9.5.a and 9.5.b show that the experimenter placing, and then the child picking off stickers from different parts of body, was the method of choice for all gestures that could be trained in this way. The addition of verbal prompts was also helpful: 78 target responses
were evoked with stickers alone, and 19 with stickers and verbal prompts. There were 14 responses evoked by touch alone; 14 targets were evoked by touch and verbal prompts; 2 targets were performed as placing of stickers, and further 2 to verbal command alone. Seven target responses were performed in anticipation of toys or stickers, and seven were emitted spontaneously in play.

It can be seen from Table 9.5 that putting through was the least successful method of evoking the target responses. All the children resisted it and had to be trained to allow physical manipulation of their hands; even then the children remained passive, and repeated only a few gestures from their trained matching repertoires. Only five correct target responses were evoked by putting through; for three of these verbal prompts and stickers were also used.

Target gestures where a hand touches contralateral body parts (shoulder, elbow, wrist, knee, and foot) were comparably easy to evoke with stickers and (later) touch, with or without verbal prompts, and were therefore the easiest and quickest to train. Shaping of palms up bowl and crossed arms responses took more time.

Palms up bowl responses were initially put through by the experimenter, who placed stickers on the child's palms; she then urged the child to look, and cheered when he did so. As the result of such training, palms up bowl responses were usually performed in anticipation of stickers or stamps coupled with verbal prompts.
Crossed arms had to be put through many times as well: the experimenter told the child that “We'll make stickers kiss!” She then placed two stickers on the child's arms, crossed these, and made kissing sounds whenever the stickers touched. Finally, she cheered and prompted the child to “Make them [stickers] kiss!” Children's attempts to do this were then shaped until one or more clear crosses were emitted to verbal prompts and stickers, without help.

**Condition 5: Testing Untrained (Target) Matching Relations**

Correct matching of trained (baseline) models remained high across conditions, sessions, and individual participants. Overall, 90% of responses were correct in probing (range: 82% - 96%) and also in testing (range: 75% - 95%). Only two participants, Cal and Rhys, performed below average in Condition 3 probing sessions, and only one participant (Lora) responded at less than 90% correct in Condition 5 testing sessions.\(^8\)

The responses to target models were (by design) incorrect in Condition 3 probing sessions; across children there were only two approximations (one open palms up for Mia and one for Lora, in early sessions), one

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8 The poorest performer in probing (Cal, 82% correct) emitted most correct responses in testing (95%), while the best performer in probing (Lora, 96% correct) emitted least correct responses in testing (75%). The remaining children were more consistent.
mirror (Cal’s hand cross to elbow), and a single correct response (arms
crossed for Dan). These responses were so infrequent that they probably
happened by chance; therefore the target models to which they were
emitted were not changed.

Responding to target gestures in Condition 5 testing, still unreinforced,
remained high for all children; no responses were recorded on only
2.2% of all trials. Readiness to respond was similar for reinforced
trained (baseline) gestures: no responses were recorded on only 1.6% of
the trials.

It was seldom necessary to present a model more than once on either
trained or target trials. Overall, the target models were presented more
than once on 14% trials in Condition 3 probing sessions, and 13% of
trials in Condition 5 testing sessions. The trained (baseline) models were
presented more than once on 13% trials in probing sessions, and 16% of
trials in testing sessions. Thus children responded promptly and
reliably to all models, in both conditions of the experiment.

Correct responses to trained (baseline) models and correct, mirror, and
approximate responses to target models in Condition 3 probing and
Condition 5 testing, for individual participants, are presented in
Figure 9.8. Probing and testing untrained matching relations for Participant Mia. Total correct matching responses to trained (baseline) gestures are plotted in the top graph. Correct responses to target models are plotted separately for each of the four gestures not trained as matches, across six probing sessions and six testing sessions. The breaks in the graphs indicate: (i) training without modelling (shaded grey), and (ii) a two week break before the last testing session.
**Figure 9.9.** Probing and testing untrained matching relations for Participant Cal. Total correct matching responses to trained (baseline) gestures are plotted in the top graph. Correct responses to target models are plotted separately for each of the four gestures not trained as matches, across nine probing sessions and five testing sessions. The breaks in the graphs indicate: (i) a two month break within the probing sessions, and (ii) training without modelling (shaded grey).
Figure 9.10. Probing and testing untrained matching relations for Participant Rhys. Total correct matching responses to trained (baseline) gestures are plotted in the top graph. Correct responses to target models are plotted separately for each of the four gestures not trained as matches, across five probing sessions and 10 testing sessions. The break in the graphs indicates training without modelling (shaded grey).
Figure 9.11. Probing and testing untrained matching relations for Participant Tony. Total correct matching responses to trained (baseline) gestures are plotted in the top graph. Correct responses to target models are plotted separately for each of the four gestures not trained as matches, across six probing sessions and eight testing sessions. The breaks in the graphs indicate: (i) training without modelling sessions (shaded grey), and (ii) a five week break in testing sessions.
Figure 9.12. Probing and testing untrained matching relations for Participant Dan. Total correct matching responses to trained (baseline) gestures are plotted in the top graph. Correct responses to target models are plotted separately for each of the four gestures not trained as matches, across six probing sessions and six testing sessions. The break in the graphs indicates training without modelling (shaded grey).
Figure 9.13. Probing and testing untrained matching relations for Participant Lora.
Total correct matching responses to trained (baseline) gestures are plotted in the top graph. Correct responses to target models are plotted separately for each of the four gestures not trained as matches, across six probing sessions and six testing sessions. The breaks in the graphs indicate: (i) a two month break within the probing sessions, and (ii) training without modelling (shaded grey).
Figures 9.8 - 9.13 show that training the target responses without modelling (Condition 4) had little or no impact on the performances of five out of six children in Condition 5 testing. Mia, Cal, and Tony never emitted a correct match, mirror, or approximation to any of the target gestures. A few mirror responses were recorded for Rhys (two hand crosses to elbow) and Dan (one hand cross to foot). The remaining child, Lora, emitted five correct matches to hand crosses to shoulder and one mirror response to a hand cross to elbow target model.

The frequencies of all target responses emitted to each of the target models are presented in Tables 9.6 - 9.11. While only matches (target gestures emitted to the appropriate models) are plotted in the graphs, these tables provide the counts of mismatches—the instances where target gestures were emitted to the inappropriate models.

---

9 After Rhys produced two mirror responses in Condition 5 testing, the experimenter introduced an additional gesture, a hand cross to foot, in the last 5 sessions of the present experiment. Rhys's responses to this additional target model are not plotted in Figure 9.10, or discussed in the present chapter; they are reported in the following chapter (Experiment 5). Rhys was one of three children who participated in both experiments; see Figures 10.4 - 10.6.
Tables 9.6. - 9.7. Frequencies of the four target responses emitted to the four target models in Condition 5 testing for Rhys and Dan. The diagonal frequencies represent correct matches; all other cells contain frequencies of target responses emitted to wrong models.

### Table 9.6.

<table>
<thead>
<tr>
<th>RHYS</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 trials for each gesture</td>
<td></td>
</tr>
<tr>
<td>Models</td>
<td>LH SH X</td>
</tr>
<tr>
<td>LH SH X</td>
<td>-</td>
</tr>
<tr>
<td>RH ELB X</td>
<td>-</td>
</tr>
<tr>
<td>X A</td>
<td>1</td>
</tr>
<tr>
<td>PB</td>
<td>-</td>
</tr>
</tbody>
</table>

### Table 9.7.

<table>
<thead>
<tr>
<th>DAN</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 trials for each gesture</td>
<td></td>
</tr>
<tr>
<td>Models</td>
<td>RH ELB X</td>
</tr>
<tr>
<td>RH ELB X</td>
<td>-</td>
</tr>
<tr>
<td>LH KNEE X</td>
<td>-</td>
</tr>
<tr>
<td>RH FOOT X</td>
<td>-</td>
</tr>
<tr>
<td>X A</td>
<td>-</td>
</tr>
</tbody>
</table>

M = mirror responses  
- = no responses  
RH= right hand  
LH= left hand  
SH X= cross to shoulder  
ELB X= cross to elbow  
FT (FOOT) X= cross to foot  
KN (KNEE) X= cross to knee  
XA= arms crossed  
PB= palms up bowl
Tables 9.8. - 9.9. Frequencies of the four target responses emitted to the four target models in Condition 5 testing for Tony and Mia. The diagonal frequencies represent correct matches; all other cells contain frequencies of target responses emitted to wrong models.

Table 9.8.

<table>
<thead>
<tr>
<th>Models</th>
<th>LH SH X</th>
<th>RH ELB X</th>
<th>X A</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH SH X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RH ELB X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>X A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 9.9.

<table>
<thead>
<tr>
<th>Models</th>
<th>LH ELB X</th>
<th>RH WR X</th>
<th>X A</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH ELB X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RH WR X</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>X A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- = no responses
SH X = cross to shoulder
ELB X = cross to elbow
XA = arms crossed
RH = right hand
WR X = cross to wrist
LH = left hand
PB = palms up bowl
Tables 9.10. - 9.11. Frequencies of the four target responses emitted to the four target models in Condition 5 testing for Cal and Lora. The diagonal frequencies represent correct matches; all other cells contain frequencies of target responses emitted to wrong models.

Table 9.10.

<table>
<thead>
<tr>
<th>CAL</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LH SH X</td>
</tr>
<tr>
<td>10 trials for each gesture</td>
<td></td>
</tr>
<tr>
<td>Models</td>
<td></td>
</tr>
<tr>
<td>LH SH X</td>
<td>-</td>
</tr>
<tr>
<td>RH ELB X</td>
<td>-</td>
</tr>
<tr>
<td>X A</td>
<td>-</td>
</tr>
<tr>
<td>PB</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 9.11

<table>
<thead>
<tr>
<th>LORA</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RH SH X</td>
</tr>
<tr>
<td>8 trials for each gesture</td>
<td></td>
</tr>
<tr>
<td>Models</td>
<td></td>
</tr>
<tr>
<td>RH SH X</td>
<td>5</td>
</tr>
<tr>
<td>LH ELB X</td>
<td>-</td>
</tr>
<tr>
<td>X A</td>
<td>2+1M</td>
</tr>
<tr>
<td>PB</td>
<td>-</td>
</tr>
</tbody>
</table>

M = mirror responses
- = no responses
RH= right hand
LH= left hand
SH X= cross to shoulder
ELB X= cross to elbow
PB= palms up bowl
XA= arms crossed
Mia, Cal, and Tony never emitted a target gesture to any of the models. Mia produced an open palms up approximation to a palms up bowl model in her first probing session, but never repeated this response in the remaining probing or testing sessions. Cal once performed a mirror elbow cross to a corresponding model in a probing session, but never emitted this gesture in the testing sessions.¹⁰

Dan emitted two left hand crosses to foot, as a mirror response to a right hand cross to foot, but also as a mismatch to a knee cross model. Although he emitted a correct match to a crossed arms model in a probing session, this was never repeated in the testing.

Rhys performed each of his target gestures at least once: one hand cross to shoulder, two hand crosses to elbow, one crossed arms, and two palms up bowl gestures. However, he emitted only two hand crosses to elbow as mirrors to the appropriate models; the remaining four gestures he emitted as mismatches.

Lora performed two of her target gestures: eight hand crosses to shoulder and two hand crosses to elbow. She emitted five of her hand crosses to shoulder as matches, but she also produced these responses three times as mismatches to crossed arms models. Her best hand cross to elbow response was produced as a mismatch to a hand cross to shoulder model; one mirror

¹⁰ Cal emitted crossed arms once to a corresponding model in testing; however, he quickly “corrected” himself on this occasion and ended up grabbing his wrist instead. This response was not counted as correct (see Coding).
was produced to the corresponding model. Earlier on, in a probing session, she emitted a single open palms up response; this was not repeated in the testing.\footnote{Lora emitted one hand cross to elbow response to the appropriate model, but then quickly emitted a trained peek-a-boo gesture; she also produced an open palms up approximation to a palms up bowl model, but ended up quickly opening her arms wide in this trial. These two responses were not counted as correct (see Coding).}

To summarise, very few target responses were emitted in the testing sessions: across six children and a total of 312 modelling trials, there were only five correct matches, four mirror matches, and nine mismatches. Only one child (Lora) matched hand cross to shoulder target models fairly consistently—but not exclusively: she also emitted hand cross to shoulder responses to one other model, and responded to a hand cross to shoulder model with another target gesture.

Descriptions of individual participants' responding to target models in Condition 3 probing and Condition 5 testing are presented in Tables 9.12.a and 9.12.b.
<table>
<thead>
<tr>
<th>Gesture</th>
<th>Child</th>
<th>Description of responses to target models</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAND CROSS TO</td>
<td>RHYS</td>
<td>Mostly used his right hand to tap back of opposite hand, wrist, or lower arm; never touched shoulder.</td>
</tr>
<tr>
<td>SHOULDER</td>
<td>TONY</td>
<td>Mostly used his left hand to tap back of opposite hand; responded with both hands (touch middle, head); never touched shoulder.</td>
</tr>
<tr>
<td></td>
<td>LORA</td>
<td>Tapped, mostly with her right hand, back of other hand and side of body; performed 5 correct crosses to shoulder in testing.</td>
</tr>
<tr>
<td></td>
<td>CAL</td>
<td>Mostly used his right hand to tap back of opposite hand, wrist, or arm; never touched shoulder.</td>
</tr>
<tr>
<td>HAND CROSS TO</td>
<td>RHYS</td>
<td>Small hand movements, mostly using right hand in lap or in front, also clapping; touched elbow only once in testing.</td>
</tr>
<tr>
<td>ELBOW</td>
<td>DAN</td>
<td>Mostly used his left hand to tap opposite mid-arm; never touched elbow.</td>
</tr>
<tr>
<td></td>
<td>TONY</td>
<td>Mostly used his left hand to tap opposite back of hand, or lower arm; never touched elbow.</td>
</tr>
<tr>
<td></td>
<td>LORA</td>
<td>Variable responding, some hugs, right hand crossing to lower opposite arm; one correct &amp; one mirror cross to elbow in testing.</td>
</tr>
<tr>
<td></td>
<td>MIA</td>
<td>Mostly used her left hand to tap opposite mid-arm or wrist, several responses with a fisted hand; never touched elbow.</td>
</tr>
<tr>
<td></td>
<td>CAL</td>
<td>Mostly used his right hand to tap opposite back of hand or arm; never touched elbow.</td>
</tr>
<tr>
<td>HAND CROSS TO</td>
<td>MIA</td>
<td>Mostly used her left hand to tap or grab opposite back of hand, wrist top, or lower arm; never tapped with opposite arm bent.</td>
</tr>
<tr>
<td>WRIST</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 9.12.b. Common responses to target models in Conditions 3 and 5. (Table continued from the previous page)

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Child</th>
<th>Description of responses to target models</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAND CROSS TO KNEE</td>
<td>DAN</td>
<td>Mostly used his right hand to touch his right lower leg, knee, or foot; never touched his contralateral knee.</td>
</tr>
<tr>
<td></td>
<td>CAL</td>
<td>Mostly used his left hand to touch ipsilateral thigh; also knee and leg; a single mirror response in Probing.</td>
</tr>
<tr>
<td>HAND CROSS TO FOOT</td>
<td>DAN</td>
<td>Consistently used his right hand to touch ipsilateral foot, occasionally thigh and knee; a single mirror cross in testing.</td>
</tr>
<tr>
<td>CROSSED ARMS</td>
<td>RHYS</td>
<td>His responding was variable with many hugs and some right hand taps on body; never crossed his arms.</td>
</tr>
<tr>
<td></td>
<td>DAN</td>
<td>Mostly used his left hand to tap or grab contralateral back of hand or wrist; never crossed his arms.</td>
</tr>
<tr>
<td></td>
<td>TONY</td>
<td>Mostly used his left hand to grab or tap contralateral back of hand, wrist, or lower arm; never crossed his arms.</td>
</tr>
<tr>
<td></td>
<td>LORA</td>
<td>Her responding was very variable; towards the end she was mostly hugging; never crossed her arms.</td>
</tr>
<tr>
<td></td>
<td>MIA</td>
<td>Her responding was variable, with many right hand taps on hand; responded with hands fisted; never crossed her arms.</td>
</tr>
<tr>
<td></td>
<td>CAL</td>
<td>His responding was variable with some right hand crossing; in testing he used right hand to grab wrist; one correct cross.</td>
</tr>
<tr>
<td>PALMS UP BOWL</td>
<td>RHYS</td>
<td>He clapped the experimenter’s palms with his right hand on all trials; never performed palms up bowl.</td>
</tr>
<tr>
<td></td>
<td>TONY</td>
<td>His responding was variable, then clapping the E’s palms with one or both hands; never performed palms up bowl.</td>
</tr>
<tr>
<td></td>
<td>LORA</td>
<td>In the first few trials responding developed into a wide open gesture; also reached a few times; never did palms up bowl.</td>
</tr>
<tr>
<td></td>
<td>MIA</td>
<td>Her responding quickly developed into a wide open arm gesture; never emitted palms up bowl.</td>
</tr>
</tbody>
</table>
DISCUSSION

The main finding of the present experiment was that the children, aged between 17 and 21 months at the end of testing, did not show matching of the conventional gestures that they emitted in play, but had not been directly trained to match.

