Imitation:

A paradigm for studying children's understanding of intentional actions

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Thesis submitted for

the degree of Doctor of Philosophy

February 2001

Abstract

In a series of four studies, A. N. Meltzoff's (1995) Failed-Attempt paradigm for exploring the role of children's understanding of intention in imitation of acts on objects was replicated and novel manipulations to the paradigm were systematically assessed. In Experiments 1 and 2, the design explored the extent to which Meltzoff's Failed-Attempt format may cue children to produce the intended subsequent but unfulfilled target acts as a result of emulation learning or observing the contiguity of the target-relevant object parts. Results showed that either exposure to the initial and end state of the object set (Experiment 1) or exposure to the initial state and contiguity of the target-relevant object parts (Experiment 2) elicited a similar number of target acts as exposure to the failed-attempt model. These findings contrast to Meltzoff's conclusion that 18-month-olds could re-enact the intended subsequent acts by observing the failed attempts. Experiments 3 and 4 dealt with an issue raised in Experiments 1 and 2: did 17- and 19-month-old children selectively imitate the observed acts when they resulted in the observed outcomes of certain kinds? Results showed that there was evidence of imitation in both 31- and 41-month-olds' reproduction of the observed control acts. In addition, the 41-month-olds were capable of imitatively copying the demonstrated failed attempts whilst they were similar to 19- and 31-month-olds in the tendency to produce the target acts. In Experiment 4, the procedure for demonstrating failed attempts was further modified by vocally marking the demonstration as intentionally or accidentally failed. Neither of 17- and 39-month-old children showed differential ways of responding according to the vocal cues. They responded to the vocally marked failed attempts in the same way as they did when no vocal marker was given. Overall, the findings present a challenge to Meltzoff's analysis of the connection between infant imitation and understanding of intention. Methodologically, Meltzoff's format of modelling an adult's failed attempts involves contradictory information about the adult's underlying intentional stance and the outcomes already afforded by the objects. As a consequence, 39- and 41-month-old children may interpret the observed outcomes of the demonstrated failed attempts as intended. Although there is evidence that 17- and 19-month-old children imitated the demonstrated acts after observing the full-demonstration model, it is not clear that ascription of intention to the model must play an essential role in their imitative performance of acts on objects.

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Acknowledgement

This research was supported by a scholarship awarded by the Ministry of Education of Taiwan. I am grateful to my supervisor Tony Charman for providing me with tuition throughout various stages of the thesis. I would also like to thank Cecilia Heyes for giving detailed and insightful feedback on the second draft of the thesis. Chapter one was developed from the essay that I presented and handed in to Tim Shallice's Research Methodology class. He had contributed some ideas which grew into this chapter.

I am grateful to the children and parents who generously gave of their time to take part in the experiments. Thanks are also due to staff of Chi Yu Nursery, Finsbury Medical Centre, Highbury Grange Health Centre, Lantry Nursery Centre, Log Cabin, One O'clock Club (Corporation of London, Hampstead Department), Rainbow Preschool Playgroup, Ta An Nursery, Taipei Municipal Women's and Children's Hospital, UCL Nursery, and Yu Chuan Nursery. I would also like to thank James Chamber and Roger Bunce for constructing test materials; Wei-Tseun Soong, Chung-Hsin Chiang, Chie-Liang Yang, Hao Teng, and Sue-Mei Chang for their assistance with subject recruitment in Taiwan; and Simon Williams and Nicky Harman for their advice on English writing.

Finally, I reserve a particular type of gratitude to Mingo for taking care of my cat "Happy" in these years when I am abroad and to my parents for their incessant love and encouragement.

Chapter One

Imitation: A paradigm for studying infant understanding of intention

1.1. Introduction

Imitation is a common yet important behavioural phenomenon in the development of young children. There is evidence, though debatable, that neonates can duplicate an adult's facial movements such as tongue protrusion and head turning less than one hour after birth (Jones, 1996; Meltzoff & Moore, 1977). By their first birthday, infants often repeat the pattern of an adult's particular action on an object when involved in a turn-taking game, and are fond of echoing familiar sounds or words heard from their parents. In nurseries and playgroups, young children learn how to play with new toys by watching what other children do around them. At times, they might not actually make sense of how others are behaving, but they seem to enjoy the pleasure of repeating unfamiliar acts from seeing them done by others. At home, they develop a keen interest in participation in the housework. In the garden, for example, they carry a shovel and make an effort to copy the way an adult is digging the ground. In the kitchen, they sometimes play with a ladle and a pot as if they are ready to serve real soup. Further, they are interested in following funny behaviour or catch-phrases which they have watched and heard on the TV again and again. Whereas imitation is manifest in a spontaneous fashion under most circumstances, it also plays an important role in a wide range of learning activities in the pre-school years. For example, children learn to dance, play the piano, or excel in a sport from copying the physical effort and skill of another model. In encountering an unfamiliar social situation, they blend into the surroundings by imitating the way others are behaving.

Piaget (1962) describes imitation as a behavioural phenomenon in relation to the child's cognitive development. In Piaget's formulation, imitation abilities develop as a function of changes in the child's level of sensorimotor functioning. For example, at stage 3, with the development of abilities to co-ordinate vision and prehension, infants of 4-5 months become capable of repeating sounds or movements that they have already seen and made on their own. The ability to imitate novel acts modelled by others is not acquired until 8-9 months; and it is thought to be an achievement of the firmer differentiation between accommodation and assimilation schemes at stage 4. Under the influence of the Piagetian account, many early studies of infant imitation have attempted to determine a range of behaviours and modelled acts of differing complexity and novelty, which infants of different ages are capable of imitating.

Piaget's analysis of imitation specifically focused on the acts of the individual child, and said very little about extrinsic factors such as the social interaction between a child and an adult, and the role of social factors in facilitating the likelihood of imitation. That is, imitation was considered as a counterpart of the child's sensorimotor activity in Piaget's theory. However, a behavioural reproduction that is characterised by an imitative match may not be always called imitation and could be induced by any possible contingency. Since the 1970s, in addition to Piaget's position, there have been several different schools looking at infant imitation in a social context. First, behavioural theories have paved the way for the idea that imitation is a behavioural phenomenon governed by external reinforcement and arises as part of the process of discriminative learning (e.g., Gewirtz, 1971; Steinman, 1970; Waxler & Yarrow, 1970). Second, it has been suggested that imitation originates from innate social and emotional motives that allow an infant to initiate an inbuilt conversational dialogue with another person as a result of immediate mutual motive transactions—the essence of imitation is called "intersubjectivity" (Trevarthen, 1974; Trevarthen & Hubley, 1978). Third, from the interpersonal perspective, imitation has been considered as a form of social interaction in which a child and an adult engage each other in mutually-shared activities (Killen & Uzgiris, 1981; Uzgiris, 1981). Accordingly, the influence of a variety of social contexts has been investigated with respect to imitation, for example, children imitating the target acts modelled by an unfamiliar experimenter, or their own parents (e.g., Masur & Ritz, 1984; McCabe & Uzgiris, 1983), or peers (e.g., Eckerman, Whatley, & Kutz, 1975), or in the form of a film (McCall, Parke, & Kavanaugh, 1977).

On the other hand, during the last two or three decades many important discoveries have challenged Piaget's analysis of infant imitation. Whereas Piaget (1962) indicated that a child begins to imitate the facial movements of others at 8-11 months (stage 4) with the emergence of abilities to represent movements that a child cannot see herself make, there is some evidence to show that imitation of facial movements such as tongue protrusion and mouth opening occurs earlier than 2 months of age (Abravanel & Sigafoos, 1984; Anisfeld, 1991; Fontaine, 1984; Meltzoff & Moore, 1977). In addition, a central concern in Piaget's formulation was to characterise changes in imitation as a trajectory toward the development of symbolic functioning. However, it was not clear whether there is a unique mechanism of imitation accounting for a child's abilities to imitate different types of behaviour from seeing a model at different stages. During recent years, inspired by the literature on social learning in animals, there has been a growing interest in developmental studies about the issue of specifying imitation by attempting to differentiate imitation from other forms of social learning underlying behavioural correspondence (Call & Tomasello, 1995; Want & Harris, in press a; Whiten & Custance, 1996).

In general, since Meltzoff's (1977) systematic research on imitation in human infants, the climate of opinion about the phenomenon of imitation in child development has changed. Contemporary studies have been concerned with research procedure for specifying infant behaviour as imitation (e.g., Jones, 1996; Meltzoff & Moore, 1977, 1983a,b), the social roots of imitation (e.g., Meltzoff & Gopnik, 1993; Trevarthen, Kokkinaki, & Fiamenghi, 1999; Uzgiris, 1981), the cognitive significance and development of imitation (e.g., Abravanel & Gingold, 1985; Meltzoff, 1988a, b), and the phylogeny of imitation across human and non-human primates (e.g., Tomasello, Savage-Rumbaugh, & Kruger, 1993; Whiten & Custance, 1996; Whiten & Brown, 1999). In the meantime, there has been a plenitude of research on social understanding in infants and a consensus has emerged about infants' social behaviours directed toward external entities (e.g., objects) at around one year. Behaviours such as joint visual attention, social referencing, and protoconversational acts have been interpreted as the beginning of a triadic situation in which a child shares attention to an object with another individual with joint purposes (Bakerman & Adamson, 1984; Trevarthen & Hubley, 1978), or even precursors of theory of mind (Bretherton, 1991; Charman, 2000). As it has been demonstrated that a child becomes capable of imitating novel acts on objects between 9 and 12 months of age (Meltzoff, 1988a, b; Piaget, 1951), it is not at all surprising that there is a convergence between infants' abilities to imitate object-related behaviours and their early social understanding in terms of the age onset. However, most theoretical analyses of infants' early social behaviours such as joint visual attention and social referencing do not include imitation (e.g., Corkum & Moore, 1995; Franco & Butterworth, 1996). Although theorists have appreciated the interpersonal significance as a primary essence of imitation in infants, so far there have been a limited number of studies looking at imitation in relation to other relevant aspects of early social understanding (Carpenter, Nagell, & Tomasello, 1998; Meltzoff, 1995).

1.2. Meltzoff's Failed-Attempt paradigm as starting point

Meltzoff's (1995) study was probably the first investigation in research on connections between infant imitation and the concept of intention, which has been thought to be a possible antecedent of theory of mind (Astington, 1991; Poulin-Dubois & Shultz, 1988; Zelazo, Astington, & Olson, 1999).

In Meltzoff's study, a novel demonstration (intention) condition was designed to explore infants' understanding of the intentional actions of others in imitation of acts on objects. In this condition, the demonstrator was seen to attempt but fail to bring about certain target acts, which the adult judged to be the intended subsequent acts, on the object sets. For example, the demonstrator was trying to put a ring over a protruding prong, but missed the bulbous tip of the prong so that the loop did not rest on the prong and inappropriately dropped to the table. The children's spontaneous behavioural production after watching the failed-attempt display was recorded and analysed as a non-verbal measurement of their interpretation of the demonstrator's behaviour. The results indicated that the infants were as likely to produce the target acts which the adult attempted but failed to accomplish as they were in the demonstration (target) condition where they watched the demonstrator successfully carry out these target acts. In addition and more importantly, the infants did not spontaneously produce these acts in two other controls—the baseline control in which the adult did not handle the objects at all, and the adult-manipulation control in which he manipulated the objects but without producing the target acts or the failed attempts. It was concluded that 18-month-old infants can infer an adult's intentions by reading the failed attempts, for they do not simply re-enact what the adult literally does but rather what he intends to do (Meltzoff, 1995).

In the second part of the same study, the infants were shown a mechanical device which had two pincers that could be manipulated to mimic the way the demonstrator acted on the dumbbell-shaped toy in the failed-attempt display: grasping it on the two ends; pulling them outwards; and one pincer slipping off one of the two ends. The results showed that the infants did not pull the dumbbell apart after watching the same pattern of the unsuccessful acts done by the mechanical device as often as they did after watching the same action demonstrated by a human actor. It suggested that 18-month-olds are able to situate people, but not inanimate objects, within a "psychological framework" that differentiates the surface behaviour of people and a deeper level involving goals and intentions (Meltzoff, 1995).

One of the most striking features of Meltzoff's study is the behavioural re-enactment technique. It takes infants' behavioural production in an imitative situation as a non-verbal interpretation of the model's behaviour, and exploits such a response to explore the concept of intention in infants. Its important methodological implication is that "theory-of-mind" questions may be posed in preverbal infants through non-verbal or productive measures. Whereas the habituation paradigm uses looking time measure as a non-verbal assessment of infants' knowledge about representations of intended meaning (e.g., Gergely, Nádasdy, Csibra, & Bíró, 1995), infants' behavioural production derived from the behavioural re-enactment procedure would be a more revealing measure, because it does not only tell us what infants know about the intentions of others but also what they are inclined to do from knowledge of the intentions of others. Theoretically, the results appear to suggest that 18-month-olds may have acquired an implicit theory of mind, because the infants watching the failed-attempt display in Meltzoff's (1995) study perhaps performed the target acts from an understanding that the demonstrator was intending to achieve them. Also, as the infants did not copy the behavioural form of the demonstrator's failed attempts, it seems that 18-month-olds do not look at an adult's behaviour in merely physical terms. Furthermore, as far as imitation is concerned, the results seem to suggest that beyond the behavioural convergence principle, infants imitate an adult's failed attempts in terms of an intentional convergence and as a result produce the adult's intended acts.

The behavioural re-enactment procedure is fascinating in that it poses "theory-of-mind" questions in infants in the prelinguistic stage. Very little research has assessed the ability to impute internal states to self and others formally defined by Premack and Woodruff (1978) in prelinguistic children. However, there are some methodological considerations about its use in terms of a child's imitative tendency to re-enact the intentional actions of others as a non-verbal measurement of their understanding of intentions. On the one hand, the validation of an imitation paradigm for looking into children's understanding of intentions is already under way (Carpenter, Akhtar & Tomasello, 1998; Meltzoff, 1995; Tomasello & Barton, 1994). On the other hand, such a paradigm defines imitation as a form of social learning which involves the ascription of intention to the demonstrator, and such ascription, being an essentially covert activity, is difficult to detect in behaviour (Heyes, 1996). That is, the concept of intention which is an essential quality of imitation is unobservable and cannot be operationally defined, and thus phenomenon that involves imitation and intentionality can only be identified by eliminating the possibilities that it may belong to other forms of social learning.

1.3. Behavioural re-enactment procedure

The combination of a behavioural re-enactment procedure and Meltzoff's Failed-Attempt paradigm was developed on the basis that infants' behavioural reconstruction of events reveals how they represent and interpret the behaviour of others (Meltzoff, 1995). This notion takes advantage of the findings of infant deferred imitation of novel acts on objects from recall memory. In one study, 9-month-old infants were found to be able to retain and subsequently imitate simple acts which they saw the experimenter perform with novel objects 24 hours earlier (Meltzoff, 1988b). Four groups were included in each of immediate and deferred imitation conditions, respectively. In the imitation group, the infants watched the experimenter demonstrate the target acts three times. The three control groups were: the baseline group, in which the infants received no demonstration; the adult-touching group, in which the infants saw the adult reach out and hold each object three times; the adult-manipulation group, in which the infants watched the demonstrator perform different acts from those modelled for the imitation group to produce the consequences of the target acts. In the immediate imitation condition, the experimenter gave each object to the infants immediately after a pre-set modelling period. In the deferred imitation condition, the infants were not allowed to touch or play with the objects after seeing the experimenter's displays on the first day of testing. They returned to the laboratory after a 24-hour delay and were given a chance to handle these objects. The results showed that the imitation effect was revealed in both immediate and deferred tasks. That is, the 9-month-olds' ability to imitate demonstrated target acts was not affected by the 24-hour delay.

In another study, 14-month-old infants were found to imitate a variety of novel acts after a 1-week delay (Meltzoff, 1988 a). The design of this study was similar to that described above. There were one imitation group and two control groups—baseline and adult-manipulation—in both immediate and deferred imitation conditions. It was found that the infants produced more target acts in the imitation group than in the control groups in both the immediate and deferred imitation conditions. After the long-term delay interval, most of the infants in the imitation group remembered and imitated at least three of the six target acts they had seen before and some of them even imitated up to five such acts.

According to Meltzoff (1988 a, b), findings of deferred imitation show that infants younger than 18 months are able to internally represent the behaviour of others and re-enact it on the basis of the stored representation, even after a delay interval. From a social point of view, deferred imitation entails that infants re-enact or imitate the actions of others as a result of their interpretation of past events (Meltzoff, 1995). Hence, infants' behavioural tendency to retain and reproduce what they saw adults perform earlier may be used to address the issue of understanding intentions in preverbal children (Meltzoff, 1995). This implies that infants may be induced to re-enact or reproduce something of the adult's psychological states as a result of their representation or interpretation of his behaviour. Meltzoff thus combined the behavioural re-enactment technique and the failed-attempt display to pose the fundamental "theory-of-mind" question: could 18-month-olds see beyond the literal surface behaviour to re-enact something about an adult's psychological states, such as goals and intentions? In other words, could 18-month-olds re-enact an adult's intended acts on the basis of their representation of his failed attempts?

Although several recent studies have replicated Meltzoff's (1995) paradigm to explore the concept of intention using a non-verbal measurement (e.g., Aldridge, Stone, Sweeney, & Bower, 2000; Assanelli & D'Odorico, 2000; Bellagamba & Tomasello, 1999), imitation as phenomena entailing the notion that infants reproduce the intentional actions of others has not been put to an empirical test. It seems that there is a considerable gap to be bridged between a behavioural re-enactment procedure and the phenomenon of imitation. For example, in deferred imitation, infants may just re-enact the actions that they saw an adult perform earlier by way of representing the visual events. It does not appear to be necessary for them to remember an adult's behaviour in terms of intentions. As in immediate imitation, infants can simply repeat the actions that have been observed in the past and do not need to remember or make sense of whether the adult was intending to perform these actions. However, the behavioural re-enactment procedure gives primary significance to the idea that deferred imitation reveals how infants interpret actions they saw performed by the adult. Second, it is not quite clear whether infants' behavioural response derived from the behavioural re-enactment procedure should be called imitation. In cases where there is a lack of imitative match between infants' behavioural performance and what they have witnessed an adult demonstrate, it would be difficult to assess whether they have difficulties imitating the visual acts or are re-enacting what they interpret. As the phenomenon of imitation lends credence to deferred imitation, should infants' behavioural production induced during the behavioural re-enactment procedure be called imitation?

To address these methodological issues concerning the adequacy of Meltzoff's (1995) Failed-Attempt paradigm which uses a behavioural re-enactment procedure to obtain infants' productive measure, his findings will be examined by raising three important questions:

1. Could children's production of target acts after observing the failed-attempt display be identified as a phenomenon of imitation?
2. Does children's production of target acts after observing the failed-attempt display entail a possession of the concept of intention?
3. Could children's production of target acts after observing the failed-attempt display be recognised as other forms of social learning?

1.4. Can infants' performance on target acts in Meltzoff's Failed-Attempt paradigm be the phenomenon of imitation?

Despite the fact that the phenomenon of imitation is well-recognised in human infants (Butterworth, 1999; Meltzoff, 1996), the inquiry about its definition has been relatively silent compared to that within the literature on social learning in animals. A consensus concerning the methods of identifying imitation in infants has emerged after the last two decades of inquiry, for example, the paradigm for distinguishing imitation from non-imitation (Meltzoff, 1996). In the meantime, a number of recent theories have been proposed for the mechanism underlying infant imitation (e.g., Meltzoff, 1999; Trevarthen, Kokkinaki, & Fiamenghi, 1999; Uzgiris, 1981). Nevertheless, according to Butterworth (1999), the issue of defining imitation has not gone very much further than those given by Baldwin and Piaget. It is interesting to note that, in the study of particular interest here, Meltzoff (1995) used the expression of "re-enactment" to phrase the infant's behavioural reproduction after watching the demonstrated failed attempts, instead of characterising it as imitation. Perhaps he had foreseen the controversial issue raised with respect to defining imitation, because there would be no behavioural convergence between the infant and the model if the infant's production of the target acts under such a circumstance were called imitation.

Although Meltzoff's findings have tended to be interpreted as evidence that infants "imitate" the intended acts of others but not their literal bodily movements (Bruner, 1999), it is important to check whether infants' performance on target acts in Meltzoff's Failed-Attempt paradigm necessarily involves the concept of imitation, and whether infants produce such acts by way of carrying out the model's intended goals.

Among a variety of definitions of imitation, a distinction can be drawn between definitions requiring a strict rule of behavioural convergence and those emphasizing an imitator's cognitive activities. At the strict extreme, in the sense of exactitude of imitative match, imitation has been defined largely as a process of learning a new behaviour from seeing it done by a model. At the other extreme, imitation has been formulated in relation to a putative psychological process involving the representation of goals and intentions of the model. Next, Meltzoff's (1995) findings will be explored in the light of the two perspectives of defining imitation.

1.4.1. Definition by behavioural convergence

Copying novel or improbable acts

Thorpe (1963) had defined imitation as "the copying of a novel or otherwise improbable act or utterance, or some act for which there is clearly no instinctive tendency" (p. 122). Such a definition emphasised that, by imitation, an imitator does not merely copy a specific act done by a model, but also the copied act should not be included in the imitator's current behavioural repertoire. Although there is some debate about whether a behaviour could be entirely novel in the literature on social learning in animals (Whiten & Custance, 1996; Heyes, 1996), a lax criterion for determining behavioural novelty has been generally agreed among developmental studies of infant imitation. A behaviour which infants imitate is novel in the sense that they do not elicit it on their own in the absence of the modelling.

The infants' production of the target acts after watching the failed-attempt display in Meltzoff's (1995) study apparently could not be called imitation by Thorpe's definition. There was a lack of behavioural convergence between the infant and the model. It is thus uncertain whether the infant has copied some specific behaviours of the model. More importantly, while the target acts involved could be novel in the sense that the infants in both the baseline and adult-manipulation control groups generated such acts themselves relatively infrequently, the demonstrated failed acts could be novel in the identical sense that the infants in the two control groups did not spontaneously elicit them, either. But why did the infants after observing the failed-attempt display bring about the target acts more frequently than they copied the unsuccessful acts? Did the intended target acts imply more behavioural novelty than the failed acts explicitly observed? Or, were the failed acts unlikely to happen in terms of their improbabilities so that the infants found it difficult to copy them?

Transfer of information and behavioural correspondence

Butterworth (1999) suggested that imitation has three defining characteristics. First, imitation occurs when an individual voluntarily reproduces the behaviour demonstrated by the model, by observing the demonstration. Second, the behavioural correspondence achieved during imitation entails an essential quality of transfer of information from one individual to another. The input from observing behaviour performed by the model, but not other contingent factors such as movement and location, ensures the imitator's copying of the behaviour of the model. On this criterion, other forms of social learning must be excluded from imitation. Finally, in contrast to Tomasello (1996) who regarded mimicry as non-imitative behaviour in that one individual reproduces another's behaviour with no grasp of the relations between the observed behaviour and the outcome that the behaviour is designed to achieve, Butterworth (1999) related mimicry to imitation as an evolved capacity for ensuring that infants blend into their social environments.

The infants' performance on target acts in Meltzoff's Failed-Attempt paradigm did not appear to be imitation according to the first definition, because their performance did not meet the criterion for behavioural correspondence. But can such a behavioural phenomenon imply a transfer of the information about the target acts from the demonstrator to the infant? It is possible that the infant may bring about the target acts with an understanding that the adult is undertaking such acts intending to fulfil them. Nevertheless, as will be argued later in the present chapter, it is not clear that the cognitive process involved when a demonstrator generates bodily movements in order to produce the scripted failed acts has the critical elements that correspond to those involved in execution of the successful target acts. Whether the failed-attempt model could show the demonstrator's intended subsequent but unconsummated target acts is an open question. It is thus not clear that the correspondence between a child's production of the target acts and the demonstrator's "intended" goals is based on a transfer of the information about the target acts from the demonstrator to the child. However, if what the demonstrator is intending to achieve may be interpreted in different ways, the correspondence between the child and the demonstrator in terms of intentional match will be questioned.

Reduced or expanded matches

Although behavioural correspondence plays an inclusive role in defining imitation, scientists have been confronted with the empirical problem of how to identify imitation by assessing the behavioural match. So far, the inter-scorer rating procedure has been broadly adopted in developmental studies. However, even an entire agreement does not necessarily imply that there is a perfect match between the imitator and the model. An exact imitative match rarely occurs and seems difficult to measure by visually describing the behaviour itself. Therefore, it has been suggested that, instead of defining imitation as copying the details of the behaviour observed, imitation may be characterised as involving the partial copying of the demonstrator's behaviour (Whiten & Ham, 1992), or the degree of match or similarity between the imitator's and the model's behaviour (Moerk, 1989; Snow, 1981). Based on Moerk's (1989) framework on imitation in young children's language acquisition, Russon (1996) assessed the degree of match in orangutan imitation by describing the orangutan's behavioural reproduction as an exact, or reduced, or expanded match. Exact match refers to occasions when the imitator reproduces the identical form of the model's behaviour with no additions or omissions; reduced match, when some part of the model's behaviour is omitted; and expanded match, when, while replicating some part of the model's behaviour, the imitator introduces new elements which are not observed in the demonstration. According to Moerk (1989), reduced imitation often indicates children's difficulty in handling and reproducing all the inputs from the demonstration, and expanded imitation implies that the inputs are processed at more advanced levels.

In the definition, considered above, true imitation in Meltzoff's (1995) Failed-Attempt paradigm could only occur when the infant exactly duplicated the demonstrator's failed attempts. It might be sensible to relate the infant's performance on the target acts under such a paradigm to expanded imitation. The target acts were not demonstrated in the adult's modelling, so they were new elements independently contributed by the infant. The infant could probably associate the observed failed attempts with the target acts based on an understanding that the adult was intending to complete them, for the performance on the target acts might require that the infant processed the inputs demonstrated at higher cognitive levels, rather than merely handling them in physical terms. On the other hand, one possibility would be the case where the infant might imitatively learn the target acts with more advanced cognitive skills, but the processing of the inputs demonstrated may not involve an understanding of the demonstrator's intentions. An example of such cognitively advanced options is what Tomasello (1996) called "emulation": an individual learns about the end result of a sequence of acts from knowledge of the causal structure of the demonstrated sequence. That is, it is possible that the infant produced the target acts in Meltzoff's Failed-Attempt paradigm just because these acts were taken to be the end results effected by a sequence of object-directed acts. Although it has been argued that emulation requires intelligence to decode the final act in a goal-directed sequence and may be characterised as less exact imitation including the final act (Whiten & Ham, 1992), the current concern about Meltzoff's Failed-Attempt paradigm is whether the infant brought about the target acts by way of decoding what the demonstrator was taking to be intended in the failed-attempt display. To put the question simply, if Meltzoff's (1995) findings entail expanded imitation, it is important to clarify whether the infant's additions belonged to an understanding of the model's intentions or that of the causal structure of the task.

Furthermore, in Meltzoff's (1995) study, the infants reproduced relatively few of the failed attempts demonstrated. One potential explanation of their performance on the target acts in such a circumstance would be that exact imitative copies of the demonstrated inputs were difficult to process compared to the production of the target acts already afforded by the objects. Reproduction of the observed acts in the full demonstration model may have required only that the infant remember the final configuration of the objects, for example, the loop resting on the prong. In contrast, reproduction of the observed acts in the failed-attempt model may have required recollection of the exact sequence of movements of the demonstrator, of the objects, or both. At some point, the infant might have to have some awareness of the distinction between the actual information given in the demonstration and their knowledge of object-elicited goals involved in the sequences of movements evoked by the failed-attempt model. As far as such a possibility is concerned, the infants' performance on the target acts after observing the failed-attempt display would perhaps indicated the opposite: some constraints on the capacity for the exact copying of the failed attempts which they had witnessed.

1.4.2. Definition by intentionality

Children's performance on target acts in Meltzoff's Failed-Attempt paradigm does not appear to be imitation by the defining feature of behavioural correspondence. In Meltzoff's (1995) study, there was a mismatch between the child's production of the target acts and the demonstrated failed attempts. Would it be termed imitation by the definitions emphasizing intentionality as the primary essence of imitation?

Metarepresentation

It has been suggested that imitative copying may involve second order representation required for pretence and mindreading (Whiten & Byrne, 1991; Whiten & Ham, 1992; Whiten & Brown, 1999). Upon seeing an action done by another person, imitative copying requires that the action be represented from how it was originally organised from the other's perspective into a metarepresentation. Then, the action can be reproduced from the observer's point of view.

Is children's performance on target acts in Meltzoff's Failed-Attempt paradigm an example of metarepresentation? If yes, their reproduction of the target acts would appear to be translated from the original form in which the scripted failed attempts are represented from the demonstrator's point of view. However, it does not seem necessary that infants explicitly represent a demonstrator's knowledge of what end results are entailed in the failed attempts, then perform the end results from their own perspective. Even if infants overlook what is represented in the demonstrator's mind, it is probable that they could elicit the target act by assuming it to be a specific end point of a sequence of object-related acts. On the other hand, the validity of the procedure for modelling the failed attempts is questionable. As what the demonstrator intends to do in the failed-attempt display is not observable, there is reason to doubt whether there ought to be an intentional correspondence between the target acts and the demonstrated failed acts. In fact, in Meltzoff's (1995) study, while comparing the infants' performance on the target acts after watching the failed-attempt display to that after observing the target display, there was no information about the reliability of the procedure for modelling the failed attempts. For example, it is not clear whether two adults rating the demonstrator's failed acts would result in the same opinion about what he is intending to complete. It is probable that a naïve observer would interpret the demonstration as the demonstrator intending to produce the unconsummated target acts, rather than the consummated target acts.

Intentional relation / Barresi and Moore

According to Barresi and Moore (1996), imitation is related to a basic capacity to represent intentional relations that an individual is directing his or her activities towards external entities or some future states of affairs; for example, changes of state of an object. Such an understanding requires that one co-ordinate first and third person sources of information about one's directed activities into representations that link agents to objects through intentional relations. In imitating actions on objects, for example, while an observer and a model display matched actions on shared objects, the observer generates first person information about his own actions on objects such as kinaesthetic and proprioceptive changes to match third person visual information from observing the model's actions on the objects. Barresi and Moore (1996) also developed a four-level framework of social understanding within which the forms that representations of intentional relations take can be identified.

1. *Level 1*: infants treat first person information about their own intentional relations separately from third person information about the intentional relations of others;

2. *Level 2*: infants cannot recognise the intentional relations as existing in first or third person perspective alone, but can represent the intentional relations by integrating the first and third person information derived from the

matched object-directed activities during participation in the shared intentional relations with others;

3. *Level 3*: infants develop a concept of intentional agent, and can understand that others' third person information about their activities in relation to objects involves an accompanying first person experience of the intentional relations. On the other hand, they become aware of the corresponding third person information when experiencing first person information about their own activities in relation to objects. Such a capacity to recognise others as intentional agents requires the infants to imagine or represent the first person information of the other by observing another individual's activities, or their own third person information about the activities in which they are taking part;

4. *Level 4*: children develop a concept of mental agent at around 4 years, and are capable of generating representations of the intentional relations of the other in the absence of both the first and third person information about another person's behaviour. That is, children now can represent intentional relations for which both first and third person information is imagined. A typical form of children's social understanding at level 4 is the ability to represent an individual's false belief. For example, in Wimmer and Perner's (1983) false belief task, the child was required to predict the story character's behaviour by imagining the first person information of the character's intentional relation while the character's third person information was not perceptually given.

Towards the end of the first year, infants are capable of imitating others' behaviour in relation to external entities. According to the framework of Barresi and Moore (1996), the ability to imitate object-directed activities emerges with the representation of intentional relations at level 2. When a child observes and imitates another person's behaviour, there is immediately available to her both the first and comparable third person information necessary for the representation of the matched intentional relations. Deferred imitation, in which the behavioural re-enactment procedure is grounded (Meltzoff, 1995), is identified at level 3, for imitation after an interval delay requires a child to represent nonpresent or noncurrent objects and events that occurred in the past or have not yet occurred but could. In benefiting from this form of representation of intentional relations, children can hold in mind the first person information of the other by observing another person's behaviour, and re-enact it later on in the absence of the comparable third person information of the other.

In Meltzoff's Failed-Attempt paradigm, the ability required for re-enacting another person's failed attempts appears to be in the form of the level 3 representation of intentional relations. As the behavioural re-enactment procedure capitalises on infants' abilities of deferred imitation (Meltzoff, 1988a,b), let us pose the question: do children's performance on target acts in Meltzoff's Failed-Attempt paradigm tell us something about imitation in terms of the representation of intentional relations?