In the introductory chapters, higher-order matching was defined as an ability to emit, without direct training, topographically similar responses to a variety of modelled gestures (actions). At minimum, to demonstrate higher-order matching, the actions already within an individual's behavioural repertoire ought to be emitted in response to the corresponding models, without direct training and external reinforcement for doing so. This minimal requirement was explicitly tested in the present experiment; no evidence of higher-order matching was found with any of the participants.

In the remaining paragraphs, the present findings are compared with the earlier behaviour analytic reports of generalised imitation; experimental controls and some alternative explanations of the findings are discussed; some improvements to the design are suggested.

Higher-Order Matching in Infants?

Earlier studies of generalised imitation in infants (Poulson & Kymissis, 1988; Poulson et al., 1991) used actions on objects or vocalisations
rather than gestures, as in the present study. Like the present experiment (also see Experiment 2), these studies employed repeated modelling of several conventional behaviours: correct matching responses to some of the models received external reinforcement; responding to the remaining (target) models had no scheduled consequences. Unlike the present experiment, the target models were chosen without any reference to the participants' training histories. Poulson and her colleagues (1988, 1991), following the rest of the behaviour-analytic literature, apparently assumed that actions (or vocalisations) that were not directly trained as matches within the experiments were not directly trained as matches at all. Therefore, unreinforced matching of target actions was reported as evidence of generalised imitation; the results were discussed as if higher-order matching had been demonstrated.

In earlier chapters, a critique of such assumptions led to a suggestion that, under the conditions of ignorance with respect to the participants' training histories, and on grounds of parsimony, the apparently untrained matching shown in these experiments ought to be regarded as the result of the comparably simple process of generalisation—along the lines of similar topography—of trained matching across a range of contexts and models. In order to be confident that, prior to the experiment, a particular gesture had never been trained as a match to a corresponding model of that gesture, behavioural evidence needs to be obtained for each individual participant; this is what the probing condition of the present experiment was designed to do.

The sets of four target gestures were modelled over many trials (12 on
average); only half the children emitted any correct matches or approximations to these.\(^\text{12}\) The correct matching of target models was interpreted as the result of training outside of the experiment (i.e. as generalisation of trained matching) and not as evidence of higher-order matching, as would have been the case in the earlier studies.

Condition 3 probing data supported this interpretation. The correct matching of target models did not take time to develop: full matches, as opposed to approximations that gradually improved, appeared in the first probing sessions, in a manner no different from trained matches in the familiarisation sessions. This suggested either that the matching of target models was due to previous training of these matching relations, or that the children had advanced higher-order matching abilities.\(^\text{13}\) The second possibility can be ruled out, however, because the children never matched the remaining probes of comparable difficulty, presented in the same sessions.

\(^{12}\) The unmatched targets were considered untrained; the matched few were replaced.

\(^{13}\) In higher-order matching, a child responds to similarity between modelled (seen) behaviours and his own varied responses; similarity acts as a reinforcer and selects the (matching) responses that achieve it. As higher-order matching becomes more advanced, a child may become able to respond to similarity between modelled (seen) behaviours and his own covert responses; the selection-by-similarity (acquisition of novel untrained matching relations) may end up as an entirely covert process.
An Adequate Test of Higher-Order Matching?

The children's failure to correctly match the target models was not due to their unresponsiveness: unreinforced responding to target models was excellent, comparable in rate (responses were emitted on over 95% trials) and promptness (responses were emitted after a single model on over 85% of trials) to intermittently reinforced responding to trained (baseline) models.

The target gestures were chosen with some care. Note:

- If higher-order matching is achieved by visual comparison of own and others' actions (Baer & Deguchi, 1985) then gestures which appear similar when seen and performed ought to be the easiest to match of all: palms up bowl and crossed arms come as close to this ideal as possible.

- Many accounts of imitation (e.g., Meltzoff, 1992) postulate that "invisible" gestures may be difficult to match; therefore several targets in the present experiment: palms up bowl, crossed arms, hand crosses to knee, and hand crosses to foot, were chosen for their visibility.

- Some recent studies (e.g., Bekkering, Wolchlager, & Gattis, 2000; see previous chapter) suggest that gestures involving crossing of body midline and touching contralateral body parts may be difficult to match for pre-school children. Therefore two of the targets in the present experiment, palms up bowl and crossed arms, were designed to be symmetrical, performed in front, and not involve touching of parts of
body.

- Gestures chosen as targets did not require especially fine motor control, and in this respect differed minimally from trained matches. For example, turning two palms up (palms up bowl target gesture) could not have been more difficult than placing the tip of an extended index finger in the middle of the opposite upturned palm (trained gesture palm point). Indeed, the children quite readily emitted the target gestures in play—once the experimenter found effective ways of evoking them.

- Matching responses to few of the target models were emitted once or twice—and never again—in the probing and testing sessions; on some of these trials the children “corrected” themselves quickly and performed other, non-matching gestures. This is inconsistent with a higher-order matching ability.

Common responses to the target models, presented in Tables 9.12.a and 9.12.b, were similar to the behaviours recorded in Experiment 2. As discussed in the earlier chapters, the following features of responses to target models were consistent with generalisation of trained matching to novel models, sharing some of the physical attributes of the trained ones, and inconsistent with a higher-order matching ability. Thus:

- All the children emitted the same responses to several different target models (e.g., tapping back of hand in response to hand crosses to shoulder, elbow, and wrist, and to crossed arms targets).
• Several different responses were emitted to each of the target models (e.g., responding to crossed arms models with hugs, tapping back of hand, clapping, and peek-a-boo).

• Complementary, non-matching conventional responses were emitted to some of the target models (e.g., responding to palms up bowl models—upturned empty palms—with reaching and slapping, as in the “gimme five” game).

• Although the variability in responding was often high, better approximations to the target did not develop over time; often the responses resembled the models less as trials progressed (e.g., responding to palms up bowl models starting with palms up open, slightly to side, and stabilising as arms open wide, palms down, as in the “all gone” gesture).

Design Improvements

As noted in Results, only one child’s performance changed after the training without modelling intervention. Lora matched a hand cross to shoulder target gesture on five out of eight trials in the testing, but her performance was not exclusive enough to be taken as the evidence of higher-order matching: she emitted hand crosses to shoulder almost as frequently as mismatches to crossed arms models, and responded to a hand cross to shoulder model with another target response—a hand cross to elbow—which she also performed once as a mirror match.
Lora's data suggested design improvements. She performed 26 shoulder crosses and 21 elbow crosses in Condition 4 training; most of the other target responses were elicited less than 10 times in this condition, for all the children. Further, Lora performed these gestures in a number of ways—spontaneously, to peel off stickers, in response to verbal prompts, in response to touch, in response to stickers and verbal requests, in response to touch and verbal requests, and as placing of stickers. Through overtraining in play without modelling, these gestures may have also become likely to be emitted in the next condition of the experiment, as the context was largely shared: the same social partner, seating arrangement, turn-taking games, verbal prompts to perform gestures, the availability of stickers, and reinforcement for some of the gestures, were all present in testing as well. Indeed, half of the children emitted at least some of the target responses in Condition 5 testing, not exclusively to the appropriate models, but across the board, including play with stickers which was presented in this condition as reinforcement.

Overtraining of the target responses in Condition 4 training without modelling, leading to an increase in the frequencies in which these gestures are later emitted in a variety of contexts, may be a good way of maximising the chances of demonstrating higher-order matching in very young children. It is possible that, early on, children can only show higher-order matching of very frequent, well practiced responses: the more often responses are emitted, the more chance the children have to respond to the perceived similarity between these responses and the seen models.
The expected outcome is the development of more selective matching of the target models over time. Even if responding never became perfect, providing that many trials of modelling are presented, it would be possible to look for evidence of selective matching by comparing the frequencies of matches and mismatches within and between the individual gestures and children.\textsuperscript{14}

In the present study the experimenter strived to minimise the time spent in the probing, training without modelling, and testing conditions. It was necessary to present several modelling trials for each of the target gestures in order to give sufficient time for the correct matching to appear; however, the longer the children spent in these conditions, the larger were the chances that at least some of the target responses would become trained as matches outside of the experiment. Further, once the target responses were (over)trained in the experiment, there was a risk of these behaviours being emitted in play with caregivers, who were in turn likely to incorporate them in games, and thereby train them as matches. The longer the procedure, the larger the chances of false positive results!

In order to remedy this problem, the improved design would have to incorporate multiple baseline training (without modelling) of each target response. Larger numbers of probing and testing sessions could be run, and each of the targets could be over-trained in turn, without compromising

\textsuperscript{14} Unfortunately, in the present experiment, it was not possible to collect sufficient data for Lora, who left the Nursery after just four testing sessions.
the results; a multiple baseline design would allow the experimenter to establish whether any matching seen in the testing was a specific result of over-training, in the training without modelling condition, of a target gesture.

To summarise. Lora's matching could have been the result of generalisation of over-trained responses to a similar setting, or matching training outside of the experiment, or both; there is no conclusive evidence for higher-order matching in her data. The remaining five children's data show that no matching without direct training took place in the experiment.

The present experiment was the first to include a training without modelling intervention, and subsequent testing for untrained matching relations; the results could not be compared to behaviour analytic or other developmental literature, and stand in need of replication. The last experiment of the present thesis was designed to do just that. It also incorporated the suggested improvements.
Experiment 5: Can 17 - 23 Month Old Children Match Gestures that are Frequent in Play but Not Trained as Matches?

The present experiment was designed to replicate and extend the findings of Experiment 4; the five conditions were essentially the same. Thus:

In Familiarisation (Condition 1) and Training Baseline Matching Relations (Condition 2), sets of four trained matching relations were identified for each participant. For each of these relations, correct matching responses to the corresponding models were reinforced at 100% and then at 50%, until reliable baselines were established; these were maintained, with intermittent reinforcement, throughout Conditions 3 and 5.

In Probing for Untrained (Target) Matching Relations (Condition 3), sets of four conventional target gestures, to which correct matching responses were not emitted over a minimum of 10 modelling trials, were identified for each participant.

In Training Target Responses Without Modelling (Condition 4), each target response was evoked in the absence of the corresponding modelled gestures,
demonstrating that motor development was not a limiting factor for the children’s ability to produce matching target responses.

In Testing Untrained (Target) Matching Relations (Condition 5), the target gestures were again modelled, interspersed with the trained (baseline) matches trials; as in Condition 3, only trained (baseline) matching responses received intermittent reinforcement.

Conditions 4 and 5 in the present experiment differed from those employed in Experiment 4 in two important ways.

First, the target responses were trained one at a time rather than all at once. In Experiment 4 all four target responses were trained in Condition 4 before Condition 5 was implemented; in the present experiment these two conditions were combined in a within-participant multiple baseline across-target behavioural design. Multiple baseline training and testing was included to provide a total of four opportunities to evaluate the effect of the independent variable (overtraining of target responses in the absence of modelling corresponding gestures) and as a control for extraexperimental matching training of target gestures.

Second, the intervention, which was introduced in a staggered manner across the four target responses, consisted of overtraining to a criterion of 18 or more correct responses, rather than comparably brief training to a criterion of 1 or more correct responses as in Experiment 4. It was hypothesized that overtraining target responses in play might maximize the chances of observing higher-order matching in Condition 5. Following
each overtraining intervention, matching of all target responses was tested, that is, there were four Condition 4 overtraining intervention phases (one per target gesture) and each of these was followed by matching tests for all four target gestures, making four Condition 5 test phases in total (see Figure 10.1.).

Higher-order matching would be demonstrated if the children, following Condition 4 motor overtraining of a particular target response, produced the response to the corresponding model in the Condition 5 testing sessions that followed.

If the children produced matching responses in Condition 5 to individual target models before overtraining of the corresponding target responses had been conducted (or long after it had been completed), such would indicate that events other than the experimental intervention—most probably direct matching training outside of the experiment—were instrumental in their newly emerged matching performances.

Participants' failure to match gestures that they had learned to produce reliably in Condition 4, but under alternative stimulus control, would suggest that extension of their matching repertoires still requires direct matching training for each new matching relation.
METHOD

Participants

Two girls and three boys, aged between 9 and 17 months at the start of the experiment and between 18 and 23 months at the end, participated in this experiment. Three children (Mia, Rhys, and Tony) participated in Experiment 4; they were included in the present experiment immediately after completing it. The first three conditions (Familiarisation, Training Baseline Matching Relations, and Probing for Untrained /Target/ Matching Relations) did not differ between Experiments 4 and 5; therefore these three children were, in the present experiment, immediately presented with Conditions 4 and 5 (Training Target Responses Without Modelling and Testing Untrained /Target/ Matching Relations). The remaining two children (Emma and Jack) participated in the present experiment only.

All children were attending the Nursery at least three days per week, and were recruited by parental consent.

The Griffiths Mental Development Scales’ scores (Griffiths, 1954), obtained at the end of the experiment for all the children, showed that they were developing normally (see Table 10.1). Four children came from English speaking families, and one was exposed to English and Welsh. Griffiths comprehension scores showed that all were competent English listeners.
Table 10.1. The participants' general quotient (GQ) scores, gender, and age in months and days (m-d) at the start and end of Experiment 5.

<table>
<thead>
<tr>
<th>Child</th>
<th>GQ score</th>
<th>Gender</th>
<th>Age at start (m-d)</th>
<th>Age at end (m-d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhys</td>
<td>109</td>
<td>male</td>
<td>08-20</td>
<td>17-28</td>
</tr>
<tr>
<td>Emma</td>
<td>127</td>
<td>female</td>
<td>11-05</td>
<td>18-29</td>
</tr>
<tr>
<td>Jack</td>
<td>111</td>
<td>male</td>
<td>11-18</td>
<td>19-14</td>
</tr>
<tr>
<td>Tony</td>
<td>107</td>
<td>male</td>
<td>14-12</td>
<td>21-22</td>
</tr>
<tr>
<td>Mia</td>
<td>115</td>
<td>female</td>
<td>16-14</td>
<td>23-02</td>
</tr>
</tbody>
</table>

Materials and Apparatus

The materials and apparatus were the same as those in Experiment 4.

Design

As in Experiment 4, a single participant design was adopted; this was appropriate for the aims of the present study.

The aims included (a) investigating individual participants' existing (and presumed previously trained) matching repertoires; (b) maintaining their responding (whether correct or incorrect) to modelled target gestures over long periods of probing and testing; and (c) manipulating their behavioural repertoires (i.e. providing training—the independent variable—of target responses—the dependent variable—under alternative stimulus control). Replication across five participants was included as a
control for generalisibility and reliability of the findings.

An essentially ABA (within-participant, across-gestures, and multiple baseline) design was used. Target gestures were modelled under 0% reinforcement in Condition 3 probing and Condition 5 testing; in the intervening Condition 4 the corresponding target responses were trained without modelling. Condition 4 training of target responses without modelling (intervention) was implemented on one target gesture at a time, in four blocks; Condition 5 testing sessions were administered after each of these. Multiple baseline scheduling of Condition 4 training and Condition 5 testing was used to provide a total of 20 opportunities (across participants and gestures) for evaluating effects of training without modelling on children's subsequent matching performances. It also provided a control for ongoing matching training of target gestures outside of the experiment; this was in order to minimise the likelihood of false positive results.