If a child's performance on target acts in Meltzoff's Failed-Attempt paradigm is a manifestation of the phenomenon of imitation, this could imply several things with respect to the representation of the intentional relations of others. First, by observing another person's failed attempts (third person information of the other's intentional activities), the child could probably imagine what the agent is trying to accomplish (first person information of the other). Second, by producing the target acts (first and third person information of the child), she perhaps re-enacts the first person information of the agent's intentional relations to the objects. Third, the child appears to have a proclivity to imitate what another person intends to do (i.e. first person information of the other's intentional activities), because she does not replicate the agent's failed acts literally. Thus, a child's performance on target acts in Meltzoff's Failed-Attempt paradigm may be tantamount to the behavioural reconstruction of the agent's first and third person information.

However, it is doubtful to what extent children's performance on target acts would faithfully reflect the model's first person information. In the Failed-Attempt paradigm, the adult performs the failed attempts in an effortful manner, while in fact he does not use the proper means to achieve the target acts. In presenting the failed attempts, he must disguise the bodily movements and the force required for bringing about the target acts otherwise they would be revealed. In one sense, the adult models the failed attempts in a manner to manifest his corresponding first person information as intending to produce the target acts. Nonetheless, the bodily movements and the force that he uses to model the failed attempts are not equivalent to those that he actually uses when modelling the successful target acts. The demonstrator's first person information such as kinaesthetic and proprioceptive feedback during the two types of demonstration should be very different. It is thus questionable whether children's performance on target acts in Meltzoff's Failed-Attempt paradigm may reveal a true understanding of the demonstrator's corresponding first person information accompanying the scripted failed attempts. Therefore, in this regard, it may not be sensible to interpret children's performance on target acts under this paradigm as imitation, because we have reason to believe that children's first person information about such a performance could be different from that of the demonstrator during modelling of the failed attempts.

Intentional relation / Tomasello

Tomasello (1996, 1999) emphasised that, in imitation learning, an imitator must understand the intentional relations between the behaviour produced and the outcome in the environment that behaviour is designed to achieve (not just the form of others' behaviour, and not just the result that that behaviour elicits). In this way, imitation consists of reproducing the intentional actions of others.

Given this definition, children's performance on target acts in Meltzoff's Failed-Attempt paradigm may be called imitation. In Meltzoff's (1995) study, the infants after watching the experimenter's failed attempts, did not seem to see the observed acts simply in terms of motoric movements. Instead, they appeared to produce the target acts with a good understanding that the adult performed these failed acts by way of carrying out some intended subsequent outcomes. That is, in imitative learning, children may prefer to re-enact the goals that an adult ought to fulfil in the failed attempts. However, in contrast to Meltzoff, Tomasello's methodology towards imitation as a paradigm for exploring children's social understanding is more precautionary.

As can be seen in the studies of Tomasello and his colleagues (Carpenter, Akhtar, & Tomasello, 1998; Tomasello & Barton, 1994; Tomasello, Strosberg, & Akhtar, 1996), the concept of intention has been assessed through imitation in a situation where the goals involved in two actions are the same, but only one is intentionally achieved. That is, the end is the same, but the means differ. In the study of Carpenter, Akhtar, and Tomasello (1998), for example, the experimenter performed a series of actions to make the interesting end results of the objects occur. In one condition, the modelled actions were marked vocally as intentional ("There!"); in the other condition, they were marked vocally as accidental ("Oops!"). After watching each demonstration, the child was given a chance to act on the object spontaneously. As the ends in both cases were identical and observable, there might be a straightforward solution to the empirical problem of determining the behavioural convergence between the intentionally modelled action and the child's behaviour. By contrast, Meltzoff's Failed-Attempt paradigm is not formulated on the basis of such a contrast between an intended and unintended outcomes, both of which are observable. On the contrary, the intended outcomes are covert and not observed in the failed-attempt display; they are only observable in the target display. Then, there would be reason to question whether the target acts are necessarily the goals of the modelled failed attempts. Because there is a lack of a behavioural account of what the demonstrator's intended goals are, the convergence between a child's and a model's intentional acts cannot be assessed based on the same behavioural accounts. This could lead us to query whether, in Meltzoff's paradigm, what the demonstrator intends to fulfil in the failed attempts can be interpreted in different ways. Therefore, it is not clear whether the infants watching the experimenter's failed attempts in Meltzoff's (1995) study were imitating his intentional actions by producing the target acts.

1.4.3. Summary

To summarize, the behavioural re-enactment technique has put Meltzoff's Failed-Attempt paradigm in a difficult position. On the one hand, the technique gives precedence to an essential idea that imitation involves the ascription of goals or intentions by the imitator to the demonstrator. On the other hand, in the Failed-Attempt paradigm, such an idea is difficult to validate by directly testing the convergence between a child's and a demonstrator's behaviours. Assessing the behavioural correspondence is more straightforward when the child observes the target display. Then an alternative, as seen in Meltzoff's (1995) study, is to seek convergence by comparing how children behave after observing the failed attempts and how they behave after observing the successful target acts. However, it is unclear whether the demonstrator, from modelling the failed attempts, generates the essential elements that match the experience of watching the target display, despite the result that there is a convergence between the two cases with respect to the child's behaviour. Also, there is a lack of evidence that even two adult observers would agree with each other about what the demonstrator is taking to be intended in the failed-attempt display. Moreover, in the above discussion, both conceptually and methodologically, there are good grounds to challenge whether what the demonstrator is taking to be intended in Meltzoff's Failed-Attempt paradigm could be interpreted in only one way. By contrast, Tomasello's imitation paradigm for studying infants' understanding of intended actions is more conservative. The means and end results involved in both the intentional and unintentional cases are observable. Therefore, it is possible to measure infants' reproduction of the intentional acts of the model by testing the imitative match between infant's and model's behaviour in each case. Finally, Meltzoff (1995) intended to use infants' imitative response as a non-verbal measurement to pose the issue of understanding of intentions in preverbal infants. However, he seemed to ascribe too much significance to the assumption that imitation consists of interpreting and reproducing the intentional actions of others. As a result, it may risk overshooting the convergence criterion for all imitative behaviour, and underestimating the cases that may involve an advanced understanding of false belief, and verbal measures may be more appropriate.

1.5. Does infants' production of target acts in Meltzoff's Failed-Attempt paradigm entail possession of the concept of intention?

After looking at its relevance to imitation, let us now consider more closely what children's production of target acts in Meltzoff's Failed-Attempt means to their possession of the concept of intention. Is such a behavioural performance tantamount to saying that children re-enact what the model is intending to complete in the failed-attempt display?

Described in general terms, intentions are the purposes or goals that one can ascribe to the behaviours of others. For example, when a child sees someone pull the lid off a Pringles carton, the act of pulling at the lid may make sense to her in terms of the person trying to get the crisps inside the carton. If children do not construe the behaviour of others with the idea of intention, the actions that they are seeing will be merely a succession of physical movements coming about independently. In addition, intentions relating to one's behaviour can be manifest overtly or covertly. For example, someone is seen to pull the lid off a Pringles carton but finds that the inside is empty. This event may suggest to toddlers that the person is intending to get the crisps by way of pulling at the lid, even if they do not witness the sight of the crisps. In contrast, young infants may see such an event differently. Without seeing the crisps, they probably do not relate the person's act of pulling at the lid to the goal of getting the crisps. Paraphrased in psychological terms, to act intentionally is to perform two or more acts in sequence, with the first produced in order to accomplish the second or subsequent acts (Frye, 1991).

1.5.1. Action directed towards some future state of affairs

Anscombe's (1963) definition of intention has laid the basis for exploring infants' possession of the idea of intention in developmental research, including both means-end and imitation paradigms. In her influential analysis on the topic, intentions underlying one's acts are tested by a fundamental question: "Why are you doing X?" or "Why are you X-ing?". She says, "the future state of affairs mentioned in one's answer to the question must be such that we can understand the agent's thinking it will or may be brought about by the action about which he is being questioned" (p.35). An act produced by an individual is intentional if it is being done in relation to a certain future state of affairs, and what is being done is directed towards bringing about that future state of affairs. Both conditions have to be satisfied when one's action is characterised as an intentional action.

Anscombe's definition of intention provides a simple but straightforward conceptual framework. It is not only testable, but also useful, to examine whether the acts that others produce are intentional or unintentional (Frye, 1991). For example, a person hits a standing Pringles carton with their elbow by accident; the Pringles carton falls to the ground and its lid comes off; and then he grabs the crisps from the carton. Obviously, the person is not intending to get the crisps by hitting the Pringles with their elbow. What he is doing by accident is not directed towards causing the appearance of the crisps from the carton. Therefore, his behaviour in this case is more appropriately described as fortuitous success rather than intentional action.

The experimental situation created in Meltzoff's Failed-Attempt paradigm appears to borrow its legitimacy from Anscombe's definition. Although the action that the model is carrying out is not fulfilled, it can qualify as an intentional action as long as it is being performed to cause the future state of affairs that the model is attempting to attain. It is important to note that one's action is not necessarily qualified as intentional as a result of the fulfilment of the future state of affairs. To put it in another way, an act is intentional if it consists of a goal and a means directed towards bringing about that goal. Even though the goal is not achieved, an unfulfilled act can be counted as intentional provided that one is performing it to carry out the goal. Moreover, people do not always have to learn about what others are intending to do by relating their intentions to explicitly fulfilled outcomes. However, how sensible is it that unfulfilled actions could be taken into account as a scenario for demonstrating one's intentions?

In Meltzoff's (1995) study, the behavioural re-enactment technique and failed-attempt imitation tasks combined to investigate infants' possession of the idea of intention. Meltzoff assumed that infants' non-verbal construction or interpretative structure of events could be induced through their behavioural tendency to imitate novel acts on objects in the behavioural re-enactment procedure (Meltzoff, 1995). However, the infants' production of the target acts in the failed-attempt tasks can be assumed to reveal what they learn about the model's intentions providing that the demonstrated failed attempts can only be interpreted as leading to these target acts. On the other hand, the critical information necessary for the infants' production of target acts when observing the failed-attempt display must be assumed to converge with that when observing the target display. Their performance on target acts after watching the failed attempts can then be interpreted in terms of re-enacting the demonstrator's intended acts. To put it more simply, the actor models the failed act "A" to produce the goal "B". Although "B" is unfulfilled and not observable, it has to be the only goal that the actor is intending to achieve by way of modelling "A". That is, the goal intended by "A" in modelling a person's failed attempt has to be exclusively B, and can not be interpreted in any way other than "B". If not so, the person's production of "B" after watching the failed act "A" will not justify his re-enacting the model's intended goal.

These assumptions have yet to be examined in Meltzoff's Failed-Attempt paradigm. It may be questioned whether the end results assumed to underlie the scripted failed attempts can only be interpreted as the target acts involved in the target display. How faithfully can the demonstrator present his intended goals, which are unobservable, to children by way of enacting Meltzoff's Failed-Attempt script?

From my point of view, there are reasons to believe that the ends assumed to underlie the demonstrator's intended acts in Meltzoff's Failed-Attempt script may be assigned to other end states instead of the target acts. First, children must have seen adults in daily life cope with more challenging and complex activities compared to the failed-attempt tasks in Meltzoff's (1995) study. Thus, the intentions accounting for the demonstrator's production of the failed attempts may be interpreted as his intending to miss the target acts as a result of the production of the failed attempts. If the demonstrator did not fail to consummate the target acts by intention, it would be difficult to explain why he is capable of completing the acts that he is intending to attain but leaves this intention unfulfilled. The incongruity of the failed-attempt display may be diminished if there are external events accounting for the demonstrator's failure in some way. For example, some accident prevents the actor from producing the target acts when he is trying to bring about such acts, and, as a consequence, he produces the unsuccessful acts by accident. In brief, the demonstrator in the failed-attempt display has the potential to present both the intentionally and accidentally failed attempts. That is, in Meltzoff's Failed-Attempt paradigm, there is no clue whether the failure to complete the target acts ought to be ascribed to the demonstrator's "true" purposes (intentionally failed attempts) or external events (accidentally failed attempts). Therefore, it is possible that children after seeing the failed-attempt display may selectively reproduce the specific aspects of the modelling that they interpret as the demonstrator's intended acts based on their preferences and abilities (Moerk, 1989). Children may copy the failed attempts literally, for example, if their interpretation is that the demonstrator failed to accomplish the target acts on purpose. Or, they perhaps prefer to create the target acts, just because they interpret that the demonstrator misses the goals by accident. Therefore, the assumptions considered above, on which Meltzoff's Failed-Attempt paradigm is based, have to be seriously challenged.

1.5.2. Planning and intention

Bratman (1987) has maintained that the central problem for a theory of intention is to provide reasonable accounts of how actions and mental states are related to a common-sense psychological framework. According to Bratman (1987), intentions are typically part of larger plans, and these plans are necessary for co-ordinating one's everyday activities in the same way, as intentions are elements in co-ordinating plans. Moreover, one can only co-ordinate one's activities if intentions are put into a larger plan that is internally consistent. That is, a good co-ordinating plan needs to satisfy consistency constraints and means-end coherence. Intentions consisting of a plan need to be strongly consistent when the entire plan is successfully executed. A plan needs to be filled in with sub-plans concerning the means and a relatively specific course of action, at least as extensive as one believes these sub-plans are now required for what he plans to do (Bratman, 1987). For example, it is not sensible that one is intending to get some crisps from a Pringles carton at the same time as he believes that there are no crisps at all in the carton (that is, a false belief). In this circumstance, one's action plan is not consistent with one's current belief. That is, there is an incongruity between the belief and what one is intending to carry out. As a consequence, it will be difficult to carry out intentions, which serve as a coordinating part of the entire action plan.

Davidson (1985) gave another relevant definition. In Davidson's desire-belief framework, intention underlying one's action is considered as an event in which the action one produced is related to one's mental states such as desires and beliefs. Thus, it is not possible to identify intention underlying one's action without recognising and analysing one's desires and beliefs. That is, the idea of intention presupposes a possession of the concept of belief. One's intention to produce an action is closely related to one's belief at the same time that the action will be actually produced; this is called an action belief (Moses, 1993). For example, one is intending to get the crisps in a Pringles carton at the same time as he believes they are in the box. Even if the carton is empty in reality, his belief renders the action of opening the carton intentional. Furthermore, the unfulfilled result (that is, getting no crisps) does not affect the action as intentional. On the other hand, for example, while believing that the carton is empty, one is intending to grab the crisps from the carton. Such behaviour can hardly qualify as an intentional action, because the false belief one holds and the intention underlying one's act are not consistent. Instead, it may more appropriately be described as a mistake.

Let us turn to the failed-attempt tasks included in Meltzoff's (1995) study. First, in the target display, the demonstrator intends to perform the target acts on the objects and obviously succeeds in producing them. As there is no explicit information about whether the target acts might have been elicited by accident or mistake, according to Davidson's (1985) framework, the demonstrator's production of these acts should have been accompanied by a positive belief that he will carry them out. In contrast, the demonstrator in the failed-attempt display intends to perform the same acts, but fails to bring them about. For the failed attempts to be recognised as intentional acts directed towards producing the target acts, there is a demand that the demonstrator believe that he will carry out the target acts at the same time as he fails to elicit them. However, if he believes that he will accomplish the target acts, he should be successful in eliciting them as he does in the target display. It does not appear to be the case that he holds a false belief that he will miss the target acts as a result of the failure to bring about them. It is probably sensible that he believes but fails because of some accidents, but there is no clue whether the demonstrator fails to do so by accident in Meltzoff's Failed-Attempt script. That is, the kind of intention entailed in Meltzoff's Failed-Attempt paradigm should involve the demonstrator's inherent belief at the same time as he enacts the script. Therefore, an alternative to Meltzoff's (1995) interpretation could be that the ability required for the failed-attempt tasks involves an understanding of one's intentional actions that presuppose an understanding of one's action belief. The extent to which infants' production of target acts in Meltzoff's paradigm refers to an understanding of the intentional actions of others thus remains an open question.

1.5.3. Prior intention and intention-in-action

Searle (1983) has provided a causal account of the relations between intention and action. He draws a distinction between two types of intention: intention-in-action and prior intention. Intention-in-action is the intentional component that causes one's bodily movement to be an intentional action. A bodily movement without intention-in-action is not an action. That is, intention-in-action and the bodily movement occurring together comprise the action under Searle's (1983) definition. In contrast to intention-in-action that immediately causes only one's bodily movement, prior intention is the kind of intention that one has prior to execution of the entire action. Analogous to what planning theory refers to as beliefs and desires (Bratman, 1987; Davidson, 1983), prior intention relates to the future state of affairs that one is planning or attempting to carry out. In some ways, prior intention presents the psychological mode to which the action that one is performing is related.

Not all intentional actions constitute prior intentions, but intentional actions lacking of prior intentions can not be called planned intentional actions. One's action can only be described as "attempted", "failed", or "successful" on the basis of an understanding of one's prior intention. Thus, one's failed attempt or intended action has to justify a planned intentional action, for one's prior intention forms the necessary psychological mode that renders one's action "failed" or "intended". In other words, an unfulfilled action qualifies as a failed attempt provided that the action is directed towards a certain future state of affairs entailed in the prior intention. For example, one is intending to get the crisps in the Pringles carton, but finds the carton is empty when pulling the lid off. Such an event can be characterised as one's failed attempt, because he has some plan to get the crisps (prior intention) and that causes him to pick up the Pringles carton and perform the act of intentionally pulling the lid off the carton (intention-in-action). More importantly, he does not know the carton is empty in advance. He should have a positive belief that there are crisps in the carton at the same time as pulling the lid. So the intention-in-action causing the bodily movement is directly caused by the prior intention.

As suggested by Meltzoff (1995) himself, the results obtained in a Failed-Attempt paradigm may be interpreted conservatively as infants reading the goals of the actions within a psychological framework, if not in terms of reading a person's intentions. Could 18-month-olds' production of target acts, under Searle's (1983) definition, be described as an understanding of intention-in-action, if not that of prior intention? Being sympathetic to the proposal, it infers that 18-month-old infants may not possess a deep understanding of the prior intention of the demonstrator who has deliberately produced the failed attempt scripted in advance. On the contrary, they may simply understand the intention-in-action by which the demonstrator's purposeful execution of the particular bodily movement is immediately caused (Meltzoff, 1995). However, one's bodily movement produced without prior intention or only by intention-in-action can hardly be qualified as the kind of failed attempt with which Meltzoff's Failed-Attempt paradigm is concerned. Why?

First, let us borrow Anscombe's checking question "Why are you X-ing?" to ask "Why is the demonstrator producing the unsuccessful acts?" in the Failed-Attempt paradigm. The answer evidently could not be that the demonstrator intends to accomplish the target acts. If he has had a plan for carrying them out prior to the execution, he should not have failed when making an effort to bring them about unless the failure was accidental. In fact, there are no identifiable accidents accounting for the demonstrator's failure to complete the target acts. Therefore, it is not clear whether the failure could be interpreted as the kind of failed attempt involving the prior intention of producing the target acts. On the contrary, the demonstrator during demonstration of the failed attempts appears to have the prior intention of producing the failed attempts rather than the target acts, otherwise he would not have missed the target acts in three unsuccessful attempts. In this regard, it might be sensible to characterise the failed attempts demonstrated as intentional actions directed towards producing failed acts. That is, the prior intention of producing the failed attempts, but not that of producing the target acts, directly caused the performance of the failed act.

Second, an unplanned intentional action refers to an action that consists of an intention-in-action and bodily movement and is produced without prior intention. In contrast, a failed effort or attempt refers to an action that is not fulfilled and is produced in the presence of both prior intention and intention-in-action (Searle, 1983; Astington, 1991). As the kind of failed attempt concerned in Meltzoff's Failed-Attempt paradigm is the intended action, the demonstrated failed attempts ought not to be the unplanned intentional actions. Instead, what the adult demonstrates for children ought theoretically to be the unfulfilled but planned intentional actions. There might be a possibility that infants in the Failed-Attempt paradigm learn little about the demonstrator's prior intentions of performing the target acts, but they are able to produce these acts from an understanding that the bodily movements and the intention-in-actions constituting the actions occur together. If this is the case, it would imply that children interpret the failed attempts as unplanned intentional actions, rather than planned or intended actions. As unplanned intentional actions can be performed without prior intentions, it is the case that the effortful way in which the adult demonstrates the failed attempts appears to be unnecessary. This is obviously not what Meltzoff's Failed-Attempt paradigm is intended to represent. If the paradigm is aimed at serving as a basis for infants' understanding of intention-in-action, displaying a range of bodily movements should be sufficient. However, the way in which the failed attempts are scripted in Meltzoff's paradigm presupposes the prior intention of the demonstrator, so that they can be interpreted as intended actions.

Finally, as the kind of failed attempt concerned here is a planned intentional action, it can hardly be captured by looking into only the intention-in-action or prior intention. The intention-in-action and prior intention constituting a planned intentional action are causally self-referential (Searle, 1983). A planned failed attempt can only be recognised when both of them are present. Take, for example, the dumbbell used in Meltzoff's (1995) study. In the failed-attempt display, the demonstrator slips one of his hands off the dumbbell while moving its two ends outward so that the dumbbell does not come apart. Let us assume that the demonstrator has the prior intention of pulling the dumbbell apart. Why does he fail to fulfil the prior intention? If the failure to pull the dumbbell apart is not caused by accident, it will not be sensible to interpret the unfulfilled action in terms of the intention-in-action that concurs with the bodily movement of pulling the dumbbell apart. If the failure is intentionally caused, the demonstrator should possess the prior intention of moving the dumbbell outward without instead pulling it out. In other words, the unfulfilled action in this case will refer to the intention-in-action that concurs with the same force and movement used to slip one hand off the dumbbell without pulling it apart. In the above analysis, it is important to emphasize that the intention-in-action in a failed attempt, either intentionally or accidentally caused, is caused by the prior intention, because the prior intention and intention-in-action are causally self-referential in a planned intended action.

However, in particular circumstances, the prior intention may be incongruous with the intention-in-action. Following the foregoing example, an actor has the prior intention of pulling the dumbbell outward but without splitting it into two halves, while he uses too much force so as to pull the dumbbell apart by accident. If an observer has no clue of the prior intention in advance, he is very likely to interpret such an action as the actor having the intention of pulling the dumbbell apart. The actor actually makes a mistake because he does not exert proper force on the dumbbell. In a similar way, the demonstrator in Meltzoff's Failed-Attempt paradigm also has to use proper force so as not to pull the dumbbell apart by accident. He can not apply the force used to complete the target acts to the production of the failed attempts. At some point, the force used to perform the failed attempts is a virtual force. Even if it looks so nearly true, it cannot be identical to the force actually used to produce the target acts. In this sense, we have reason to believe that the intention-in-actions concurring with the demonstrator's bodily movements when generating the failed attempts must differ from those concurring with his movements when successfully producing the target acts. Unless the demonstration of the failed attempts ensures the same force used to generate the successful target acts, whether the demonstrator has the prior intention of carrying out the target acts can be seriously challenged. If the demonstrator's failed attempts do not presuppose the prior intention of carrying out the target acts, the failed attempts could possibly be interpreted as intentionally failed. Therefore, Meltzoff's (1995) suggestion that infants' production of target acts in the Failed-Attempt paradigm may involve an understanding of intention-in action in isolation from prior intention, needs to be reconsidered.

1.5.4. Summary

To sum up, Meltzoff's Failed-Attempt paradigm is intended to provide an experimental situation in which infants' possession of the concept of intention can be tested by investigating their behavioural construction of others' failed attempts. Conceptually, a person's intentions can be manifest by looking into his failed attempts, as failed attempts are unfulfilled but planned intentional actions (Astington, 1991; Searle, 1983). However, technically, there are difficulties putting the notion into operation. First, the manner in which Meltzoff's Failed-Attempt format is scripted can not ensure that the goals of the demonstrator's failed attempts will not be interpreted as producing any acts other than the target acts. Second, the paradigm is unable to offer a causal explanation as to why the actor has a plan to carry out the target acts but fails when executing the plan. Does he fail to produce the target acts by accident, or by intention? There is a lack of information in the scenario pointing out the cause of the failure to consummate the end results. Third, there is an inherent limitation in the Failed-Attempt paradigm. The force that the demonstrator uses to demonstrate the failed acts is not identical to that required for producing the target acts. This is an unusual way to code a person's failed efforts. It can be questioned why the actor does not choose proper means as he is intending to accomplish the target acts. Is he making useless efforts on purpose? Therefore, as Meltzoff's Failed-Attempt paradigm can not ensure a congruity between the demonstrator's prior intention and intention-in-action in terms of producing the target acts, it is not even justified to conclude that children's production of target acts in this paradigm entails a minimum understanding of the intention-in-actions of the demonstrator's bodily movements when performing the failed acts.

1.6. Can infants' production of target acts in Meltzoff's Failed-Attempt paradigm be recognised as other forms of social learning?

Although it is questionable whether the infants' production of the target acts in the failed-attempt tasks in Meltzoff's (1995) study may be regarded as imitation by the definitions considered above, it might be helpful to examine whether it could be recognised as other forms of social learning. Several types of non-imitative learning have been identified in the animal kingdom (Galef, 1988; Heyes, 1996; Thorpe, 1963; Whiten & Ham, 1992). Tomasello (1996) points out three types of social learning which often lead to a behavioural correspondence between an observer and a model but are distinct from the phenomenon of imitation. This distinction is based on the role of the differing aspects of the social information in the acquisition of a new behaviour. They are: local or stimulus enhancement, emulation learning, and mimicking.

1.6.1. Local or stimulus enhancement

In literature on social learning in animals, imitation was distinguished from behavioural reproduction resembling imitative match but arising from local or stimulus enhancement effect (Thorpe, 1963; Whiten & Ham, 1992; Tomasello, 1996). It specifies that such a behavioural reproduction is contingent on occasions when observation of the manipulations of others draws an individual's attention to particular environmental locations ("local enhancement") or relevant parts of objects ("stimulus enhancement"), and thus the individual learns to adjust to specific environmental features without learning about the observed actions (Whiten & Ham, 1992; also see Tomasello, 1996, for a definition). The fundamental difference between imitation and stimulus enhancement is that in stimulus enhancement an individual orients himself to a specific part of an object highlighted by the behaviour of others, while in imitation he reproduces the same behaviour of others as a result of learning something about its intrinsic form, such as intentional relation (Tomasello, 1996; Barresi & Moore, 1996) and metarepresentation (Whiten & Ham, 1992) (see Section 1.3 for a discussion).

In Meltzoff's (1995) study, an adult-manipulation control group was designed to control the possibility that infants might tend to play with the objects if they see the adult manipulate them, and that this alone would probably induce them to produce the target acts. In this control, the experimenter acted at the relevant parts of the test objects for the same length of time as in the demonstration groups, but without producing the target acts or the failed attempts. For example, the experimenter picked up and moved the plastic square vertically along the sides of the wooden base. Thus, he was not seen even to attempt to put the square over the base, and the target act of aligning the hole in the centre of the square over the dowel was not observed. The adult-manipulation control should be sufficient to assess whether the child's performance on target acts was based on local enhancement.

However, in the demonstration (intention or failed-attempt) group, the experimenter did not merely handle the relevant parts of the objects, but deliberately moved them so that they were contiguous with each other. For example, the beads fell to the table beside the cylinder without touching it in the adult-manipulation control, whereas the beads crossed the upper rim of the cylinder each time the experimenter attempted but failed to deposit them in the cylinder. The infants watching the failed attempts put the beads into the cylinder more often than they did in the adult-manipulation control, perhaps because they saw the beads and the cylinder touch each other in the experimenter's failed attempts. It is thus probable that the infants may be attracted to the contiguity of the relevant parts of the objects from observing the experimenter's failed attempts and that may act as stimulus enhancement processes for the infants' performance on the target acts. However, this kind of stimulus enhancement has not been ruled out in Meltzoff's (1995) study.

1.6.2. Emulation learning

Primatologists have described two types of emulation learning in which an observer reproduces the end result of a demonstrator's behaviour instead of copying the behaviour that brought about the end result. According to Tomasello (1990, 1996), the term "emulation learning" refers to situations where an individual during observation learns something about the changes of state in the environment (e.g., objects) as a result of the behaviour of the model, but not about the model's behaviour or behavioural strategy. For example, having seen a model use a hammer to crack open a nut, the observer might seek to reproduce the same result through his or her own behavioural strategy, such as biting into the nut to open it. Under such circumstances, the observer could learn little about the specific actions performed by the model, but produce the effect of these observed acts by learning about the dynamic properties of the nut (e.g., its solidity). In emulation learning, an observer's behaviour might involve reproducing the end result of the object that the model intended to achieve. However, this does not always mean that he has understood the goal or intention of the model.

Whereas Tomasello (1990, 1996) emphasised that the observer's reproduction of the end result in emulation learning involves learning neither the model's behaviour nor even the model's goal, Whiten and Ham (1992) suggested that the observer might reproduce the end result via his or her own method with an understanding that the model held a goal towards such an outcome. Thus, Whiten and Ham distinguished a special type of emulation learning called goal emulation from Tomasello's original definition. In goal emulation, an observer learns that a modelled action sequence was designed to produce a particular goal of the model, and devises his or her own method to achieve that goal by producing the end result of the model's behaviour. For example, having seen a model use a hammer to open a nut but without success, the observer might learn that the final act in the modelled action sequence is to open the nut, and reproduce the end result using his or her own method (e.g., biting into the nut or using a stone to crack open it).

In addition to these two types of emulation learning, a potential effect of emulation learning might take place when an observer is exposed to the particular end result of a model's actions but without seeing the model's actions. It is possible that the observer could derive action information required for reproducing the end result by himself or herself from seeing only the end result of the model's acts. Under such circumstances, exposure to the end result of the model's actions might elicit an effect of emulation learning similar to that due to exposure to the model's actions. For example, the individual might learn to crack open nuts with a stone from observing two halves of the cracked ones without seeing a model do so beforehand. That is, in any of the above mentioned types of emulation learning, the individual devises his or her own behavioural strategy to achieve the end result that he or she has learnt during observation of the demonstration.

Even if, in emulation learning, an individual overlooks the behaviour of the model and is attempting to replicate the outcomes involved in the modelling with his or her own devised method, this does not imply that emulation involves a less intelligent learning process than imitation. Instead, under some circumstances, emulation is a more adaptive and creative strategy than imitation, which by contrast is a more social one (Tomasello, 1999). For example, knowing the affordances or typical uses of objects allows children to incorporate this knowledge into their own attempts to find out how novel objects could be used to fulfil the same role. Similar to Tomasello's characterisation of emulation, Whiten and Custance (1996) referred to a cognitive ability to reproduce the outcome by intelligently selecting and extracting useful information from the demonstration. Whereas Tomasello (1996) has attempted to exclude emulation from phenomenon of imitation, Whiten suggested that emulation can be specified as a cruder level of imitation on a continuum of copying fidelity and it may not be necessary to draw a clear-cut distinction between imitation and emulation (Whiten & Ham, 1992; Whiten & Custance, 1996). At some point and in some circumstances, emulation learning presents an advanced cognitive strategy compared to imitation. For example, a model attempted to achieve a particular goal in the task but used an invalid or inefficient method. If the individual learns from his or her observation the affordances or functional relations in the task as result of emulation learning, the individual might adopt a valid or more efficient strategy devised by himself or herself without copying the model's actual actions. In contrast, in imitative learning, the individual is expected to precisely copy the model's inefficient or invalid method in the task completion.

The notion of emulation learning raises several questions about the interpretation of the child's production of target acts in Meltzoff's failed-attempt tasks. Could the infants understand nothing about the demonstrator's behaviour, but only the dynamic affordances of the objects that they might not have discovered in the control conditions? Or could the infants fail to copy the demonstrator's failed attempts, because the results they themselves found out during observation were more attractive? Or perhaps the affordances of the objects that the infants learned as a result of the failed actions coincided with the target acts that the demonstrator was taking to be intended in the failed-attempt tasks?

Meltzoff (1988 b) used an adult-manipulation control to provide a basis for emulation learning in an early study of infant deferred imitation. In this control, the experimenter presented the same consequences of the objects as in the imitation group but without demonstrating the target acts. For example, one of the objects was a box with a recessed button on its top surface, as well as a hidden beeper underneath the button. Whereas the experimenter pushed the button to activate the beeper inside the box in the imitation group, he secretly triggered the beeping via a hidden switch when handling the box in the adult-manipulation control. The results showed that the 9-month-old infants exposed to the end results of the target acts did not produce the target acts as frequently as they did when observing the experimenter demonstrate these acts. However, no control was used to elicit emulation learning in Meltzoff's (1995) study of 18-month-olds' imitation in failed-attempt tasks. As emulation has been thought to be a creative and intelligent behavioural strategy under appropriate circumstances (Tomasello, 1996; Whiten & Custance, 1996; Whiten & Ham, 1992), it is quite probable that 18-month-olds may be more capable than 9-month-olds of using what they learn about the consequences of the target acts to recreate the entire actions. Therefore, the demonstration (intention or failed attempt) condition used in Meltzoff's (1995) study was more likely to involve emulation learning than the adult-manipulation control, for the experimenter in the failed-attempt display was seen to attempt to bring about the target acts but not to succeed and that seemed to be sufficient to instigate infants to explore what dynamic affordances of the objects are likely to elicit.