The data are presented in graphs and tables. These were analysed visually; statistical analyses were not used.

The design is illustrated in Figure 10.1.
Figure 10.1. An illustration of Design in Experiment 5.
Procedure

The procedure for Conditions 1 - 3 was as in Experiment 4. The procedure for Conditions 4 and 5 was as in Experiment 4 except that these were introduced in a multiple-baseline design (see Experiment 4 for full details of procedures for Conditions 1 - 5). In brief:

In Conditions 1 and 2, the experimenter reinforced children's correct trained (baseline) matching responses, emitted to the verbal request, "Do this," followed by modelling of one of the baseline gestures. The Condition 2 sessions contained three trials for each of four baseline gestures (12 trials in total per session). Correct matching responses were reinforced by the experimenter cheering, clapping, and engaging the child in play with toys. Training baseline matching relations was complete when children emitted at least 5 out of 6 correct matching responses to each of the four corresponding (baseline) models, over two consecutive sessions, under 100% reinforcement, and made no more than one incorrect response, over all gestures, in a single session under 50% reinforcement (11 out of 12 correct).

After correct and reliable matching with intermittent reinforcement was achieved with baseline gestures, modelling of new sets of four conventional gestures, responses to which were never reinforced or corrected, was introduced in Condition 3. Each session now contained two modelling trials for each of four trained (baseline) gestures, correct responses to which continued to receive intermittent reinforcement; these were
interspersed with two trials for each of four untrained (target) models (16 trials per session in all). Probing for untrained (target) matching relations ended when four target gestures, to which no correct matching responses were emitted over a minimum of five sessions (10 trials), were identified for each participant.

A list of participants' Conditions 1 and 2 trained (baseline) matching relations is presented in Table 10.2; the Condition 3 target gestures selected for each child (untrained matching relations) are listed in Table 10.3.

**Table 10.2. Trained baseline matching relations: descriptions of modelled gestures and corresponding correct matching responses.**

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model Description</th>
<th>Correct Responses</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>HANDS ON HEAD (2 hands)</td>
<td>Both hands on top of head, once or tapping.</td>
<td>Both hands on head, touching hair.</td>
<td>Rhys , Emma, Jack.</td>
</tr>
<tr>
<td>PEEK-A-BOO (2 hands)</td>
<td>Both hands covering eyes, opening wide with a sound 'boo'.</td>
<td>Both hands on face.</td>
<td>Rhys , Mia, Tony, Jack.</td>
</tr>
<tr>
<td>HANDS UP (2 hands)</td>
<td>Both hands over head, stretching, looking up.</td>
<td>Both hands at head level or above.</td>
<td>Rhys, Tony, Mia, Jack.</td>
</tr>
<tr>
<td>PALM POINT (2 hands)</td>
<td>Index of right hand touching or tapping up-turned palm of left hand.</td>
<td>Index of right hand touching left palm.</td>
<td>Emma</td>
</tr>
<tr>
<td>HANDS ON BELLY (2 hands)</td>
<td>Both hands tapping middle of body (belly/chest).</td>
<td>Both hands touching middle of body.</td>
<td>Tony, Mia, Jack, Emma.</td>
</tr>
<tr>
<td>HAND-MOUTH (2 hands)</td>
<td>Palm of right hand tapping open mouth to produce sound 'ahh'.</td>
<td>Right hand touching mouth.</td>
<td>Rhys, Tony, Mia, Jack, Emma.</td>
</tr>
<tr>
<td>HANDS-FRAME (2 hands)</td>
<td>Both hands tapping infant chair frame.</td>
<td>Both hands tapping chair frame.</td>
<td>Rhys, Jack.</td>
</tr>
<tr>
<td>BODY SWAYING</td>
<td>Upper part of body swaying from side to side.</td>
<td>Noticeable side-to-side movement.</td>
<td>Emma, Jack.</td>
</tr>
</tbody>
</table>
Table 10.3. Target gestures: models and responses coded as correct, mirror, and incorrect in the probing, training, and testing sessions.

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Model</th>
<th>Correct Response Criteria</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARMS CROSSED IN FRONT</td>
<td>Arms crossed in front, forearms overlapping, hands fisted.</td>
<td>YES: Arms clearly crossed, forearms or wrists overlapping. NO: Arms slightly crossed while grabbing opposite arm/hand; all other gestures.</td>
<td>Rhys, Tony, Mia, Jack, Emma</td>
</tr>
<tr>
<td>PALMS UP BOWL</td>
<td>Palms turned up, joined to form a bowl, extended to front.</td>
<td>YES: Both palms up in front, joined (coded closed) or slightly apart (coded open). NO: Hands in front with palms down or to side; hands spread wide (to side) with palms up; all other gestures.</td>
<td>Rhys, Tony, Mia, Jack, Emma</td>
</tr>
<tr>
<td>HAND CROSS TO SHOULDER</td>
<td>Hand touching or tapping top of contralateral shoulder.</td>
<td>YES: Hand touching top, side, or front of contralateral shoulder. MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch. NO: All other gestures.</td>
<td>Right hand: Emma, Left hand: Rhys, Tony, Jack</td>
</tr>
<tr>
<td>HAND CROSS TO ELBOW</td>
<td>Hand touching or tapping bottom of contralateral elbow, other arm bent.</td>
<td>YES: Hand touching bottom, front, or side of contralateral elbow, with other arm bent at elbow. MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch. NO: All other gestures.</td>
<td>Right hand: Tony, Jack, Left hand: Mia, Emma</td>
</tr>
<tr>
<td>HAND CROSS TO WRIST</td>
<td>Hand grabbing or tapping contralateral wrist, with other arm bent.</td>
<td>YES: Hand touching front or side of contralateral wrist, with other arm bent at elbow. MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch. NO: All other gestures.</td>
<td>Right hand: Mia</td>
</tr>
<tr>
<td>HAND CROSS TO FOOT</td>
<td>Hand touching or tapping tip of contralateral foot (shoe).</td>
<td>YES: Hand touching tip, side, or top of contralateral foot (shoe). MIRROR: Left hand responses to right hand models and vice versa, with correct crossing and touch. NO: All other gestures.</td>
<td>Right hand: Rhys</td>
</tr>
</tbody>
</table>
In Condition 4, the target responses were overtrained, one at a time, in play with stickers and toys. Each block of training without modelling lasted until a target response was evoked at least 18 times.

A Condition 5 block of testing all four untrained (target) matching relations followed overtraining of each target response. Condition 5 sessions were identical to those in Condition 3, and contained two modelling trials for each of the four trained (baseline) and four target gestures (16 trials per session in all). Condition 5 sessions were presented in blocks, with a minimum of three sessions (6 trials per gesture) in each block. Correct matching responses to trained (baseline) models were reinforced intermittently; there were no scheduled consequences for responding to the target models.

For each individual participant, the experiment ended when each of the target responses had been overtrained, and the impact of that training had been assessed in a Condition 5 test of all four target responses, making four Condition 5 tests in total by the end of the multiple baseline procedure. Next, a trained member of the Nursery and University staff tested all participants on the Griffiths Mental Development Scales. Videotapes containing a selection of experimental recordings were presented to parents, together with debriefing letters containing comprehensive explanation of the procedures and the results. The experimenter met all parents, answered their questions, and encouraged them to comment on what they had seen. Each child was also given a small toy as a reward for participating in the experiment.
Coding

The coding criteria were identical to those described for Experiment 4.

*Intra- and Inter-Observer Reliability*

A total of 3818 trials were coded for baseline, probe, training, and testing sessions across five participants. Out of these, 91% of the trials (3469) were coded immediately after testing and at the end, and the remaining 9% of trials (349) were coded only at the end; second coding was done without reference to the first codes. Intra-observer agreement was almost perfect, with 99% of the trials (3421 out of 3469) coded the same, with respect to four main coding categories (correct, incorrect, mirror, and no response) on both occasions.

As in Experiment 4, data for two children were coded independently by a postgraduate researcher with experience in working with children under two years old. The second observer coded 37% of all data (1419 trials in baseline, probing, training, and testing conditions). Inter-observer agreement was 96.5%, with 1368 out of 1419 responses coded the same across the four main categories; the two observers never disagreed with respect to children's responses to target models in probing and testing.

Disagreements were clarified through viewing of tapes and discussion. As in Experiment 4, the majority of differences concerned responses in training without modelling: the second observer tended to code the responses which were slightly imperfect, or had received a little help
from the experimenter, as correct. The first observer (experimenter) counted only very good, independently produced responses as correct. This more stringent coding was used in the final analyses.

RESULTS

The number of sessions in each experimental condition for individual participants, with their ages at the start and the end of the experiment, is presented in Table 10.4.

Table 10.4. Participants' ages in months (m) and days (d) at the start and end of experiment, number of sessions conducted in each experimental condition, and total sessions.

<table>
<thead>
<tr>
<th>Child</th>
<th>Age at start (m-d)</th>
<th>Age at end (m-d)</th>
<th>Familiarisation (c1)</th>
<th>Baseline Sessions (c2)</th>
<th>Probing Sessions (c3)</th>
<th>Training Sessions (c4)</th>
<th>Testing Sessions (c5)</th>
<th>Total Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhys*</td>
<td>08-20</td>
<td>17-28</td>
<td>13</td>
<td>11</td>
<td>15</td>
<td>3 + 6</td>
<td>14</td>
<td>62</td>
</tr>
<tr>
<td>Emma</td>
<td>11-05</td>
<td>18-29</td>
<td>13</td>
<td>5</td>
<td>5</td>
<td>26</td>
<td>19</td>
<td>68</td>
</tr>
<tr>
<td>Jack</td>
<td>11-18</td>
<td>19-14</td>
<td>10</td>
<td>7</td>
<td>5</td>
<td>11</td>
<td>21</td>
<td>53</td>
</tr>
<tr>
<td>Tony*</td>
<td>14-12</td>
<td>21-22</td>
<td>7</td>
<td>8</td>
<td>14</td>
<td>6 + 9</td>
<td>15</td>
<td>59</td>
</tr>
<tr>
<td>Mia*</td>
<td>16-14</td>
<td>23-02</td>
<td>1</td>
<td>5</td>
<td>12</td>
<td>10 + 15</td>
<td>21</td>
<td>64</td>
</tr>
</tbody>
</table>

* = children who also participated in Experiment 4. For these children sessions run in Experiment 4 are shaded gray. These include all sessions in Conditions 1-3, and a part of Condition 4 training sessions.
Conditions 1 and 2: Familiarisation and Training Baseline

Matching Relations

It can be seen from Table 10.4 that the number of sessions in Conditions 1 and 2 required to establish reliable performances across the four trained matching relations differed between individual children, and was inversely proportional to their ages at the start of the experiment; it ranged from 6 for the oldest child (Mia) to 24 for the youngest one (Rhys).

Correct matching of trained gestures in Condition 3 baseline sessions for Emma and Jack is plotted in Figures 10.2 and 10.3; for the remaining children (Mia, Tony, and Rhys) who participated in Experiment 4, see Figures 9.3, 9.5, and 9.6 respectively, in the previous chapter.

Figure 10.2 shows that good performance of the four trained matching relations was quickly achieved with Emma; a three week break, due to illness, did not disrupt her baseline matching.

It can be seen from Figure 10.3 that Jack's correct responding to baseline models, initially established in only three sessions, was markedly disrupted after his 2 month long absence from the Nursery. At this point, three out of four baseline gestures were replaced; good matching performance with the new baseline (trained) set was achieved immediately, and maintained thereafter.
Figure 10.2. Four trained (baseline) matching relations for Participant Emma. The numbers of correct matching responses, out of a maximum of three, are plotted for each of four trained gestures, across five baseline sessions. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions. The break in the graph represents a three week interval between training sessions.
Figure 10.3. Trained (baseline) matching relations for Participant Jack. The numbers of correct matching responses, out of a maximum of three, are plotted for each of seven trained gestures, across seven baseline sessions. The break in the graphs (after Session 3) indicates a point at which there was a two month long break in testing; three of Jack’s baseline gestures had to be replaced after correct responding to these stopped. The reinforcement rate was 50% where shaded grey, and 100% on all other sessions.
Condition 3: Probing for Untrained (Target) Matching Relations

In this condition the correct matching responses to trained (baseline) models continued to be reinforced intermittently, at about 50%. As in Experiment 4, the initial sets of four target models were the same for all children, and consisted of a hand cross to shoulder, a hand cross to elbow, a palms up bowl, and crossed arms gestures (see Table 10.3). Any correct matching responses that the participants emitted to these target models in Condition 3 were presumed to be the result of direct matching training outside of the experiment, and were therefore replaced.

Tony, Emma, and Jack did not respond correctly to any of the target models in the Condition 3 probing sessions; these contained 10 or more trials per gesture for each child. The remaining two children, whose Condition 3 probing data were obtained in Experiment 4 (as noted in Method section), had one gesture each replaced. Mia's hand cross to shoulder, to which she responded correctly in early sessions of Condition 3 probing, was replaced by a hand cross to wrist target gesture. Rhys emitted two mirror responses to hand cross to elbow models in Condition 5 testing sessions of Experiment 4. This target gesture was replaced in Experiment 5 by a hand cross to foot.¹

¹ As noted earlier, data from Condition 5 in Experiment 4 were regarded as extensions of Condition 3 probing with respect to the present experiment for the three children who participated in Experiment 4 (see Figures 10.4 - 10.6). This was deemed appropriate because these children never produced correct matching responses in Condition 5 testing (i.e. Condition 4 training without modelling intervention did not change these participants' responding in Experiment 4). After Rhys produced two mirror responses to
Although responses to target gestures were never reinforced or corrected, all participants responded consistently—even correctly—to these models: failure to respond occurred in only 2.4% of the trials. Comparably high responding to trained (baseline) models was recorded: the children failed to produce a response in only 2.0% of the trials.

All the children responded promptly to modelling of both trained (baseline) and target gestures: each gesture could have been modelled up to three times per trial, but one model was sufficient to evoke a response on 90.2% of baseline trials, and on 89.5% of target trials.

Condition 4: Training Target Responses Without Modelling

It took between 6 and 26 sessions to overtrain all the target responses in play with individual children (see Table 10.4.). A minimum of 18 correct target responses was required before overtraining of each individual target gesture was completed, but many more were often recorded for all the children.

Target responses that could be trained by the experimenter placing, and then the child picking off stickers from different parts of body—hand crosses to shoulder, elbow, wrist, and foot—were the easiest and quickest to train; one of his target models in Condition 5 testing, the experimenter introduced an additional gesture, a hand cross to foot, in the last 5 sessions of Experiment 4, and in this way collected the required data for Condition 3 probing in the present experiment.
these target responses were occasionally overtrained within a single session.

Palms up bowl and crossed arms target gestures had to be shaped until they were reliably emitted to stickers and verbal commands. Usually, crossed arms were evoked after stickers had been placed on the child's hands and the experimenter had asked, "Can you make them [the stickers] kiss?" Palms up bowl responses were normally evoked in anticipation of receiving stickers, which the experimenter held while asking, "Where shall we put these?" Shaping of these target responses took up to 12 trials to complete. (For further details of ways in which individual target responses were evoked, see the Method and Results sections for Experiment 4).

A list of target responses performed by the participants in this condition, the antecedents of these responses, and total number of correct responses, are presented in Tables 10.5.a and 10.5.b.

***

**Table 10.5.a and 10.5.b.** (Tables on the next two pages) Correct target responses evoked in overtraining without modelling (Condition 4). In the first 4 columns are: target responses emitted in overtraining in Experiment 5; antecedent events; and (E5) total number of correct responses emitted in Training in Experiment 5. In the last 3 columns are: E4, the total correct responses from Training in Experiment 4 (for 3 children who participated); Play, the number of correct responses emitted after overtraining of each gesture (in play within the testing sessions and during overtraining of other gestures), and Total Correct, the final totals of correct target responses for each child at the end of Experiment 5.
### Table 10.5.a. Correct target responses evoked in overtraining without modelling.

<table>
<thead>
<tr>
<th>Child</th>
<th>Gesture</th>
<th>Antecedent Events</th>
<th>E5</th>
<th>E4</th>
<th>Play</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>RHYS</td>
<td>Right hand cross to foot</td>
<td>24 to stickers; 1 to sticker &amp; touch; 3 to sticker, touch, &amp; verbal request</td>
<td>28</td>
<td>-</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to shoulder</td>
<td>9 mirror to touch; 15 mirror to stickers; 7 to touch; 1 to sticker, touch &amp; verbal request; 1 to sticker &amp; verbal request; 1 to verbal request; 16 to sticker</td>
<td>50</td>
<td>3</td>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>15 to sticker &amp; verbal request; 3 to sticker</td>
<td>18</td>
<td>4</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>7 in anticipation of stickers; 7 open to stickers; 1 open in anticipation of stickers; 1 open spontaneous; 6 open in anticipation of stickers &amp; verbal request; 1 in anticipation of stickers &amp; verbal request</td>
<td>26</td>
<td>7</td>
<td>2</td>
<td>35</td>
</tr>
<tr>
<td>TONY</td>
<td>Crossed arms</td>
<td>16 to stickers &amp; verbal request; 5 to stickers</td>
<td>21</td>
<td>4</td>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>10 open to stickers; 1 open spontaneous; 5 open in anticipation of stickers; 1 to verbal request; 11 open to stamps; 1 open to stickers &amp; verbal request; 4 to stamps; 3 open in anticipation of stickers &amp; verbal</td>
<td>36</td>
<td>8</td>
<td>-</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to elbow</td>
<td>15 to stickers; 5 to touch; 6 to stickers and touch; 1 to sticker &amp; verbal request</td>
<td>27</td>
<td>8</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to shoulder</td>
<td>3 mirror to stickers; 16 to stickers; 4 to stickers &amp; touch; 5 to touch</td>
<td>26</td>
<td>4</td>
<td>-</td>
<td>30</td>
</tr>
<tr>
<td>MIA</td>
<td>Left hand cross to elbow</td>
<td>7 to stickers &amp; verbal request; 14 to touch and verbal request; 17 to stickers; 18 to touch; 1 to touch, sticker &amp; verbal; 1 mirror to touch; 7 placing stickers; 1 placing stickers to touch; 2 to touch &amp; stickers</td>
<td>67</td>
<td>14</td>
<td>28</td>
<td>109</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to wrist</td>
<td>1 mirror spontaneous; 18 to stickers; 3 placing stickers to touch; 1 placing stickers to verbal request; 2 placing stickers; 5 to touch and verbal request; 1 placing stickers to touch and verbal request; 1 to touch &amp; stickers; 1 to stickers &amp; verbal</td>
<td>33</td>
<td>14</td>
<td>13</td>
<td>60</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Child</th>
<th>Gesture</th>
<th>Antecedent Events</th>
<th>E5</th>
<th>E4</th>
<th>Play</th>
<th>Total Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIA</td>
<td>Palms up bowl</td>
<td>9 to stickers; 15 open in anticipation of stickers; 13 in anticipation of stickers; 1 to putting through &amp; stickers; 8 open to stickers; 3 to stickers &amp; verbal request; 4 in anticipation of stickers &amp; verbal request; 4 open in anticipation of stickers &amp; verbal request; 4 spontaneous; 1 open spontaneous; 10 to verbal request; 2 open to verbal</td>
<td>74</td>
<td>5</td>
<td>16</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>21 to stickers &amp; verbal request</td>
<td>21</td>
<td>1</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td>JACK</td>
<td>Palms up bowl</td>
<td>1 to sticker; 7 to touch and verbal request; 9 in anticipation of stickers; 3 open in anticipation of stickers; 1 after putting through &amp; verbal request; 7 to verbal request; 1 to touch and verbal request; 2 open to touch and verbal request</td>
<td>31</td>
<td>-</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to shoulder</td>
<td>2 to stickers &amp; touch; 22 to stickers; 6 to touch; 1 to touch &amp; verbal request; 1 to sticker &amp; verbal request</td>
<td>32</td>
<td>-</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Right hand cross to elbow</td>
<td>27 to stickers; 10 to touch; 5 to touch &amp; verbal request; 1 to touch &amp; stickers</td>
<td>43</td>
<td>-</td>
<td>28</td>
<td>71</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>25 to stickers &amp; verbal request</td>
<td>25</td>
<td>-</td>
<td>1</td>
<td>26</td>
</tr>
<tr>
<td>EMMA</td>
<td>Right hand cross to shoulder</td>
<td>20 to stickers; 3 to stickers &amp; touch; 2 to stickers &amp; verbal request; 2 to stickers, touch &amp; verbal request; 7 to touch</td>
<td>34</td>
<td>-</td>
<td>-</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Palms up bowl</td>
<td>3 to stickers; 2 open to stickers; 2 open to touch &amp; verbal request; 2 to touch and verbal request; 1 open after putting through; 19 open to verbal request; 1 to verbal request; 1 open in anticipation of stickers &amp; verbal</td>
<td>31</td>
<td>-</td>
<td>3</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td>Left hand cross to elbow</td>
<td>12 to stickers; 4 to stickers &amp; verbal request; 7 to touch; 1 to touch, stickers &amp; verbal request</td>
<td>24</td>
<td>-</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Crossed arms</td>
<td>13 to stickers &amp; verbal request; 1 to stickers; 4 to verbal request; 5 to touch and verbal request</td>
<td>22</td>
<td>-</td>
<td>-</td>
<td>22</td>
</tr>
</tbody>
</table>
Target responses were evoked in (over)training without modelling (Condition 4) 33 times on average, across gestures and children; the responses ranged from 18 correct crossed arms for Rhys to 74 correct palms up bowls for Mia. Most target responses were evoked by a variety of antecedent events, including stickers, stamps, bubbles, touch, verbal prompts, putting through, and their various combinations.

In addition to overtraining (Condition 4 in the present experiment), the target responses were evoked in the following contexts:

1. Training without modelling condition of Experiment 4, for three children who participated (Rhys, Tony, and Mia). This preceded overtraining in Experiment 5 and did not, in itself, change these participants' responses to modelling of the target gestures in the subsequent Condition 5 test conducted in Experiment 4.

2. Play presented as reinforcement for correct matching of baseline models within testing sessions. Children often performed target responses that were trained in response to stickers (with or without verbal prompts) when given stickers later on. The experimenter encouraged such play, as it presented opportunities for observing children's correct performances of target responses and their (usually incorrect) responses to the corresponding target models within the same sessions (see Discussion).

3. Play within subsequent training sessions for other target responses. For example, crossed arms target responses were often evoked by the
experimenter placing two stickers on the child's arms. In removing these stickers, the child would sometimes bend an arm and peel the sticker—placed close to elbow—with the opposite hand, thus performing a hand cross to elbow target response as well.

Tables 10.5.a and 10.5.b display the overall counts of target responses emitted to stimuli other than models of the corresponding gestures. On average there were 43 correct responses per gesture across children, ranging between 22 correct crossed arms for Mia and Emma and 109 correct hand crosses to elbow for Mia.

**Condition 5: Testing Untrained (Target) Matching Relations**

Correct responses to trained (baseline) models and correct, mirror, and approximate responses to target models in Probing (Condition 3) and Testing (Condition 5), for individual participants, are presented in Figures 10.4 - 10.8.

Frequencies of all target responses emitted to each of the target models are presented in Tables 10.6 - 10.10. While only matches (target gestures emitted to the appropriate models) are plotted in the graphs, these tables provide the counts of both matches and mismatches—the instances where target responses were emitted to the inappropriate models—for each child.

Correct baseline matching remained high across sessions, conditions, and individual participants. Overall, 91.1% of trained (baseline) responses were correct in Condition 3 probing (range: 88.3% - 97.5%) and
94.6% were correct in Condition 5 testing (range: 90.1% - 98%). The responses to target models were (by design) incorrect in Condition 3 probing sessions; across all the children, only a single approximation was recorded (an open palms up for Mia) during this phase.

Responding to target models in Testing (Condition 5), while still unreinforced, was high for all children; failures to respond were recorded on only 0.7% of all such trials. Readiness to respond was similar for reinforced trained (baseline) gestures: failures to respond were recorded on only 1.3% of the trials.

As was the case in Probing (Condition 3), it was seldom necessary to present a model more than once on either trained or target trials; the children continued to respond promptly and reliably to all models in testing. Overall, the target models were presented more than once on only 6.8% trials; baseline models were presented more than once on 6.1% of the trials.
Figure 10.4. Probing and testing untrained matching relations for Participant Rhys.

Total correct matching responses to trained (baseline) gestures are plotted in the top graph; the list of baseline gestures is given on the left-hand side of this graph. The number of correct responses to target models are plotted separately for each of the four gestures not trained as matches, across probing sessions (P1 - P15), and four blocks of Condition 5 testing sessions (T1 - T14). As noted, this child’s probing data were obtained in Experiment 4 (Conditions 3 and 5); these sessions are shaded yellow. One target gesture (hand cross to foot) was changed from Experiment 4.

Target gestures (models and correct responses) are pictured to the left of the individual graphs. The breaks in the graphs indicating overtraining of individual target responses (Condition 4 blocks) are shaded grey and marked with text detailing which target was overtrained at that point, and over how many trials. Target gestures are presented, top to bottom, in the order in which the corresponding target responses were overtrained in Condition 4. After the points at which overtraining of each target gesture was completed, the corresponding graphs are shaded blue.

Filled squares represent the number of correct matching responses—red in the upper graph for trained matching relations, blue in the lower four graphs for untrained matching relations.
Figure 10.4. Probing and testing untrained matching relations for Participant Rhys.
Figure 10.5. Probing and testing untrained matching relations for Participant Tony.

Total correct matching responses to trained (baseline) gestures are plotted in the top graph; the list of baseline gestures is given on the left-hand side of this graph. The number of correct responses to target models are plotted separately for each of the four gestures not trained as matches, across probing sessions (P1 - P14), and four blocks of Condition 5 testing sessions (T1 - T15). As noted, this child's probing data were obtained in Experiment 4 (Conditions 3 and 5); these sessions are shaded yellow.

Target gestures (models and correct responses) are pictured to the left of the individual graphs. The breaks in the graphs indicating overtraining of individual target responses (Condition 4 blocks) are shaded grey and marked with text detailing which target was overtrained at that point, and over how many trials. Target gestures are presented, top to bottom, in the order in which the corresponding target responses were overtrained in Condition 4. After the points at which overtraining of each target gesture was completed, the corresponding graphs are shaded blue.

Filled squares represent the number of correct matching responses—red in the upper graph for trained matching relations, blue in the lower four graphs for untrained matching relations.
Figure 10.5. Probing and testing untrained matching relations for Participant Tony.
**Figure 10.6.** Probing and testing untrained matching relations for Participant Mia.

Total correct matching responses to trained (baseline) gestures are plotted in the top graph; the list of baseline gestures is given on the left-hand side of this graph. The number of correct responses to target models are plotted separately for each of the four gestures not trained as matches, across probing sessions (P1 - P12), and four blocks of Condition 5 testing sessions (T1 - T21). As noted, this child's probing data were obtained in Experiment 4 (Conditions 3 and 5); these sessions are shaded yellow.

Target gestures (models and correct responses) are pictured to the left of the individual graphs. The breaks in the graphs indicating overtraining of individual target responses (Condition 4 blocks) are shaded grey and marked with text detailing which target was overtrained at that point, and over how many trials. Target gestures are presented, top to bottom, in the order in which the corresponding target responses were overtrained in Condition 4. After the points at which overtraining of each target gesture was completed, the corresponding graphs are shaded blue.

Filled squares represent the number of correct matching responses—red in the upper graph for trained matching relations, blue in the lower four graphs for untrained matching relations. Unfilled circles represent open palm bowl responses (approximations to palms up bowl target responses).
Figure 10.6. Probing and testing untrained matching relations for Participant Mia.
Figure 10.7. Probing and testing untrained matching relations for Participant Emma.

Total correct matching responses to trained (baseline) gestures are plotted in the top graph; the list of baseline gestures is given on the left-hand side of this graph. The number of correct responses to target models are plotted separately for each of the four gestures not trained as matches, across Condition 3 probing sessions (P1 - P5), and four blocks of Condition 5 testing sessions (T1 - T19).

Target gestures (models and correct responses) are pictured to the left of the individual graphs. The breaks in the graphs indicating overtraining of individual target responses (Condition 4 blocks) are shaded grey and marked with text detailing which target was overtrained at that point, and over how many trials. Target gestures are presented, top to bottom, in the order in which the corresponding target responses were overtrained in Condition 4. After the points at which overtraining of each target gesture was completed, the corresponding graphs are shaded blue.

A break in the graphs between T6 and T7 sessions indicates Emma's one month long absence from testing.

Filled squares represent the number of correct matching responses—red in the upper graph for trained matching relations, blue in the lower four graphs for untrained matching relations.
Chapter 10

Experiment 5

Figure 10.7: Probing and testing untrained matching relations for Participant Emma.
Figure 10.8. Probing and testing untrained matching relations for Participant Jack.

Total correct matching responses to trained (baseline) gestures are plotted in the top graph; the list of baseline gestures is given on the left-hand side of this graph. The number of correct responses to target models are plotted separately for each of the four gestures not trained as matches, across Condition 3 probing sessions (P1 - P5), and four blocks of Condition 5 testing sessions (T1 - T21).

Target gestures (models and correct responses) are pictured to the left of the individual graphs. The breaks in the graphs indicating overtraining of individual target responses (Condition 4 blocks) are shaded grey and marked with text detailing which target was overtrained at that point, and over how many trials. Target gestures are presented, top to bottom, in the order in which the corresponding target responses were overtrained in Condition 4. After the points at which overtraining of each target gesture was completed, the corresponding graphs are shaded blue.

A break in the graphs between T3 and T4 sessions indicates Jack's two month long absence from testing.

Filled squares represent the number of correct matching responses—red in the upper graph for trained matching relations, blue in the lower four graphs for untrained matching relations. Unfilled circles represent open palm bowl responses (approximations to palms up bowl target responses), and unfilled squares represent mirror correct target responses (approximations to target models where a hand touches a contralateral body part).
Figure 10.8. Probing and testing untrained matching relations for Participant Jack.
Tables 10.6 - 10.8. Frequencies of four target responses emitted to four target models in Testing (Condition 5) for Rhys, Tony, and Mia. The diagonal frequencies represent correct matches; all other cells contain frequencies of target responses emitted to wrong (mismatched) models.

Table 10.6.

<table>
<thead>
<tr>
<th>Models</th>
<th>RH FT X (28)</th>
<th>LH SH X</th>
<th>XA</th>
<th>PB</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH FT X (28)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LH SH X (22)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>XA (16)</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PB (10)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 10.7.

<table>
<thead>
<tr>
<th>Models</th>
<th>XA (30)</th>
<th>PB (24)</th>
<th>RH ELB X</th>
<th>LH SH X</th>
</tr>
</thead>
<tbody>
<tr>
<td>XA (30)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PB (24)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RH ELB X (18)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>LH SH X (12)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 10.8.

<table>
<thead>
<tr>
<th>Models</th>
<th>LH ELB X (42)</th>
<th>RH WR X (36)</th>
<th>PB (30)</th>
<th>XA (24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LH ELB X (42)</td>
<td>15</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RH WR X (36)</td>
<td>7</td>
<td>-</td>
<td>6 + 19 op</td>
<td>-</td>
</tr>
<tr>
<td>PB (30)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>XA (24)</td>
<td>7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

PB = palms up bowl
XA = crossed arms
SH X = hand cross to shoulder
- = no correct responses
ELB X = hand cross to elbow
WR X = hand cross to wrist
FT X = hand cross to foot
op = open palms up bowl
RH = right hand gestures
LH = left hand gestures
**Tables 10.9 - 10.10.** Frequencies of four target responses emitted to four target models in Testing (Condition 5) for Emma and Jack. The diagonal frequencies represent correct matches; all other cells contain frequencies of target responses emitted to wrong (mismatched) models.