On the other hand, in Meltzoff's (1995) study, the pattern of the object movements characterising the failed attempts was similar and relevant to that presented in the target display as compared with the acts included in the adult-manipulation control. Take, for example, the plastic square and the dowel (see appendix): the square was moved along the sides of the wooden base in a vertical position in the adult-manipulation control. In contrast, in the failed-attempt demonstration, the hole of the square overshot the dowel as a result of the square sloping down on the base almost horizontally. Presumably that movement resembled and had a relevance to the intended target act—the hole was aligned over the dowel as a result of the square lying on the base horizontally. Likewise, for example, the dumbbell (see appendix): the experimenter pushed its two ends inward in the adult-manipulation control, while he exhibited the action of moving his hands outward in both the target and failed-attempt displays. Thus, even if the infants did not learn to produce the target acts through stimulus enhancement by observing the demonstrated failed attempts, it is quite probable that they may have learned the dynamic affordances of the objects from seeing the movements featuring the failed attempts and that may have led to their performance on the target acts. Similarly, it is possible that the infants learnt simply the final configurations of the objects by observing the modelled failed attempts. In other words, observation of the demonstrated failed attempts might have evoked the infants' knowledge of the causal structure of the test materials—what end points the sequence of movements could lead to—and thereby resulted in the infants' producing the target acts more frequently than they did by watching the adult-manipulation control acts that were dissimilar and irrelevant to the target acts. If this were the case, Meltzoff's (1995) Failed-Attempt paradigm would seem to provide a basis for emulation learning rather than imitation or re-enactment of the intentional actions of others.

1.6.3. Mimicking

Tomasello (1996) characterised mimicking as reproducing the bodily movements of others on the sensory-motor level. He emphasised that, in mimicking, an individual merely learns the extrinsic form of the behaviour observed without understanding what effect it has on the environment (emulation learning) or the intentional significance of how the behaviour is designed to produce that effect by the model (imitative learning).

The infants' production of the target acts in Meltzoff's (1995) Failed-Attempt paradigm obviously was not mimicking, because they reproduced relatively few of the failed attempts that they had actually observed. On the contrary, their performance indicated that they learned about something more than they had perceived during observation of the failed attempts. However, it would not be at all clear whether the infants were mimicking the experimenter even if they did replicate the form of the failed attempts. As discussed in Sections 1.4.1 and 1.4.2, there seem to be enormous difficulties specifying the phenomenon of imitation in Meltzoff's Failed-Attempt paradigm in terms of behavioural convergence or understanding of intentionality. While Meltzoff (1995) appreciated that the infants did not copy the demonstrator's behaviour literally in the failed-attempt imitation tasks, the previous discussion has given rise to a possibility that they might copy the failed attempts but with an advanced understanding of something about the demonstrator's first person experience in the execution of the scenario for the failed attempts. Moreover, the infants elicited relatively few of the target acts and the scripted failed attempts on their own in the baseline and adult-manipulation controls. According to Thorpe's (1963) definition of imitation, would the reproduction of the failed attempts observed not be more appropriately characterised as copying "a novel or otherwise improbable act" compared to that of the target acts?

1.6.4. Summary

Basically, Meltzoff's Failed-Attempt paradigm may tend to provide infants with a situation sufficient for emulation learning. The foregoing discussion suggests that the pattern of the movements produced when demonstrating the failed attempts resembles the scheme for bringing about the target acts, and infants might learn about the target-relevant affordances of the objects by watching the demonstrated failed attempts. In addition, the contiguity of the relevant parts of the objects that the experimenter manipulated in the failed-attempt display may be sufficient to elicit a potential stimulus enhancement effect. Although it has been questioned whether there is a qualitative distinction between imitation and emulation (Whiten & Ham, 1992; Whiten & Custance, 1996), an essential concern about Meltzoff's Failed-Attempt paradigm is whether it is sufficient to provide a basis for infants' learning of the intrinsic form of others' behaviour through the behavioural re-enactment technique. Therefore, it is necessary to include additional controls to compare the effects of emulation learning and stimulus enhancement with respect to Meltzoff's Failed-Attempt paradigm.

1.7. Plan of the study

Although Meltzoff (1995) pioneered a paradigm for studying the "theory-of-mind" questions in preverbal infants with the assistance of object-related imitation tasks, the social significance he assigned to the behavioural re-enactment procedure needs carefully checking. More important, there have been a few studies attempting to follow Meltzoff's Failed-Attempt paradigm (Aldridge, Stone, Sweeney, & Bower, 2000; Bellagamba & Tomasello, 1999; Call & Carpenter, 2000), however, there are virtually no studies aimed at assessing the adequacy of such a paradigm. The goals of the current studies are thus to explore the various methodological aspects of the Failed-Attempt paradigm.

Experiment 1 included 19-month-old infants and replicated three conditions of Meltzoff's (1995) study—Demonstration (target), Demonstration (intention or failed attempt), and Control (adult manipulation). In addition, a novel condition of Emulation Learning was designed as a control for the possibility that infants learned some affordances of objects during observation of the experimenter's failed attempts and that led to their production of the target acts. In this novel condition, children were exposed to the initial and end states of the target display (e.g., the dumbbell split into two halves) but without watching the experimenter's manipulations of the test objects (by using a screen) and then were invited to make the end results occur on their own. The critical question was whether children engaging in a kind of emulation process would produce the target acts as frequently as they did by observing the target or failed-attempt display.

Experiment 2 included 17-month-old infants and extended the design of Experiment 1 with the replacement of a new condition of Spatial Contiguity for the adult-manipulation control. The Spatial-Contiguity condition examined whether children's performance on target acts after watching the failed-attempt display was based on observation of the particular transitional states that the individual parts of the objects were contiguous to each other (e.g., the square crossing the dowel, or the beads touching the rim of the cylinder). In this control condition, the experimenter merely introduced such transitional states in the demonstration without highlighting all of the dynamic properties of the objects and thus produced neither target acts nor failed attempts. Children's production of target acts after watching the spatia-contiguity display was assessed in terms of a stimulus enhancement effect from observing the individual parts of the objects adjoining each other.

In Experiments 1 and 2, the effect of the failed-attempt display on children's production of target acts was more refined with the inclusion of two further experimental controls. These two studies provided an appropriate evaluation of Meltzoff's Failed-Attempt paradigm by comparing the effects of emulation learning and stimulus enhancement. Also, the data established to what extent children observing the failed-attempt display would produce the target acts with an understanding of the intended consequences of the demonstrator. The data might give rise to a potential situation in which children observing the failed-attempt display brought about the target acts as frequently as they did in the Emulation-Learning and Spatial-Closeness controls, while children in these three groups produced the target acts less often than they did after watching the target display. In that case, children's performance on target acts obtained using Meltzoff's Failed-Attempt paradigm would be interpreted as a stimulus enhancement or emulation effect. However, what if that is due to their inability to read the demonstrator's intended actions?

Experiment 3 replicated the design of Experiment 1, while two other samples of 28- and 40-month-old children participated in this study. As considered above, in case there is a chance that the inability to read intended acts would account for 19- and 17-month-olds' performance on the target acts after watching the failed-attempt display in Experiments 1 and 2, would older children in the same circumstance be more successful in producing the target acts? That is, we have reason to believe that they ought to be more capable of understanding the intentions of others than 19- and 17-month-olds. Moreover, is there a possibility that older children are not as likely to produce the target acts after watching the failed-attempt demonstration as they are after watching the target demonstration? If so, would it imply that they were incapable of decoding the target acts underlying the failed attempts? Or, might the failed attempts demonstrated be insufficient to manifest the target acts as intended?

Would older and younger children interpret the failed-attempt scenario in different ways? This experiment posed straightforwardly the methodological question of whether the demonstrator in Meltzoff's Failed-Attempt format can be comfortably justified in intending to achieve the target acts.

In Meltzoff's script of the failed-attempt display, the demonstrator refrained from showing linguistic or facial expressions of failure. However, as pointed out in 1.4 of the present chapter, were it not for accidental events accounting for the failure to consummate the target acts, it might be the case that the demonstrator failed to produce the target acts on purpose. Experiment 4 incorporated two modifications into Meltzoff's Failed-Attempt format. These modifications were based on the imitation paradigm of Tomasello and his colleagues (Tomasello & Barton, 1994; Carpenter, Akhtar, & Tomasello, 1998). To ensure that children were not simply responding to the physical events, independent of the experimenter's intended results, the demonstrated failed attempts were vocally marked as accidentally failed ("Oops!") in one version and intentionally failed ("There!") in the other. The question asked was whether children would be more successful in generating the target acts with the diminution of the likelihood that the demonstrator failed to accomplish these acts on purpose. On the other hand, it is interesting to see how children would respond to the demonstration of the intentionally failed attempts. Would they be more likely to copy the form of the failed acts?

In summary, the goals of the study are:

1. Overall, the study is aimed at examining the adequacy of Meltzoff's Failed-Attempt paradigm as a basis for investigating the concept of intention in preverbal children.

2. Experiments 1 and 2 tested and established to what extent children's production of target acts in Meltzoff's Failed-Attempt paradigm may belong to other categories of non-imitative learning by ruling out the possibilities of stimulus enhancement and emulation learning effects.

3. Experiments 3 and 4 served as possible modifications of Meltzoff's format so that the question of children's understanding of intentional actions may be appropriately posed based on object-related imitation tasks.

Chapter Two

Imitating failed attempts:
Reading intentions vs. emulation learning

Experiment 1

2.1. Introduction

Theoretically, there are grounds for supporting imitation as a potential paradigm for exploring the concept of intention in infants. In the foregoing chapter, the review of definitions of imitation indicated that most theorists have appreciated that a putative psychological process involving transfer of information about the mental states of others underlies the phenomenon of imitation. This process, for example, has been characterised as mindreading (Whiten & Brown, 1999), or understanding of intentional relations (Tomasello, 1996). In addition, it has been emphasised that, in identifying imitation, phenomena involving behavioural correspondence but without transfer of inputs from the model by the observer should be assigned to other categories of non-imitative learning. Although there are various types of imitation and the critical processes that they encompass may be different, the current study is concerned with the type of imitation involving acts on objects. In this regard, the issue of infants' understanding of intentional actions can benefit in several ways from the study of imitation of acts on objects. First, toward the end of the first year of life, the emergence of early social behaviours involving objects (e.g., visual joint attention) converges with infants' ability to imitate object-related behaviours. The evidence that infants are capable of imitating novel acts on objects comes at around 9 months of age (Meltzoff, 1988b), and that appears to be in keeping with the age of onset for joint attention and social referencing at around 10-12 months (Corkum & Moore, 1995). Furthermore, imitation of actions on objects, like early social behaviours involving objects, involves a triadic situation and requires that infants follow the adult's attention and intentions toward changes of state of the objects

(Carpenter, Nagell, & Tomasello, 1998). For such reasons, imitation may be considered as a basis for investigating infant social understanding.

Methodologically, however, there are some limitations on the use of object-related tasks for probing imitation and its relation to infants' possession of mental state concepts. The empirical problem concerns whether the critical input infants receive from observing the demonstration is something they learn about the behaviour of others or the dynamic properties of objects based on their own discovery. The latter case is what Tomasello (1996) referred to as "learning about the environment", such as stimulus enhancement and emulation learning. Nevertheless, only a few studies have attempted to deal with such possibilities with the inclusion of appropriate control groups (e.g., Meltzoff, 1988a, b, 1995). For example, in the study of Meltzoff (1988b), the baseline control provided a basis for the spontaneous elicitation of the demonstrated acts, the adult-touching control for the possibility of stimulus enhancement, and the adult-manipulation control for the possibility of emulation learning. Imitation of object-related acts is thus identified by ruling out the possible effects of other forms of non-imitative learning. Another empirical query concerns whether infants replicate a modelled action because it has been observed with an accompanying salient effect that they find interesting. In most developmental studies, reproduction of modelled control acts is not considered a part of analyses of imitation, perhaps because the test question simply asks whether infants in the control groups trigger modelled target acts on their own. On the contrary, even if they produce relatively few modelled target acts under control groups of various types, it is quite probable that they recreate relatively few observed control acts, such as imitating the adult's act of reaching out and touching the specific location of an object. Furthermore, it might be the case that infants do not imitate modelled control acts for they cannot find out attractive outcomes themselves. Under such circumstances, their imitation of actions on objects would be confined to those acts leading to interesting results. In other words, it is possible that infants will be unlikely to imitate modelled control acts because whilst performing such acts it is difficult to highlight interesting outcomes, as compared with modelled target acts.

The affordance theory (Gibson, 1979) maintains that almost all environmental givens entail affordances of various kinds, hence it is unlikely that infants learn about object-related acts of others in isolation from the absorption of environmental endowments. Palmer (1989) investigated infants' exploration of a range of objects varying systematically in action-relevant properties such as rigidity, weight, texture, and noise. She found that mouthing was specific to weight changes; texture changes resulted in more switching; and sound changes elicited more waving, switching, and mouthing acts. In addition, the spongy and rubber toys were squeezed more than the rigid materials (see also Gibson & Walker, 1984), and the wheeled toys were scooted more than the other objects. Although the infants in the study did not watch the adult's manipulations of objects, they acted distinctly on objects according to their action-relevant affordances.

The effect of modelling on infants' exploration of objects has also been demonstrated. For example, Hofsten and Siddiqui (1993) investigated 6- and 12-month-old infants' exploration of objects of differing properties by observing the mother manipulate them. The testing procedure consisted of three phases: in the baseline phase, the mother simply handed the objects to her child one at a time without demonstrating any manipulation; in the modelling phase, the mother was asked to produce a specific act on each of the objects before they were presented to the child; and in the post-test phase, the mother again placed the objects in front of the child without manipulating them. The results showed that the infants selectively reproduced the actions modelled by the mother according to the objects used. For example, in the modelling phase, the infants rubbed the doll more frequently than they rubbed the rattle, while they banged the rattle more often than they banged the doll. That is, the infants repeated more of the modelled acts, which were appropriate to the properties of the objects. Hofsten et al. suggested that the mother's actions serve as a reference for infants' finding out affordances of objects. On the other hand, it is interesting to note that the infants followed relatively few of the mother's acts inappropriate to the action-relevant properties of the objects in their exploratory activities.

There seems to be a parallel between the ability to use uncommon acts for object exploration and that required for imitation of novel acts on objects. Killen and Uzgiris (1981) studied 7 to 22-month-old infants' abilities to imitate a series of acts, each of which was modelled twice—once with an appropriate object (e.g., "drinking the cup") and once with an inappropriate object (e.g., "drinking the car"). They found that the 10- and 16-month-old infants imitated the acts appropriate to the objects more frequently, while the types of objects with which the acts were modelled did not affect the 22-month-olds' imitative performance. In another study involving 12 to 22-month-old infants' imitation of object-related acts, McCabe and Uzgiris (1983) used a design similar to the foregoing study. The acts modelled were divided into simple and complex acts. The simple acts included three types: acts modelled with appropriate objects (conventional), acts modelled with abstract-shaped objects (neutral), and acts modelled with inappropriate objects (counter-conventional). The infants watched each of these acts demonstrated by both the mother and the experimenter in turn. The results showed that the infants imitated both the mother and the experimenter similarly and overall the ability to imitate the complex and neutral simple acts increased with age. Older children were not found to imitate more of the counter-conventional acts, perhaps because the acts involved in this demonstration were simple acts, and the performance of the 12-month-old sample was superior to that of the 12-month-old sample investigated in Killen et al.'s study.

Devouche (1998) suggested that lack of object affordances may account for infants' inability to reproduce acts carried out with inappropriate objects. For example, the infants in the study of Hofsten et al. (1993) banged the rattle more often than they banged the doll, perhaps because they had observed the mother bring about the interesting sound by banging the rattle, but not the doll (Devouche, 1998). In other words, the role of modelling in eliciting infants' imitation of object-related acts is perhaps to highlight the affordances of the objects in hand. To address this issue, Devouche presented the 9-month-old infants with two types of shaking and pressing acts according to whether the modelled acts elicited the acoustic affordances of the objects. In the noise condition, for example, the experimenter pushed a button on the top of the box and a beeping sound was then induced; in the other condition, he did so but made no noise. In addition, these two types of target acts were demonstrated in two social situations of differing familiarity: one allowed the experimenter to play an interesting game with the infant in the warm-up, and the other did not. The results indicated that the infants reproduced more of the target acts when they were demonstrated with accompanying acoustic affordances than when they were not, and this was not affected by the familiarity between the infant and the experimenter.

Devouche's findings suggested that infants' imitation of novel acts on objects is subject to particular object characteristics. Therefore, this kind of imitation as a paradigm for studying infants' ascription of intentions or goals to a model needs to be seriously examined. The main constraint on the use of object-related imitation tasks, of interest here, is whether infants imitate only actions relevant to specific properties of objects (e.g., shaking a rattle). Such a tendency is very likely to lead infants to focus on what objects could afford rather than what a model is intending to achieve. However, it is not always the case that an individual acts on an object with the intention of eliciting its action-relevant end results. Under some circumstances, an individual may just act on an object in a specific way but without revealing some salient changes of state of the object (e.g., shaking an empty Smartie box). Hence, imitation as a paradigm for exploring infants' possession of the concept of intention has another limitation. Goals intended by the model may be ascribed only to the results coinciding with the dynamic affordances of objects, because, if the modelled acts do not shed light on the distinctive features of objects, infants may lack the motivation to replicate such acts (Devouche, 1998). Then, it would not be possible to explore infants' understanding of intentional acts by demonstrating for them acts that do not elicit salient features of the objects in hand. From this point of view, it is quite probable that lack of object affordances will account for the relatively few control acts the infants replicated in Devouche's study, and the relative infrequency of the acts carried out with the inappropriate objects the infants produced in the studies of Hofsten et al. (1993) and Killen et al. (1981). On the other hand, as infants selectively replicate the acts modelled with appropriate objects or produced with accompanying salient affordances, it is interesting to ask whether the effect of specific object affordances on infants' imitation of acts on objects may be more appropriately characterised as a kind of emulation learning, or imitative learning, or a combination of both.

Let us return to these methodological concerns in relation to Meltzoff's Failed-Attempt paradigm. In Section 1.6.2, it was suggested that the infants in Meltzoff's (1995) study may learn the dynamic affordances of the objects while observing the experimenter's failed-attempt display and this may have resulted in their production of the target acts. That is, in contrast to Meltzoff's interpretation that the infants produced the target acts with an understanding of the adult's intended goals, such a performance may be accounted for by the effect of emulation learning. In addition, it has been indicated that the pattern of the object movements presented in the failed-attempt display was more target-relevant as compared with that presented in the adult-manipulation control which was irrelevant and dissimilar to the target acts. For example, the object set of square and dowel: in the adult-manipulation model the square was moved along the sides of the wooden base in an upright position, while in both the full-demonstration and failed-attempt models the square was moved downwards to the base in a horizontal position. Similarly, for instance, the dumbbell: in the adult-manipulation model the experimenter handled the dumbbell with an inward movement, while in both the full-demonstration and failed-attempt models the experimenter handled it with an outward movement. The infants watching the failed-attempt display might interpret the final acts of a sequence of target-relevant failed acts as the target acts. Instead of construing the model's failed attempts as psychological events, they might simply perform these acts with knowledge of the causal structure of the test objects. On the other hand, they did not produce the target acts frequently after watching the adult-manipulation control acts. It is probable that these control acts were not target-relevant and thus the infants did not assign the target acts to the end points of the adult-manipulation control acts. Although, in contrast to the target display, the affordances of the objects revealed in the failed-attempt display were less available to the infants, the dynamic properties of the objects could be revealed through the way in which the demonstrator carried out his unsuccessful acts on the objects.

In Meltzoff's (1988b) study of infant deferred imitation, an adult-manipulation control was used to assess the possibility of emulation learning (see Section 1.5.2 for a review). However, such a control group was not included in Meltzoff's (1995) later study. In the adult-manipulation control of Meltzoff's (1988b) study, the experimenter demonstrated for the infants the results of the target acts by means of non-target-relevant acts. Although the 9-month-olds in this control did not achieve the target acts as frequently as they did by observing the target display, the possibility that the 18-month-olds may be more likely to use the strategy of emulation learning is yet to be ruled out in Meltzoff's (1995) study.

In a recent study replicating and extending Meltzoff's (1995) Failed-Attempt paradigm, Bellagamba and Tomasello (1999) included a novel control of demonstration (end state) for the possibility that children watching a failed-attempt display may learn about object configurations of target acts and thus design their own strategies to generate these configurations. Similar to the adult-manipulation control used in Meltzoff's (1988b) study, the experimenter presented the specific end points of the objects to the infants in this demonstration (end state) control. Whereas the experimenter in Meltzoff's (1988b) adult-manipulation control surreptitiously elicited the end results of the target acts during manipulation of the objects, the experimenter in the demonstration (end state) control of Bellagamba and Tomasello's study directly presented the infants with the objects in their configurations of the target acts without manipulating them. Bellagamba and Tomasello found that both the 12- and 18-month-olds reproduced more of the target acts after watching the target display than they did after watching the end-state display, while only the 18-month-olds in the demonstration (intention or failed attempt) group reproduced the target acts as frequently as they did in the demonstration (target) group.

The adult-manipulation control included in the study of Meltzoff (1988a) should be sufficient to elicit emulation learning, but the experimenter's non-target-relevant actions on the objects could also provide a basis for stimulus enhancement. By contrast, the action scheme characteristic of Meltzoff's (1995) Failed-Attempt format is more target-relevant. Is it more likely that observing the failed-attempt display may involve an emulation learning effect than observing the surreptitiously elicited end results? Although the infants in Bellagamba and Tomasello's demonstration (end state) control did not observe the experimenter's manipulations of the objects, they did not have access to the initial states of the objects at the beginning as those in the other groups did. One possibility here is that the infants watching the end-state display might have done better if they could have seen the initial states of the objects before the end results of the target acts were presented to them. In addition, the infants' attention may have been drawn to specific parts of the objects when they saw the experimenter take these objects behind her back for restoring their configurations to the initial states. Could this provide an extra basis for a stimulus enhancement effect?

To rule out the possibility of an emulation effect on infants' production of target acts in Meltzoff's Failed-Attempt paradigm, a more refined control was developed in Experiment 1. Similar to Bellagamba and Tomasello's demonstration (end state) control, the emulation-learning control of the present study involved demonstrating each of the end points of the target acts to the infants, who were then given opportunities to make the end points occur on their own. The question asked is whether infants are able to find out appropriate means themselves to reproduce affordances of objects they have already learned. For example, infants may make sense of the moveable properties of a dumbbell toy from seeing its two divided halves, and then learn to pull it apart. In order to control for the possible influence of seeing the initial states, the experimenter in the emulation-learning control set the objects in their initial states before their end results were presented to the infants, while in Bellagamba and Tomasello's demonstration (end state) control the objects were already set in the end states at the start of the presentation. Furthermore, in order to minimise the stimulus enhancement process due to observation of the experimenter's manual contact with the objects, a screen was introduced between the infant and the experimenter while he was producing the target acts on the objects. The screen was removed after the objects were set in the end states. In this way, the experimenter did not need to move the objects to take them from behind his back as in the procedure involved in Bellagamba and Tomasello's demonstration (end state) control.

2.2. Methods

2.2.1. Participants

The participants were forty 19-month-old children (M = 19.10, SD = 1.47) recruited from a number of playgroups in the North London district. Twenty-four of the children were males and sixteen were females. One child was dropped from the study due to an emotional tantrum and replaced by another child in the playgroup. The subjects were 65% White, 17.5% Asian, 2.5% African, and 15% mixed ethnicity.

2.2.2. Test situation

The test sessions were conducted in a quiet corner in the playgroup where the disturbance from other children and carers was minimal, or at home if the parents favoured such an arrangement. Twelve of the children were tested at home, twenty-seven at the playgroup, and one at a laboratory in the department of psychology at University College London. During the session, the child was seated in front of a small table opposite the experimenter. The parent sat behind the child. If the small table was not available, the child sat on the floor facing the experimenter. A camcorder fixed on the tripod stood behind and to the left of the experimenter, focusing on the child's head, hands, torso, and the surface of the table. On arrival at the playgroup or the child's home, the experimenter firstly showed the child some rubber animals or a picture book to help her sit in front of the table. Meanwhile, the experimenter explained relevant information about the study to the parent and asked them not to give hints or feedback to the child once the test had started. After the child seemed settled and comfortable with the experimenter, the toys were withdrawn and the first test object was presented.

2.2.3. Test materials

The materials were replicas of the five objects devised in Meltzoff's (1995) study, which were replicated in the workshop of the department (see Appendix).

Dumbbell–The first object was a dumbbell-shaped toy that could be pulled apart and put back together again. It consisted of two wooden cubes, each with a plastic tube extending from its one side. The two cubes could thus be connected into one piece by one tube fitting snugly inside the other.

Box and stick—The second object consisted of a rectangular block of wood and a blue box. The front surface of this box tilted 30 degrees off the table and unfolded perpendicular to the other side. A slightly recessed rectangular button, which could activate a buzzer inside the box, lay on the right half of the front surface. The area of the recession could also contain the tip of the wooden block.

Prong and loop—The third object consisted of a rubber loop and a green rectangular board which was set on a wooden base. A plastic prong with a bulbous point protruded horizontally from the standing board at a position slightly beneath its upper edge.

Cylinder and beads—The fourth object consisted of a chain of purple beads, about 20 cm long when suspended, and a hollow yellow cylinder with a flared base.

Square and dowel—The fifth object consisted of a transparent plastic square and a wooden dowel. The dowel stood in the centre of a wooden base plate. The square had a round hole cut out of the centre so that the dowel could pass through the hole when the square was put over the base.

2.2.4. Experimental design

There were four groups in the study: Full-Demonstration, Failed-Attempt, Emulation-Learning, and Adult-Manipulation. Except for the Emulation-Learning group, which served as a novel control, the displays for the other three groups were the same as those used in Meltzoff's (1995) study. Participants were randomly assigned to one of the four conditions, which were characterised by the ways the experimenter acted on the objects. The following briefly describes these demonstrated actions.

Full-Demonstration condition

The Full-Demonstration condition was designed as a replication of the demonstration (target) group in Meltzoff's study, and equated with the typical imitative situation. In this condition, the child watched the experimenter demonstrate a specific means to bring about a target act upon each of the five objects. Each modeling was repeated three times in approximately 20 seconds; then the object was placed in front of the child.

Dumbbell—The experimenter held the dumbbell on the two cubes, then pulled the cubes outwards. The result was that the dumbbell split into two halves.

Box and stick—The experimenter picked up the stick, then used it to push the button on the top of the box. The result was that the buzzer inside the box was activated.

Prong and loop—The experimenter raised the loop, then passed it through the prong. The result was that the loop rested on the prong.

Beads and cylinder—The experimenter raised the chain of beads and put it into the cylinder. The result was that the beads were deposited on the bottom of the cylinder.

Square and dowel—The experimenter picked up the square, then put it over the wooden base plate. The result was that the dowel protruded through the round hole in the centre of the square.

Failed-Attempt condition

The Failed-Attempt condition was designed as a replication of the demonstration (intention) group in Meltzoff's study, and according to Meltzoff (1995) this provided a basis for assessment of children's understanding of intended acts underlying one's failed attempts. In this condition, the child watched the experimenter attempt but fail to bring about the results of the target acts produced in the Full-Demonstration condition. The experimenter's attempt at the target act was repeated in three relevant unsuccessful acts on each of the five objects, then the object was placed in front of the child.

Dumbbell—The experimenter held on to the two cubes, then one hand slipped off the cube when he was trying to pull the cubes outwards. The direction of movement alternated from left, to right, and to left over the three tries.

Box and stick—The experimenter picked up the stick and used it to push the button but did not hit it so that the stick touched down outside the recessed area. First, the stick missed to the left; next, it missed to the right; and finally, it fell too high.

Prong and loop—The experimenter raised the loop and inappropriately released it when he was putting it over the prong so that the loop dropped to the table. First, the loop was released to the left of the bulbous tip of the prong; next, to the right; and finally, it fell from below it.

Beads and cylinder—The experimenter raised the chain of beads and inappropriately released it around the opening when he was trying to put it into the cylinder so that it fell to the table outside the cylinder. First, the chain was released to the left over the opening; next, to the right; and finally, from its front.

Square and dowel—The experimenter picked up the square and did not hit the dowel when he was trying to align it with the round hole in the centre of the square so that the square sloped on the wooden base. First, the square missed to the left; next, to the right and finally it undershot in front of the dowel.

Emulation-Learning condition

The novel condition of Emulation-Learning controlled for the possibility that infants might be induced to elicit the end points of the target acts by learning the dynamic affordances of the objects during observation of the failed attempts. In contrast to Meltzoff's Adult-Manipulation control serving as a basis for stimulus enhancement, the Emulation-Learning control provided a refinement for the effect of emulation learning on children's production of the target acts in the Failed-Attempt condition. In this condition, the child observed only the results of the target acts presented in the Full-Demonstration condition. First, the experimenter introduced the initial state of the object set on the table for 10 seconds as it was presented in the beginning phase of the other three conditions, but the object was not directly manipulated. Then, a screen made of cardboard was placed between the child and the object. Thus, the screen prevented the child from seeing the experimenter's physical contact with the object when he was producing the target act behind it. After completing the target act on the object, the experimenter removed the screen and presented the end state to the child for another 10 seconds. The screen was placed between the child and the object again, and the experimenter restored the object configuration to the initial state behind the screen. After that, the screen was withdrawn and the object set was placed in front of the child in the initial state. In this way, the child was invited to make the result already observed occur by themselves.

Dumbbell—The result was the two halves of the wooden cubes separated from each other, each with a plastic tube extending from it.

Box and stick—The result was the activation of the beeper inside the box, which gave rise to a beeping sound. Note that the experimenter did not demonstrate for the child an observable result. Instead, the child learned the acoustic affordance of the object set by listening to the beeping sound, and never saw the stick related to the box in close proximity.

Prong and loop—The result was the loop resting on the prong.

Beads and cylinder—The experimenter showed the child that the chain of beads was lying inside on the base of the cylinder.

Square and dowel—The result was the square aligned over the base and the dowel protruding through the hole in the square.

Adult-Manipulation condition

The Adult-Manipulation condition was designed as a replication of the control (adult-manipulation) group in Meltzoff's (1995) study. In Experiment 1, it was aimed at testing the possibility that children's attention may be drawn to specific parts of the objects during observation of the experimenter's manipulations of the objects in the Failed-Attempt condition and that probably resulted in their production of the target acts. In this condition, the demonstrator manipulated the relevant parts of the objects that he handled in the Full-Demonstration and Failed-Attempt conditions for the same length of time, but neither the target acts nor the failed attempts were presented. Each manipulation was modeled three times with each of the five objects in approximately 20 seconds.

Dumbbell—The experimenter held the dumbbell onto the two cubes, then pushed them inwards so that the joined tubes were never seen to move outwards.

Box and stick—The experimenter held the stick horizontally and moved it back and forth along the top of the box, each time with the tip of the stick passing next to and over the button. First, the stick started from the lower edge of the top; next, from the left; and third, from the right. Each time, the movement ended in the stick staying centered on the surface.

Prong and loop—The experimenter raised the loop, then slid it along the upper edge of the board past the prong. The loop was released when it reached the other end of the board. First, the loop started from the left of the upper edge; next, from the right and third, it moved along the base supporting the board and fell underneath the end of the prong close to the board.

Beads and cylinder—The experimenter raised the chain of beads, then dropped it onto the table at a distance from the cylinder without touching it. First, the beads fell to the left of the cylinder; next, to the right and finally, they were gathered in a loosely held fist and fell onto the table to the left of the cylinder again.

Square and dowel—The experimenter held the square in a vertical position, then moved it along the sides of the wooden base. First, the square was moved along the front side of the base; second, along the back; and third, along the front again.

The participants were randomly assigned to one of the four conditions, resulting in 10 children per condition. The presenting sequence of the five objects was counter-balanced within the condition. The experimenter did not prompt the child to respond, but most children appeared to be used to taking turns and readily made contact with the objects placed in front of them. On occasions when the children were distracted, the experimenter just called their names or said "Look!" to engage them in the session, but never used definite instructions such as "Do what I do!" "Copy me!" or "Pull it out!" etc. Neither did he give affective or linguistic cues to accompany the demonstrated actions in any condition.