**Table 10.9.**

<table>
<thead>
<tr>
<th>EMMA</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>38 trials per gesture</td>
<td>RH SH X</td>
</tr>
<tr>
<td>Models</td>
<td>RH SH X (38)</td>
</tr>
<tr>
<td></td>
<td>PB (32)</td>
</tr>
<tr>
<td></td>
<td>LH ELB X (20)</td>
</tr>
<tr>
<td></td>
<td>XA (14)</td>
</tr>
</tbody>
</table>

**Table 10.10.**

<table>
<thead>
<tr>
<th>JACK</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>42 trials per gesture</td>
<td>PB</td>
</tr>
<tr>
<td>Models</td>
<td>PB (42)</td>
</tr>
<tr>
<td></td>
<td>LH SH X (30)</td>
</tr>
<tr>
<td></td>
<td>RH ELB X (24)</td>
</tr>
<tr>
<td></td>
<td>XA (18)</td>
</tr>
</tbody>
</table>

PB = palms up bowl  
XA = crossed arms  
SH X = hand cross to shoulder  
ELB X = hand cross to elbow  
RH = right hand gestures  
LH = left hand gestures  
= no correct responses  
op = open palms up bowl  
m = mirror responses

Figures 10.4, 10.5, and 10.7 show that (over)training without modelling did not affect the matching performances of three out of five children. Rhys and Tony never emitted a correct target response to any of the models in Testing; Emma emitted a single correct response to a crossed arms model.
Table 10.6 shows that the only correct target response emitted by Rhys in testing was a mismatch (a hand cross to shoulder to a crossed arms model).

Table 10.7 shows that Tony's single correct target response emitted in testing was also a mismatch (a hand cross to shoulder to a hand cross to elbow model).²

Emma emitted a total of four correct target responses in testing; Table 10.9 shows that out of these only one was a match (a crossed arms response to the corresponding model) while three were mismatches (hand crosses to shoulder were emitted to hand cross to elbow models, twice, and to a crossed arms model, once).

It can be seen from Figure 10.6 that Mia emitted correct matching responses in testing to three out of four target models. Her responding to palms up bowl models changed in the three Condition 5 sessions immediately after overtraining of the corresponding target response, but deteriorated in the Condition 5 sessions that followed.

The onset of correct matching of hand crosses to elbow appeared to occur in the twelfth session following overtraining, but the same response was also produced to the hand crosses to elbow and crossed arms models. Following completion of Condition 4 overtraining, performance of the crossed arms target gesture appeared in the sixth Condition 5 test session. Coincidentally,

² Tony emitted one crossed arms response to the appropriate model in testing session 4, but quickly "corrected" himself and tapped backhand instead; this was not counted as correct (see Coding).
performance of hand cross to elbow target response fell to zero in the same test session.

Frequencies of matches and mismatches across target gestures for Mia are presented in Table 10.8. They show that

- She emitted hand crosses to elbow 15 times as matches to the corresponding models, but also 14 times as mismatches to hand crosses to wrist (7) and crossed arms models (7). Thus Mia's hand cross to elbow target responses were emitted equally frequently as matches and as mismatches.

- She responded to crossed arms models seven times with matching gestures, but also seven times with mismatched gestures (hand crosses to elbow). Thus Mia was equally likely to respond to crossed arms models with matches and with mismatches.

Figure 10.8 shows that the remaining child, Jack, consistently emitted correct matches to only one of his target gestures (crossed arms). Importantly, he emitted crossed arms responses in testing trials conducted prior to overtraining of this target gesture. Table 10.10 shows that his matching was consistent and exclusive—the crossed arms response was emitted 18 times as a match to the corresponding model, and only twice as mismatches (to a hand cross to shoulder and a hand cross to elbow model);
further, he emitted incorrect target responses (hand crosses to elbow) to crossed arms models only 3 times. 3

Across the remaining three target gestures, Jack's performance was at chance levels. He emitted three correct approximations (one open palms up and two mirror hand crosses to shoulder) and four mismatches (hand crosses to elbow were emitted to crossed arms models three times, and to a hand cross to shoulder model once). Two mismatched hand crosses to elbow were emitted prior to overtraining of this target response.

To summarise. Matching performances differed markedly between children and gestures. For three children (Rhys, Tony, and Emma) target responses were emitted only six times, with one match and five mismatches. For the remaining two children (Mia and Jack), target responses (including approximations) were emitted on 88 testing trials, consisting of 46 matches, 20 mismatches, and 22 approximate matches. Only one child (Jack) emitted target responses in testing prior to being (over)trained to perform these in play without modelling: crossed arms were emitted as three matches and one mismatch, and hand crosses to elbow as three mismatches.

Descriptions of individual children's responding to target models in probing (Condition 3) and testing (Condition 5) are presented in Table 10.11.

---

3 Early in Condition 5 testing, prior to overtraining of this target gesture, Jack emitted crossed arms target responses on four further trials, twice matching and twice to different models, but on these occasions "corrected" himself and produced other responses promptly; these instances were not plotted or tabulated (see Coding).
Table 10.11.a. Responses to target models in Conditions 3 and 5.

(Table continues on the next page).

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Child</th>
<th>Description of responses to target models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arms crossed in front</td>
<td>RHYS</td>
<td>In probing &amp; testing: mostly right hand tapping left backhand; some hugs; some baseline responses; towards end of testing hands fumbling in front, then peculiar treading of fingers; no crossed arms.</td>
</tr>
<tr>
<td></td>
<td>TONY</td>
<td>In probing &amp; testing: mostly left hand taps right backhand or lower arm or grabs wrist; some baseline responses; no crossed arms.</td>
</tr>
<tr>
<td></td>
<td>MIA</td>
<td>In probing: fisted left hand taps right backhand or lower arm. After overtraining: as probing for 5 sessions; then many correct (at end wrong again?).</td>
</tr>
<tr>
<td></td>
<td>JACK</td>
<td>In probing: mostly right hand taps left backhand. In testing prior to overtraining: some correct responses, some hand crosses to elbow (mismatched), rest as above. After overtraining: mostly correct.</td>
</tr>
<tr>
<td></td>
<td>EMMA</td>
<td>In probing &amp; testing: mostly right hand taps left backhand, lower arm, or grabs wrist; after overtraining one small correct cross and rest as above.</td>
</tr>
<tr>
<td>Palms up bowl</td>
<td>RHYS</td>
<td>In probing &amp; testing: taps experimenter's palms with right hand, later with both hands; never produced palms up bowl.</td>
</tr>
<tr>
<td></td>
<td>TONY</td>
<td>In probing &amp; testing: taps experimenter's palms with both hands; few baseline responses; never produced palms up bowl.</td>
</tr>
<tr>
<td></td>
<td>MIA</td>
<td>In probing: over first few sessions her performance changed from hands to front and open palms up to arms spread wide; stabilised as 'allgone' gesture. After overtraining: correct but deteriorating from closed to open palms up; towards end several 'peek-a-boo' responses.</td>
</tr>
<tr>
<td></td>
<td>JACK</td>
<td>In probing &amp; testing: mostly reaches with two hands to touch experimenter's palms; only one open palms up after overtraining (several more 'corrected' to reach).</td>
</tr>
<tr>
<td></td>
<td>EMMA</td>
<td>In probing &amp; testing: mostly reaches with both hands to experimenter's palms; few baseline responses; never correct.</td>
</tr>
</tbody>
</table>
Table 10.11.b. Responses to target models in Conditions 3 and 5.

(Table continued from the previous page)

<table>
<thead>
<tr>
<th>Gesture</th>
<th>Child</th>
<th>Description of responses to target models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand cross to shoulder</td>
<td>RHYS</td>
<td>In probing &amp; testing: mostly right hand taps left backhand or lower arm; some clapping; some baseline responses; never touched shoulder.</td>
</tr>
<tr>
<td></td>
<td>TONY</td>
<td>In probing &amp; testing: mostly left hand taps right backhand or lower arm; few baseline responses; never touched shoulder.</td>
</tr>
<tr>
<td></td>
<td>JACK</td>
<td>In probing &amp; testing: mostly right hand taps lower left arm; after overtraining only two mirror correct, other as above.</td>
</tr>
<tr>
<td></td>
<td>EMMA</td>
<td>In probing &amp; testing: mostly right hand taps left backhand or lower arm; never touched shoulder.</td>
</tr>
<tr>
<td>Hand cross to elbow</td>
<td>TONY</td>
<td>In probing &amp; testing: mostly left hand taps right backhand or lower arm; few baseline responses; never touched elbow.</td>
</tr>
<tr>
<td></td>
<td>MIA</td>
<td>In probing: mostly left hand fisted taps right backhand or low arm. After overtraining: as probing for 9 sessions; then many correct but some still as above.</td>
</tr>
<tr>
<td></td>
<td>JACK</td>
<td>In probing &amp; testing: mostly right hand taps left backhand and lower arm; never correct.</td>
</tr>
<tr>
<td></td>
<td>EMMA</td>
<td>In probing &amp; testing: mostly right hand taps left backhand or lower arm; never touched elbow.</td>
</tr>
<tr>
<td>Hand cross to wrist</td>
<td>MIA</td>
<td>In probing &amp; testing: mostly left hand taps right backhand or lower arm; never correct.</td>
</tr>
<tr>
<td>Hand cross to foot</td>
<td>RHYS</td>
<td>In probing &amp; testing: consistently right hand taps left backhand; never touched foot.</td>
</tr>
</tbody>
</table>

DISCUSSION
The aim of the present experiment was to replicate and extend the findings of Experiment 4, presented in the previous chapter (Experiment 4 found that children under 21 months old did not match conventional gestures without direct training, even after they emitted these gestures in other contexts). The present experiment differed from Experiment 4 in two ways. First, each target gesture was evoked, in play without modelling, at least 18 times (43 on average). Thus target responses were overtrained, rather than evoked few times only, before the corresponding models were presented in testing for higher-order matching. The results were therefore meant to show whether a response that is frequent and well established in a child's behavioural repertoire would be produced as a match to a model of that gesture without direct training or external reinforcement for doing so.

Second, in Experiment 5, multiple baseline (over)training without modelling of each of the four target gestures and four blocks of testing sessions for higher-order matching of these gestures was conducted, rather than training all four target responses before conducting a single block of testing sessions, as in Experiment 4. The multiple baseline procedure was used as a control for ongoing extra-experimental matching training, and provided larger numbers of testing trials for children's matching performances. A large number of Condition 5 test sessions were administered following overtraining of the last target response in order to assess the stability of children's responding over time.

In the following chapters individual children's performances are discussed in detail; the discussion shows that apparently emergent matching of some
target gestures for two out of five children in the present experiment can be attributed to extra-experimental learning and generalisation of trained matching. It will be argued that, within and between children, the results of the present experiment show no evidence of higher-order matching.

**Rhys, Tony, and Emma**

Data for three out of five children show no higher-order matching of target gestures. Two of these children (Rhys and Tony) also participated in Experiment 4; the remaining child (Emma) participated in Experiment 5 only. As noted in the Results, these children between them emitted only six target responses in testing, with one correct match and five mismatches. Therefore these data suggest that (over)training without modelling seldom results in target responses being produced in testing, as responses to corresponding or other models.

**Mia and Jack**

Data for the remaining two children show that correct matching of at least some target models took place in testing sessions; many mismatches were also emitted. Thus training without modelling changed these children's responding to the target models presented in testing. Jack took part in the present experiment only; Mia also participated in Experiment 4, where training without modelling did not result in her matching of target models.

As noted in Results, Mia emitted correct matches to three out of four target
models at some point in testing; the remaining target gesture was never emitted in response to modelling.

The left hand cross to elbow target response was overtrained first. By the end of training without modelling, Mia emitted this target response 81 times to a variety of antecedent stimuli. However, she did not emit this target response to the corresponding models in nine testing sessions following training; she started responding correctly only in the last block of testing, after the crossed arms target response had been overtrained.

During overtraining of the crossed arms target gesture, hand crosses to elbow were also frequently evoked. In these training trials, the experimenter placed stickers on Mia's arms; Mia was then asked to "make them kiss" and thus cross her arms. Afterwards, she would peel stickers off and, in doing so, she often performed hand crosses to elbow. As can be seen from Table 10.5, a further 28 hand crosses to elbow were evoked in this way, bringing Mia's total for this target gesture up to 109; it is only at this point that she started emitting it in response to modelling.

Table 10.8 shows that Mia's left hand crosses to elbow were emitted 15 times to the appropriate models as correct matches; however, Mia emitted these responses equally often as mismatches to 2 other target models (right hand crosses to wrist and crossed arms, a total of 14 times). Thus her performance in these sessions was not exclusive and therefore did not demonstrate higher-order matching of this target gesture.

Mia's second target gesture, overtrained next, was the right hand cross to
wrist. The correct responses were evoked in the absence of modelling a total of 60 times, with 14 correct in training for Experiment 4, 33 correct in overtraining in the present experiment, and 13 further instances in play. Yet this target response was never emitted to any of the models in testing.

The palms up bowl was Mia's third target gesture. Closed and open palms up responses were evoked 95 times, with 5 instances in training for Experiment 4, 74 in overtraining in the present experiment, and further 16 in play with stickers within other sessions. Mia's performance in testing changed immediately after overtraining without modelling.

Overtraining without modelling started with the experimenter placing stickers on Mia's palms and asking her to look at them, thus turning her palms up; some putting through was also used in the early trials. Mia then gradually started turning her palms up whenever the experimenter produced stickers and asked, "Where shall we put these?" In the later trials the experimenter often asked Mia to repeat the gesture she just performed by saying, "Can you do it again?"; this command was then shortened to, "Can you do. . ." Towards the end of training, the palms up bowl target response was reliably evoked with a verbal request, "Can you do. . .".

In the testing sessions that followed, the experimenter once again presented modelling of baseline and target gestures; as noted in Procedure, this was always done by saying, "Can you do (this)" followed by modelling. As Mia's palms up bowl target response was at this point trained to the same verbal prompt, she initially responded on many trials by turning her palms up just before the experimenter presented modelling; Mia then corrected her
responses after seeing the models other than palms up bowl. This extinguished after about 15 trials, when Mia once again started waiting to see the modelled gestures before responding with a gesture herself. She continued turning her palms up after seeing the corresponding models, and never emitted this response as a mismatch to other target models.

It is possible that training a target response to the verbal prompt, "Can you do..."—not commonly done across other gestures and children—later presented opportunities for Mia to visually compare her gesture with the experimenter's model of the same gesture, and to respond to the perceived similarity between the two. This would demonstrate higher-order matching, albeit under unique conditions.4 No strong conclusions can be drawn, however, because extra-experimental training may have been instrumental in Mia's matching of this target response, and there were changes in her responding over time that were not indicative of higher-order matching. Thus:

Towards the end of overtraining, Mia was absent from the Nursery for a whole month. At this point the palms up bowl target response was already evoked over 50 times; it was likely to be emitted in play with caregivers, and to be incorporated in various games, including matching ones. Indeed, Mia's mother approached the experimenter towards the end of the study and remarked that many "strange" gestures must have been taught in the experiment. Apparently, Mia started gesturing widely at home; this did not

4 The possibility that higher-order matching may be promoted by correct responses being trained to verbal prompts also used in modelling was briefly explored with the remaining child (Jack), as described below.
Chapter 10

Experiment 5

go unnoticed: some of the gestures were novel for her parents. Further, the experimenter noticed, in the first session after Mia's return to the Nursery and training of this target response had been resumed, that it was more easily evoked than was the case previously, especially with verbal prompts. In addition to this, most of Mia's responses before the break were approximations (open palms up), but after the break most of her responses were correct.

As noted in Results, and plotted in Figure 10.6, Mia's responding after overtraining was initially correct, but deteriorated after a couple of sessions; thereafter, only approximations (open palms up) were emitted to the corresponding models. Further, in the last five testing sessions, half of the responses were incorrect; they were similar to those emitted prior to training.

Thus, in spite of initial impressions, Mia's matching of palms up bowl gesture did not provide evidence for higher-order matching; this was because of indications that this target response was trained as a match extra-experimentally. The deterioration of her performance over testing trials was also suspicious: if Mia had acquired higher-order matching, correct responding—once achieved—ought to have been maintained.

Mia's last target was the crossed arms response. Her performance did not change over six testing sessions following overtraining of this gesture, but some correct matching appeared in later trials. Table 10.8 shows that Mia responded correctly on seven trials; however, she was equally likely to emit mismatched hand crosses to elbow (seven trials) to crossed arms models.
Thus Mia's performance for the last of her target gestures was not exclusive, and once again not indicative of higher-order matching.

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As noted in the Results, Jack's performance on three out of four target gestures was at chance levels, with three approximate matches (one open palm bowl and two mirror hand crosses to shoulder) and four mismatches (hand crosses to elbow were emitted to three crossed arms models and one hand cross to shoulder model).

The palms up bowl target gesture was trained to Jack in the same way as it was to Mia. Therefore, in the last of Jack's overtraining sessions, correct palms up bowls were emitted to the verbal prompt, "Can you do...", which was also used in testing prior to modelling of all gestures. Thus the possibility that higher-order matching may more readily occur when a child performs a gesture immediately before seeing the corresponding model being performed by the experimenter was briefly explored.

Jack produced the palms up bowl target response in overtraining 31 times (his overall total for this gesture was 41). Like Mia, Jack then emitted palms up bowls just before seeing models on 10 testing trials, before responding to the verbal prompt "Can you do (this)" extinguished, and he once again started waiting to see the modelling before responding with a gesture himself. Like Mia, Jack corrected himself quickly on all trials when gestures other than palms up bowl were modelled. Unlike Mia, Jack also promptly "corrected" himself when palms up bowl models were presented on all but
one trial, and emitted the incorrect responses (clapping the experimenter's hands) instead. Jack clearly did not respond to the similarity between his own and other's gestures in this case.

It is possible that the non-matching responses Jack consistently emitted to palms up bowl models were competing with the correct, matching responses. However, non-matching responses were never reinforced within the experiment, during which correct matching responses (to baseline models) received clapping, cheering, and play reinforcement. In this context, if higher-order imitation had been learned, it ought to have been manifested in these children's responding.

The only target gesture that Jack consistently matched was crossed arms. This response was overtrained last and emitted to verbal prompts and stickers 25 times. Some correct matching started prior to overtraining of this target response. Jack emitted crossed arms three times as matches and two times as mismatches at this time; a further four arm crosses were quickly "corrected" to other gestures and were not included in the counts. Jack's matching of crossed arms became near perfect, and exclusive, after training without modelling.

It is possible that Jack's matching of crossed arms models developed over time because he was able to respond to similarity between some of his responses and the models presented by the experimenter; this similarity may have reinforced such responses, which consequently became more frequent. However, it is also possible that this gesture was trained extraexperimentally and that trained matching generalised to the experimental
Jack's matching certainly improved following overtraining of crossed arms gesture; this is consistent with higher-order matching. However, his failure to show matching of other target models argues against this possibility. For example, two hand crosses to shoulder were emitted to the corresponding models, but Jack's matching performance did not improve for this target; this would have been expected if similarity between his and others' responses had been a reinforcer for him. Jack's responding to palms up bowl models, discussed earlier, where correct responses were often quickly "corrected" to non-matching ones, was also incompatible with higher-order matching. The remaining target response, hand cross to elbow, was emitted exclusively as a mismatch (four times). Taken together, Jack's data do not show evidence for higher-order matching.

**Extra-Experimental Training**

In several chapters of the present thesis it was argued that children's past and ongoing experiences outside of the experimental setting need to be taken into account when interpreting the matching data. While there is no single, perfect way of controlling or mapping children's learning outside experimental sessions, the following procedures were employed in the present study:

- Children's trained matching repertoires were probed to identify individuals' untrained matching relations; these target gestures were
thereafter used for training without modelling and testing of higher-order matching.

- The multiple baseline design provided the means for distinguishing between the effects of the experimental intervention (overtraining without modelling) and any training administered outside the experiment. For example, Jack emitted several crossed arms and two hand crosses to elbow in response to modelling before training of the corresponding target responses took place. At this point consistent matching was not yet observed, but the data informed the experimenter that conventional gestures used as targets in the experiment could have been trained by caregivers at this time.

- Encouraging parents to talk about their children's behaviour alerted the experimenter to the possibility that Mia's matching of palms up bowl was trained at home; unfortunately, this occurred just prior to testing in the experiment.

- The experimenter completed overtraining without modelling of each target response as quickly as possible. This minimised the chances that newly trained and frequent responses would be emitted in play outside the experiment, and trained as matches by caregivers, before at least some testing sessions were administered. On several occasions, the experimenter was able to overtrain a target response in play without modelling, and then administer a testing session within the same day. Across children, more than half the target responses were overtrained in three or fewer sessions, and tested immediately after; across these (12) target gestures
none was emitted in response to modelling in the first testing sessions that followed overtraining within the same week.

**Experiment 5: No Higher-Order Matching**

If strong multiple baseline design criteria are adopted, the target behaviours (dependent variable) ought to change immediately following the end of the corresponding interventions (independent variable). The present experiment provided 20 opportunities, across children, to assess the effects of Condition 4 (over)training target responses without modelling on subsequent matching of the corresponding models. Across children, there was only one instance in which correct matching in Condition 5 testing occurred immediately after Condition 4 overtraining (of the palms up bowl response for Mia), and this behaviour disappeared in the subsequent testing sessions. One more behaviour (Jack's crossed arms target responses) increased in the second Condition 5 testing session following the corresponding Condition 4 overtraining, and remained stable thereafter. Therefore the present experiment showed that overtraining without modelling had no effect on children's matching of target models across 18 out of 20 behaviours.

To summarise.

Children in the present experiment did not show higher-order matching of conventional gestures that were frequent in play, but were not directly trained as matches. Overtraining in the absence of modelling led to some of the target responses being emitted in testing. However, children's
responding to target models in testing was usually not exclusive and did not show consistent matching. For two target responses where correct matching did develop, extra-experimental matching training could not be ruled out.

The present study replicated the main result of Experiment 4.

**Final Comments**

The same set of target gestures, chosen to maximize the chances of observing higher-order matching (see Discussion, Chapter 9), and straightforward to train to antecedent events other than modelling, was used in both experiments. Many features of children's responding were similar across the two experiments.

Children in the present study did not fail the higher-order matching test because they were unresponsive to modelling of target gestures: unreinforced responding to target models was comparable in rate and promptness to intermittently reinforced responding to baseline (trained) models.

Common responses to target models in probing and testing, as can be seen in Table 8.11, were consistent with generalisation of trained matching to novel models, sharing some of the physical attributes of the trained ones. Thus:

- The same responses were emitted across different models (e.g. hand tapping backhand in response to hand crosses to elbow, wrist, foot, and shoulder; also to crossed arms).
- Several different (trained) responses were often emitted to each of the
target models (e.g. tapping experimenter's palms, peek-a-boo, and hand rubbing were emitted to palms up bowl models).

- Non-matching (complementary) responses were consistently emitted to some of the target models (e.g. "gimme five" gesture to palms up bowl models).

- Variability in responding to target models did not result in better approximations over trials.

- Occasional correct matching of many target models in testing did not lead to consistent correct responding to these target models.

In the following chapter of the present thesis, these points are discussed further. An overall summary of the findings presented in the experimental chapters is given, and their implications for the theoretical accounts of matching and imitation, outlined in the early chapters, are explored.
CHAPTER 11

General Discussion

Generalised imitation—children's matching of modelled behaviours without direct reinforcement for doing so—has often been cited as a paradigm case of a higher-order response class (see Baer & Deguchi, 1985). However, its determinants have not been explored; as discussed in Chapters 2 - 5, many non-imitative processes can result in apparently emergent matching in an experiment. Confounding sources of control are minimal when arbitrary actions or gestures are modelled as target behaviours. On the other hand, when the target behaviours are conventional, non-arbitrary, object-directed actions, the matching of those behaviours is more likely to be based on non-imitative mechanisms, with the result that such data are difficult to interpret. The studies published to date have employed the latter procedure, with infants and older children; consequently, their data do not provide conclusive evidence bearing on determinants of children's matching of target behaviours.

The present series of experiments was designed to present more conclusive data. They explored the determinants of matching of arbitrary actions in 3 infants (aged 9 - 15 months, in Experiment 1), of various gestures in 13 infants (aged 15 - 25 months, in Experiments 2, 4, and 5), and of hand-to-body gestures in 20 young children (aged 24 - 42 months, in Experiment
In Chapter 3, it was argued that apparently emergent matching of arbitrary actions and gestures in an experiment could be attributed to either (i) generalisation of extra-experimentally trained matching, (ii) verbally-controlled matching, (iii) higher-order matching (imitation), or (iv) any combination of the above processes. In the experimental behaviour analytic literature to date, the distinction between these processes has not been made; all apparently emergent matching has been reported and discussed under the common label of generalised imitation. Thus participants' unreinforced responses to modelling of target behaviours were coded categorically, either as incorrect responses or as correct matches; if the latter occurred, generalised imitation was reported.

The present experiments were designed to examine children's responses to modelling of target behaviours in more detail, within and across modelling trials. Thus evidence concerning the relative contributions of generalisation of trained matching, higher-order matching, and, to a lesser extent, verbally controlled matching, to matching outcomes could be obtained. Further, the last two experiments were designed to test infants' higher-order matching abilities directly.

In the following paragraphs, the present data are discussed with respect to these three different matching processes.
Chapter 11
Generalisation of Trained Matching

If children's matching of target behaviours is determined by generalisation of extra-experimentally trained matching, and not by higher-order matching, their responses are expected to show

- Good resemblance to the modelled behaviours across a limited set of target behaviours. Such responses will be emitted whenever the target behaviours modelled present discriminative stimuli that resemble those that featured in previously trained matching relations. Infants' trained matching repertoires are expected to increase with age, as they learn more and more matching relations in the course of social interactions which include matching games.

- Partial resemblance to the modelled behaviours across many target behaviours that are novel in some respect. Such incomplete matching responses will be emitted whenever at least some components of the modelled target behaviours provide discriminative stimuli for individual previously trained matching responses. Multiple previously trained matching responses may be emitted, across or within trials, to novel models that contain multiple discriminative stimuli. Similarity between modelled behaviours and responses will depend on (i) how many discriminative stimuli are common across the novel and previously trained matching responses, and (ii) whether multiple stimuli evoke trained responses that are complementary to, or conflicting with, each other.
• No resemblance to the modelled behaviours (or no response) to some of the modelled target behaviours. Such responses will be emitted whenever none of the components of the modelled behaviour provide discriminative stimuli for previously trained matching responses. Further, non-matching, complementary responses may occur when the target behaviours modelled present discriminative stimuli for previously trained non-matching responses.

• No self-correction of responses in the absence of external shaping. Correct matching responses are not expected to develop, over time, from partially similar responses (approximations), without external reinforcement for successive approximations to the target behaviour.

In the present experiments, participants' unreinforced matching of target behaviours was tested following (i) a no-modelling baseline (Experiment 1), or (ii) the training of four baseline matching relations (Experiments 2-5). In the latter experiments, modelling of the target gestures was presented interspersed with modelling of the baseline (trained) gestures. While correct matching responses to the baseline (trained) models received intermittent reinforcement, there were no contingent consequences for participants' matching of the interspersed target models. Overall, infants' matching of the target behaviours (Experiments 1, 2, 4, and 5) was consistent with generalisation of trained matching and inconsistent with higher-order matching. Most of the young childrens' data (Experiment 3) were also consistent with generalisation of trained matching.

Across the experiments, the following features of the participants'
responses were consistent with generalisation of trained matching:

- In Experiment 1, repeated modelling of the three target actions had no effect on the youngest infant's object manipulation. For the remaining, older infants, modelling of the target actions resulted in an increase in object-directed behaviours that were emitted prior to modelling in the baseline phase and that could be considered as approximations to the target actions. Entirely correct target responses did not develop; there was no specific correspondence between the action modelled and the response produced for each object, but rather a general increase in target responses, whichever object was presented, in the post-modelling test phase. Overall, the results are consistent with an explanation in terms of social stimulus enhancement of the target objects and with generalisation of trained matching, but not with higher-order matching.

- In Experiments 2 - 5, entirely correct matching responses were often emitted in the first modelling trials, as would have been expected if such responses had been directly trained as matches, extra-experimentally. This was not because the infants were proficient imitators; they did not show correct matching of other modelled behaviours that were not obviously more difficult to perform. For example, infants matched a "palm-point" gesture in which the index finger touched the middle of the up-turned palm, but not a "palms-up-bowl" gesture, in which two upturned palms were shown (see Experiments 4 and 5).

- Often, the same response was emitted to a range of target models, which shared some physical feature(s) of the response. This would be expected if
the infants had already learned extra-experimentally a matching relation in which the modelled gesture and the response had similar physical properties to those presented as target models in the experimental setting. For example, infants emitted the "hand-to-backhand" response not only to modelling of the corresponding gesture, but also to modelling of hand touches to shoulder, elbow, knee, and foot (see Experiments 2, 4, and 5). The infants appeared to be responding only to the common feature of a hand touching a body surface; the physical characteristics of the body part touched (e.g. a knee vs. an elbow) appeared to have no additional discriminative control over the response produced.

- Individual infants emitted several different responses per target for some of the target models, within and across trials. This also would be expected if some feature of the model resembled a discriminative stimulus in several other extra-experimentally trained matching relations. For example, one infant responded to a "palms-up-bowl" target gesture, where joined hands with upturned palms were modelled, with (i) hand rubbing and (ii) the "peek-a-boo" gesture in which palms are placed over eyes (for more examples, see Experiments 2, 4, and 5). Presumably this occurred because the sight of two palms being brought into close proximity served as a discriminative stimulus for both of the non-matching behaviours the infant produced.

- Non-matching or complementary responses were also emitted to some target models. This would be expected if such responses had been directly trained in games, extra-experimentally. For example, infants responded
to the "thumb(s)-up" target gesture by pointing and giggling (see Experiment 2); they responded to the "palms-up-bowl" target gesture by opening their arms wide ("allgone" gesture) or by tapping the experimenter's palms (as in "gimme-five" game; see Experiments 4 and 5). As discussed in Chapter 3, the provision of intermittent reinforcement for a subset of matching responses would be expected to also support non-matching responses that derived from generalisation of extra-experimental training. This would be less likely, however, if infants had learned higher-order matching; non-matching responses did not achieve the similarity between infants' and models' responses and so should not be repeated (but see later discussion).

- Infants seldom showed matching of complex target models which consisted of two or more simple component responses, each of which they had previously emitted as matches to the corresponding models; this was especially true if the component responses had to be modified in some way. For example, infants responded to the "nose-wiggle" target gesture by touching their nose, or by opening/closing their hands, but not both (see Experiment 2). This is consistent with an extra-experimental training of the "simple" component responses, and no such training of the "complex" target responses.

- Across target gestures, infants often emitted very poor approximations to the target responses, and showed no evidence of self-correction over many modelling trials. This would be expected if responses somewhat similar to the targets had been directly trained as matches, extra-experimentally. The persistence of incorrect responses is inconsistent
with higher-order matching. Further, infants occasionally emitted correct matching responses once or twice and never again; their subsequent responses were poorer approximations (see Experiments 1, 2, 4, and 5). This is also consistent with generalisation of trained matching but inconsistent with higher-order matching. Infants' responses were often variable; correct matching responses may have been emitted by chance. These responses would be expected to increase in frequency only if they had been reinforced by the similarity between the model's and the infant's behaviour, as is the case in higher-order matching; no such reinforcement was available if infants responded solely through generalisation of trained matching.

* In Experiment 3, the two to three and a half year old children showed better matching of common gestures than did the infant participants in Experiments 2, 4, and 5. The two to three and a half year olds still produced better matches to gestures that featured in naming-and-matching games commonly played in the Nursery, than of physically similar, uncommon gestures, that had no such training history. Further, the children emitted the common gestures in response to modelling of similar uncommon gestures, but not vice versa. For example, children showed more correct matching of "lower-arm touches" if these were modelled on the top-of-arm surface (common) than if they were modelled on the underside-of-arm surface (uncommon); the common "lower-arm touches" were emitted in response to the uncommon ones much more frequently than vice versa.