2.2.5. Scoring

2.2.5.1. Background

A number of scoring strategies has been employed in the literature on infants' imitation of acts on objects. In general, the strategies for coding infants' responses as imitation can be divided into three approaches: dichotomous scoring, multiple scoring, and degree of match. As regards dichotomous scoring, an overall yes or no code is assigned to the child's behavioural performance during a short period of response time depending on whether the modelled act is reproduced or not (e.g., Devouche, 1998; Heimann & Meltzoff, 1996; Meltzoff, 1988a, 1988b, 1995). For multiple scoring, the child's behavioral performance during a response period is coded into one of several predefined scoring categories. For example, Tomasello, Savage-Rumbaugh, and Kruger (1993) scored the children's actions on the objects according to whether they reproduced: (1) both means and end result that the experimenter demonstrated, (2) demonstrated means only, (3) demonstrated end result only, or (4) neither one. However, exact copying of the model is not commonly observed and can not be strictly assessed. Under most circumstances, the child's behaviour coded as imitation by a scorer actually does not replicate all the demonstrated inputs. Instead, it often involves some type of similarity between observer's behaviour and demonstrator's behaviour (Russon, 1996), or some part of the demonstrator's behaviour (Whiten & Ham, 1992). Hence, an alternative strategy is to measure the degree of match. For example, on a seven-point scale, Whiten, Custance, Gomez, Teixidor, and Bard (1996) scored the children's and chimpanzees' manipulations of an artificial fruit device after watching a display according to how confident the scorer felt that the performer had witnessed the demonstrator's behavioural strategy. Heimann, Ullstadius, Dahlgren, and Gillberg (1992) coded the child's response into one of the three categories: full imitation, partial imitation, or no imitation.

Whatever scoring strategy is used, the central methodological concern is about the rating of the convergence between imitator and demonstrator's behaviour. However, the occurrence of imitation can be affected by the coding procedure in several ways, such as the length of the scoring time during which the child's behavioural performance is rated, and the number of actions that the child produces within the scoring time. For example, children may reproduce the modelled behaviour through their own discovery of the object properties, independent of the demonstration, because the length of the response period is sufficient to allow them to explore the object. Additionally, in cases where children produced more than one action in the scoring time, it is important to decide which action or how many actions to score.

Although the importance of scoring infants' immediate responses has been suggested (Devouche, 1998; Heimann & Meltzoff, 1996; Meltzoff, 1988b; Tomasello, Savage-Rumbaugh, & Kruger, 1993), there is no conclusive evidence yet whether infants produced the modelled acts more quickly by imitation than they did through self discovery. Whereas the effect of imitation on the number of the modelled acts infants reproduced has been robustly demonstrated, there has been no consensus among researchers regarding the length of the scoring time that might best capture the immediacy of infants' imitative responding. Tomasello et al. (1993) did not specify the length of the scoring time in their coding procedure, but they claimed that the subjects' behaviours scored as reproducing the modelled actions were usually observed within 10 seconds. Heimann et al. (1992) scored the subjects' behavioural reproduction as imitation only if it was performed in 10 seconds after the presentation. In a study of infant deferred imitation, Heimann and Meltzoff (1996) coded the 9-month-old infants' behaviours in 20 seconds and 30 seconds of the scoring time. The results obtained using either scoring procedure supported the hypothesis that the infants in the imitation group produced more of the modelled acts than did the controls. That is, the occurrence of imitation was not affected by the length of the response period for which the infants were allowed to manipulate the test objects. In an early study of deferred imitation in

14-month-old infants, Meltzoff (1988a) used 20 seconds of the scoring time and recorded the latency with which the first target act was produced within 20 seconds. Meltzoff (1988a) found that the infants reproduced the target acts with shorter latencies in the imitation condition than they did on their own in the base line and adult-manipulation controls. Of special interest here is Meltzoff's (1995) study in which he used 20 seconds of the scoring time and recorded the latency to produce the first target act within 20 seconds. There were no differences in the latency between the demonstration (target) and demonstration (intention) groups, but the data for the control (baseline) and control (adult manipulation) were not reported. In contrast, Devouche (1998) used 30 seconds of the scoring time and recorded the latency to reproduce the modelled action. He found that infants reproduced the acts modelled with object-afforded sounds more frequently than those without acoustic properties, but there were no group differences in the latency to generate the modelled acts. Therefore, although the length of the response period appears to be an important methodological issue, it has not been systematically examined yet.

In contrast to the latency measure, the number of the modelled actions children reproduce is a robust measure of testing the hypothesis of imitation. In the studies considered above, the effect of observing the model on children's learning about specific acts has been consistently confirmed by assessing their behavioural reproduction after observing the model. However, it is important to note that children are likely to bring about a range of acts including the modelled act in the response period at the same time as their behavioural performance is scored as the occurrence of imitation. In that case, a scorer would be confronted with how to decide which action to score and which action to ignore. To date, whether the number of acts observed within the scoring period could affect the scoring procedure has not been discussed in the literature on infant imitation. During pilot work conducted for Experiment 1, it was observed that most of the children who performed the action that was coded as producing the target act did not perform only that action in the 20-second scoring period. For example, although children watched the experimenter start by raising the loop in the failed-attempt display, they themselves started by touching the bulbous tip of the prong, then picked the loop up to put it over the prong, thus producing the target act during the response period. Nevertheless, it is not clear whether the first action of touching the prong should be considered a part of the target act or a distinct action. That is, there was a possibility that, if the target act was not performed at the first action, the other produced acts preceding it in the scoring period would increase the latency to make the target act occur. On the other hand, it might be the case that the children attempted to discover what the object could afford by way of producing other acts, and that led to their production of the target act. In this way, the scoring procedure does not appear to be as simple as whether the children produce only the behaviour matching the target act in the pre-set period, regardless of whether they produce other non-target acts in the meantime. However, such a methodological issue concerning the coding procedure has not been reported by the previous studies.

2.2.5.2. Two-action scoring strategy

Despite the fact that the number of the modelled acts reproduced by children has been commonly used as the robust measure of testing the hypothesis of imitation, the scoring procedure needs to be refined to take account of both the target and non-target acts that children potentially produce in a scoring period. In Experiment 1, the two-action coding strategy—a refinement of multiple scoring—was developed to examine the methodological issue considered above. In contrast to the dichotomous scoring strategy with which the scorer rated a range of actions a child produced during a scoring period as a whole, the two-action coding strategy considered only the first two distinct actions in the scoring period and coded each of them respectively. In addition, instead of coding the individual action depending on whether it matched the target act, the scorer assigned one of several pre-set scoring categories to each of the first and second actions. The two-action coding strategy was proposed for three reasons.

First, as an alternative to the latency measure, the immediacy of imitation may be more adequately captured by the order in which the target and other non-target acts were performed. The assumption is that if a child learned to perform the target act by imitation, she should elicit it more directly with a relative infrequency of exploratory responses before it was produced. In cases where the target act was not produced directly at the first action, the other non-target acts produced ahead of it may perhaps indicate behavioural strategies different from that of imitation. Thus, coding both the target and non-target actions observed in the scoring period may help us gain more understanding of the behavioural strategies children used to achieve the target acts under different conditions. Therefore, in the present study, the first two actions observed in the recorded time period were independently coded in order to determine whether there might be group differences in the order in which the target and non-target acts were produced.

Second, the latency indicates how quickly, but not how directly, a child produces the target act. The child may spend a relatively short latency bringing about the target act, whereas there was still a likelihood that she elicited other non-target acts in a very short interval before it was produced. In the pilot work of Experiment 1, for example, it was noticed that at times the children spent less than 5 seconds producing a target act, but it was scored at the second action or even after that. On the other hand, under some circumstances it could take the children 15 seconds or more to complete a target act, perhaps due to carefulness or lack of manual dexterity. Nonetheless, the target act should be scored at their first action. It appeared that the order in which the target act was produced could not be ensured by the latency to generate it. Although the two-action scoring strategy developed in the present study did not take account of all the actions the child produced during the scoring period, it is useful to distinguish the case in which the target act was not produced directly at the first action. That is, the child's production of the target act at the first action was assumed to be characteristic of the immediacy of imitation. In contrast, regardless of whether the child produced other non-target acts preceding the target act, the dichotomous coding strategy (e.g., Meltzoff, 1988b, 1995) related the immediacy of imitation to the latency to produce it.

Third, in cases where a child's responses observed in a scoring period did not meet all the operational descriptions of the target act, the scorer might find it difficult to rate these responses as a whole by simply assigning a yes or no credit. It may be plausible to broaden the coding categories or measure the degree of match rather than reducing the responses to a dichotomy between the target and non-target action. However, neither the multiple scoring strategy nor the strategy of measuring the degree of match has considered the number of actions that a child actually produces during a scoring period. Basically the traditional scoring strategies, discussed in this section, rate all the actions that a child produces during the scoring period as a whole. In order to examine this methodological issue, it is important to parse the child's responses observed in the scoring period so that the actions, which are actually scored, can be recognised in individual segments. Instead of assigning an overall rating to all the actions that the children produced in the response phase, the two-action scoring strategy scored only their first and second actions distinctly observed in the recorded time period. In addition, it was anticipated that adopting a multiple scoring strategy would more adequately deal with the foregoing methodological issues.

2.2.5.3. Scoring criteria

Control groups of various types have been designed as the basis for establishing the novelty of the acts modelled in the imitation group (e.g., Abravanel, Levan-Goldschmidt, & Stevenson, 1976; Abravanel & Gingold, 1985; Meltzoff, 1988 a, b, 1995). Although previous researchers have been concerned with children's self exploration of the modelled acts, they have not asked questions such as: Did the children in the imitation group spontaneously elicit the control acts that the experimenter demonstrated for them in the controls? Did the children in the controls reproduce the demonstrated control acts as often as they reproduced the demonstrated target acts in the imitation group? As discussed in the introduction to the present chapter, it is possible that children may selectively imitate certain types of the modelled action. For example, they may be more likely to reproduce the observed act that coincides with the object-afforded act (Devouche, 1998). In Meltzoff's (1995) study, infants' production of the target acts after watching the failed-attempt display was interpreted in terms of re-enacting the intended acts of the adult. Meltzoff (1995) suggested that the infants produced the intended target acts because they did not copy the adult's failed acts literally. However, it might be the case that the infants had difficulties or were not interested in copying the failed acts observed in the display. In contrast, it is probable that the infants produced the target acts after watching the failed-attempt display because they were induced to elicit the affordances of the objects highlighted by the demonstrator (See Chapter 1 for a discussion). Therefore, it is important to look at how infants responded to the experimenter's non-target-relevant manipulations of the objects in the control. If the infants did not imitatively respond on the demonstrated non-target-relevant acts as often as they re-enacted the intended target acts after watching the failed-attempt display, it would suggest that their production of the target acts after watching the failed-attempt display may not be comfortably interpreted as reproducing the intended acts. In order to examine these questions, the categories comprising the scoring system were as extensive as possible to cover what the children in the present study could potentially produce.

Except in the Emulation-Learning condition where the children did not see the experimenter act on the objects, the actions of various types that they observed in the other three conditions were included in the scoring system. They were Target Act, Failed Act, and Adult Manipulation. Under some circumstances, the children did not fully produce the target acts, but their failure appeared to be caused by difficulties manipulating the objects. Such acts looked like the target acts and the failed attempts in some ways. In order not to boost the number of the actions falling into Target Act and Failed Act, the failure to accomplish the target acts due lack of manual dexterity was coded into a separate category called Unfinished Target Act.

Unfinished Target Act was distinguished from Target Act and Failed Act in several differing ways. First, the acts falling into Unfinished Target Act did not produce the end results of the target acts, while the acts falling into Target Act involved the children fully replicating the target acts including the end results. Second, the acts falling into Unfinished Target Act were mainly characterised by a sequence of two or more continuous attempts to complete the target act in a distinct action, while the acts falling into Failed Act should not involve the above behavioural feature. For example, in the Failed-Attempt condition, the experimenter raised the loop and released it next to the prong. If the loop touched the prong twice or more then dropped to the ground during the child's copying of the adult's failed act, that performance would not be coded as Failed Act, because it involved the positive criterion for Unfinished Target Act. Finally, Unfinished Target Act could not be assigned to the acts resulting in the identical end states of the failed-attempt display. For example, the child tried to pass the loop through the prong but failed to complete it within the scoring period. Instead of putting the loop back on the table, she dropped the loop next to the prong. That performance should not be scored as Unfinished Target Act, as dropping the loop was the end result observed in the failed-attempt display.

If the children did not respond at all in the scoring period, it was coded as No Act. If their actions did not conform to any of the above categories, it was scored as Other Action instead. Altogether there were six scoring categories in Experiment 1: Target Act, Failed Act, Adult Manipulation, Unfinished Target Act, Other Act, and No Act. The scoring system was designed to capture the range of acts that children potentially produced as comprehensively as possible. Thus, a series of five 20 seconds recorded response periods were obtained for each child. Each of a child's first and second actions that were observed in the scoring period was coded in one of these categories.

In addition, the following measures were also included in the subsidiary analysis.

(1) The latency for the first target act produced in the scoring period. It was timed starting from when the infant touched the object.

(2) The target acts produced after the first and second actions but not beyond 20 seconds of the scoring period. The measurement of the total number of the target acts produced within 20 seconds could provide a basis for making a direct comparison between the present study and Meltzoff's (1995) study. Also, it is possible to examine whether the occurrence of imitation may be affected by the coding procedure in which the order of the actions falling into Target Act was considered.

(3) The part of the object set that the children touched first during the scoring period. This measurement may be helpful to explore whether the children might tend to

manipulate a particular part of the object set depending on what they watched the experimenter act on it.

(4) The use of a finger to activate the beeper in the object set of box and stick. In the Emulation-Learning condition, except for the object set of box and stick, the experimenter demonstrated for the children the other objects in the observable end states. The children received only the beeping sound when the experimenter used the stick to push the button to activate the beeper in the box behind the screen. As the beeping sound was quite attractive, it is possible that the children would be more likely to reproduce it. However, they were not cued to use the stick, because the experimenter's manual contact with the object was not seen. Were they able to devise their own behavioural strategy to activate the beeper? For example, instead of using the stick, they might use a finger to push the recessed button.

The operational definitions of each of these scoring categories were the following.

1. Target Act—TA

Dumbbell—The child held the dumbbell by the two cubes, and then pulled them outwards so that it split into two halves. If the dumbbell came apart at the first action followed by the child putting the two halves back to start another action, putting the two halves back was regarded as a transition and not coded for the second action. However, Other Action was assigned to the second action if the child discontinued their response after the transition.

Box and stick—The child held the stick upright and used it to push the recessed button on the top of the box so that the beeper inside the box was activated. If the beeper was activated by the stick at the first action followed by the child pulling back the stick to start another action, pulling back the stick was regarded as a transition and not coded for the second action. However, Other Action was assigned to the second action if the child discontinued responding after the transition.

Loop and prong—The child raised the loop up to the prong, and then put it over the end so that the prong protruded through it. The loop might not rest on the very end of the prong, but had to pass through the prong and go beyond its halfway point. If the loop came to rest on the prong at first action followed by the child removing the loop to start another action, removing the loop from the prong was regarded as a transition and not coded for the second action. However, Other Action was assigned to the second action if the child discontinued his or her response after the transition.

Beads and cylinder—The child raised the chain of beads up over the upper edge of the cylinder, and then put the beads into the cylinder so that the beads were deposited on its base. The beads need not be released from the child's hand, but they had to be completely within the cylinder and underneath its opening edge. If the beads were put into the cylinder at the first action followed by the child pulling the chain out of the cylinder to start another action, pulling the chain out of the cylinder was regarded as a transition and not coded for the second action. However, Other Action was assigned to the second action if the child discontinued responding after the transition.

Square and dowel —The child picked up the square and then put the round hole in the centre of the square over the dowel so that the dowel protruded through the round hole. The position of the square could be either upward or downward. If the square and the dowel were aligned at the first action followed by the child separating one from the other to start another action, separating the square from the dowel was regarded as a transition and not coded for the second action. However, Other Action was assigned to the second action if the child discontinued their response after the transition.

2. Unfinished Target Act—TA (UN)

Unfinished Target Act served to identify the child's failure to complete the target acts due to manipulation problems, particularly in order to distinguish this from Failed Act. It was developed on the basis of an inclusion and an exclusion rule. The inclusion rule specified the sequence of two or more continuous attempts to accomplish the target act in one distinct action. It involved occasions when two target-relevant parts of the object set touched each other or were in close proximity. For example, the beads touched the edge of the cylinder on a number of occasions when the child was attempting to lower the beads down into the cylinder. The child's failure to complete the object configuration due to manipulation problems was mainly scored by the inclusion rule. On the other hand, the inclusion rule of the Unfinished-Target-Act criteria formed an exclusion of the Failed-Act criteria. The child's action must not meet the inclusion rule of the Unfinished-Target-Act criteria, when it was scored as Failed Act. Conversely, the inclusion rule of the Failed-Act criteria formed an exclusion of the Unfinished-Target-Act criteria. The exclusion rule specified that the child's acts falling into Unfinished Target Act must not include the end states of the modelled failed attempts. For example, the beads dropped to the table when the child was attempting to put them into the cylinder. That performance would not fall into Unfinished Target Act, as the dropping action matched the end results of the failed-attempt display. The exclusion rule involved in the Unfinished-Target-Act criteria is to ensure that some unfinished target acts resembling the failed attempts but due to difficulties handling the objects would not boost the number of the acts falling within the category of Failed Act.

Dumbbell—There were no Unfinished-Target-Act criteria for the dumbbell. Due to its special structure, the target act of the dumbbell was designed to restore a configuration to two parts. As the inclusion rule specified the number of occasions when two individual target-relevant parts of the object touched or were related in close proximity, such occasions did not apply to the dumbbell. Unless the two cubes became separated from each other, they could not be seen as two individual parts. That is, if the dumbbell did not completely split into two halves, its configuration would remain non-transformed. By contrast, the target acts of the other four objects were designed to combine two detached parts of the object set to form a configuration, and it is possible to apply the inclusion rule to such occasions. Moreover, the experimenter's failed acts on the dumbbell did not result in any change of its initial state in the display. Therefore, the exclusion rule would always apply unless the child changed the initial state. The exclusion rule might be met if the child moved the cubes outwards but did not separate them from each other. Even so, such an action could not be scored as Unfinished Target Act in the absence of the inclusion rule

Box and stick—Unfinished Target Act was scored if the action met both of the following conditions. (1) Inclusion criterion: the tip of the stick overlapped with the recessed button in two or more successive attempts, and at least on one occasion part of the tip went in and covered some of the recessed area. (2) Exclusion criterion: these attempts did not end in the tip of the stick resting on the periphery of the recession in an upright position (the inclusion criterion for Failed Act).

Loop and prong—Unfinished Target Act was scored if the action met both of the following conditions. (1) Inclusion criterion: the loop crossed the bulbous tip of the prong in two or more successive attempts, and at least on one occasion the loop went beyond the bulbous tip. (2) Exclusion criterion: these attempts did not end in that the loop was released next to the bulbous tip as a result of the loop dropping to the table (the inclusion criterion for Failed Act).

Beads and cylinder—Unfinished Target Act was scored if the action met both of the following conditions. (1) Inclusion criterion: some of the beads crossed the edge of the opening in two or more successive attempts, and at least on one occasion some of the beads were within and underneath the edge. (2) Exclusion criterion: these attempts did not end in that the beads were released next to the opening as a result of the beads falling to the table outside the cylinder (the inclusion criterion for Failed Act).

Square and dowel—Unfinished Target Act was scored if the action met both of the following conditions. (1) Inclusion criterion: the square overlapped with the wooden base plate in two or more successive attempts, and at least on one occasion the dowel crossed the edge of the round hole. (2) Exclusion criterion: these attempts did not end in that the square remained over the dowel with a tilt or slid off it (the inclusion criterion for Failed Act).

3.Failed Act—FA

Dumbbell—The child picked it up with both hands, and then one hand moved away the cube without moving the two joint tubes so that the inner tube was never revealed. The direction of the hand movement could be left or right.

Box and stick—The child held the stick upright and then put it down on the periphery outside the recession on the top of the box. Also, the action met all the following conditions. (1) The location the stick overlapped was within the half the recessed button lay in. (2) The tip of the stick did not go in the recession. (3) It did not cross the lines of the recession more than once (an exclusion of the inclusion criterion for scoring Unfinished Target Act).

Loop and prong—The child raised the loop up to the prong, and then released it next to the bulbous tip so that the loop dropped to the table. Also, the action met all the following conditions. (1) The loop did not cross the bulbous tip more than once (an exclusion of the inclusion criterion for scoring Unfinished Target Act). (2) The loop did not reach beyond the bulbous tip.

Beads and cylinder—The child raised the chain of the beads up over the upper edge of the cylinder, and then released the beads next to the opening so that they fell to the table outside the cylinder. Also, the action met all the following conditions. (1) The beads did not cross the edge of the opening more than once (an exclusion of the inclusion criterion for scoring Unfinished Target Act). (2) Some of the beads might remain inside the cylinder but the rest of them that were revealed outside had to touch the table.

Square and dowel—The child picked up the square, and then put it over the dowel with a tilt so that the dowel did not protrude through the round hole in the centre of the square; or the square slid off the dowel when it was placed over it. Also, the action met all the following conditions. (1) The square did not cross the dowel more than once (an exclusion of the inclusion criterion for scoring Unfinished Target Act). (2) Some of the dowel might cross the edge of the hole but the dowel never passed through it.

4.Adult Manipulation—AM

Dumbbell—The child held it by the two cubes, and then pushed them inwards so that the two joint tubes were never moved outwards.

Box and stick—The child picked up the stick, and then moved it horizontally against the top surface of the box. The movement could begin at any location on the top. The stick did not have to go over the whole surface, but was never released when it was moving on the slope so that it slid down to the table.

Loop and prong—As the manipulations demonstrated in this object set involved more than two steps as compared to the other objects, the action was coded as reproducing the adult's manipulation so long as it met any of the following definitions. (1) The child picked up the loop, and then moved it along the upper edge or base of the screen board. The loop never rested over the edge or base when the movement ceased. (2) The child picked up the loop, and then dropped it at either end of the upper edge, or beneath the prong, so that the loop fell to the table. (3) The child picked up the loop, and then moved it along the upper edge or base of the screen. The loop was released when it arrived at either end of the edge, or passed beneath the prong.

Beads and cylinder—The child picked up the beads, and then dropped the vertically suspended chain all the way to the table beside the cylinder. The beads never touched any part of the cylinder.

Square and dowel—The child held the square upright on its edge, and then moved it along the edge of the wooden base plate. The location could be either side of the base.

5.Other Act—OA

This code was assigned to those actions that did not fall within one of the above categories. It covered a wide range of actions, relevant or irrelevant to Target Act, Failed Act, Unfinished Target Act, or Adult Manipulation. Some frequent examples are given in the following. For the dumbbell, the child held it by the tubular part, or twisted the cubes, or banged it on the table. For the box and stick, the child turned the box upside down, or slid the stick down the top surface, or used the stick to probe the battery device inside, or merely held the stick in her hand. For the loop and prong, the child grabbed the bulbous tip of the prong, or flicked the loop, or draped the loop on the upper edge of the screen board. For the beads and cylinder, the child attempted to put the beads around the neck, or flicked the beads, or brought her mouth to the opening of the cylinder, or merely held the cylinder. For the square and dowel, the child held the wooden plate by the dowel, or put the wooden plate over the square, or attempted to align both of them but in an upside-down position.

6.No Act—NO

This code indicated that the child did not respond and performed no action on the objects. It was assigned if the response met one of the following conditions: (1) the child did not touch the object presented to her, or (2) the child returned the object to the experimenter after she had already completed one action. If the child merely touched a certain part of the object without further actions through the rest of the response period, Other Action was given to the first action and No Action the second action.

2.2.6. Inter-rater reliability

The author coded infants' responses in each of the five test objects from the videotapes. A colleague who was familiarised with the scoring system coded 30% of the data (3 children per condition) independently for assessing inter-rater reliability. Reliability was presented in three ways: (1) the children's first actions and (2) first and second actions coded in each of the six scoring categories; and (3) the target acts produced within 20 seconds of the response period. Percentage agreement between the author and the colleague for the children's first actions falling into the pre-defined scoring categories was 87%, with a kappa of 0.78; for the first and second actions combined, 88% and a kappa of 0.79. Percentage agreement for the target acts produced in the 20-second response period was excellent, 100% with a kappa of 1.0.

2.3. Results

Each of the child's first and second actions on the object set observed in the 20-second response period was coded as falling into one of the predefined categories. If the two actions fell within the same category, the second one was corrected and coded as Repeated Response. If a category were scored twice at first and second actions, the number of actions falling within this category would be inflated. That is, a category could be ascribed to both the first and second actions once at the most. Thus, the number of the child's first actions or first and second actions combined over five response periods across the five different sets of objects would range from 0 to 5 in any of those categories. As two children did not have a complete record of five response periods due to the camcorder being faulty during the testing, proportions were substituted for frequencies in the analyses. The two missed data points included one child's response to the object set of loop and prong in the Full-Demonstration group, and one child's response to the object set of square and dowel in the Emulation-Learning group. The proportion of the acts falling into a scoring category was obtained by dividing the number of such acts by the total number of the response periods the child completed. Except for the two missed data points, the number of finished response periods for the other children was 5.

The mean proportions of the children's first actions, and combined first and second actions coded into each of the scoring categories are presented in Table 2.1. The four groups were compared with regard to the means of the proportion of their actions falling within the main categories, including Target Act (first action, and first and second actions combined), Failed Act (first action, and first and second actions combined), Adult Manipulation (first action, and first and second actions combined), and Unfinished Target Act (first action, first and second actions combined). In order to compare with the previous studies replicating Meltzoff's Failed-Attempt paradigm (Bellagamba & Tomasello, 1999; Meltzoff, 1995), the proportion of the total target acts produced within 20 seconds of the scoring period was also included in the final analyses.

The data were entered into one-way analyses of variance with experimental

Table 2.1. Means of the proportion of 19-month-old children's first actions and combination of first and second actions falling into each of the scoring categories.

Action \ Condition	Full-Demonstration	Failed-Attempt	Emulation-Learning	Adult-Manipulation
	Mean (SD)	*Mean (SD)*	*Mean (SD)*	*Mean (SD)*
TA-1st	.60 (.25)	.32 (.14)	.26 (.16)	.12 (.17)
FA-1st	.04 (.08)	.06 (.13)	.04 (.08)	.00 (.00)
AM-1st	.00 (.00)	.00 (.00)	.02 (.06)	.06 (.10)
OA-1st	.26 (.19)	.54 (.21)	.60 (.21)	.74 (.23)
NO-1st	.00(.00)	.04 (.08)	.00 (.00)	.03 (.08)
TA(UN)-1st	.11 (.11)	.04 (.08)	.02 (.06)	.00 (.00)
TA(F)-1st	.00 (.00)	.00 (.00)	.06 (.10)	.04 (.08)
Total	1.01	1.00	1.00	.99
TA-1st+2nd	.70 (.17)	.42 (.26)	.46 (.23)	.19 (.22)
FA-1st+2nd	.06 (.10)	.06 (.13)	.06 (.13)	.04 (.08)
AM-1st+2nd	.02 (.06)	.00 (.00)	.02 (.06)	.10 (.14)
OA-1st+2nd	.66 (.33)	.64 (.25)	.76 (.25)	.86 (.14)
NO-1st+2nd	.14 (.31)	.25 (.22)	.08 (.14)	.04 (.08)
TA(UN)-1st+2nd	.11 (.11)	.04 (.08)	.02 (.06)	.00 (.00)
TA(F)-1st+2nd	.00 (.00)	.00 (.00)	.12 (.10)	.04 (.08)
REPEAT	.32 (.19)	.60 (.31)	.48 (.17)	.74 (.23)
Total	2.01	2.01	2.00	2.01
TA-20sec	.76 (.18)	.54 (.28)	.48 (.25)	.25 (.23)

Note 1. TA-1st = target act produced at first action; FA-1st = failed act produced at first action; AM-1st = adult manipulation produced at first action; OA-1st = other act produced at first action; NO-1st = no act produced at first action; TA (UN)-1st = unfinished target act produced at first action; TA (F)-1st = using a finger to activate the beeper in the object set of box and stick at first action.
Note 2. TA-1st+2nd = target act produced at first and second actions combined; FA-1st+2nd = failed act produced at first and second actions combined; AM-1st+2nd = adult manipulation produced at first and second actions combined; OA-1st+2nd = other act produced at first and second actions combined; NO-1st+2nd = no act produced at first and second actions combined; TA (UN)-1st+2nd = unfinished target act produced at first and second actions combined; TA (F)-1st+2nd = using a finger to activate the beeper in the object set of box and stick at first and second actions combined; Repeat = repeated response.
Note 3. TA-20sec = target act produced in 20 seconds of the scoring period.

condition as between-subject factor. These were followed up with Tukey HSD tests to assess specific group differences. The subsidiary analyses included the following measures: (1) the proportion of children's first acts falling into the category of Other Act, (2) the latency to produce the target acts, (3) the parts of the objects that children first touched, and (4) the number of children using a finger to activate the beeper in the object set of box and stick. The proportion of children's first and second acts combined coded in the category of Other Act was not analysed, because it included a wide range of actions of various types that would be difficult to interpret. However, the proportion of their first acts coded as Other Act was analysed to examine the question of whether children might learn to produce the target acts more directly by adopting the behavioural strategy of imitation, and thus produced irrelevant other acts at the first action relatively infrequently.

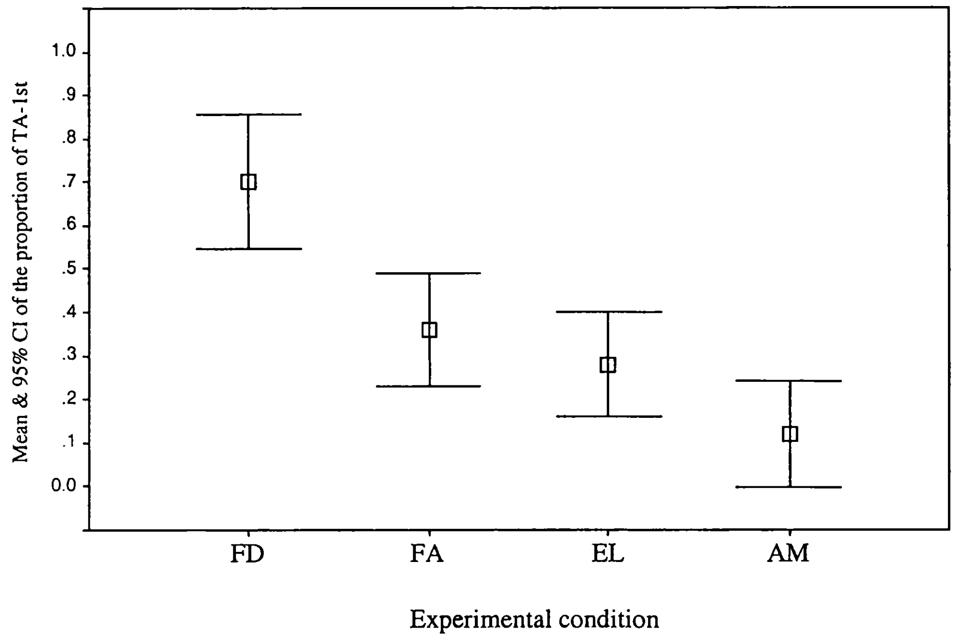
2.3.1. Main analyses

Target acts produced at first action

There was a significant difference in the mean proportion of target acts produced at the first action as a function of condition, $F(3, 36) = 11.74$, $p < 0.001$. Follow-up Tukey HSD tests indicated that the infants in the Full-Demonstration condition produced significantly more target acts at the first action than they did in the Failed-Attempt ($p < 0.01$), Emulation-Learning ($p < 0.001$), and Adult-Manipulation ($p < 0.0001$) conditions (see Figure 2.1). The infants in the latter three conditions did not differ from each other.