To summarise. In Chapter 3, it was argued that apparently emergent
matching in an experiment ought to be parsimoniously interpreted as showing generalisation of trained matching and not as higher-order matching.¹ This distinction, initially made on theoretical grounds, received support from analyses of children's responses to modelling of target gestures in the present experiments. Overall, the data from infants (under two years old) were consistent with generalisation of trained matching and inconsistent with higher-order matching. Further, much of the matching data from young children (between two and three and a half years old; see Experiment 3) were also consistent with generalisation of trained matching.

Finally, the higher-order matching abilities of 9 infants, aged between 15 and 24 months, were directly tested in Experiments 4 and 5. Target gestures which individual infants never emitted as matches to the corresponding modelled behaviours--and which, therefore, were not directly trained as matches--were trained under discriminative control other than the sight of the corresponding gestures. Thereby it was established that motor development was not a limiting factor in the infants' production of the target responses. Further, these responses became frequent and well established, under this alternative discriminative control, in the infants' behavioural repertoires. In the test sessions, the target gestures that had not been trained as matches were modelled interspersed with (reinforced) trials of baseline gestures that had been trained as matches.

¹ Unless specific evidence of higher-order matching is found in the data, as discussed below.
Infants did not show matching of the target responses. Therefore, the results of Experiments 4 and 5 were inconsistent with matching behaviour that could be described as higher-order matching (imitation); instead, they suggested that extension of the infants' matching repertoires required direct matching training for each new matching relation.

**Verbally Controlled Matching**

In Chapter 3, it was suggested that children who had learned to name objects, body parts, or movements, may show verbally controlled matching. This was not directly tested in the present experiments; the experimenter simply remained aware of the possibility that some of the children's matching may have been so occasioned. Few children emitted overt verbal responses to modelling of target gestures (e.g. said "bye-bye" when presented with a gesture that contained a hand movement, or named the body part(s) touched); naturally, the extent of children's covert naming remained unknown.

Overall, it was not possible to establish whether children's naming was functional in their matching. For example, in Experiment 3, children showed poor matching of mid-arm touches when these were modelled on the top-of-arm surface; the same children showed good matching of mid-arm touches when these were modelled on the underside-of-arm surface. The latter target gestures are commonly trained in naming-and-matching games as "touches to elbow". The former gestures are not so trained; the crook-of-arm is not one of the body parts commonly labelled for young children. In Experiment 2, in which participants were aged between
15 and 25 months, only 2 infants showed some matching of the "elbow-touches"; these children were older, and had larger naming repertoires, than the remaining 2 children. It is possible that the 2 children who matched the elbow-touch gesture correctly did so because they were able to name this body part correctly. Most children could not name "crook-of-arm" and showed much poorer matching of the modelled touches to this body part. However, naming tests were not administered; even if the children's naming abilities were known to the experimenter, she could not attribute children's matching to their naming, because naming and matching of elbow touches were likely trained together in the Nursery and at home for these children.

Higher-Order Matching

As discussed in Chapter 3, higher-order matching refers to emergent matching in the absence of external training or reinforcement for doing so. According to Baer and Deguchi (1985), the complex stimulus dimension of similarity between one's own and others' acts is not only discriminative for the delivery of reinforcement following correct matching responses in social interactions, but also becomes reinforcing in its own right. Thereafter, it is the secondary reinforcement of similarity that establishes and maintains those (matching) responses that achieve it.

If children have learned higher-order matching, their matching responses in an experiment are expected to be superior to those of children whose responses are determined solely by the generalisation of trained matching. Higher-order matching is generative: children who have learned it
can produce a reasonable approximation to modelled behaviours that have not been directly trained as matches. Those of children's varied responses that achieve similarity with the novel behaviours of a model are reinforced, and are likely to be repeated when the same antecedents are presented; those responses that do not achieve such similarity become less frequent. Thus children's responses that are indicative of higher-order matching will show evidence of self-correction and convergence on good fidelity matches to the modelled target behaviour.

As discussed above, infants did not show higher-order matching of gestures that had not been directly trained as matches in Experiments 4 and 5. Overall, very little evidence of self-correction was found across all experiments. In Experiment 2, one girl's performance (Gwen, tested between year and a half to two years of age) appeared to show generalisation of trained responding across many target gestures, but also evidence of self-correction, indicative of higher-order matching, for the remaining target gestures. In Experiment 3, several young children up to three and a half years old showed self-correction for some of the more complex target gestures, indicative of higher-order matching, but also produced errors that were consistent with the generalisation of responding that was trained extra-experimentally. As noted under the previous

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2 Variability is inherent in all behaviour; it can also increase in response to reinforcement (Page & Neuringer, 1985). Caregivers rely on variability to shape children's responses to novel models in matching games; thus children's variable responding receives, indirectly, social reinforcement. Later, children who have learned higher-order matching may rely on the variability in their own responses to emit increasingly accurate matches to novel models.
heading, verbally controlled matching was also a possibility for some of the children (see below).

This is not surprising; most complex human behaviour is multiply determined. It is important therefore that experimenters take into account that children who have learned higher-order matching may still emit extra-experimentally trained responses to many of their target gestures. In order to establish the properties of any one child's matching repertoire, matching tests should employ a wide range of target behaviours, as was the case in the present experiments.³

To summarise. The results of the present experiments—and especially of Experiments 4 and 5—showed that the performances of 11 out of 12 infants, aged between 9 and 25 months, were inconsistent with higher-order matching. These results are surprising, because all theoretical

³ Modelling of target behaviours that are commonly used in games may evoke very strong trained responses. Some of these responses may be partly incorrect; for example, "bye" responses, which consist of small open/close hand movements, are commonly trained as matches to larger, side-to-side waving of adults. Some of the trained responses may be entirely incorrect; for example, in the "gimme-five" game, the downward-clap hand movements are trained as responses to palms-up movements of adults. Children who have learned higher-order matching may nonetheless perform "poorly" if presented with modelling of well-trained behaviours only. However, the modelling of a wide range of behaviours—such as those employed in the present experiments—is likely to include some behaviours that have not been trained as matches, and that exert only "weak" discriminative control. In such cases higher-order matching can be demonstrated without conflicting sources of control.
accounts of child development agree that infants in their second year of life can imitate. However, as discussed in Chapters 1 - 5, this widespread belief is not confirmed by the available data, which are equivocal with respect to imitation of actions on objects. No study published to date in the cognitive developmental literature, or in the behaviour analytic literature, has presented an extensive test of gestural matching in infants older than six months.4

Overall, the present results are incompatible with the theoretical accounts of imitation in the cognitive developmental literature; this is discussed next.

Active Intermodal Mapping and the Goal Theory of Imitation

As discussed in Chapter 4, the active intermodal mapping theory of infant imitation is presently accepted by virtually all (cognitive) developmental researchers (see e.g. Meltzoff & Moore, 1990, 1999). According to Meltzoff and Moore, imitation is an innate matching-to-goal process that involves cross-modal comparison of others' acts, perceived in the visual modality, and one's own acts, perceived proprioceptively. Infants are said to map the organ relations that they see adults make, and their own movements that they feel themselves make, onto the same cognitive schema.

4 Modelling of a few common gestures have occasionally been presented together with modelling of conventional actions on objects, and of vocalisations; such studies were reviewed in Chapters 3 and 4.
In Chapter 4, the critical review of the infant imitation data suggested that (i) there is no convincing evidence that infants under six months imitate adults' facial or manual gestures; (ii) the wealth of data reporting infant matching of object-directed actions can be parsimoniously interpreted as being the result of generalisation of matching that had been directly trained extra-experimentally, and also, perhaps, other non-imitative matching processes, such as stimulus enhancement and emulation learning; and (iii) there is no evidence that older infants, in their first two years of life, can imitate novel arbitrary actions or gestures.

The present results are inconsistent with an active intermodal mapping account of imitation. Thus:

- In Chapter 5, it was predicted that infants' matching of object-directed actions would be much poorer than previously reported if some of the non-imitative matching processes were controlled for. In agreement with this prediction, in Experiment 1, it was found that infants of up to 15 months did not show correct matching of simple, arbitrary actions that were modelled with novel objects. Further, in Experiments 2, 4, and 5, infants of up to two years did not show correct matching of gestures in the absence of direct operant training for doing so. These infants commonly emitted responses that were poor approximations to the target gestures, and did not get better across many modelling trials.

- Meltzoff and Moore (1992) reported that six week old infants self-corrected over several trials to produce correct matching of a tongue-to-side facial gesture. In Chapter 4, it was suggested that these "self-
corrections" were the result of (i) extra-experimental training of the target responses by caregivers, and (ii) unintentional on-line cueing and shaping of infants' responses by the experimenters. By contrast, in Experiments 2, 4, and 5, infants of up to two years did not show self-correction across the many target gestures and trials presented. In these experiments, parents were unaware of the exact gestures that were used in testing, and so were not able to train them as matches between sessions (except by chance, in the course of normal social interactions); careful inspection of the split-screen video recordings for each session showed that the experimenter did not present any differential, contingent consequences that would have shaped these infants' matching responses on-line.

According to Meltzoff and Moore, infants' motor practice provides the basis for mapping of movements to the resulting body configurations; in imitation, infants attempt to match the configurations (organ relations) of others. If this was so—the process is said to commence at birth—infants in their second year of life would be expected to have very detailed maps of various organ relations, and to be able to match the modelled ones readily and with good accuracy, allowing for differences in body structure between the adult who presented the modelling and the infant who observed it. This was not the case in the present experiments, despite the fact that most of the gestures that were modelled were not novel to these infants, or very complex. For example, in Experiments 4 and 5, most of the infants consistently and persistently tapped the back of their hands in response to the experimenter's modelling of "hand-to-knee" gestures, "hand-to-elbow" gestures, "hand-to-shoulder" gestures, "hand-to-
foot" gestures, and "arms-crossed" gestures. Even if one was to argue that these simple organ relations were not initially familiar for the infants, they ought to have been able to show matching of the target gestures after the training without modelling condition had provided the required "motor practice" of the relevant responses.

According to Meltzoff and Moore, active intermodal mapping allows infants to adopt the others' perspective and reproduce their acts correctly. By contrast, and in agreement with the data from other labs (e.g. Baer & Deguchi, 1985; Gleissner et al., 2000), many of the children's responses in the present studies were mirror matches. Thus most of the older children showed a strong preference for acting in the same space as the experimenter—they responded with their left hand to the experimenter's right-hand models, and vice versa (see Experiment 3). The younger infants did not adopt the model's perspective either; many of their responses were performed with their preferred hand, regardless of which hand the experimenter used to model the gestures (see Experiments 2, 4, and 5).

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As discussed in Chapter 8, Bekkering and colleagues (2000) and Gleissner and colleagues (2000) have argued that imitation in young children is goal directed. They proposed that (i) children perceive others' acts in terms of goals, (ii) these goals are hierarchically organised, and (iii) children's attempts to reproduce other's acts are hampered by their processing limitations. With respect to the imitation of gestures, these authors
predicted that children's matching errors would show omission of inferior goals.

An extensive critique of the theory was presented in Chapter 8; it will not be repeated here. Experiment 3 was designed to test goal theory directly; the results—across a multitude of measures and for 20 target hand-to-body actions—were inconsistent with the predictions derived from the goal theory. First, children's matching was better for target gestures, that commonly feature in naming-and-matching games, than for similar gestures that had no such social training history. This was true even though some of the common gestures were more complex—in terms of their goal structure, determined according to the goal theory criteria—than the uncommon gestures. Second, analyses of children's matching errors showed that the common gestures were emitted in response to the physically similar uncommon models far more frequently than vice versa. This was true even though some of the erroneous, common responses had more complex goal structures than the correct, uncommon target responses. Therefore, children's error responses did not omit supposedly inferior goals, as predicted by the goal theory. Third, many of the children's errors contained touches to incorrect parts of the body. This finding contradicted the main goal theory prediction, which states that the goal of "object" (the body parts to be touched) is perceived by children as dominant, and therefore reproduced more readily than all other, inferior goals.

To summarise. The active intermodal mapping theory of Meltzoff and Moore, and the goal theory of Bekkering, Gleissner, and their colleagues,
cannot explain the matching of gestures in infants and young children. The results of the present experiments were inconsistent with the predictions derived from these two cognitive developmental theories, which their authors consider to be complementary and continuous accounts (see Gleissner, Meltzoff, & Bekkering, 2000). Gestural matching in infants under two years was consistent with generalisation of matching that had been trained directly, in the course of early social interactions. Therefore, as discussed in Chapter 3, the present results support a more parsimonious, learning account of imitation.

Though behaviour analysts take the view that imitation is learned, a satisfactory account of the developmental course of generalised imitation in normal infants and young children has not been presented to date. As discussed in Chapter 3, only two behaviour analytic experiments have tested matching in infants and their results were inconclusive with respect to the determinants of infants' matching performances. Thus many important issues remain to be resolved; these are discussed next.

Determinants of Infants' Matching: Future Research

In accounts of higher-order matching (imitation), the secondary reinforcement of similarity is said to establish and maintain those (matching) responses that achieve it.

For gestures, and for object-directed actions, the similarity between one's own and others' acts is perceived in the visual modality (as discussed in Chapter 4, there is no convincing evidence that infants can perform
cross-modal comparisons). In order to learn higher-order matching of gestures, infants' trained matching responses ought to resemble the modelled gestures from the infants' own perspective. It is reasonable to suggest that infants must be exposed to many different examples of such resemblances before they become able to appreciate that the complex dimension of similarity is common to all the matching games.

In Experiment 2 (and in the remaining experiments), it was found that for many of the trained gestural matching relations the observed gestures do not appear very similar to the responses performed by the infant, from the infants' perspective. The earliest trained matching relations, such as "peek-a-boo", "hands-up", "hands-to-head", "hand-to-mouth", "nose-point", "dancing" and "rocking" (upper-body movements), "hugging", "hands-on-middle", and so on, do not present very good examples of visual similarity. The small hand movements and finger configurations, such as "bye" and "palm-point", probably look more similar from infants' perspective, but not many of these are trained as matching relations early on. To further confound the issue, some non-matching responses, such as clapping of, pointing at, or reaching for, the model's hand, are apparently trained to gestures that would appear similar if matched, such as "palms-up-bowl" and "thumb(s)-up".

An a priori prediction can be derived from the higher-order matching account of imitation. Children will show higher-order matching of gestures only after considerable experience of receiving reinforcement for responses that achieve visually-perceivable similarity between their own and others' actions (naturally, exactly how much experience is necessary remains an
empirical question; see below). The results of Experiments 2, 4, and 5 are consistent with this prediction.

In Experiment 2, it was found that infants' trained matching relations consisted mostly of gestures that do not "demonstrate" good examples of similarity; no evidence of higher-order matching was found for 3 out of 4 infants that were tested in this experiment. Further, in Experiments 4 and 5, it was found that infants comparable in age, developmental level, and background—and thus presumably with similar trained matching repertoires—do not show higher-order matching of gestures.

It follows from the above predictions that infants' matching of vocal gestures may be better than their matching of manual gestures; infants may to be able to learn higher-order vocal matching comparably sooner. This is because the similarities between infants' own vocalisation and that of their caregivers may be more easily perceived in the auditory modality. In the behaviour analytic literature, only one study has reported vocal matching in infants (Poulson et al., 1991; see Chapter 3); its results were inconclusive with respect to higher-order matching. Future research ought to explore this prediction.6

5 A review of the vocal imitation data in the comparative and the (cognitive) developmental literature is outside of the scope of the present thesis.

6 Admittedly, this is easier said than done. Consider the design that was employed in Experiments 4 and 5; this is the only direct test of infants' higher-order matching abilities to date. First, it was established that target responses were not directly trained as matches (i.e. infants did not emit correct matching responses to the modelled target
As discussed above, the training of matching relations that show "good" examples of similarity would be expected to promote children's learning of higher-order matching. By contrast, the training of an equal number of matching relations that show "poor" examples of similarity would be expected to be less effective; the training of non-matching, complementary responses would also be expected to be ineffective. This can be tested experimentally. For example, in a follow-up to Experiments 2, 4, and 5, children who do not show higher-order matching could be given experimental training of matching relations that present either "good" examples of similarity, or "poor" examples of similarity, or no similarity (complementary, non-matching relations).