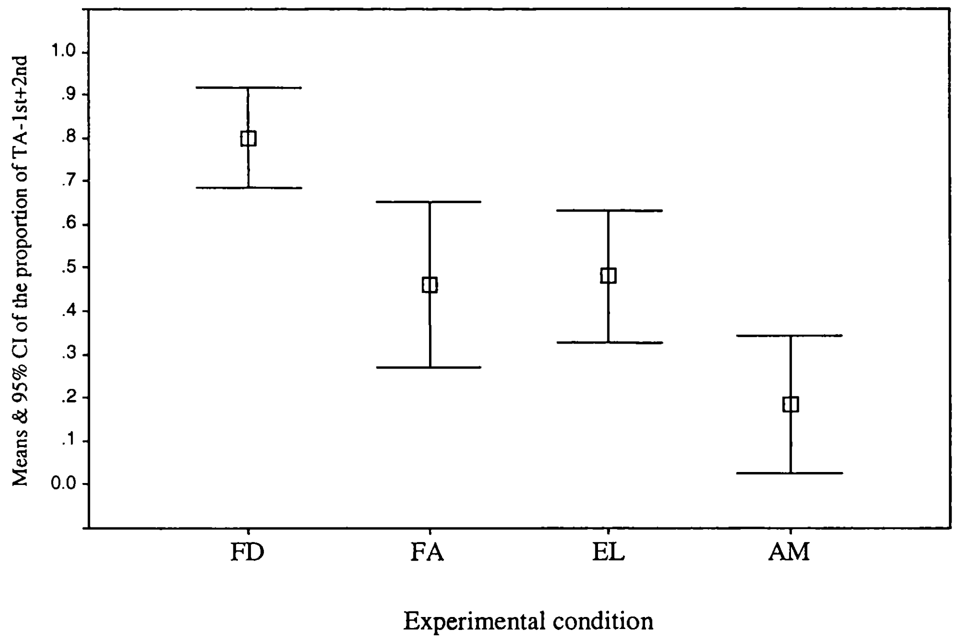
Target acts produced at first and second actions combined

There was a significant difference in the mean proportion of target acts produced at the first and second actions combined as a function of condition, $F(3, 36) = 8.86$, $p< 0.001$. Pairwise comparisons using a Tukey HSD test showed that the infants produced more target acts as their first and second acts combined in the Full-Demonstration condition than in the Failed-Attempt and Adult-Manipulation conditions ($p < 0.05$ and $p < 0.001$, respectively), neither of which differed from each other. The infants produced more target acts as their first and second acts combined in the Emulation-Learning condition than in the Adult-Manipulation



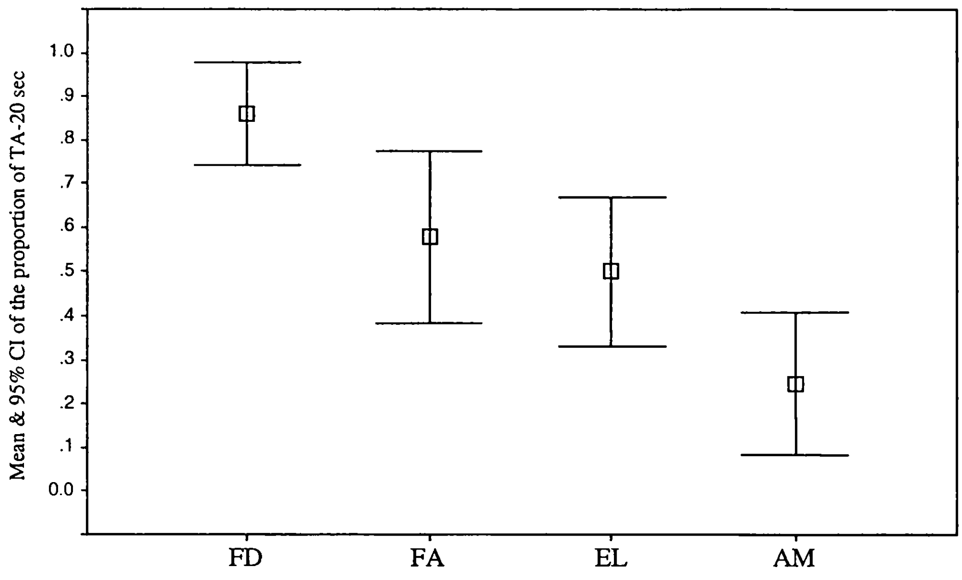
Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 2.1. Means and 95% CI of the proportion of 19-month-old children's first actions coded in the category of Target Act (TA-1^{st}) as a function of condition.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 2.2. Means and 95% CI of the proportion of 19-month-old children's first and second actions combined coded in the category of Target Act (TA-1^{st}+2^{nd}) as a function of condition.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation

Figure 2.3. Means and 95% CI of the proportion of 19-month-old children's actions produced in the 20-second response period coded in the category of Target Act (TA-20 sec) as a function of condition.

control condition ($p < 0.05$), while their performance in the Emulation-Learning condition did not differ from what they did in either of the Full-Demonstration and Failed-Attempt conditions (see Figure 2.2).

***Target acts produced during 20-second response period*[1]**

There was a significant difference in the mean proportion of target acts produced during 20 seconds of the scoring period, $F(3, 36) = 7.67$, $p < 0.001$. Follow-up Tukey HSD tests showed that the infants in the Full-Demonstration, Failed-Attempt, and Emulation-Learning conditions did not differ in the proportion of target acts when all target acts produced in the 20-second scoring period were counted. In addition, the infant in the Full-Demonstration and Failed-Attempt conditions produced more target acts in the 20-second response period than the

[1] The data analysed here were based on the scoring strategy used in Meltzoff's (1995) and Bellagamba and Tomasello's studies (1999). The results obtained using different scoring methods were compared in Section 2.4.

infants in the Adult-Manipulation condition ($p < 0.001$ and $p < 0.05$, respectively), but no difference was found between the infants in the Emulation-Learning and Adult-Manipulation conditions (see Figure 2.3).

Failed acts

As can be seen in Table 2.1, the infants in the Failed-Attempt condition reproduced relatively few of the demonstrated failed attempts: 6% as compared with 32% of the target acts they produced as their first acts, and 6% as compared with 42% of the target acts they produced as their first and second acts combined, in the Failed-Attempt condition. No significant differences were found in the proportion of failed acts reproduced at the first act, $F(3, 36) = 0.78$, $p > 0.5$, or at the first and second acts combined, $F(3, 36) = 0.08$, $P > 0.9$, as a function of condition.

Adult-manipulation control acts[2]

As in the Failed-Attempt condition, the infants in the Adult-Manipulation condition reproduced relatively few of the observed acts that had been actually demonstrated: 6% at their first act, and 10% at their first and second acts combined. A one-way ANOVA on the proportion of control acts produced at the first act as a function of condition was not significant, $F(3,36) = 2.40$, $p > 0.08$, while a marginal condition effect was found when scoring the first and second acts combined, $F(3, 36) = 2.81$, $p = 0.053$. Pairwise comparisons using a Tukey HSD test revealed that the infants in the Adult-Manipulation control produced more of the demonstrated control acts as their first and second acts combined than the infants in the Failed-Attempt condition, $p < 0.06$. No significant difference was found for the other pairs of groups.

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[2] In Meltzoff's and Bellagamba et al.'s studies, children's reproduction of the demonstrated control acts was obtained by scoring all acts produced in the 20-second response period. In Experiment 1, except for children's overall performance on target acts in the 20-second response period, the other types of response children reproduced were scored by counting their first acts and first and second act combined. See Section 2.4 for discussion concerning scoring issues.

2.3.2. Subsidiary analyses

Unfinished target acts

As none of the children's second acts fell into this category, only the proportion of unfinished target acts produced at the first action was analysed. There was a significant condition effect in the proportion of unfinished target acts produced at the first act, $F(3, 36) = 3.52$, $p < 0.03$. The infants in the Full-Demonstration condition produced unfinished target acts more frequently than they did in the Adult-Manipulation control ($p < 0.03$), and that was the only pair of group difference revealed by follow-up Tukey HSD tests.

Other acts produced at first act

The analyses of other acts produced as the children's first acts served as a supplement to the analyses of their performance on target acts. The question asked was whether the infants' behavioural tendency to produce the target acts as their first acts had a relation to various types of demonstrated acts they had seen. When the infants produced the target acts at the first act, they could have learned about these acts directly without trial and error. That is, they should have produced many fewer irrelevant other acts as their first acts. The results showed that there was a significant difference in the proportion of other acts produced at the first act as a function of condition, $F(3, 36) = 8.94$, $p < 0.001$. Pairwise comparisons using a follow-up Tukey HSD test showed that the infants in the Full-Demonstration condition produced fewer other acts falling within the category of Other Act at the first act, compared to what the infants did in the Failed-Attempt, Emulation-Learning, and Adult-Manipulation conditions, $p < 0.03$, $p < 0.005$, and $p < 0.0001$, respectively. No group differences were found among these latter three conditions.

Using a finger to activate the beeper in the object set of box and stick

Cases where the infants used the finger to push the button to activate the beeping noise in the object set of box and stick were coded independently in a sub-category. Although the infants did not watch the experimenter directly manipulate the object set in the Emulation-Learning condition, they might anticipate the button-

Table 2.2. Number of 19-month-old children using a finger or stick to activate the beeper in the object set of stick and box.

Condition \ Action	First action		First and second actions combined	
	Stick	Finger	Stick	Finger
Full-Demonstration Failed-Attempt Adult-Manipulation	7	2	7	2
Emulation-Learning	1	3	1	6

pushing action upon hearing the beeping (18-month-old infants being acquainted with buttons that are "pushable") and thus used a finger to push the button. In contrast, the infants in the Full-Demonstration, Failed-Attempt, and Emulation-Learning conditions had witnessed the experimenter's manual contact with the stick, and that perhaps would cue them to use the stick to push the button. Table 2.2 provides the number of children using the stick and a finger to activate the beeper in the Emulation-Learning condition and the other three conditions combined. Chi-Square tests using a Fisher's exact test on the number of children using their finger to activate the beeper at the first action did not reveal a reliable difference between the Emulation-Learning condition and the other three conditions combined. However, the difference was significant when counting the first and second acts combined, $p < 0.05$ (Fisher's exact test). Overall, the infants who successfully activated the beeper in the Emulation-Learning condition more frequently pushed the button with their finger, and those from the other three conditions combined were more likely to use the stick.

Object parts infants first touched

Whereas the infants in the Emulation-Learning control, like those in the other three conditions, did see the experimenter put the objects down and lift them up at the beginning of the demonstration, they did not watch the experimenter's manual contact with the object sets in relation to their transformation. Instead, the infants in the other three conditions watched the experimenter always start by acting on certain parts of the objects (i.e., cube, stick, loop, beads, and square). The infants might orient themselves to the object sets by observing the experimenter's first contact with the objects, and that could lead them to produce the target acts more efficiently.

Table 2.3. Means of the proportion of parts of objects 19-month-old children first touched in the response period.

Touched part / Condition	Consistent with the demonstration *Mean (SD)*	Different from the demonstration *Mean (SD)*	Touching more than one part *Mean (SD)*	No response *Mean (SD)*
Full-Demonstration	.80 (.21)	.16 (.16)	.04 (.08)	.00 (.00)
Failed-Attempt	.82 (.18)	.06 (.10)	.08 (.14)	.04 (.08)
Emulation-Learning	.60 (.23)	.34 (.27)	.06 (.13)	.00 (.00)
Adult-Manipulation	.64 (.20)	.22 (.26)	.12 (.14)	.03 (.08)

Thus, the parts of the object sets that the infants first touched in the scoring period were coded in several ways. Table 2.3 displays the means of the proportion of object parts the infants in the four conditions first touched, according to whether the touched parts were consistent with, or different from what the experimenter first handled, or whether they started by touching more than one part, or did not touch the object set at all. One-way ANOVAs were performed on the data with the exception of the measure of No Response because cases where the infants did not touch the object sets at all rarely happened

There was a significant difference in the proportion of first-touched object parts which were consistent with those the experimenter had first touched, $F (3, 36) = 2.98$, $p < 0.05$. Pairwise comparisons using a Tukey HSD test, however, did not show a reliable difference between any pair of groups. However, a significant effect of condition was indicated in the proportion of first-touched object parts which were different from those the experimenter had first touched, $F (3, 36) = 3.19$, $p < 0.04$. Follow-up Tukey HSD tests revealed a difference in only one pair of groups: the infants in the Emulation-Learning condition more often first touched the different parts of the objects from the experimenter than the infants in the Failed-Attempt condition, $p < 0.03$. No significant effect of condition was found as regards occasions when the infants touched more than one part when making their first contact with the object sets.

Latency to produce target acts[3]

The time the infants spent producing the target acts was analysed to study how quick they were to bring about such acts after seeing various types of demonstration. The means of the latency were calculated for the target acts produced as the children's (1) first acts, (2) first and second acts combined, and (3) overall performance in the 20-second response period. As pointed out in Section 2.2.5, there has been no conclusive evidence that infants after seeing the full demonstration of the target acts would produce the target acts more quickly than they did after seeing other types of demonstration. However, previous studies did not specify the order in which the target acts were produced (e.g., Devouche, 1998; Meltzoff, 1988 a, b, 1995). According to this account, Experiment 1 presents an attempt to analyse the latency to produce target acts according to the act at which children's performance on target acts took place (Table 2.4).

As in the foregoing analyses, a one-way ANOVA were performed on each of the three measures and that was followed by Tukey HSD tests. Counting the children's first acts only, no significant difference was found among the four conditions in the latency to produce target acts, $F(3, 28) = 1.26$, $p > 0.3$. In contrast, there was a significant difference as a function of condition when the children's first and second acts combined were scored, $F(3, 30) = 4.62$, $p < 0.009$. Pairwise comparisons showed that the infants in the Failed-Attempt condition took an overall shorter latency to produce the target acts as their first and second acts combined than the infants in the Emulation-Learning and Adult-Manipulation conditions, $p < 0.03$, in both. There was no difference among the Full-Demonstration, Emulation-Learning, and Adult-Manipulation conditions. Also, neither was any difference found between the Full-Demonstration and Failed-Attempt conditions concerning the latency to produce target acts as the first and second acts combined.

[3] The latency to produce target acts was not reported in Bellagamba et al.'s study. In Meltzoff's study, only the latency to produce target acts as the children's overall performance in the 20-second response period was reported. Similar to Meltzoff's findings, the author found that the Full-Demonstration and Failed-Attempt groups were similar in both the number of target acts produced in the 20-second response period and the latency to produce them. The two groups did not differ in the latency to produce the target acts at the first act, but the Full-Demonstration group produced more target acts at the first act than the Failed-Attempt group. See Section 2.4 for discussion concerning scoring issues.

Table 2.4. Means of the latency for target acts produced at first action (TA-1st), first and second actions combined (TA-1st + 2nd), and in 20 seconds of the response period (TA-20 sec).

Latency (sec) / Condition	TA-1st *Mean (SD)*	TA-1st+2nd *Mean (SD)*	TA-20 sec *Mean (SD)*
Full-Demonstration	5.04 (3.66) n = 10	5.12 (3.07) n = 10	5.41 (2.61) n = 10
Failed-Attempt	3.65 (1.41) n = 9	3.68 (1.41) n = 9	5.91 (4.66) n = 9
Emulation-Learning	6.05 (3.71) n = 9	7.85 (3.33) n = 10	8.03 (3.12) n = 10
Adult-Manipulation	6.65 (2.81) n = 4	8.90 (4.62) n = 5	10.91 (5.06) n = 7

Note. "n" is the valid number of children.

Finally, latency to produce target acts was computed for the children's overall performance in the 20-second response period. A significant effect of condition was found, $F(3, 32) = 4.64$, $p < 0.008$. Pairwise comparisons showed that the infants in the Adult-Manipulation condition took a longer latency to produce target acts as their overall performance in the 20-second response period compared to what they did in the Full-Demonstration and Failed-Attempt conditions, $p < 0.009$ and $p < 0.03$, respectively. No difference was found among the Full-Demonstration, Failed-Attempt, and Emulation-Learning conditions. Also, no difference was found between the Emulation-Learning and Adult-Manipulation conditions.

2.4 Discussion

Experiment 1 was the first in a series of studies that examined the adequacy of Meltzoff's Failed-Attempt paradigm for investigating children's ascription of intentions to others. The present study replicated three conditions of Meltzoff's (1995) study, including target demonstration (i.e., Full-Demonstration), intention demonstration (i.e., Failed-Attempt), and Adult-Manipulation control. A novel condition of Emulation-Learning was designed as a control for the possibility that the failed-attempt demonstration induces children to produce the target acts as a result of their learning about the dynamic affordances of the objects. Whereas Bellagamba and Tomasello (1999) and Meltzoff (1995) found that the 18-month-old infants in Meltzoff's Failed-Attempt paradigm produced the target acts as frequently as they did after watching the full demonstration model, the present study replicated the previous findings only when the scoring procedure took account of all target acts produced in 20 seconds of the scoring period. Nonetheless, the infants in the Emulation-Learning control were also as likely to produce the target acts as they were in the Full-Demonstration and Failed-Attempt conditions. Counting only their first acts, the infants produced more target acts in the Full-Demonstration condition than in any of the Failed-Attempt, Emulation-Learning, and Adult-Manipulation conditions. No difference was found among these latter three conditions in the number of target acts produced at the first act. It appears that Meltzoff's and Bellagamba and Tomasello's findings were biased by the scoring method they adopted. The results of the present study suggest that the number of target acts produced as the child's first acts was sufficient to demonstrate the effect of imitation and it is possible that emulation learning became significant when the infants' subsequent acts were entered into the scoring procedure.

Despite the fact that Experiment 1 was similar to Bellagamba and Tomasello's and Meltzoff's studies in the pattern of results obtained counting all target acts produced in 20 seconds of the response period, the infants in the present study produced fewer target acts by observing the failed-attempt model: 2.7 out of 5 trials, as compared with 3.6 and 4.0 reported by Bellagamba and Tomasello and Meltzoff, respectively. It is not clear that even the slightly lower level of target acts produced within the 20-second period might indicate at least some understanding of the adult's intended acts. Alternatively, could it be interpreted as their failure to read the adult's intended goals? Or, might emulation learning be sufficient to account for that level of target acts achieved by the infants in the Failed-Attempt condition of the present study? In the following, the author will explore a number of interpretations by expounding the possible behavioural strategies that the infants adopted to achieve the target acts across the four groups, and then discuss the implications for imitation as a paradigm for exploring children's understanding of the intentional actions of others.

Ruling out the possibility of emulation learning

In Experiment 1, the infants in the Full-Demonstration group were able to replicate 3.8 target acts in a series of five 20-second response periods. The finding is consistent with those presented by Meltzoff and Bellagamba and Tomasello: 3.8 and 4.2, respectively. Also, as in Meltzoff's and Bellagamba and Tomasello's studies, the infants in the Full-Demonstration and Failed-Attempt conditions did not differ in the number of target acts produced across five 20-second periods, and in both conditions they performed better than the Adult-Manipulation control group. The effect of observing the failed-attempt demonstration on infants' performance on target acts appeared to be tantamount to that of observing the full demonstration model. Thus, infants' production of target acts in Meltzoff's Failed-Attempt paradigm could be interpreted as re-enactment of intended acts. However, several findings of the present study should cause us to question such a position.

First, it is possible that the scoring method of counting all target acts produced in the 20-second response period amplified infants' performance in Meltzoff's Failed-Attempt paradigm. When counting the children's first acts or first and second acts combined, the Failed-Attempt and Adult-Manipulation groups did not differ in the number of target acts produced, and both of them performed more poorly than the Full-Demonstration group. Although the infants in the Failed-Attempt and Full-Demonstration conditions did not differ in their overall performance in 20 seconds of the response period, there is strong evidence that the infants after observing the full demonstration model produced the target acts more directly than they did after observing the failed-attempt model. As the important scoring issue concerns the immediacy of infants' imitative performance (see Section 2.2.5 for a discussion), that means that they should be capable of producing the target acts as their initial acts if they do so on the basis of an imitation strategy. Yet none of the Failed-Attempt, Emulation-Learning, and Adult-Manipulation groups produced the target acts at the first act as frequently as the Full-Demonstration group. It is thus questionable whether 1 ½-year-old infants in Meltzoff's Failed-Attempt paradigm learned to reproduce the intended but unfulfilled target acts on the basis of an imitation strategy.

On the other hand, as in Meltzoff's (1995) study, the results of Experiment 1 also showed that the Full-Demonstration and Failed-Attempt groups did not differ in latency to produce target acts when all target acts produced in 20 seconds of the response period were scored. However, the infants were more likely to reproduce the target acts as either their first acts or first and second acts combined in the Full-Demonstration condition than in the Failed-Attempt condition. It did not appear that shorter latency could ensure that infants would produce the target acts more readily as their initial acts. They might be quicker to bring about the target acts after observing the failed-attempt model, while they could still potentially explore the objects in a very short time before the target acts were produced. Returning to the scoring issue, that is, in contrast to the measure of latency, the immediacy of imitation appears to be more adequately captured by scoring the order in which the target acts were produced. Therefore, the scoring method of taking account of infants' overall performance in 20 seconds of the response period, on which Meltzoff and Bellagamba and Tomasello's findings were based, was likely to boost the number of target acts produced by the infants in the Failed-Attempt condition.

Next, the number of target acts elicited by observing the failed-attempt model might be accounted for by infants' learning about the affordances of the objects during observation. There are two findings suggesting that the infants in the Full-Demonstration and Failed-Attempt conditions based their performance on target acts on different behavioural strategies. First, the Full-Demonstration group reproduced the target acts as their first acts or first and second acts combined more often than the Failed-Attempt group. If there was a convergence between the two groups in terms of the behavioural strategy used to produce the target acts, their performance should not have been affected by the order in which the target acts were scored. Further, the Full-Demonstration group produced relatively few other acts at the first act as compared with the Failed-Attempt group, who did not differ from either the Emulation-Learning group or the Adult-Manipulation group. By contrast, there were some similarities between the Failed-Attempt and Emulation-Learning groups in the behavioural strategy on which infants based their production of target acts. Both the Failed-Attempt and Emulation-Learning groups were not as likely to produce the target acts at the first act as the Full-Demonstration group was, while, remarkably, both of them produced a similar number of target acts as the Full-Demonstration group when all target acts produced in the 20-second response period were scored. As the Adult-Manipulation group performed more poorly than the Full-Demonstration group all the same, the Failed-Attempt and Emulation-Learning groups should have received more demonstrated information in relation to target acts than that that the Adult-Manipulation group had received. Thus, the effect of stimulus enhancement that the Adult-Manipulation condition was intended to induce did not appear to be the operating processes influencing infants' performance in the Failed-Attempt condition. On the contrary, there is evidence suggesting that emulation learning influenced the target acts produced as the children's subsequent acts rather than the initial acts. According to this account, it is likely that emulation learning accounts for the effect of observing the failed-attempt model on children's overall performance in 20 seconds of the response period.

Overall, the infants in the Emulation-Learning condition reproduced 2.4 target acts out of five trials, which was similar to that reported by Bellagamba and Tomasello, who found that the infants reproduced 2.2 such acts by observing the end states of the target demonstration. Bellagamba and Tomasello showed that the infants performed better by observing the failed-attempt model than by observing the end states of the target demonstration. However, the results of the current study did not replicate their findings.

Although it was arguable whether Experiment 1 exactly repeated Meltzoff's Failed-Attempt format, it is important to note that Bellagamba and Tomasello and Meltzoff adopted only the scoring method of counting all target acts produced in the 20-second response period. In Experiment 1, the infants in the Failed-Attempt and Emulation-Learning conditions did not differ in the number of target acts produced whichever of the three scoring strategies was applied. As discussed above, the scoring method of counting all target acts produced in the 20-second response period is likely to inflate infants' imitative performance and thus obscure the significance of imitation, which took place as the children's first acts in the present study. What would the results have been if both the previous studies adopting Meltzoff's Failed-Attempt paradigm took account of the infants' first acts only?

A related finding was that the object parts of which infants first took hold were not necessarily related to their performance at the first act. The infants in the Emulation-Learning condition started by taking hold of the parts that the experimenter did not first touch more often than they did in the Failed-Attempt condition. However, these groups did not differ in the number of target acts or other acts produced at the first act. Moreover, no difference was found among the four groups as regards the tendency to start by touching the object parts with which the experimenter made the first manual contact, whereas only the Full-Demonstration group produced more target acts and fewer other acts at the first act. It appears that infants were likely to react to the object sets by acting on the parts which they saw the experimenter first handle, but that did not necessarily ensure that they would produce more target acts and fewer other acts at the first act. This is probably the reason why the infants in the Adult-Manipulation control never produced a level of target acts comparable to that they did in the Full-Demonstration condition, even if they had watched the experimenter touch the target-relevant parts of the object sets.

Constraints of types of demonstrated acts

As infants might selectively reproduce outcomes of demonstrated acts when they were of certain kinds, it is important to assess whether they reproduced the non-target-relevant control acts observed in Adult-Manipulation condition or the failed acts observed in the Failed-Attempt condition. As discussed in Chapter 1 and Section 2.1, if the infants in the Adult-Manipulation condition did not replicate the observed control acts as frequently as they reproduced the observed target acts in the Full-Demonstration condition, it might be the case that the infants in the Full-Demonstration condition found the observed outcomes more interesting and then were more motivated to reproduce them. In contrast, the observed outcomes resulting from the non-afforded control acts in the Adult-Manipulation condition might be less salient and not interest the infants. In this way, it would seem to be that the infants after observing the failed-attempt model produced the target acts in preference to the acts actually demonstrated because they were likely to induce the acts which they found attractive by themselves during observation. That is, they might have learned the dynamic affordances of the objects during observation of the failed-attempt display, and that might induce them to produce the target acts. On the other hand, that the infants reproduced few of the demonstrated failed acts could be interpreted as suggesting that they were not interested in or had problems in reproducing the observed outcomes when they did not specify the affordances of the objects.

Overall, the infants in the Adult-Manipulation condition did not differentially imitate the acts which they had observed. All the groups produced almost none of the adult-manipulation control acts as their first acts. Though the difference between the Adult-Manipulation and Failed-Attempt groups approached marginal significance when counting the children's first and second acts combined, the Adult-Manipulation, Full-Demonstration, and Emulation-Learning groups did not differ in the number of control acts produced. Overall, the infants in the Adult-Manipulation control replicated very few of the control acts: 0.5 out of five trials when counting the first and second acts combined, as compared with 2.6 and 1.3 reported by Meltzoff (1995) and Bellagamba and Tomasello (1999) respectively. As Meltzoff and Bellagamba and Tomasello adopted the scoring method of scoring all acts in the 20-second response period as a whole, the number of the reproduced control acts could have been overestimated in their findings. In the present study, the number of acts falling into the category of Adult

Manipulation and other scoring categories tended to be lower, because only the infants' first acts and first and second acts combined were scored. Moreover, more types of response were cross-checked in parallel. Therefore, so far as the immediacy of imitation was concerned, it did not appear that the infants in Meltzoff's and Bellagamba and Tomasello's studies were capable of reproducing the observed control acts just as they imitatively copied the observed target acts when only their first acts or first and second acts combined were counted.

Neither of the previous studies scored infants' reproduction of the demonstrated failed acts from seeing the failed-attempt model. Similar to the analysis of their reproduction of the demonstrated control acts, the present study showed that the infants in the Failed-Attempt condition copied few of the failed acts which they had actually observed. The groups brought about virtually no such acts as their first acts or their first and second acts combined. Compared to the target acts, which the infants readily replicated by observation, it seemed that there were certain constraints on their abilities to replicate the control acts and the failed acts. This matches the author's impression when scoring the videotapes. Whereas Meltzoff (1995) suggested that 18-month-olds after observing the failed-attempt model tended to re-enact the intended but unfulfilled target acts instead of copying the observed acts literally, an alternative would be that they copied few of the demonstrated failed acts as a result of their difficulties in replicating acts of this kind.

There are two possible explanations for the findings concerning infants' infrequent reproduction of the observed outcomes of the acts observed in the Failed-Attempt and Adult-Manipulation conditions. First, it might be that infants selectively reproduced the observed acts that resulted in the observed outcomes of certain kinds, particularly when they specified the affordances of the object sets. For example, they were likely to put the loop over the prong so that the prong "held" the loop, but not likely to drop the loop by the prong or move the loop along the edge of the screen. It is possible that the infants' imitative performance was most successful in the Full-Demonstration condition because the demonstrated target acts resulted in the type of outcomes that they were able and likely to replicate. On the other hand, the infants reproduced few of the demonstrated failed attempts and control acts perhaps because such acts resulted in the types of outcomes that they might find difficult to replicate.

Second, copying the observed outcomes from seeing the failed-attempt or adult-manipulation model might require that infants recognise the demonstrated failed attempts and control acts as the demonstrator's intended acts. At the outset of this section, the author claimed that the infants' performance on target acts in Meltzoff's Failed-Attempt paradigm could justify ascription of intentions to the model providing that they were capable of equally well imitating the observed outcomes in the Adult-Manipulation and Full-Demonstration conditions. If not so, infrequent reproduction of the demonstrated failed attempts would be interpreted as infants being induced to produce the type of outcomes that they were likely to replicate, for example: the object-afforded outcomes that they learned during observation of the failed-attempt demonstration. It is important to note that although the adult-manipulation model was designed to present infants with the non-target-relevant control acts, the experimenter did not produce these acts arbitrarily. These demonstrated control acts were "intended" in the sense that the experimenter enacted them according to a format. Thus, the infants in the Adult-Manipulation condition reproduced few of the observed control acts, perhaps because they had problems in reading the observed outcomes of such acts as intended. Similarly, the demonstrated failed attempts could be "intended" in the sense that the experimenter intentionally avoided consummating the end results of the target acts. Unless the scenario could show that the experimenter's failure to consummate the target acts was accidental, there is strong reason to question whether the demonstrator in Meltzoff's Failed-Attempt paradigm was intending to make mistakes or produce the intended subsequent but unfulfilled outcomes. It is possible that infants would be more likely to copy the observed outcomes of the demonstrated failed attempts if they could have understood that the adult indeed failed to consummate the target acts on purpose (see Section 1.5, Chapters 4 & 5 for related discussions).

Emulation learning and finger-button analysis

The most compelling evidence of emulation learning is perhaps the case of the infants in the Emulation-Learning condition, who efficiently used their finger to activate the beeper in the object set of box and stick as their first and second acts combined. The data showed that the infants who produced the beeping sound in the Emulation-Learning condition were more likely to push the button of the box with their finger than those in the Full-Demonstration, Failed-Attempt, and Adult-Manipulation conditions combined. On the contrary, the infants who produced the beeping sound in the latter three conditions combined pushed the button with the stick more frequently than the infants in the Emulation-Learning condition. Although the target act was scored only when the infant used the stick to push the button and produced the beeping sound, this finding suggests that exposure to the acoustic affordance of an object is sufficient to elicit a similar effect of emulation learning on infants' invention of their own behavioural strategy to reproduce the end result as exposure to the final configuration of an object.

Except for the object set of box and stick, infants saw two parts of the other object sets either physically connected (loop and prong, beads and cylinder, and square and dowel) or physically disconnected (dumbbell) in the Emulation-Learning condition. In such circumstances, they were probably induced to produce the target acts in the latter four object sets on the basis of emulation learning, because they could derive action information required for producing such acts by themselves from seeing the initial and end states of these object sets. In the object set of box and stick, the initial state was observed, but the end state was received in the form of an acoustic outcome instead. Thus, the infants did not witness the visual configuration that the stick connected with the button of the box. However, they were capable of devising their own behavioural strategy to activate the underlying beeper from hearing the beeping. It is quite probable that the third type of emulation learning described in Section 1.6.2 could take place when the very end result of the object received is either a visual configuration or an acoustic sound.

Why were infants likely to reproduce the beeping sound with their finger in the Emulation-Learning condition, and with the stick in the other three conditions combined? A possibility is that the infants in the Emulation-Learning condition were quick to associate the beeping sound with the box rather than the stick, because they did not see the experimenter move the stick and only the unchanged initial position of the stick was observed. Additionally, there is reason to believe that the size and shape of the box were more likely to capture infants' attention as compared to the stick that was smaller and less salient. It may be that they were not cued to pick up the stick and thus tended to produce their initial acts on the box where their attention was attracted. This might explain why these infants used their finger but not the stick to reproduce the heard beeping sound. In contrast, the infants in the other three conditions combined saw the experimenter first move the stick and transform its relative distance to the box. It is possible that they were not only cued to handle the stick by observing the experimenter's manipulation but also to follow the modelled sequence to use the stick to push the button of the box.

Indeed, in comparison with the infants in the Emulation-Learning condition, the infants in the other three conditions combined were more likely to learn the dynamic properties of the object set (e.g., the size of the stick and button) when observing the spatial transformation required for demonstrating the target act, failed attempt, or adult manipulation. There might be a possibility that the infants in the Failed-Attempt and Adult-Manipulation conditions produced the target act simply because they responded to the dynamic affordances of the object set highlighted by the experimenter's manipulations. For example, they used the stick to push the button, because they learned by observation that the recessed button on the top of the box was pushable. They might not have anticipated the outcome of the beeping sound when doing so. On the other hand, the infants in the Emulation-Learning condition were not given an opportunity to learn the dynamic affordances of the object set by observing the experimenter's manipulation. However, the data of the present study evidently showed that even an acoustic outcome was sufficient to induce an effect of emulation learning on infants' behavioural reproduction. The majority of children in such circumstances were capable of devising their own behavioural strategy to emulate the heard beeping sound.