In the present experiments, the experimenter sat facing the children; similar seating arrangements have been employed in most matching studies. A different arrangement, in which infants are seated on the
Chapter 11 Discussion

experimenter's lap, would restrict the range of target gestures that can be modelled to small hand movements. However, this arrangement would maximize the similarity between the experimenter's hand configurations and that of the infants, as seen from the infants' perspective. Would infants show better matching with this arrangement? A follow-up to Experiment 2 could employ this procedure. 7

In some of the published experiments, the experimenter, who presented the modelling of target actions, was seated next to the infants, in front of a table on which target objects were placed (e.g. Meltzoff, 1988a). This seating arrangement could also minimise the differences in perspective for some target behaviours. 8

7 Within this procedure, direct matching training of gestures by putting through may be comparably easy to administer; training of new matching relations would produce the best examples of similarity; consequently, infants may show learning of higher-order matching sooner that would be the case if the training was administered in the face-to-face procedure. However, this seating arrangement is impractical in several ways. In the pilot trials, not reported in the present thesis, infants did not seem to enjoy sitting in the experimenter's lap and were easily distracted, probably because there was no eye contact with the experimenter. They often reached to touch the experimenter's hands, attempted to turn around to look at the experimenter's face, and to get up and crawl or walk around the room, looking for toys. This would interfere with the modelling of target gestures.

8 This procedure was used for modelling of fairly expansive actions that demonstrated object transformations; infants were seated in their mothers' laps. The same procedure may not work well for small bimanual hand responses, because the experimenter's hand nearer to the child may block the child's view of the other hand. This seating
As discussed in the previous chapters, the use of gestures as target behaviours in matching studies is more convenient than the use of object-directed actions. This is because it is easier to identify the determinants of gestural matching; a multitude of non-imitative processes, such as social facilitation, stimulus and local enhancement, individual learning of objects' affordances, goal enhancement, affordance learning, object movement reenactment, and final state re-creation, can be functional in the spurious matching of actions on objects, but not in the matching of gestures (see Chapter 2).

The present experiments are the first to explore gestural matching in infants from a behaviour analytic perspective. In Experiment 2, the gestural matching repertoires of 4 infants were mapped to some extent; however, the lists of gestural matching relations presented in this experiment are by no means exhaustive. The experimenter could not rely on any previous publications; she modelled any gestures she could think of that were not obviously too complex for infants to perform.

It was reported that one child's performance was, for some of her target gestures, consistent with higher-order matching. Further, this child arrangement is not commonly used with very young infants; it remains to be seen whether infants' attention to modelling would be as good as that attained in the face-to-face interactions. The published studies that employed it relied on mothers to "encourage" their infants to attend to the modelling and to respond when they were supposed to; this would not be the case in better-controlled replications.
appeared to have a larger trained matching repertoire than the remaining children. However, children's matching repertoires could not be compared directly, because different gestures were presented to different children over an unequal number of trials.

In a follow-up to Experiment 2, individual infants could be presented with equal, large sets of target gestures that were beyond the matching abilities of some of participants in Experiment 2; each target gesture ought to be presented on an equal number of trials, as was the case in Experiment 3. Individual infants' matching repertoires can be correlated with (i) the evidence of higher-order matching, such as self-correction over trials, (ii) the evidence of generalisation of trained matching, such as invariant approximate responding and the presence of non-matching responses, and (iii) measures of infants' naming abilities, collected separately. This procedure, which does not test higher-order matching directly, could nonetheless provide knowledge about the development of infants' gestural

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9 In one study, the experimenter could model many different gestures of a certain type, such as small hand movements; in another study, large arm movements could be tested in more detail. These experiments would map the infants' matching repertoires for different topographical sub-classes of movements; previous studies with older children and special populations have shown that matching may be established and maintained differently in different topographical classes (small manual responses, large body movements, vocalisations; see Chapter 3).
matching in general, and over an extended age range; it could also be used to explore infants' vocal matching.  

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Throughout the present thesis, it has been argued that infants' matching of arbitrary actions and of gestures is inferior to their matching of non-arbitrary object-directed actions, because many non-imitative processes can contribute to the latter. However, the present experiments did not provide a direct demonstration of the predicted difference between infants' matching of non-arbitrary actions and gestures. A follow-up to Experiment 2 could employ modelling of two sets of target behaviours: actions performed with objects that have limiting affordances and similar actions performed as gestures, in the absence of those objects.

The critique of experiments that employed objects with limiting affordances (e.g. Meltzoff, 1988b; see Chapter 4) was presented on theoretical grounds: it is impossible to infer that infants can imitate from correct matching of such actions. However, matching of non-arbitrary actions is interesting in its own right; infants' repertoires of conventional

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10 Further, complementary data should be collected from observational studies of social interactions between infants and their caregivers (see Chapters 3 and 4). In Experiment 3, children showed better matching of gestures that feature in games commonly played in the Nursery than of similar gestures that had no such training history. These findings should be extended to younger participants and to larger gesture sets. Experiment 3-type tests could be performed with infants providing that the knowledge of the gestural matching games that are commonly played with them is available.
object manipulations may expand through the observation of the actions of others beyond what would be expected if solitary exploration was their only means of learning.

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As discussed in Chapter 1, the novelty of target behaviours can be judged in many different ways. In the present thesis, the distinction between gestures that have been directly trained as matches and those that had no such training history was made on theoretical grounds. It was suggested that it is practically impossible to establish which target gestures are not within individual children's behavioural repertoires; however, Experiments 4 and 5 presented a practical method for establishing which target gestures are not in individual children's (trained) matching repertoires.

In Chapter 3, it was suggested that only higher-order matching (imitation) is truly generative. The extension of children's matching repertoires would be expected to be different between children who had learned higher-order matching and those who had not. According to Skinner (1953, pp. 119 - 122), limited extension of children's matching repertoires can result from generalisation of trained matching. Thus:

1. Smaller response units can be acquired when several composite matching behaviours that contain them are directly trained.

2. New matches that consist of combinations of the already established
units may appear without direct training.

These predictions have not been tested directly in the present experiments (but see below); future studies can be designed to provide such tests.

With respect to Skinner's first point, children who had learned higher-order matching would be expected to (i) emit matches to gestural models comprised of smaller units than those that feature in previously trained matching relations, and also (ii) correctly match target gestures that are modifications of such units. Children who had not learned higher-order matching may do the former, but will not be able to do the latter.

For example, in Experiment 2, infants did not match the "thumb-up" target gesture. In a follow-up to this experiment, infants may be trained to place their thumb on their nose, palm, ear, and so on, when presented with modelling of the corresponding gestures; all these gestures would contain a "thumb-up" component. Infants can then be presented with a (previously unmatched) "thumb-up" model. If Skinner is right, they ought to be able to match this target gesture without direct training for doing so. However, only the infants who had learned higher-order matching would be expected to correctly match the modified, "thumb-down" models.

With respect to Skinner's second point, children who had learned higher-order matching would be expected to (i) match target gestures that consist of combinations of the already established units, and (ii) correctly match target gestures that consist of modified combinations of such units. Children who had not learned higher-order matching may do the former,
but will not be able to do the latter.

The results from Experiment 2 provided a tentative confirmation of these predictions. Infants' trained matching relations included "joined-hands" and "waving" (up/down hand movements); they showed some integration of the two responses and matching of the composite "up/down-joined" target gesture. However, infants did not show good matching of another composite target gesture which required modifications of the trained component gestures. Infants' trained matching relations included "nose-points" (in which the index finger touched the nose) and "bye" gestures (in which the hand produced a open/close movement). Infants did not match "nose-wiggle" target gestures in which the thumb was placed on the tip of nose while the hand performed open/close movements. As reported above, these infants showed generalisation of trained matching, but not higher-order matching.

A follow-up to Experiment 2 could provide infants with matching training of several component gestures, and then with tests for matching of composite target gestures.11 These composite gestures may consist of

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11 Bauer and her colleagues have reported that, of those infants who participated in their experiments, infants close to their second birthday, but not younger infants, correctly reproduced arbitrarily ordered sequences of object manipulations. These authors also reported that infants as young as 9 months showed some correctly-ordered matching of familiar and causal action sequences (see e.g. Bauer, 1996; Bauer & Mandler, 1989; Carver & Bauer, 1999). Unfortunately, as discussed in Chapter 4, these data contained confounding sources of control, such as the possibility of parental cueing of correct
unmodified or of modified components. Further, the composite target gestures could be designed to consist of two, three, or more, component (trained) gestures.

To conclude.

Generalised imitation has commonly been cited as a paradigm case of a higher-order response class; it has been incorporated into behaviour analytic accounts of child development. Implicitly or explicitly, theoretical accounts of generalised imitation have distinguished between trained matching, which may generalise to the experimental context but is not generative, and higher-order matching, through which novel responses can be emitted to the corresponding modelled behaviours in the absence of direct training. It has also been acknowledged that matching can be verbally- or rule-governed.

However, these different matching processes, each of which is interesting in its own right, have not been directly investigated; there has been no comprehensive programme of matching research with normally developing infants and young children.

Such a programme has been outlined in the present thesis. Its basic procedures, first employed in the present experiments, include (i) controls for the confounding processes that can lead to apparent matching of target behaviours, (ii) detailed, qualitative analyses of infants' responses to target performances, and verbal narratives and instructions that were presented by the experimenters.
models, (iii) criteria that differentiate between generalisation of trained matching and higher-order matching, and (iv) direct tests of individual infants' higher-order matching abilities.

The present experiments were the first to explore the determinants of generalised imitation in infants. The results suggest that infants' higher-order matching abilities, not previously directly tested, have been overestimated in the behaviour analytic literature.

The issues that await empirical investigation include (i) further mapping of trained matching repertoires in normally developing infants, (ii) demonstrations of the extension of infants' trained matching repertoires of gestures, actions, and vocalisations through higher-order matching, (iii) exploration of the conditions that establish the reinforcing function of similarity, and (iv) tests of the role that naming training may play in matching of non-vocal behaviours.

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The present research grew out of a behaviour analytic programme that has, so far, explored the determinants of verbal behaviour and categorisation in infants and young children; it has been going strong for about a decade. At present, there are too few such labs. The proposed programme of matching research is one more step in the right direction.
References


Imitation

References


Imitation


Imitation


Imitation


Imitation References


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Imitation References


Appendix: A sample consent form (English)

Dear Parent / Guardian,

At Tir na n-Og we are about to begin another study of infant development, which builds upon the previous studies that have been conducted here. We are interested in finding out more about how very young children learn new ways to manipulate objects and hope to observe how this benefits the child's learning generally.

This particular study is to be directed by Mihela Erjavec, a graduate member of our research team, working under my supervision. Mihela will be happy to discuss the details of the study with you and will keep you fully informed as to how it proceeds. Mihela will be investigating the role of imitation in children's early learning and whether imitation changes with development of linguistic skills, especially naming.

It is difficult to determine how long it will take to observe the imitation effects we are investigating, but we anticipate that the study will last approximately 2-3 months and will involve daily sessions that will be approximately 10 minutes in duration. Each session will be conducted in a play context.

The tasks involved will consist of play with novel soft toys and modelling of novel actions with these toys. When the study has finished, a summary of
the findings will be given to parents whose children take part. As a token of our appreciation of children's participation in the research we shall also provide, in consultation with parents, a gift for each child at the conclusion of the study.

Every effort will be made to ensure that the process will be very enjoyable for the children. The procedures to be employed have been used in a range of similar studies and the children have enjoyed their participation very much. Many of the parents were very positive indeed about the value of these daily one-to-one interactions.

As you are aware, it is Nursery policy to obtain parental approval for any studies in which the children participate, so we would be grateful if you would take the trouble to complete the slip below and return it to Sue Kennedy (Nursery Manager). Sue will also help to keep you informed about all aspects of the study and your child's progress.

Many thanks for your help.

Yours sincerely,

C. Fergus Lowe

Professor of Psychology and Head of Department
Appendix

Consent Forms

Name(s) of child or children: ________________________________

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I consent for my child to take part in the imitation study [ ]*

I do not consent for my child to take part in the imitation study [ ]*

I would like more information about the imitation study [ ]*

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Name of Parent(s): _______________________________________

Telephone Number: _______________________________________

Signed: ______________________

Date: ______________________

* Please tick as appropriate.
Appendix: A sample consent form (Welsh)

Annwyl Riant/Gwarcheidwad,

Yn Nhîr na n-Og rydym ar fin dechnau astudiaeth arall i ddatblygiad plant bach, sydd yn adeiladu ar yr astudiaethau blaenorol a gynhaliwyd yma. Mae gennym ddiddordeb mewn canfod mwy yngl n â'r modd y mae plant ifanc iawn yn dysgu ffyrdd newydd o drin a thrafod gwrthrychau a gobeithiwn arsysliw sut y mae hyn â fantais i’r modd y mae eich plentyn yn dysgu yn gyffredin.

Cyfarwyddir yr astudiaeth neilltuol hon gan Mihela Erjavec, aelod graddedig o’n tîm ymchwilio, a fydd yn gweithio o dan fy ngoruchwyliaeth. Bydd Mihela yn barod iawn i drafod manylion yr astudiaeth â chi, a bydd yn rhoi gwybod i chi sut y bydd yn mynd yn ei blaen. Bydd Mihela yn ymchwilio i swyddogaeth efelychiad yn nysgu cynnar plant a ph’run a ydyw efelychiad yn newid ai peidio wrth i blant ddatblygu medrau ieithyddol, yn arbennig enwi pethau.

Mae’n anodd penderfynu pa mor hir y bydd angen arsysliw’r efelithiau efelychiad yr ydym yn ymchwilio iddynt, ond rydym yn rhagweld y bydd yr astudiaeth yn para oddeutu 2-3 mis gan gynnwys sesiynau dyddiol a fydd yn para tua 10 munud yr un. Cynhelir pob sesiwn mewn cyd-destun chwarae.

Bydd y tasgau’n cynnwys chwarae â theganau meddal cwbl newydd ac
efelychu gweithredoedd newydd gyda’r tegau hyn. Pan fydd yr astudiaeth wedi ei chwblhau, rhoddir crynodeb o’r darganfyddiadau i rieni’r plant a gymerodd ran. Fel arwydd o’n gwerthfawrogiad am i’r plant gymryd rhan yn yr astudiaeth byddwn hefyd, mewn ymgynghoriad â rhieni, yn rhoi rhodd i bob plentyn ar ddiwedd yr astudiaeth.

Gwneir pob ymdrech i sicrhau y bydd y broses yn un bleserus iawn i’r plant. Mae’r trefniadau a ddefnyddir eisoes wedi cael eu defnyddio mewn amrywiaeth o astudiaethau cyffelyb ac mae’r plant wedi mwynhau cymryd rhan yn fawr iawn. Roedd llawer o’r rhieni yn bositif iawn yn wir yngl n â gwerth y cysylltiadau un-i-un dyddiol hyn.

Fel yr ydych yn ymwybodol, mae’n bolisi gan y Feithrinfa i gael cymeradwyaeth y rhieni ar gyfer unrhyw astudiaethau y bydd y plant yn cymryd rhan yn ynddynt. Felly, byddem yn ddiolchgar pe gallech lenwi’r ffurflen isod a’i dychwelyd at Sue Kennedy (Rheolwraig y Feithrinfa). Bydd Sue hefyd yn cynorthwyo i’ch hysbysu yngl n â phob agwedd ar yr astudiaeth a chynnwd eich plentyn.

Llawer o ddiolch am eich cymorth.

Yn gywir,

C. Fergus Lowe

Athro Seicoleg a Phennaeth yr Adran
Appendix

Consent Forms

Enw/Enwau y plentyn neu blant: ____________________________

Rwyf yn caniatáu i'm plentyn gymryd rhan yn yr astudiaeth efelychu
[ ]*

Nid wyf yn caniatáu i'm plentyn gymryd rhan yn yr astudiaeth efelychu
[ ]*

Hoffwn gael rhagor o wybodaeth am yr astudiaeth efelychu
[ ]*

Enw Rhiant/Rhieni: ____________________________

Rhif Ffôn: ____________________________

Llofnod: ____________________________

Dyddiad: ____________________________

*Ticiwch fel y bo'n briodol