Summary

In summary, the findings of Experiment 1 seriously challenge Meltzoff's (1995)

Failed-Attempt paradigm that attempts to take advantage of infants' ability to imitate acts on objects to explore their possession of the concept of intention. The extent to which infants' performance on target acts in Meltzoff's paradigm could be interpreted in terms of emulation learning was revealed as the scoring procedure took account of all target acts produced in 20 seconds of the scoring period. The effect of imitation was recognised only when the infants' first acts were scored. If infants learned to produce the target acts by way of imitating or re-enacting the intended subsequent but unfulfilled target acts from seeing the demonstrated failed attempts, they should theoretically have produced these acts as directly as they did after observing the full demonstration of the target acts. However, the present study replicated Meltzoff's (1995) and Bellagamba and Tomasello's (1999) findings only when the infants' overall performance in the 20-second response period was considered. Moreover, the significance of emulation learning was revealed as the target acts scored as the children's subsequent responses were entered into the analyses. It can be argued that Meltzoff's and Bellagamba and Tomasello's findings were biased by their scoring strategy. Thus, the two-action scoring strategy first used in the present study provides a potential methodology of ruling out emulation learning by scoring the order in which the target acts were produced. Yet, it is not clear whether in Experiment 1 the slightly lower level of target acts produced by the infants in the Failed-Attempt condition was due to their inability to read intention content or methodological limitations of Meltzoff's Failed-Attempt paradigm. Experiment 3 (see Chapter 4) will serve to address these issues. Nonetheless, there is some evidence that the infants in the Failed-Attempt and Emulation-Learning conditions were similar in the behaviour strategy that they used to produce the target acts. Although the infants in the Failed-Attempt condition did not witness the end results of the target acts, it is possible that the experimenter highlighted the afforded end states of the object sets during demonstration of the failed attempts which were similar and relevant to the target acts. In this way, the infants in the Failed-Attempt condition could learn the object-afforded target acts by themselves. This possibly explains why exposure to the failed-attempt model and the initial and end states of the object sets elicited a similar number of target acts. Further, exposure to the failed-attempt model and the initial and end states of the object sets elicited fewer target acts as the infants' first acts than exposure to the full demonstration model, but no difference was found among the three types of model in the 20-second response period. This suggests that imitative learning is likely to take place as the infants' initial acts as contrasted with emulation learning which influences their subsequent acts. As it is likely that the infants were basing their performance on emulation learning after observing the failed-attempt model, this probably accounts for why they reproduced fewer target acts as their first acts than they did after observing the full demonstration model. Finally, except in the Full-Demonstration condition, there is no evidence that the infants could imitatively copy the observed acts in the Adult-Manipulation and Failed-Attempt conditions. This suggests that in imitating acts on objects, infants selectively reproduced the demonstrated acts when they resulted in the observed outcomes that were afforded by the objects. As 18-month-old infants' ability to imitate acts on objects appears to be reliant on the observed outcomes that specified affordances, it is questionable that their imitative performance in Meltzoff's Failed-Attempt paradigm was guided by ascription of intention to the model.

Chapter Three

Imitating failed attempts: Reading intentions vs. spatial contiguity

Experiment 2

3.1. Introduction

In Experiment 1, while Meltzoff's (1995) and Bellagamba and Tomasello's (1999) findings about infants' re-enactment of intended target acts in Meltzoff's Failed-Attempt paradigm were replicated when all target acts produced in the 20-second response period were scored, the evidence of imitation for their performance on target acts was revealed at the first act only. Only the children who observed the full demonstration of the target acts were found to differentially imitate these acts at the first action. Additionally, the findings of Experiment 1 showed that the effect of observing the failed-attempt model on children's production of target acts is similar to that of observing the initial and target end states of the object sets. It was suggested that infants were induced to reproduce the afforded end states of the object sets by observing the demonstrated failed attempts. Emulation learning appears to account for their overall performance on target acts in 20 seconds of the response period.

Recall that the demonstrator in Meltzoff's Failed-Attempt format not only manipulated the target-relevant parts of the object set but also moved them close to one another in order to transform the object set from its initial state to the unconsummated end state of the target act. In Section 1.6.1, it has been suggested that infants during observation of the failed-attempt model might be attracted to the contiguity of the target-relevant parts of the object set. They might simply produce the target act as a result of reacting to the observed contiguity. This might be interpreted as a potential stimulus enhancement[1]. Experiment 2 was designed to explore how being exposed to the initial and transitional state[2] of the object set influences infants' behavioural performance in Meltzoff's Failed-Attempt paradigm.

Table 3.1 displays a summary of analyses of the four types of demonstration employed in Experiment 1. First, consider the Full-Demonstration and Emulation-Learning conditions. Although children in these two conditions had equal access to the end results of the target acts, the Full-Demonstration group produced the target acts more directly than the Emulation-Learning group. As can be seen in Table 3.1, the main difference between these two conditions was that in the Full-Demonstration condition the end results followed the experimenter's actions on the objects, whereas in the Emulation-Learning condition the experimenter only presented the end results without directly acting on the objects except that he placed them on the table. As all groups watched the experimenter place the objects on the table at the beginning, the likelihood of that giving rise to stimulus enhancement should have been controlled. Thus, information containing only end results does not appear to be sufficient to contribute to children's performance on target acts at the first act compared to that when information on both actions and following end results is available. However, when the overall performance in 20 seconds of the response period was considered, there is evidence of emulation learning that infants could efficiently utilise inputs consisting of only the initial and end states of the object sets to reproduce the target acts.

Next, as shown in Table 3.1, the Failed-Attempt condition differed from the Full-Demonstration condition in that the end results of the target acts were not available in the failed-attempt display, whereas the end results were fully presented in the target display. Although both the failed-attempt and target displays involved

[1] Stimulus enhancement refers to situations where an observer's attention is drawn to a part of an object by the actions of the demonstrator (Spence, 1937; Whiten & Ham, 1992). C. It is implicitly assumed in the animal literature that the demonstrator's contact with a stimulus is also likely to attract an observer's attention and to facilitate responding to the stimulus (Zentall, 1996). In Experiment 2, the term stimulus enhancement is used in an extended, unconventional way to refer to the situation where the children's attention was drawn to the contiguity between the target-relevant parts of the object sets by observing the failed-attempt model.

[2] The transitional state here refers to the specific setting of the target-relevant object parts being contiguous. Such a state occurs prior to completion of the target act as contrasted with the end state which refers to the end point of the target act.

the experimenter's actions and manual contact with the relevant parts of the objects which were close to one another, the Failed-Attempt group did not produce the target acts as directly as the Full-Demonstration group. In contrast to inputs consisting of both actions and end results, information including target-relevant actions but without explicit end results such as those involved in the failed-attempt demonstration was less efficient in inducing infants' production of target acts at the first act. In spite of that, the results showed that children's overall production of target acts in 20 seconds of the response period could benefit from the inputs demonstrated in the failed-attempt display. Analogous to the process of emulation learning, it is possible that the failed-attempt model involves target-relevant acts which induces children to produce the target acts by highlighting the afforded end results of the target acts.

Table 3.1. Analyses of the four types of demonstration used in Experiment 1.

Condition[1] Availability	FD	FA	EL	AM
		End results of target acts		
Dumbbell	Observed	Not observed	Observed	Not observed
Box & stick	Observed & beeping	Not observed & no beeping	Not observed & beeping	Not observed & no beeping
Prong & loop	Observed	Not observed	Observed	Not observed
Cylinder & beads	Observed	Not observed	Observed	Not observed
Post & square	Observed	Not observed	Observed	Not observed
		Experimenter's manual contact with objects in modelling phase		
Dumbbell	Observed	Observed	Not observed	Observed
Box & stick	Observed	Observed	Not observed	Observed
Prong & loop	Observed	Observed	Not observed	Observed
Cylinder & beads	Observed	Observed	Not observed	Observed
Post & square	Observed	Observed	Not observed	Observed
		Spatial contiguity of target-relevant parts of objects[2]		
Dumbbell	Split into two	Not transformed	split into two	Not transformed
Box & stick	++	+ (vertical)[3]	not observed	+ (horizontal)[3]
Prong & loop	++	+	++	-
Cylinder & beads	++	+	++	-
Post & square	++	+	++	-

Note 1.FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; and AM = Adult-Manipulation.
Note 2. "++" indicates that target-relevant parts touched and overlapped with one another; "+" indicates that target-relevant parts touched but did not overlap with one another; and "-" indicates that target-relevant parts did not touch one another.
Note 3. The end of the stick touched the button on the top of the box in a vertical or horizontal position.

As regards the Adult-Manipulation and Failed-Attempt conditions, the adult-manipulation display, like the failed-attempt display, involved the experimenter's manual contact with the target-relevant parts of the objects. In addition, the end results of the target acts were not available in either display. Although the experimenter handled the target-relevant parts of the objects in the Adult-Manipulation condition, the manipulations presented were non-target-relevant. In contrast, the actions involved in the Failed-Attempt condition were target-relevant in the sense that the sequences of movements leading to the demonstrator's failure to consummate the target acts overlapped with those leading to their full production. In Meltzoff's (1995) study, the adult-manipulation display served as a control for the possibility that children are induced to produce the target acts by observing the adult manipulate the objects. In Experiment 1, the adult-manipulation display was replicated to provide a basis for stimulus enhancement. It assessed whether children were merely attracted to the object parts that the demonstrator handled during demonstration of the target acts or failed attempts. The results of Experiment 1 confirmed Meltzoff's (1995) and Bellagamba and Tomasello's (1999) findings that exposure to the adult-manipulation model elicited a relatively insignificant effect on children's overall production of target acts in 20 seconds of the response period, as compared with the other types of demonstration.

Another crucial feature distinguishing the Failed-Attempt condition from the Adult-Manipulation condition concerned a variation in the distance between the target-relevant parts of the objects. As shown in Table 3.1, except for the dumbbell object set, the acts demonstrated with the other four objects in the failed-attempt display involved the transitional states of the target-relevant object parts being contiguous. In contrast, in the adult-manipulation display, such a transitional state was characteristic only of the acts demonstrated with the object set of box and stick, and those with the other four objects did not involve the contiguity of the target-relevant parts of the objects. For example, in the Failed-Attempt condition, the beads touched the upper rim of the cylinder every time they fell to the table, whereas in the Adult-Manipulation condition, the beads fell to the table without touching any part of the cylinder. In Meltzoff's (1995) study, the adult-manipulation display was cautiously scripted to draw children's attention to the target-relevant parts of the objects, which the demonstrator manipulated in the target and failed-attempt displays. However, the contiguity of the relevant parts of the objects involved in the adult-manipulation display was not controlled as much as that involved in demonstration of the target and failed acts. Could children be induced to produce the target acts by way of observing the particular settings that the target-relevant parts of the objects touched or were contiguous? It is possible that the adult-manipulation control acts exerted a relatively insignificant effect on children's production of target acts because children were not attracted to the contiguity of the target-relevant parts of the object sets during observation of the adult-manipulation model. Such a possibility clearly cannot yet be ruled out.

The results of Experiment 1 have tempered Meltzoff's (1995) and Bellagamba and Tomasello's (1999) findings as regards children's performance on target acts in Meltzoff's Failed-Attempt paradigm in two ways. On the one hand, the effect of imitation on children's production of target acts was revealed as their first actions in the response period. None of the Failed-Attempt, Emulation-Learning, and Adult-Manipulation groups brought about the target acts at the first action as directly as the Full-Demonstration group. On the other hand, Meltzoff's and Bellagamba et al.'s findings that the Failed-Attempt and Full-Demonstration groups did not differ were replicated when all target acts produced during the 20-second response period were considered. However, children's overall production of target acts in 20 seconds of the response period could also be attributed to the combined effects of imitative and non-imitative learning, as each of the Emulation-Learning, Failed-Attempt, and Full-Demonstration groups obtained a similar level of target acts. Experiment 2 was modelled on Experiment 1, with an additional control for an alternative view that children after observing the failed-attempt model may simply produce the target acts as a result of reacting to the contiguity of the target-relevant parts of the object sets. At some point, it might be that children learned little about the dynamic affordances involved from seeing the failed-attempt display. That is, could the kind of stimulus enhancement induced by the spatial contiguity of the target-relevant parts of the objects be sufficient to account for children's performance on target acts in Meltzoff's Failed-Attempt paradigm?

A novel condition of spatial contiguity was designed to address the issue considered above. Three distinguishing features characterising the settings comprising the Spatial-Contiguity control are the following. First, as in the Full-Demonstration and Failed-Attempt conditions, the experimenter behaved at the target-relevant parts of the objects. Second, instead of manipulating the objects by way of a sequence of acts, the experimenter merely moved the parts of the objects close to one another and then presented children with the settings in which the target-relevant parts were contiguous. Each of the five settings lasted for a preset duration and in this way drew children's attention to the spatial contiguity of the target-relevant parts of the objects. Third, whereas the modelled action was repeated three times with each object set in the Full-Demonstration and Failed-Attempt conditions, each spatial-contiguity setting was presented only once in the modelling phase. If the experimenter repeatedly displayed the same setting, children could possibly interpret the repetitive acts as his failed attempts. In this way, the Spatial-Contiguity control offered a situation in which children were simply attracted to the settings that the target-relevant parts of the objects were contiguous. As each setting was presented once rather than three times, the Spatial-Contiguity condition provided a highly conservative test of the hypothesis of non-imitative learning.

If children in Meltzoff's Failed-Attempt paradigm are induced to bring about the target acts by observing the contiguity of the parts of the objects handled by the experimenter, then the Failed-Attempt and Spatial-Contiguity groups should be similar in levels of target acts achieved. If, however, the Spatial-Contiguity group performs more poorly than both of the Failed-Attempt and Emulation-Learning groups, which do not differ from each other, then that would suggest that Meltzoff's Failed-Attempt paradigm provides a basis for emulation learning.

3.2. Methods

3.2.1. Participants

Forty 17-month-old infants (M = 17.3, SD = 1.6) from North London participated in the study. They were recruited from a number of playgroups and health centres via posters and invitation from their health visitors. There were twenty males and twenty females. No child was dropped from the final sample. The subjects consisted of 67.5% White, 20.0% Asian, and 12.5% African.

3.2.2. Test situation

The testing took place in a consulting room at the health centre, or at home if such an arrangement was favoured by parents, or at a laboratory in the Department of Psychology at University College London. Twenty-five of the infants were tested at home, nine at the Health Centres, and six at the laboratory. The test situation including the placement of video camera, warm-up procedure, and instructions for parents, is identical to that described in Experiment 1 of Chapter 2.

3.2.3. Test materials

The test objects were the same as those used in Experiment 1 (see Appendix). They were replicas of the five object sets devised in Meltzoff's (1995) study.

3.2.4. Experimental design

There were four groups in the study: Full-Demonstration, Failed-Attempt, Emulation-Learning, and Spatial-Contiguity. With the exception of the novel condition of Spatial Contiguity, the types of demonstration presented to the Full-Demonstration, Failed-Attempt, and Emulation-Leaning groups were identical to those described in Experiment 1. As in the previous study, the Emulation-Learning group served as a control for the possibility: that infants after watching the failed-attempt demonstration produce some target acts because they learn the final configurations of the target acts through the process of emulation learning. The Spatial-Contiguity group was designed to control for another possibility that infants are attracted to the contiguity of the target-relevant object parts during observation of the failed-attempt demonstration and that induces the potential effect of stimulus enhancement on their production of target acts. In this novel condition, the experimenter merely moved two individual parts of the object set to bring them in close proximity so that they were contiguous with each other. In a sense, the spatial-contiguity display was used to mimic the transitional states prior to the consummation of the target acts. Such states typically occurred in the process of demonstrating both the target and failed acts. Also, to diminish the involvement of target-relevant actions, the experimenter simply drew infants' attention to the closeness of two target-relevant parts of the object set by moving its one part (e.g., loop) close to another part (e.g., prong). More importantly, he did not directly manipulate the object set as he did in the Full-Demonstration and Failed-Attempt conditions. Furthermore, as infants might interpret a series of trials in a single demonstration period as the adult repeatedly attempting to produce the target act, each object array in the spatial-contiguity demonstration was presented only once for 10 seconds, instead of being repeated in three consecutive trials. After that presentation, the moved object part was brought back to its initial state. As a consequence, the demonstrator did not produce the observed outcome of the demonstrated failed act. Similar to the other three conditions, the experimenter completed each spatial-contiguity display in approximately 20 seconds, then the object set was handed on to the child.

The following describes the modelling procedure in the Spatial-Contiguity condition.

Dumbbell—In comparison to the other object sets of which the target acts required transformations in which two object parts become physically connected, the target act of the dumbbell involved one object becoming two disconnected parts. Thus, rather than moving one half of the dumbbell adjacent to the other half, the experimenter merely picked it up by the two cubes, then held it still in a horizontal position for 10 seconds. During the modelling period, the cubes were never pulled outwards or pushed inwards, nor did the experimenter's hands leave the cubes. After that, the dumbbell was put back on the table.

Box and stick—The experimenter picked up the stick, then held it still in a vertical position above the button on the top of the box at a distance of approximately 1 cm for 10 seconds. During the modelling period, the stick was never pushed into the button, nor did it ever move cross the top of the box. After that, the stick was put back to where it was picked up initially.

Prong and loop—The experimenter raised the loop, then held it still in front of the bulbous tip of the prong at a distance of approximately 1 cm for 10 seconds. During the modelling period, the loop was never moved a little closer to the tip, and thus the loop never went beyond the tip, nor did it ever rest on the prong. After that, the loop was put back to where it was picked up initially.

Beads and cylinder—The experimenter raised the beads, then held the vertically suspended chain of beads still approximately 1 cm above the upper rim of the cylinder for 10 seconds. During the modelling period, the beads were never lowered down into the cylinder, nor were they released to fall to the table outside the cylinder. After that, the beads were put back to where it was picked up initially.

Square and dowel—The experimenter picked up the square with two hands, then held it still in a horizontal position above the wooden base at a distance of approximately 1 cm for 10 seconds. Thus, the dowel standing on the wooden base was directly below the round hole in the centre of the square. During the modelling period, the square was never moved closer than 1 cm to the wooden base. The dowel never did protrude through the round hole nor did the square ever cross the base. After that, the square was put back to where it was picked up initially.

3.2.5. Scoring

The scoring followed the two-action scoring procedure employed in Experiment 1. The first and second actions the infants produced in the five 20-second response periods were scored for the analyses. To enable the scoring system to capture the full range of acts that the infants could potentially perform, the types of actions demonstrated for the Full-Demonstration, Failed-Attempt, and Spatial-Contiguity groups comprised the main scoring categories. Thus, the first and second actions in 20 seconds of the scoring period were coded depending on whether they corresponded to the operational criteria of one of the scoring categories, respectively. As in the previous study, the infant's failure to complete the target acts due to manipulation problems was assigned to an independent category of Unfinished Target Act, in distinction from those actions falling into the categories of Failed Act and Target Act. Altogether, there were six scoring categories in the present study: (1) Target Act, (2) Unfinished Target Act, (3) Failed Act, (4) Spatial Contiguity, (5) Other Act, and (6) No Act. Except for the category of Spatial Contiguity, the operational criteria for the rest were identical to those described in Section 2.2.5. The criteria for scoring the category of Spatial Contiguity are as follows:

> *Dumbbell*—The child held the dumbbell with two hands, so that each hand grasped a cube. The cubes were never pulled outwards or pushed inwards. In cases where the child held the dumbbell with two hands but one hand moved away from the cube, the action was scored as Failed Act. If the child twisted or moved the connecting tubular piece but without splitting the dumbbell into two halves, these actions were coded in Other Act. Target Act was assigned only when the dumbbell split into two.
>
> *Box and stick*—The child raised the stick, then held it in an upright position at a distance from the button on the top of the box. The end of the stick had never to touch the top of the box. In cases where the stick was not above the half of the top in which the button was located, the act was scored Other Act. If the stick crossed the box once, the action was scored Failed Act only when the stick touched the half of the top in which the button was located and did not go in the recess.
>
> *Loop and prong*—The child picked up the loop, then held it in front of the bulbous tip of the prong. The child must never put the loop over the prong, or drop it to the table. The loop could cross some of the bulbous tip, but must never cross it more than once and never go beyond it. If the loop crossed the tip more than

once and at least on one occasion went beyond the tip, the action was scored Unfinished Target Act as long as the loop did not drop to the table. In the case that the loop crossed the tip once and did not go beyond it, Spatial Contiguity was assigned only when the loop was never released from the child's hand; otherwise the act was coded in Failed Act. If the loop was held next to other parts of the prong rather than the bulbous tip, the act was scored Other Act.

Beads and cylinder—The child raised the beads, then held the chain of beads near the upper rim of the cylinder. Some of the beads were allowed to cross the rim only once and the whole chain had never to be fully underneath the rim. On occasions when the beads crossed the edge more than once and at least on one occasion some of the beads went into the cylinder, the action was coded as Unfinished Target Action if the beads were not released from the child's hand; otherwise, Other Act was scored instead. If the beads crossed the edge once and did not completely go inside the cylinder, Spatial Contiguity was assigned to the act so long as the beads were not released from the child's hand.

Square and dowel—The child picked up the square with either two hands or one hand, then held it in a horizontal position at a distance above the wooden base plate. The protruding post had never to cross the round hole or the square, and the square had never to cross the wooden base. If the square crossed the dowel once and the dowel did not pass through the round hole, the act was considered Failed Act only when the square was released from the child's hand and then remained over the dowel with a tilt or slid down it; otherwise, Other Action was assigned instead.

3.2.6. Inter-rater Reliability

The author coded infants' responses in each of the five test objects from the videotapes. A colleague who was taught to use the scoring system coded 30% of the data (3 children per condition) independently for the purpose of assessing inter-rater reliability. As in Experiment 1, reliability was obtained in three aspects: (1) the children's first actions, or (2) first and second actions combined coded in each of the six scoring categories, or (3) the target acts produced in the 20-second response period. Percentage agreement between the author and the colleague for infants' responses falling into the pre-defined scoring categories as the first action was 92%, with a kappa of 0.86, similar to 90% and a kappa of 0.83 for their first and second actions combined. Percentage agreement for infants' overall production of the target acts in the 20-second response period was quite high, 97% with a kappa of 0.93.

3.3. Results

As in Experiment 1, the number of acts falling into each of the scoring categories was transformed into a proportion because three participants in the present study did not have a complete record of five response periods. One child in the Full-Demonstration group walked away when the object set of box and stick was placed in front of her, apparently because she was scared of the beeping noise made by the experimenter. Two other missed data points were caused by a camcorder fault during the experiment: on one child's response to the object set of loop and prong in the Emulation-Learning group and on one child's response to that of beads and cylinder in the Full-Demonstration group. The means of the proportion of infants' first acts and first and second acts combined coded in each of the scoring categories are presented in Table 3.2. As in Experiment 1, the four conditions were compared with regard to the proportion of infants' responses falling within the following categories, including Target Act (first act, and first and second acts combined, and in the 20-second response period), Failed Act (first act, and first and second acts combined), Spatial Contiguity (first act, and first and second acts combined), and Unfinished Target Act (first act, and first and second acts combined). These data were entered into one-way analyses of variance assessing the effect of condition. Following a one-way ANOVA, pairwise comparisons were performed by the use of a Tukey HSD test. The subsidiary analyses included: (1) the latency to produce the target acts, (2) the proportion of infants' first acts falling into the category of Other Act, (3) the parts of the objects that infants first touched, and (4) the number of infants using a finger to activate the beeper in the object set of box and stick.

3.3.1. Main analyses

Target acts produced at first action

There was a significant difference in the proportion of target acts produced at the first action as a function of condition, $F(3, 36) = 8.20$, $p < 0.001$. Follow-up Tukey HSD tests showed that the infants produced significantly more target acts as their first acts in the Full-Demonstration condition than they did in the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning conditions, $p < 0.003$,

Table 3.2. Means of the proportion of 17-month-old children's first actions and combination of first and second actions falling into each of the scoring categories.

Condition / Action	Full-Demonstration *Mean (SD)*	Failed-Attempt *Mean (SD)*	Spatial-Closeness *Mean (SD)*	Emulation-Learning *Mean (SD)*
TA-1st	.62 (.27)	.24 (.25)	.28 (.22)	.16 (.13)
FA-1st	.02 (.06)	.06 (.10)	.04 (.08)	.04 (.08)
SC-1st	.04 (.08)	.04 (.08)	.08 (.14)	.05 (.10)
OA-1st	.27 (.21)	.60 (.25)	.54 (.28)	.70 (.19)
NO-1st	.00 (.00)	.00 (.00)	.00 (.00)	.00 (.00)
TA (UN)-1st	.06 (.10)	.06 (.10)	.06 (.14)	.02 (.06)
TA(F)-1st	.00 (.00)	.00 (.00)	.00 (.00)	.04 (.08)
Total	1.01	1.00	1.0	1.01
TA-1st+2nd	.70 (.19)	.38 (.29)	.34 (.25)	.34 (.25)
FA-1st+2nd	.04 (.08)	.10 (.14)	.06 (.10)	.08 (.14)
SC-1st+2nd	.08 (.14)	.06 (.10)	.14 (.14)	.05 (.10)
OA-1st+2nd	.63 (.16)	.80 (.25)	.74 (.35)	.80 (.16)
NO-1st+2nd	.11 (.17)	.04 (.08)	.00 (.00)	.16 (.25)
TA (UN)-1st + 2nd	.10 (.11)	.10 (.14)	.08 (.17)	.04 (.08)
TA (F)-1st+2nd	.00 (.00)	.02 (.06)	.04 (.08)	.09 (.11)
REPEAT	.35 (.20)	.50 (.22)	.60 (.21)	.46 (.26)
Total	2.01	2.00	2.0	2.02
TA-20 sec	.70 (.19)	.44 (.32)	.48 (.30)	.39 (.22)

Note 1. TA-1st = target act produced at first action; FA-1st = failed act produced at first action; SC-1st = spatial contiguity produced at first action; OA-1st = other acts produced at first action; NO-1st = no act produced at first action; TA (UN)-1st = unfinished target act produced at first action; TA (F)-1st = using finger to activate the beeper in the object set of box and stick at first action.
Note 2. TA-1st+2nd = target act produced at first and second actions combined; FA-1st+2nd = failed act produced at first and second actions combined; SC-1st+2nd = spatial contiguity produced at first and second actions combined; OA-1st+2nd = other act produced at first and second actions combined; NO-1st+2nd = no act produced at first and second actions combined; TA (UN)-1st+2nd = unfinished target act produced at first and second actions combined; TA (F)-1st+2nd = using finger to activate the beeper in the object set of box and stick at first and second actions combined; Repeat = repeated response.
Note 3. TA-20 sec = target act produced within 20 seconds of the scoring period.

$p < 0.009$, and $p < 0.001$, respectively (see Figure 3.1). No group differences were found among the latter three conditions.

Target acts produced at first and second acts combined

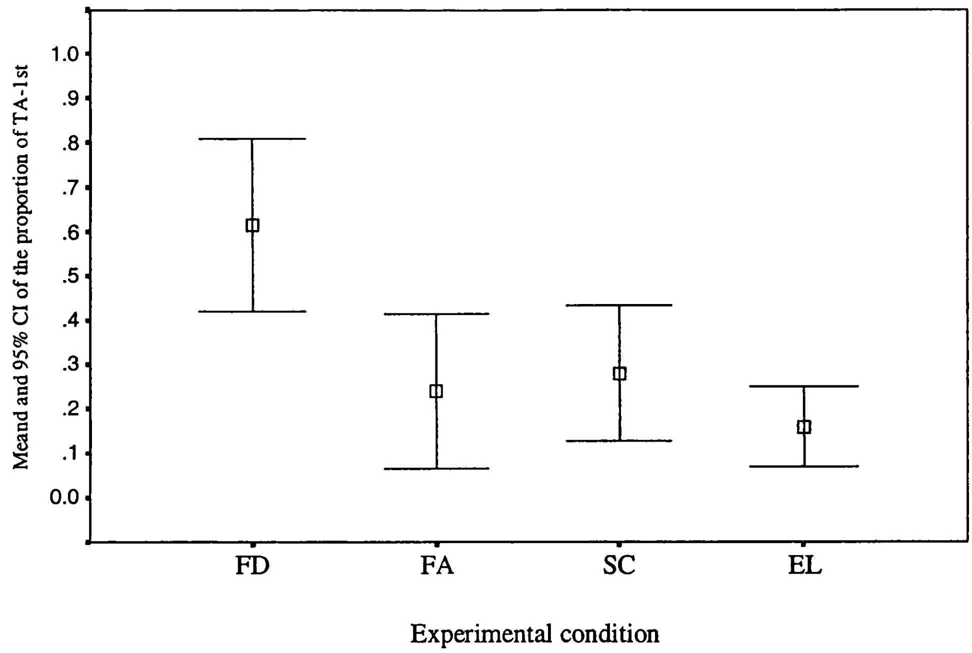
There was a significant difference in the proportion of target acts produced at the first and second acts combined as a function of condition, $F (3, 36) = 4.80$, $p< 0.007$. Similar to the previous analysis, follow-up Tukey HSD tests revealed that the infants in the Full-Demonstration condition produced more target acts as the first and second acts combined than the infants in any of the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning conditions, $p < 0.04$, $p < 0.02$, and $p < 0.02$, respectively (see Figure 3.2). None of the latter three groups differed from one another significantly.

Target acts produced in 20-second response period

The effect of condition on the proportion of target acts produced in 20 seconds of the response period only reached a marginally significant level, $F (3, 36) = 2.64$, $p = 0.069$. Follow-up Tukey HSD tests showed that the infants in the Full-Demonstration condition produced more target acts in the 20-second response period than the infants in the Emulation-Learning condition. However, the statistical significance was marginal, $p = 0.059$ (see Figure 3.3). There were no other apparent group differences.

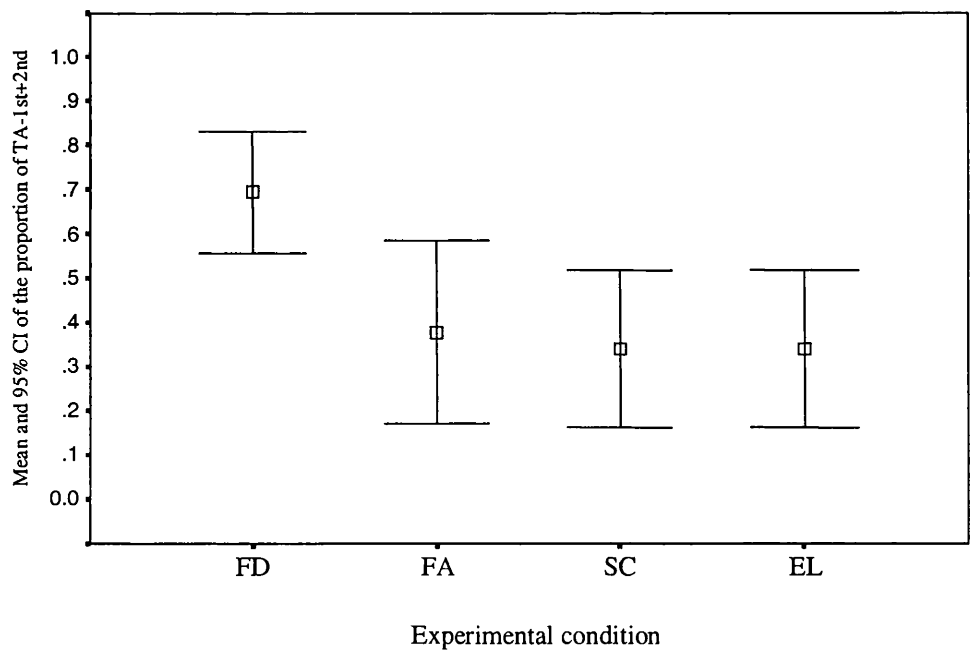
Failed acts

As can be seen in Table 3.2, the infants in the Failed-Attempt condition reproduced few of the demonstrated failed attempts which had been observed: 6% as compared with 24% of the target acts produced as their first acts; and 10% as compared with 38% of the target acts produced as their first and second acts combined. There was no significant difference in the proportion of demonstrated failed acts reproduced at either the first act or the first and second acts combined as a function of condition, $F (3, 36) = 0.39$, $p > 0.7$, and $F (3, 36) = 0.48$, $p > 0.7$, respectively.



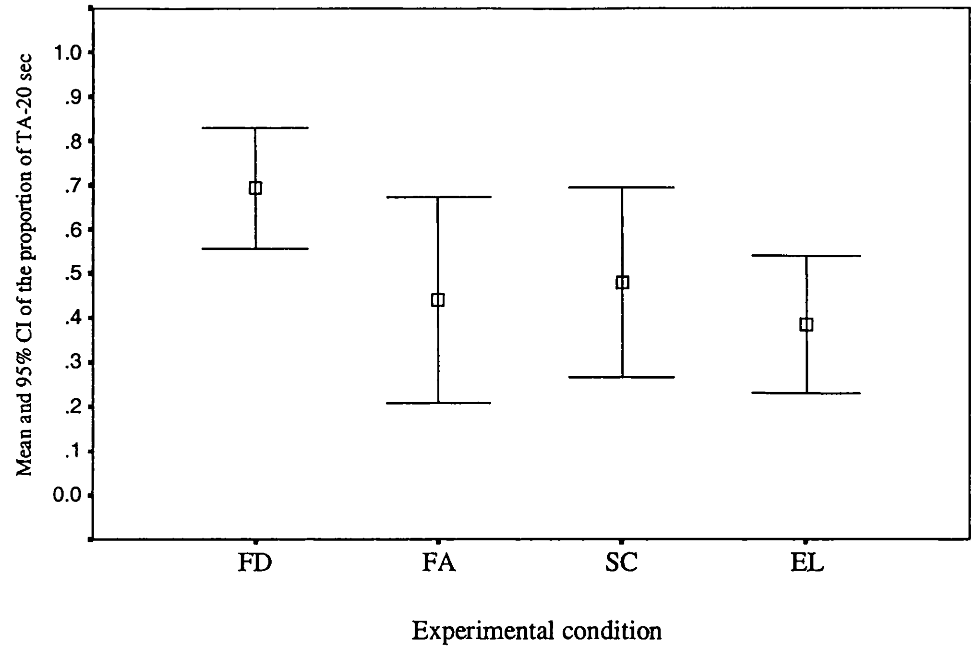
Note. FD = Full-Demonstration; FA = Failed-Attempt; SC = Spatial-Contiguity; EL = Emulation-Learning.

Figure 3.1. Means and 95% CI of the proportion of 17-month-old children's first actions coded in the category of Target Act (TA-1st) as a function of condition.



Note. FD = Full-Demonstration; FA = Failed-Attempt; SC = Spatial-Contiguity; EL = Emulation-Learning.

Figure 3.2. Means and 95% CI of the proportion of 17-month-old children's first and second actions combined coded in the category of Target Act (TA-1st+2nd) as a function of condition.



Note. FD = Full-Demonstration; FA = Failed-Attempt; SC = Spatial-Contiguity; EL = Emulation-Learning.

Figure 3.3. Means and 95% CI of the proportion of 17-month-old children's actions produced during the 20-second response period coded in the category of Target Act (TA-20 sec) as a function of condition.

Spatial-Contiguity control acts

Similar to what they did in the Failed-Attempt condition, the infants in the Spatial-Contiguity condition reproduced relatively few of the acts actually demonstrated: 8% as compared with 28% of the target acts produced as their first acts; and 14% as compared with 34% of the target acts produced as their first and second acts combined. There was no significant difference in the proportion of spatial-contiguity control acts reproduced at either the first act or the first and second acts combined as a function of condition, $F(3, 36) = 0.35$, $p > 0.7$, and $F(3, 36) = 1.24$, $p > 0.3$, respectively.

3.3.2. Subsidiary analyses

Other acts produced at first action

There was a significant difference in the proportion of other acts produced at the first action as a function of condition, $F(3, 36) = 6.09$, $p < 0.002$. Pairwise comparisons using a post-hoc Tukey HSD test indicated that the infants produced fewer other acts as their first acts in the Full-Demonstration condition than they did in the Emulation-Learning and Failed-Attempt conditions, $p < 0.001$ and $p < 0.01$, respectively. No difference was found between the Emulation-Learning and Failed-Attempt groups. Neither did any of the Full-Demonstration, Failed-Attempt and Emulation-Learning groups differ from the Spatial-Contiguity group.

Unfinished target acts

No significant effect of condition was revealed in the proportion of unfinished target acts produced at either the first act or the first and second acts combined, $F(3, 36) = 0.39$, $p > 0.7$, and $F(3, 36) = 0.48$, $p > 0.6$, respectively.

Using a finger to activate the beeper in the object set of box and stick

Table 3.3 shows the number of infants in the Emulation-Learning condition successfully using the stick or their finger to activate the underlying beeper in the box compared to those in the other three conditions combined. The finger-using and stick-using responses obtained from the Full-Demonstration, Failed-Attempt, and Spatial-Contiguity conditions were grouped for overall analyses, because the infants in these three conditions watched the experimenter start by picking up the stick in the demonstration. In contrast, the infants in the Emulation-Learning condition never saw the experimenter manipulate the stick in order to transform its initial state. Thus, the number of children who used the stick or their finger to induce the beeping noise was analysed as a function of whether they had observed the experimenter's hand in contact with the stick. The results from the 2×2 cross tables showed that the infants in the Full-Demonstration, Failed-Attempt, and Spatial-Contiguity conditions combined more frequently used the stick to activate the beeper as their first act than the infants in the Emulation-Learning condition, $p < 0.02$ (Fisher's exact test). Similarly, counting the children's first and second acts combined, there was a significant effect of observing the experimenter's manual contact with the stick on infants' use of the stick to produce the beeping noise, $p < 0.03$ (Fisher's exact test).

Table 3.3. Number of 17-month-old children using a finger or stick to activate the beeper in the object set of box and stick.

Action / Condition	Firs action		First and second actions combined	
	Finger	Stick	Finger	Stick
Full-Demonstration Failed-Attempt Spatial-Contiguity	0	9	3	11
Emulation- Learning	2	0	4	1

Object parts infants first touched

Analyses of the parts of the object sets infants first touched were intended to assess whether infants tended to start by acting on the same object parts which the experimenter first handled in the demonstrations. Except for the Emulation-Learning group, the other three groups always watched the experimenter start by acting on a certain part of the object set; that is, cube, stick, loop, beads, and square. As in Experiment 1, the parts of the objects infants first touched were scored according to whether they were consistent with, or different from the five parts listed above, or infants touched more than one part at a time, or did not touch the object set at all. Table 3.4 gives the means of the proportion of object parts infants first touched, coded on each of the four occasions. A one-way ANOVA performed on the proportion of first-touched object parts which were consistent with those the experimenter had first touched revealed a significant effect of condition, $F(3, 36) = 4.75$, $p < 0.007$. Follow-up Tukey HSD tests showed that the Full-Demonstration group more often first touched the object parts on which the experimenter started by acting than the Emulation-Learning group, $p < 0.005$. The Full-Demonstration group did not differ from either of the Failed-Attempt and Spatial-Contiguity groups. No differences were found among the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning groups.

The foregoing analyses were complemented by a one-way ANOVA on the proportion of first-touched object parts which were different from those the experimenter had first touched. There was a significant difference as a function of condition, $F(3, 36) = 4.05$, $p < 0.02$. Follow-up Tukey HSD tests showed that the Emulation-Learning group more frequently first touched the different parts of the

Table 3.4. Means of the proportion of parts of objects 17-month-old children first touched in the response period.

Object part Condition	Consistent with the demonstration *Mean (SD)*	Different from the demonstration *Mean (SD)*	Touching more than one part *Mean (SD)*	No response *Mean (SD)*
Full-Demonstration	.92 (.15)	.02 (.06)	.07 (.14)	.00 (.00)
Failed-Attempt	.70 (.17)	.22 (.20)	.08 (.14)	.00 (.00)
Spatial-Contiguity	.80 (.25)	.18 (.26)	.02 (.06)	.00 (.00)
Emulation-Learning	.57 (.25)	.34 (.25)	.09 (.11)	.00 (.00)

object sets from the experimenter than the Full-Demonstration group, $p < 0.008$. Neither were any differences apparent among the Emulation-Learning, Failed-Attempt, and Spatial-Contiguity groups. No group differences were apparent among the Full-Demonstration, Failed-Attempt, and Spatial-Contiguity groups either.

As regards occasions when infants started by taking hold of more than one part at a time, a one-way ANOVA on the data did not yield a significant effect of condition, $F(3, 36) = 0.63$, $p > 0.60$.

Latency to produce target acts

The means of the latency to produce the target acts were analysed for such acts produced as the children's first acts, first and second acts combined, and overall performance in the 20-second response period (Table 3.5). No significant difference was found in the latency to produce the target acts as a function of condition regardless of which scoring method was adopted: $F(3, 26) = 0.24$, $p > 0.8$, when counting the first acts only; $F(3, 29) = 0.29$, $p > 0.8$, when counting the first and second acts combined; and $F(3, 32) = 0.81$, $p > 0.4$, when counting all target acts produced in the 20-second response period.

Table 3.5. Means of the latency for target acts produced at first action (TA-1st), first and second actions combined (TA-1st+2nd), and in 20 seconds of the response period (TA-20 sec).

Latency (sec) / Condition	TA-1st *Mean (SD)*	TA-1st+2nd *Mean (SD)*	TA-20 sec *Mean (SD)*
Full-Demonstration	4.62 (1.64) n = 9	6.12 (3.58) n = 10	6.12 (3.58) n = 10
Failed-Attempt	5.23 (1.24) n = 6	7.50 (2.86) n = 7	8.40 (2.69) n = 8
Spatial-Contiguity	5.66 (2.59) n = 8	6.48 (2.28) n = 8	8.41 (3.71) n = 9
Emulation-Learning	5.31 (4.07) n = 7	6.16 (3.98) n = 8	7.52 (4.40) n = 9

Note 1. "n" is the valid number of infants.

3.4. Discussion

Both Experiments 1 and 2 were designed to examine the extent to which children's production of target acts in Meltzoff's Failed-Attempt paradigm may be interpreted as falling into other forms of nonimitative learning. One possibility is that infants are basing their production of target acts on the affordances of the objects they learn during observation of the failed-attempt model. In Experiment 1, a novel condition of Emulation-Learning in which the infants were exposed to the initial and end states of the object sets but without seeing the demonstrator transform the object sets was designed to explore this possibility. The end states specified the affordances involved in the failed-attempt and the full demonstration models. Another possibility is that infants merely react to spatial contiguity of the target-relevant object parts noticeable in the demonstrated failed attempts and that results in their production of target act. In an extended sense, the demonstrator's failed attempts could draw infants' attention to contiguity of object parts and that might act as stimulus enhancement processes for their production of target acts. In Experiment 2, the design of Experiment 1 was replicated and extended with the replacement of a novel condition of Spatial Contiguity for the Adult-Manipulation control. The Adult-Manipulation control developed by Meltzoff (1995) involved the experimenter manipulating the object parts relevant to what the demonstrator did in the Full-Demonstration and Failed-Attempt conditions. The Spatial-Contiguity control served as an advanced control for contiguity of object parts that required manipulation in order to transform the object set from its initial state to its consummated or unconsummated end state of the target act. In this condition, the infants were exposed to the initial state of the object set and the transitional state of the target-relevant parts being contiguous but without seeing either the consummated or unconsummated end state of the target act. The Spatial-Contiguity control provided a highly conservative test of the role of observing contiguity of object parts in infants' production of target acts in Meltzoff's Failed-Attempt paradigm, because the initial and transitional state of each object set was presented once rather than three times.

The findings of the present study strongly suggest that either emulation learning or spatial contiguity has the potential to account for infants' performance on target acts in Meltzoff's Failed-Attempt paradigm. Whatever scoring strategy was adopted, the Failed-Attempt, Emulation-Learning, and Spatial-Contiguity groups did not differ from one another in the number of target acts produced. Counting the children's first acts or first and second acts combined, none of the three groups attained a level of target acts similar to that which the Full-Demonstration group had. On the contrary, when all target acts produced in 20 seconds of the response period were considered, the Full-Demonstration group did not outperform any of the other three groups. A slight difference between Experiments 1 and 2 is that in Experiment 1 the Full-Demonstration and Emulation-Learning groups did not differ in the number of target acts produced as the first and second acts combined, whereas in Experiment 2 the Emulation-Learning group produced a lower number of target acts than the Full-Demonstration group under this analysis. Additionally, counting all target acts produced in 20 seconds of the response period, a marginally significant difference was found between the Full-Demonstration and Emulation-Learning groups in Experiment 2, whereas these two groups did not differ under this analysis in Experiment 1. However, overall the pattern of the findings of Experiment 2 was similar to that indicated in Experiment 1. The infants after observing the full demonstration of the target acts imitatively reproduced such acts as their first acts as compared with occasions when they observed the other types of demonstration. On the other hand, with the inclusion of target acts produced as the children's subsequent acts in 20 seconds of the response period, the nonimitative learning processes of emulation learning and reacting to spatial contiguity became significant variables.

Emulating target acts as subsequent responses

There are a number of reasons to challenge Meltzoff's (1995) and Bellagamba and Tomasello's (1999) interpretation that infants in Meltzoff's Failed-Attempt paradigm are re-enacting the demonstrator's intended acts by way of producing the target acts. First, as in Experiment 1, Experiment 2 replicated Meltzoff's and Bellagamba et al.'s findings only when all target acts produced in 20 seconds of the response period were counted. Under this analysis, however, not only the Failed-Attempt group but also both of the Emulation-Learning and Spatial-Contiguity groups were able to produce a similar number of target acts as the Full-Demonstration group. It is thus questionable whether infants' performance on target acts after observing the failed-attempt model was guided by ascription of intentions to the demonstrator, because the effects of emulation learning or this kind of stimulus enhancement induced by observing spatial contiguity of object parts could also account for such a performance.

Second, the evidence of imitation for children's performance on target acts was revealed when counting the first acts or the first and second acts combined. As in Experiment 1, exposure to the full demonstration of the target acts elicited more of the target acts as the children's first acts than exposure to the other three types of demonstration. Consider the notion that the behavioural re-enactment technique exploits infants' behavioural tendency to imitate the intentional actions of others (Meltzoff, 1995). If the infants were re-enacting the adult's intended but unconsummated target acts from seeing the failed-attempt model, they should theoretically have produced the target acts at the first act as frequently as they did from observing the full demonstration of the target acts. Yet both Experiments 1 and 2 showed that the Failed-Attempt group attained the level of target acts that the Full-Demonstration group did only when the scoring procedure took account of the children's overall performance in 20 seconds of the response period. Therefore, as in Experiment 1, the results of Experiment 2 support the assertion that Meltzoff's and Bellagamba et al.'s findings could be biased by scoring all target acts produced in 20 seconds of the response period. It may be that the scoring method capitalising on children's overall performance in the 20-second response period conceals the effect of imitation on their tendency to produce the target acts at the first act.

While there is evidence that the infants after observing the failed-attempt model were not basing their performance on target acts on the behavioural strategy of imitation, either emulation learning or reacting to spatial contiguity could be the potential behavioural strategy they adopted in such circumstances. The findings of Experiment 1 suggested that infants learned the end states of the target acts afforded by the objects during observation of the demonstrated failed attempts, as the number of target acts they produced after observing the failed-attempt model was similar to that they did after observing the initial and end states of the object sets. Nonetheless, it has not been concluded that the infants in these two conditions used the shared behavioural strategy to produce the target acts. To date, in the infant literature, there has been little existing developmental research attempting to assess the effect of emulation learning by expounding the child's behavioural strategy in relation to the order in which the demonstrated act is reproduced. While there is the likelihood that the processes of emulation learning influence infants' subsequent responses rather than initial responses, might it be the case that the infants in the Failed-Attempt condition merely reacted to spatial contiguity of target-relevant object parts without cognitively learning about the affordances of the objects? That is, they might be just attracted to the transitional states of the target-relevant parts being contiguous as a consequence of producing the target acts, and probably learn little about the afforded end states of the target acts during observation of the failed-attempt model.

Emulation learning vs. reacting to spatial contiguity?

Basically, the results of Experiment 2 suggest that the infants from the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning groups used a similar behavioural strategy to bring about the target acts. First, it did not appear that the infants in the Failed-Attempt or Spatial-Contiguity condition produced the target acts without learning the afforded end states of the target acts by observation. The straightforward evidence comes from the finding that exposure to the failed-attempt model elicited a similar number of target acts as exposure to the initial and transitional states of the object sets regardless of whatever scoring procedure was applied, and neither differed from exposure to the initial and end states of the object sets. In addition, counting all target acts produced in 20 seconds of the response period, exposure to any of the above three types of demonstration elicited a number of target acts similar to that elicited by exposure to the full demonstration of the target acts. Thus, it did not seem that infants' performance on target acts in Meltzoff's Failed-Attempt paradigm could be simply interpreted as their reacting to the transitional states of the target-relevant object parts being contiguous, because their performance in the Spatial-Contiguity condition might also be interpreted as a differing aspect of emulation learning.

Second, none of the infants in the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning conditions produced the target acts at the first act as often as they did in the Full-Demonstration condition. Although the infants in the Failed-Attempt and Spatial-Contiguity conditions were as likely to start by following the object parts on which the demonstrator first acted as the infants in the Full-Demonstration condition were, neither of them in these former two conditions produced the target acts at the first act as often as the Full-Demonstration group. On the other hand, the infants in the Emulation-Learning condition started by acting on the object parts which differed from those the experimenter first touched more frequently than they did in the Full-Demonstration condition. The infants in the Emulation-Learning condition did not produce fewer target acts than they did in the Failed-Attempt or Spatial-Contiguity condition. Moreover, even if the infants in these latter two conditions started by following the object parts of which the experimenter first took hold, they did not produce fewer other acts as their first acts than the infants in the Emulation-Learning condition. On the contrary, the infants in any of these above three conditions were more likely to produce other acts as their first acts than they were in the Full-Demonstration condition. These findings showed that the infants in the Failed-Attempt and Spatial-Contiguity conditions did not benefit from observing the experimenter's first contact with the object sets so as to produce the target acts more directly than the infants in the Emulation-Learning condition. Alternatively, similar to exposure to the initial and end states of the object sets, exposure to the failed-attempt model and spatial contiguity models influences infants' subsequent acts rather than their initial acts.

It appears that infants' performance on target acts in Meltzoff's Failed-Attempt paradigm cannot simply be reduced to the effect of emulation learning or this kind of stimulus enhancement specified in the current study. It might be that both effects combined to give rise to such a performance. Further, it is possible that the spatial-contiguity model not only drew children's attention to the transitional states of the target-relevant object parts being contiguous but also highlighted the afforded end states of the target acts. The spatial-contiguity model was intended to focus children's interest on specific settings in which the target-relevant parts of the objects were contiguous to one another with a minimum of act content. However, the demonstration might shed light on the dynamic affordances of the objects when the experimenter moved the object set from its initial state to its transitional state of spatial contiguity. The sequences of movement required for transforming the object set from its initial state to its transitional state could probably have elicited an effect similar to emulation learning. That is, children might learn the afforded end states of the target acts by observing the track of object movement. Unless the modelling procedure could prevent infants from seeing the experimenter transform the object set, the spatial-contiguity display would unavoidably involve target-relevant acts.

According to this account, children's production of target acts in the Failed-Attempt and Spatial-Contiguity conditions could be explained in terms of their learning about the object-afforded target acts. None of the children in the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning conditions were able to produce the target acts at the first act as directly as the children in the Full-Demonstration condition were. In Experiment 1, it was strongly suggested that children's first acts adequately capture the immediacy of imitation compared to their overall performance in 20 seconds of the response period. It is important to emphasise that group comparisons based on infants' production of target acts in 20 seconds of the response period as in the analyses done by Meltzoff (1995) and Bellagamba and Tomasello (1999) could possibly cover the effect of imitation with other nonimitative contingent performances. Ensuring that analyses of group differences give precedence to the basis of imitative performance, the author suggests that only the acts produced at the first act be entered into the scoring procedure.

Constraints of types of demonstrated acts

One other finding worth emphasising is that, as in Experiment 1, in Experiment 2 the infants in the Failed-Attempt condition copied few of the demonstrated failed attempts compared to the number of target acts produced. Similarly, the infants in the Spatial-Contiguity control were also found to replicate few of the observed demonstrated acts. In Experiment 1, it was suggested that infants were not likely to reproduce the observed failed acts and non-afforded control acts because infants may be used to acting on objects with elicitation of their dynamic properties and copying the observed outcomes of these acts would not result in the object-afforded outcomes. In the same way, in the present study the infants did not show a tendency to replicate the observed spatial-contiguity settings, perhaps because they could not make sense of whether copying such settings would bring the affordances of the objects to light. In a sense, these findings suggest that 18- or 19-month-old infants' imitative performance in situations involving acts on objects might be confined to acts that result in certain types of outcomes, for example, when they specify affordances of objects. Thus, Meltzoff's (1995) interpretation that 18-month-old infants re-enacted the target acts in preference to the observed failed attempts as a result of their ability to read the adult's intended acts could be questioned. Alternatively, it might be that infants copied few of the demonstrated failed acts as a result of other constraints on their ability to replicate the observed outcomes of these acts without producing the affordances involved.

Moreover, infants' failure to replicate the spatial-contiguity settings (Experiment 2) and non-afforded control acts (Experiment 1) raises a methodological question concerning the adequacy of imitation as a paradigm for exploring infants' understanding of intentions. As considered above, to assess understanding of the concept of intention would require an imitating situation where the outcome resulting from the demonstrator's act be of certain kinds. In Experiments 1 and 2, for example, the infants after observing the full demonstration model reproduced most target acts as their first acts. They were capable of copying the observed acts in such circumstances where there was the matched relation between the resulting outcomes and the affordances involved. In the Failed-Attempt and Spatial-Contiguity conditions where the observed outcomes resulting from the demonstrator's acts did not specify explicit affordances, the infants tended to produce the object-afforded but unobserved outcomes instead of copying the observed outcomes, similar to what they did in the Emulation-Learning condition. Thus, while there is strong evidence that the infants in the Full-Demonstration condition imitatively reproduced the target acts at the first act, it is not clear whether their imitative performance was guided by the observed outcomes that specify the affordances involved or by attribution of goals to the adult. As in the full demonstration model the observed outcomes specified both the intended outcomes and the object affordances, it does not appear that the intentional aspect of infants' imitative performance in such circumstances could be delineated. Similarly, the infants did not imitatively reproduce the acts observed in the Failed-Attempt and Spatial-Contiguity conditions perhaps because of their failure to decode the observed outcomes of these acts as the goals of the model in the absence of elicited affordances. Indeed, the observed outcomes of many acts that infants see the adult carry out with objects in the world do not always specify or highlight affordances of objects, however, unquestionably the adult is intending to perform them in such ways.

Furthermore, infants' failure to replicate the spatial-contiguity settings and non-afforded manipulations could challenge the assertion that the target acts are the only acts that justify the demonstrator's goals in Meltzoff's Failed-Attempt format. In Sections 1.5 and 2.4, the author suggested that the infants' failure to copy the acts observed in the Failed-Attempt condition was related to an inability to read the observed acts presupposing an underlying intentional stance of the demonstrator. It was emphasised that the acts involved in each type of demonstration in Experiments 1 and 2 were "intended", rather than "arbitrary", in the sense that they were presented by the experimenter following a scripted sequence of parts of a movement, even if the resulting outcomes did not specify affordances of objects. However, in both Experiments 1 and 2, only the infants in the Full-Demonstration condition were found to imitatively reproduce the observed acts as their first acts. There was no evidence of imitation that the infants differentially copied the acts observed in the Failed-Attempt, Spatial-Contiguity, and Adult-Manipulation conditions. As the adult-manipulation control acts were non-afforded as contrasted with the demonstrated failed attempts and spatial-contiguity settings which were similar and relevant to the target acts, the infants' failure to reproduce the control acts could lead to the claim that they have problems either in replicating certain types of demonstrated acts or in interpreting the observed outcomes of certain types of demonstrated acts as intended. In this way, it is possible that the infants in the present study copied few of the demonstrated failed acts and spatial-contiguity settings because they were not aware that the observed outcomes of these acts entailed intention content. On the other hand, the infants exhibited a considerable tendency to emulate the target acts in the Failed-Attempt and Spatial-Contiguity conditions. This might suggest that they were more interested in inducing the affordances they found out by observation than copying the observed outcomes without producing the results already in place. These highlighted but unobserved outcomes were supposed to be more attractive than the observed outcomes. Thus, it did not appear that the infants in the Failed-Attempt, Spatial-Contiguity, and Adult-Manipulation conditions did not reproduce the observed acts because these acts entailed no intention content. Alternatively, there is reason to believe that 18- or 19-month-olds' imitative performance in situations involving acts on objects is highly reliant on the types of demonstrated acts, for example, when the observed outcomes of the acts specify both goals and affordances. Thus, a critical methodological issue confronting imitation as a paradigm for investigating the concept of intention would be infants' ascription of goals to the model when there is no matched relation between the affordances involved and the observed outcomes. For future research on infants' understanding of intentions using an imitation paradigm, it is important to clarify the constraints of various types of demonstrated acts on their imitative performance.

Finally, as in Experiment 1, the analysis of infants' use of their finger or the stick to activate the beeper in the object set of box and stick showed that the infants who successfully produced the beeping sound pushed the button with their finger in the Emulation-Learning condition more often than they did in the Full-Demonstration, Failed-Attempt, and Spatial-Contiguity conditions combined. The infants in the latter three conditions combined, similarly to what they did in the Full-Demonstration, Failed-Attempt, and Adult-Manipulation conditions combined in Experiment 1, were more likely to produce the beeping sound using the stick as compared to the infants in the Emulation-Learning condition. It may be that the infants in these three conditions combined observed the experimenter's manual contact with the stick when he transformed the initial state of the stick to produce the target act, failed attempt, and spatial contiguity. As a result, they may be cued to pick up the stick and to push the button as compared to the infants in the Emulation-Learning condition where the initial state was unchanged and the end state was received in the form of an acoustic stimulus. Both findings of Experiments 1 and 2 support the suggestion that exposure to the initial and acoustic outcome of the object could elicit a similar effect of emulation learning as exposure to the initial and visual configuration of the object.

Summary

In summary, the results of the current study support the suggestion of Experiment 1 that Meltzoff's (1995) and Bellagamba and Tomasello's (1999) analyses of infants' re-enactment of intended acts in Meltzoff's Failed-Attempt paradigm were biased by counting all target acts produced in 20 seconds of the response period. None of the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning groups produced the target acts at the first act as frequently as the Full-Demonstration group did. On the contrary, the four groups did not differ from one another when all target acts produced in 20 seconds of the response period were entered into the scoring. The pattern of findings suggests that children's production of target acts based on the overall performance in the 20-second response could include some contingent learning processes, which fall into other forms of nonimitative learning, such as the effects of emulation learning and observing spatial contiguity of objects. It is important to note that in the Spatial-Contiguity condition the track of object movement when the experimenter moved the object set from its initial state to the transitional state of spatial contiguity was not controlled, and that could probably induce children to learn the dynamic affordances of the objects. It is possible that the spatial-contiguity model provided a basis for a differing aspect of emulation learning, rather than the kind of stimulus enhancement that had been specified in the present study. It is thus not clear that children after observing the failed-attempt model simply produced the target acts as a result of reacting to contiguity of the target-relevant object parts. Overall, the infants from the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning groups were similar in the behavioural strategy that they used to achieve the target acts. Both of the demonstrated failed attempts and spatial-contiguity settings were likely to highlight the end states of the target acts, and influenced children's subsequent responses in a similar way as exposure to the initial and end states of the object sets.

Further, except for exposure to the full demonstration of the target acts, there was no evidence that exposure to the other types of demonstration elicited the effect of imitation on children's reproduction of the observed acts. This suggests that 18- or 19-month-olds' imitative performance in situations involving acts on objects is susceptible to occasions when the observed outcomes of the demonstrated acts are of certain kinds, for example, when there is the matched relation between goals and affordances. While there is evidence that exposure to the full demonstration model elicited a manifest effect of imitation on infants' performance on target acts, it is not clear whether their imitative performance was guided by attribution of intentions or by the observed outcomes. Because in such circumstances the observed outcomes specified both the goals and the affordances involved. Therefore, the adequacy of imitation of acts on objects as a paradigm for assessing infants' possession of the concept of intention was discussed with regard to constraints of types of demonstrated acts.

Chapter Four

Imitating failed attempts: What is demonstrated vs. what is intended?

Experiment 3

4.1. Introduction

Experiments 1 and 2 explored to what extent children's production of target acts in Meltzoff's Failed-Attempt paradigm may be interpreted as children imitatively learning the intended but unfulfilled subsequent acts. In both studies, the evidence of imitation came from the Full-Demonstration condition where the infants who watched the target display differentially reproduced the target acts as their first actions. There was no evidence that the infants in the Failed-Attempt condition imitatively reproduced the target acts that the experimenter judged to be the intended but unfulfilled subsequent acts. Alternatively, it was suggested that infants learned the dynamic affordances of the objects by observing the failed-attempt model and that this accounted for their higher level of target acts in the 20-second response period than that they produced from observing the adult-manipulation model. Another possibility, as discussed in Experiment 1, was that the infants in the Failed-Attempt condition did not produce the target acts as directly as they did at the first action in the Full-Demonstration condition because they had difficulty in decoding the intended acts underlying the demonstrator's failed attempts. Although the infants in the Failed-Attempt condition were less successful in bringing about the target acts as their first acts than they were in the Full-Demonstration condition, they displayed a proclivity to produce the target acts instead of replicating the observed failed acts. In Meltzoff's Failed-Attempt format, the acts demonstrated in the display were judged to lead to the intended subsequent but unfulfilled target acts by the demonstrator. Theoretically, if the infants in the Failed-Attempt condition were capable of adopting an imitation strategy to reproduce the intended target acts, they should have brought about these acts at the first action as directly as they did in the Full-Demonstration condition where there was evidence of imitation. On the other hand, however, the infants in the Adult-Manipulation condition reproduced neither the target acts nor the non-target-relevant control acts observed. This raises questions such as: Did the infants not read any intended acts from the observed acts in the Adult-Manipulation condition? Why should infants not read the acts actually demonstrated as the intended acts and imitatively respond to these control acts? Were the control acts arbitrary or non-afforded in nature, and thus not able to induce the infants to imitate?

Experiment 3 extended Experiment 1 by including two novel age groups of 31- and 41-month-old children. Experiment 3 examined the hypothesis that there might be evidence of imitation in older children's production of target acts in Meltzoff's Failed-Attempt paradigm. That is, older children may equally frequently produce the target acts as their first actions in both the Full-Demonstration and Failed-Attempt conditions as a consequence of their superior abilities to ascribe intentions to others' behaviour compared to the 19-month-olds studied in Experiment 1.

Children of 31 and 41 months of age were recruited for two reasons. First, previous research has shown that children as young as three years of age have developed the ability to distinguish intended actions from unintended ones such as mistakes (Moses, 1993; Shultz & Wells, 1985; Shultz, Wells, & Sarda, 1980; Yuill, 1984). For example, Yuill (1984) presented 3-year-olds picture stories in which a "thought bubble" indicated whether the protagonist in the picture wanted the outcome (e.g., throwing a ball to a particular child) to happen or not. Yuill showed that 3-year-olds were able to identify, based on the protagonist's motives, which of the two outcomes was the intended one and would make the protagonist more pleased. In Shultz, Wells, and Sarda's (1980) study, 3-year-olds observed themselves or an adult pick up a shiny penny between a shiny and a dull penny on the table. In the *intention* condition, the adult or children was asked to notice where each penny was, and to pick up the shiny penny with their eyes closed. In the *mistake* condition, the adult or children wore a set of prism glasses that distorted their field of vision, and thus picked up the dull penny by mistake. The results showed that 3-year-olds correctly identified the intentional actions and mistaken ones between the two conditions, for both their own and the adult's behaviour.

Second, although considerable imitation research has chosen to test 2-year-olds in learning tool use (e.g., Call & Tomasello, 1995; Nagell, Olguin, & Tomasello, 1993; Tomasello, Savage-Rumbaugh, & Kruger, 1993; Want & Harris, in press b; Whiten, Custance, Gomez, Teixidor, & Bard, 1996), previous researchers did not specify a particular age range in the 2- to 3-year-old period. In addition, very little research on children's understanding of intention has looked at this age period. Nevertheless, there is evidence that children as young as 2 ½-year-olds possess the ability to impute internal states such as emotions (e.g., happy, sad) to a protagonist in a story, based on the match between the protagonist's desires and the outcome (Wellman & Woolley, 1990). Further, it has been suggested that a theory-like understanding of the mind may extend to cover children of 2 ½ to 3 years of age (Wellman, 1990). Therefore, in Experiment 3, two older groups of 31- and 41-month-old children were recruited to examine the hypothesis that the older children who observe the failed-attempt model are more likely to imitatively reproduce the intended subsequent but unfulfilled target acts as a result of their ability to generate inferences about the intended outcomes than the 19-month-olds investigated in Experiment 1.

Consider the methodological issue raised in Section 1.5.1. Children's production of target acts in Meltzoff's Failed-Attempt paradigm may imply that they are re-enacting the adult's intended subsequent but unfulfilled outcomes, but it is still an open question whether the demonstrated failed attempts can only be interpreted as leading to the target acts. If Meltzoff's Failed-Attempt format is adequate for assessing children's understanding of the intended target acts, the older children should be more likely to reproduce the target acts at the first action equally well in both the Full-Demonstration and Failed-Attempt conditions because they benefit from a greater ability to recognize the intentions of others than the 19-month-olds. Then the slightly lower level of target acts produced by the infants in the Failed-Attempt condition of Experiments 1 and 2 would be interpreted as their difficulties in reading the unfulfilled intentions. That is, understanding of the unfulfilled intentions predicted that the children in the Failed-Attempt condition imitatively reproduced the intended target acts at the first action just the same as they did in the Full-Demonstration condition. By contrast, if there were no evidence that the older children could produce the target acts at the first action equally frequently in both the Failed-Attempt and Full-Demonstration conditions, the methodological adequacy of Meltzoff's Failed-Attempt paradigm would be questioned. Several possibilities suggested in Experiments 1 and 2 would then emerge in such a case. For example, the validity of the scenario for demonstrating the unfulfilled intentions through the adult's failure to consummate the target acts would be challenged. Alternatively, it might be the case that the demonstrator highlights other aspects of peripheral information such as the action-relevant properties of the object whilst demonstrating the unfulfilled intentions. On the other hand, could the target acts intended in the demonstrated failed attempts be too difficult even for the older children to decode? Or, might the older children read the intentions underlying the observed acts involved in the failed-attempt display in a different way?

4.2. Method

4.2.1. Participants

For purposes of comparison, the data obtained from the 19-month-old group (M = 19.1, SD = 1.5) in Experiment 1 were analysed along with the data obtained from the two novel age groups of 31- and 41-month-old children in the present study. For the 31-month-old group (M = 31.0, SD = 1.9), the participants were 22 males and 18 females; the sample comprised 70.0% White, 15.0% Asian, 7.5% African, and 7.5% mixed ethnicity. For the 41-month-old group (M = 40.9, SD = 3.8), the participants were 28 males and 12 females; the sample comprised 77.5% White, 7.5% Asian, 7.5% African, and 7.5% mixed ethnicity. Children in both of the two older groups were recruited from a number of playgroups and nurseries in North London.

4.2.2. Test situation

As in Experiment 1, test sessions took place at a quiet corner in the playgroup or nursery where disturbances from other children and carers could be reduced to the minimum, or at home if such an arrangement was favoured by parents, or at a laboratory in the Department of Psychology at University College London. In the 31-month-old group, 12 of the subjects were tested at home, 22 at the playgroup, 5 at the nursery and 1 at the laboratory. In the 41-month-old group, 2 of the subjects were tested at home, 31 at the playgroup, and 7 at the nursery. The arrangement of video camera, warm-up procedure, and instructions for parents, were identical to those described in Experiment 1, except that the children in the two older groups tested at the nursery and playgroup were accompanied by their worker, rather than their parents.

4.2.3. Test materials

The test materials were the same as those used in Experiment 1 (see Appendix). They were replicas of the five objects in the study of Meltzoff (1995).

4.2.4. Experimental design

All of the four conditions in Experiment 1 were followed precisely in the 31- and 41-

month-old groups of this study. In each age group, the participants were randomly assigned to one of the four conditions: Full-Demonstration, Failed-Attempt, Emulation-Learning, and Adult-Manipulation. There were 10 children per condition. The orders in which the five presentations of the test objects occurred were counter balanced within each condition so that each object was presented at each of the five orders with identical frequency.

4.2.5. Scoring

The coding procedure was identical to that used in Experiment 1. The first and second actions produced in the 20-second response period in each of the five trials were coded as producing one of the following acts: (1) Target Act, (2) Unfinished Target Act, (3) Failed Act, (4) Adult Manipulation, (4) Other Act, (5) No Act. The operational criteria for these scoring categories followed those defined in Experiment 1. As in the preceding experiments, the following measures were also recorded: (1) the latency to produce the target acts, (2) the parts of the object s that children first touched, (3) the overall performance on target acts in the 20-second response period[1], and (4) the use of a finger to activate the beeper in the object set of box and stick.

4.2.6. Inter-rater reliability

Children's responses were coded from the videotapes by the author. Inter-rater reliability was assessed for 30% of the data (3 children per condition) by a colleague who has been familiarised with the scoring system in Experiments 1 and 2. The reliability was established with regard to: (1) the children's first acts and (2) first and second acts combined falling into Target Act, Unfinished Target Act, Failed Act, Adult Manipulation, Other Act, No Response, and the use of a finger to activate the beeper in the object set of box and stick; (3) the overall performance on target acts within 20 seconds of the response period. For the 19-month-old group, the data has been reported in Experiment 1 (see Section 2.2.6). For the 31-month-old group, the percentage agreement was 92%, (kappa = 0.86), concerning the children's first actions; 87% (kappa = 0.79), concerning the first and second actions combined; and

[1] This was the scoring method used in Meltzoff's (1995) and Bellagamba and Tomasello's (1999)

100%, (kappa = 1.00), concerning the target acts produced within 20 seconds of the response period. For the 41-month-old group, the percentage agreement was 97%, (kappa = 0.94), concerning the children's first actions; 92% (kappa = 0.88), concerning the first and second actions combined; and 100%, (kappa = 1.00), concerning the target acts produced within 20 seconds of the response period.

studies.

4.3. Results

As in Experiments 1 and 2, the number of acts produced falling within each scoring category was added for each of the first action and combined first and second actions, and converted into a proportion by dividing the summation by the number of valid trials. Except for two participants in the 19-month-old group and four in the 31-month-old group, who obtained four data points due to a camcorder fault, interruption, or non-cooperation, all the other children had a complete record of five valid trials. In the 19-month-old group, the missed data points consisted of one child's response to the object set of prong and loop in the Full-Demonstration condition, and one child's response to that of square and dowel in the Emulation-Learning condition. In the 31-month-old group, two missed data points were observed in the Adult-Manipulation condition (both, the dumbbell object set), one in the Emulation-Learning condition (the dumbbell object set), and one in the Failed-Attempt condition (the object set of beads and cylinder). There were no invalid data points in the 41-month-old group.

The means of the proportion of children's first actions and first and second actions combined coded in each of the scoring categories across the five different sets of objects are displayed in Table 4.1. The main analyses included Target Act (first action, first and second actions combined, overall performance in the 20-second response period), Failed Act (first action, first and second actions combined), and Adult Manipulation (first action, first and second actions combined). The data were subjected to 3 × 4 (age × condition) analyses of variance. Following this, pairwise comparisons were assessed by the use of a post hoc Tukey HSD test. If there was a significant age × condition interaction, the main effects were further analysed by tests of simple main effects. The means of the proportion of Unfinished Target Act (first action and first and second actions combined) were not entered into the analyses because only two children in the 31-month-old group and one in the 41-month-old group produced a response falling into this category. The subsidiary analyses consisted of: (1) Other Act (first action), (2) latency to produce target acts, (3) parts of objects that infants first touched, and (4) the number of infants using a finger to activate the beeper in the object set of box and stick.

Table 4.1. Means of the proportion of 19-, 31-, and 41-month-old children's first actions and combination of first and second actions falling into each of the scoring categories.

Condition Action / age	Full Demonstration *Mean (SD)*	Failed Attempt *Mean (SD)*	Emulation Learning *Mean (SD)*	Adult Manipulation *Mean (SD)*
TA-1st				
19-month-old	.60 (.25)	.32 (.14)	.26 (.16)	.12 (.17)
31-month-old	.78 (.18)	.65 (.34)	.44 (.24)	.20 (.16)
41-month-old	.84 (.18)	.52 (.30)	.58 (.15)	.18 (.20)
FA-1st				
19-month-old	.04 (.08)	.06 (.13)	.04 (.08)	.00 (.00)
31-month-old	.04 (.08)	.10 (.17)	.06 (.10)	.06 (.10)
41-month-old	.00 (.00)	.34 (.31)	.04 (.08)	.06 (.10)
AM-1st				
19-month-old	.00 (.00)	.00 (.00)	.02 (.06)	.06 (.10)
31-month-old	.02 (.06)	.00 (.00)	.02 (.06)	.22 (.18)
41-month-old	.00 (.00)	.00 (.00)	.00 (.00)	.54 (.30)
OA-1st				
19-month-old	.26 (.19)	.54 (.21)	.60 (.21)	.74 (.23)
31-month-old	.16 (.21)	.21 (.22)	.45 (.31)	.53 (.26)
41-month-old	.14 (.16)	.14 (.19)	.34 (.16)	.22 (.11)
NO-1st				
19-month-old	.00 (.00)	.04 (.08)	.00 (.00)	.03 (.08)
31-month-old	.00 (.00)	.00 (.00)	.00 (.00)	.00 (.00)
41-month-old	.00 (.00)	.00 (.00)	.00 (.00)	.00 (.00)
TA(UN)-1st				
19-month-old	.11 (.11)	.04 (.08)	.02 (.06)	.00 (.00)
31-month-old	.00 (.00)	.02 (.06)	.00 (.00)	.00 (.00)
41-month-old	.02 (.06)	.00 (.00)	.00 (.00)	.00 (.00)
TA(F)-1st				
19-month-old	.00 (.00)	.00 (.00)	.06 (.10)	.04 (.08)
31-month-old	.00 (.00)	.02 (.06)	.04 (.08)	.00 (.00)
41-month-old	.00 (.00)	.00 (.00)	.04 (.08)	.00 (.00)
Total				
19-month-old	1.01	1.00	1.00	1.00
31-month-old	1.00	1.00	1.01	1.01
41-month-old	1.00	1.00	1.00	1.00

Table 4.1(continued)

Condition Action / age	Full Demonstration *Mean (SD)*	Failed Attempt *Mean (SD)*	Emulation Learning *Mean (SD)*	Adult Manipulation *Mean (SD)*
TA-1st+2nd				
19-month-old	.70 (.17)	.42 (.26)	.46 (.23)	.19 (.22)
31-month-old	.94 (.10)	.75 (.22)	.56 (.20)	.44 (.15)
41-month-old	.96 (.08)	.66 (.28)	.70 (.17)	.26 (.25)
FA-1st+2nd				
19-month-old	.06 (.10)	.06 (.13)	.06 (.13)	.04 (.08)
31-month-old	.06 (.10)	.14 (.16)	.08 (.10)	.06 (.10)
41-month-old	.00 (.00)	.54 (.40)	.04 (.08)	.06 (.10)
AM-1st+2nd				
19-month-old	.02 (.06)	.00 (.00)	.02 (.06)	.10 (.14)
31-month-old	.02 (.06)	.00 (.00)	.02 (.06)	.28 (.22)
41-month-old	.02 (.06)	.00 (.00)	.00 (.00)	.68 (.29)
OA-1st+2nd				
19-month-old	.66 (.33)	.64 (.25)	.76 (.25)	.86 (.14)
31-month-old	.34 (.25)	.43 (.26)	.65 (.27)	.72 (.24)
41-month-old	.30 (.27)	.28 (.25)	.64 (.31)	.40 (.27)
NO-1st+2nd				
19-month-old	.14 (.31)	.25 (.22)	.08 (.14)	.04 (.08)
31-month-old	.24 (.30)	.17 (.25)	.20 (.25)	.04 (.08)
41-month-old	.10 (.22)	.32 (.42)	.28 (.33)	.10 (.25)
TA(UN)-1st+2nd				
19-month-old	.11 (.11)	.04 (.08)	.02 (.06)	.00 (.00)
31-month-old	.00 (.00)	.02 (.06)	.00 (.00)	.02 (.06)
41-month-old	.02 (.06)	.00 (.00)	.00 (.00)	.00 (.00)
TA(F)-1st+2nd				
19-month-old	.00 (.00)	.00 (.00)	.12 (.10)	.04 (.08)
31-month-old	.02 (.06)	.02 (.06)	.08 (.10)	.00 (.00)
41-month-old	.00 (.00)	.00 (.00)	.08 (.10)	.00 (.00)
REPEAT				
19-month-old	.32 (.19)	.60 (.31)	.48 (.17)	.74 (.23)
31-month-old	.38 (.33)	.45 (.18)	.43 (.14)	.44 (.20)
41-month-old	.58 (.35)	.20 (.28)	.26 (.21)	.50 (.32)
Total				
19-month-old	2.01	2.01	2.00	2.01
31-month-old	2.00	1.98	2.02	2.00
41-month-old	1.98	2.00	2.00	2.00
TA-20sec				
19-month-old	.76 (.18)	.54 (.28)	.48 (.25)	.25 (.23)
31-month-old	.94 (.10)	.83 (.18)	.68 (.21)	.55 (.22)
41-month-old	.96 (.08)	.68 (.29)	.74 (.13)	.44 (.34)

Note 1. TA-1st = target act produced at first action; FA-1st = failed act produced at first action; AM-1st = adult manipulation produced at first action; OA-1st = other act produced at first action; NO-1st = no act produced at first action; TA (UN)-1st = unfinished target act produced at first action; TA (F)-1st = using finger to activate the beeper in the object set of box and stick at first action.
Note 2. TA-1st+2nd = target act produced at first and second actions combined; FA-1st+2nd = failed act produced at first and second actions combined; AM-1st+2nd = adult manipulation

produced at first and second actions combined; OA-$1^{st}+2^{nd}$ = other act produced at first and second actions combined; NO-$1^{st}+2^{nd}$ = no act produced at first and second actions combined; TA (UN)-$1^{st}+2^{nd}$ = unfinished target act produced at first and second actions combined; TA (F)-$1^{st}+2^{nd}$ = using finger to activate the beeper in the object set of box and stick at first and second actions combined; Repeat = repeated response.
Note 3. TA-20sec = target act produced during 20 seconds of the scoring period.

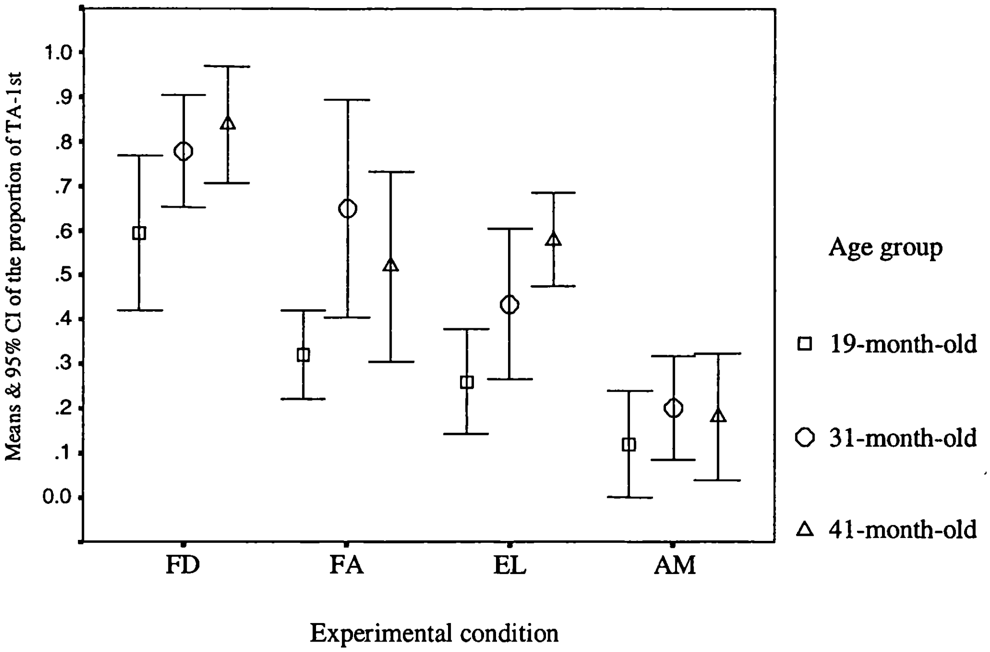
4.3.1 Main analyses

Target acts produced at first action

There was a main effect of age, $F(2, 108) = 11.53$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 36.00$, $p < 0.001$. Follow-up Tukey HSD tests indicated that collapsing over conditions, the 19-month-old group produced a lower proportion of target acts as the first acts than the 31- and 41-month-old groups (both, $p < 0.001$), and the latter two older groups did not differ from each other. On the other hand, collapsing over age groups, the Full-Demonstration group produced a higher proportion of target acts as the first acts than the Failed-Attempt, Emulation-Learning, and Adult-Manipulation groups (all, $p < 0.001$). The Failed-Attempt group did not differ from the Emulation-Learning group, and both of them performed better than the Adult-Manipulation group (both, $p < 0.001$) (see Figure 4.1). There was no significant age $\times$ condition interaction, $F(6, 108) = 1.31$, $p = 0.26$.

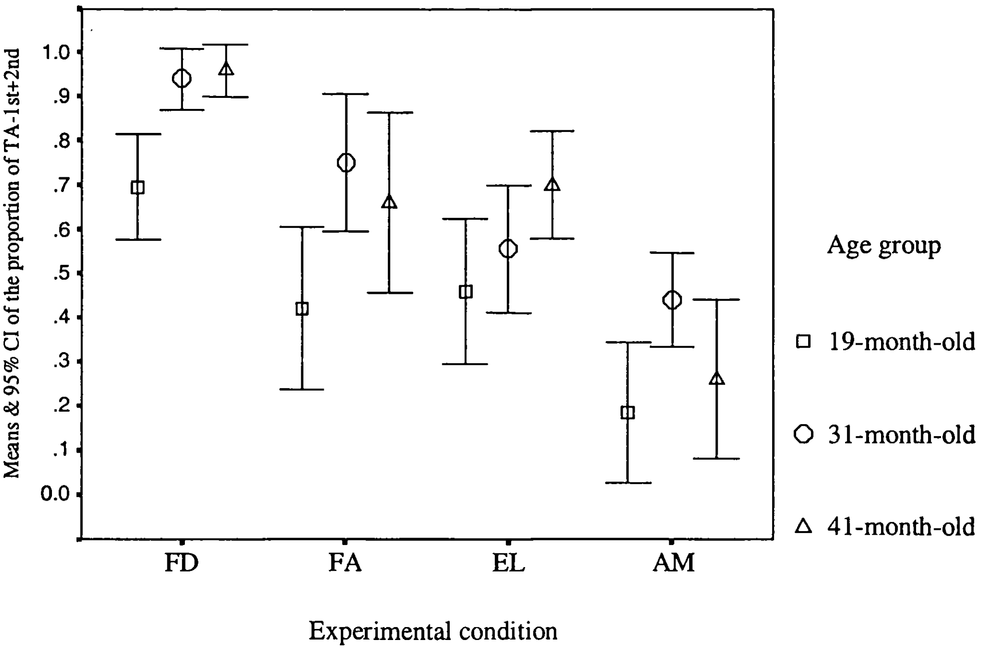
Target acts produced at first and second actions combined

There was a main effect of age, $F(2, 108) = 15.53$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 39.55$, $p < 0.001$. As in the analyses of target acts produced at first action, pairwise comparisons using a Tukey HSD test showed that collapsing over conditions, the 19-month-old group performed less target acts as the first and second acts combine than the 31- and 41-month-old groups (both, $p < 0.001$), and no difference was found between the latter two older groups. Similarly, collapsing over age groups, the Full-Demonstration group produced more target acts as the first and second acts combined than the Failed-Attempt, Emulation-Learning, and Adult-Manipulation groups (all, $p < 0.001$). The Failed-Attempt group did not differ from the Emulation-Learning group, and both of them produced more target acts as the first and second acts combined than the Adult-Manipulation group (both, $p < 0.001$) (see Figure 4.2). There was no significant age $\times$ condition interaction, $F(6, 108) = 1.50$, $p = 0.19$.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.1. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first actions coded in the category of Target Act (TA-1st) as a function of age and a function of condition.

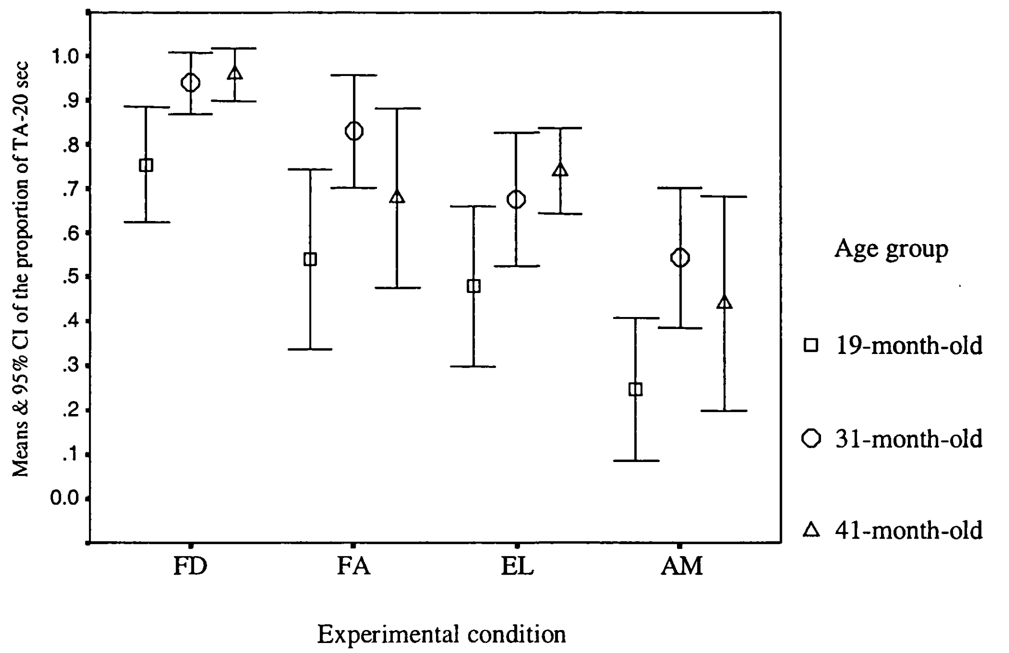


Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.2. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first and second actions combined coded in the category of Target Act (TA-1st+2nd) as a function of age and a function of condition.

Target acts produced during 20 seconds of the response period

There was a main effect of age, $F(2, 108) = 13.76$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 23.43$, $p < 0.001$. No significant age × condition interaction was found, $F(6, 108) = 0.56$, $p = 0.76$. Similar to the foregoing analyses, follow-up Tukey HSD tests showed that collapsing over conditions, the 19-month-old group had a lower level of target acts in the 20-second response period than those of the 31- and 41-month-old groups (both, $p < 0.01$), and the latter two older groups did not differ. Collapsing over age groups, the Full-Demonstration group produced more target acts in the 20-second response period than the Failed-Attempt, Emulation-Learning, and Adult-Manipulation groups, $p < 0.003$, $p < 0.001$, $p < 0.001$, respectively. There was no difference between the Failed-Attempt and Emulation-Learning groups, and both of them had a higher level of target acts in the 20-second response period than that of the Adult-Manipulation group (both, $p < 0.001$) (see Figure 4.3). The pattern of findings with respect to children's overall performance on target acts in the 20-second response period was identical to both of the analyses of target acts produced at the first action and at the first and second actions combined.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.3. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's acts produced in the 20-second response period coded in the category of Target Act (TA-20 sec) as a function of age and a function of condition.

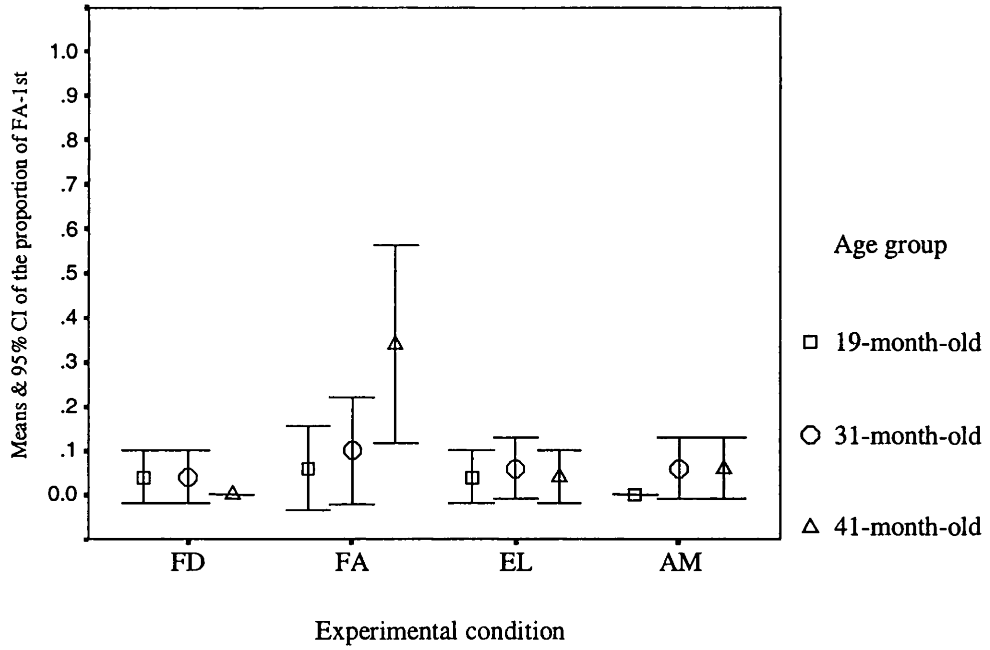
Failed acts produced at first action

In 3 × 4 (age × condition) analyses of variance, these yielded a main effect of age, $F(2, 108) = 3.39$, $p < 0.04$, and a main effect of condition, $F(3, 108) = 7.53$, $p < 0.001$. The main effects were subject to a higher-order age × condition interaction, $F(6, 108) = 3.79$, $p < 0.002$. The analyses of simple main effects revealed that there was a significant difference in the proportion of failed acts reproduced as the first acts as a function of condition within the 41-month-old group, $F(3, 108) = 14.35$, $p < 0.001$. Post hoc Tukey HSD tests showed that the 41-month-olds in the Failed-Attempt condition reproduced the demonstrated failed attempts as their first acts more often than they did in the Full-Demonstration, Emulation-Learning, and Adult-Manipulation conditions, $p < 0.001$, $p < 0.002$, and $p < 0.004$, respectively (see Figure 4.4). No difference was found among these latter three conditions.

Furthermore, the analyses of simple main effects revealed that there was a significant difference in the proportion of failed acts reproduced as the first acts among the three age groups in the Failed-Attempt condition, $F(2, 108) = 13.65$, $p < 0.001$. Pairwise comparisons using Tukey HSD tests showed that in the Failed-Attempt condition, the 41-month-old group reproduced the demonstrated failed attempts as the first acts more frequently than the 19-month-old group, $p < 0.03$. The difference between the 41- and 31-month-old groups was marginally significant, $p = 0.055$ (see Figure 4.4). No difference was found between the 19- and 31-month-old groups.

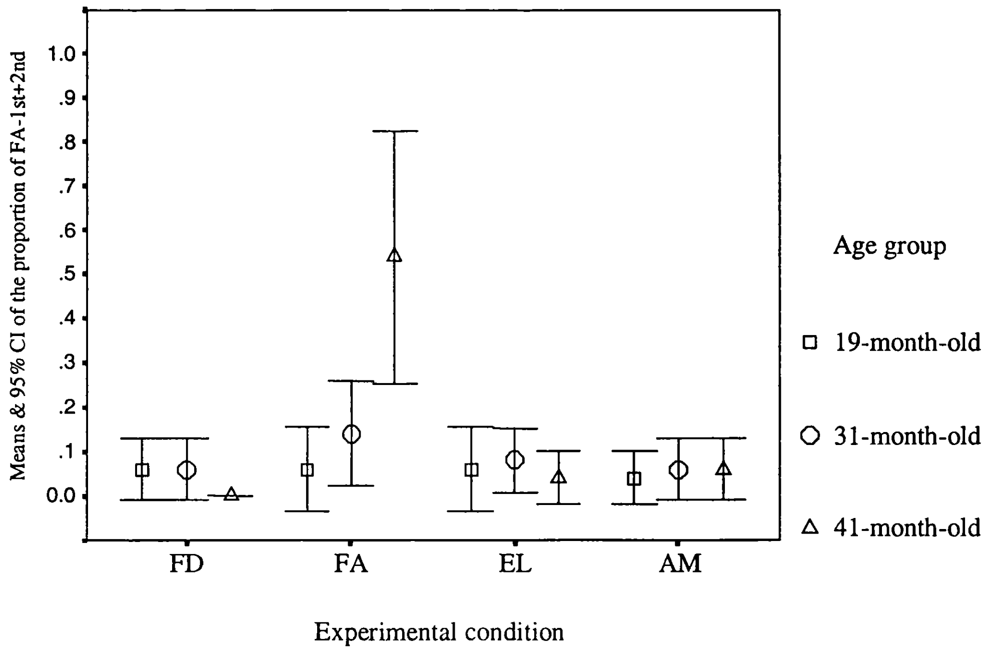
Failed acts produced at first and second actions combined

There was a main effect of age, $F(2, 108) = 4.91$, $p < 0.009$, and a main effect of condition, $F(3, 108) = 12.11$, $p < 0.001$. The main effects were subject to a higher-order age × condition interaction, $F(6, 108) = 7.85$, $p < 0.001$. Tests of simple main effects indicated that there was a significant difference in the proportion of failed acts reproduced as the first and second acts combined as a function of condition within the 41-month-old group, $F(3, 108) = 27.17$, $p < 0.001$. Post hoc Tukey HSD tests showed that the 41-month-old children in the Failed-Attempt condition reproduced the demonstrated failed attempts as their first and second acts combined more frequently than they did in the Full-Demonstration, Emulation-



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.4. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first actions coded in the category of Failed Act (FA-1st) as a function of age × condition.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.5. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first and second actions combined coded in the category of Failed Act (FA-1st+2nd) as a function of age × condition.

Learning, and Adult-Manipulation conditions (all, $p < 0.001$; see Figure 4.5). No difference was found among the latter three conditions.

Furthermore, the analyses of simple main effects revealed that there were significant differences in the proportion of failed acts reproduced as the first and second acts combined among the three age groups in the Failed-Attempt condition, $F(2, 108) = 27.74$, $p < 0.001$. Post hoc Tukey HSD tests showed that in the Failed-Attempt condition, the 41-month-old group reproduced the demonstrated failed attempts as the first and second acts combined more frequently than the 19- and 31-month-old groups, $p < 0.001$ and $p < 0.006$, respectively (see Figure 4.5). The 19- and 31-month-old groups did not differ from each other.

Adult-manipulation control acts produced at first action

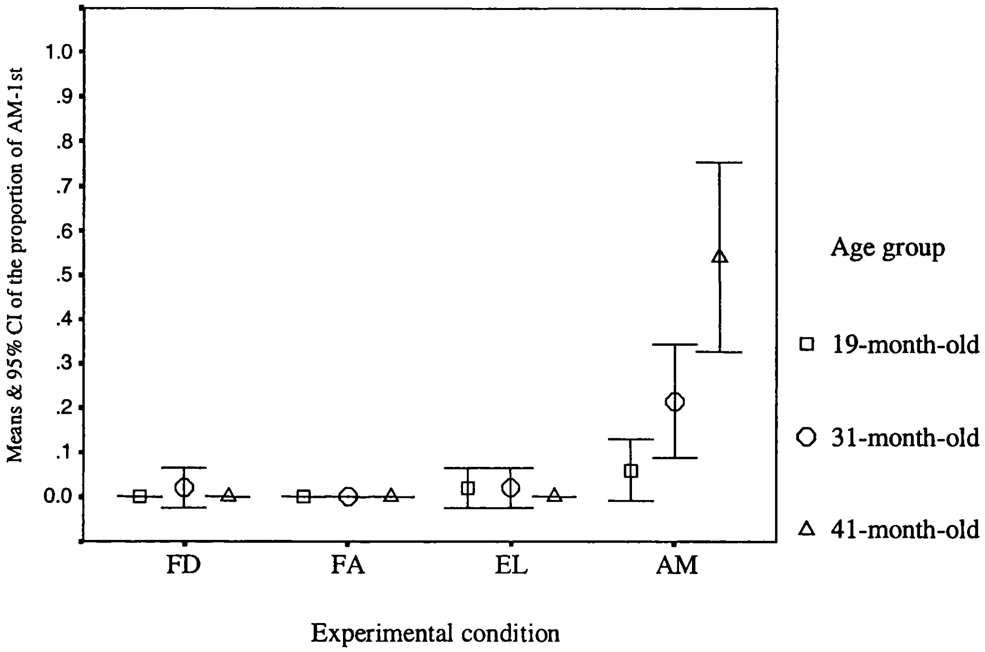
There was a main effect of age, $F(2, 108) = 11.32$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 44.30$, $p < 0.001$. The main effects were subject to a higher-order age × condition interaction, $F(6, 108) = 13.10$, $p < 0.001$. The analyses of simple main effects showed that there was a significant difference in the proportion of adult-manipulation control acts reproduced as the first acts as a function of condition within each of the 31- and 41-month-old groups, $F(3, 108) = 8.59$, $p < 0.001$, and $F(3, 108) = 61.21$, $p < 0.001$, respectively. Post hoc Tukey HSD tests showed that either the 31-month-olds or the 41-month-olds in the Adult-Manipulation condition reproduced the demonstrated control acts as their first acts more frequently than they did in the Full-Demonstration, Failed-Attempt, and Emulation Learning conditions (all, $p < 0.001$, in each of the 31- and 41-month-old groups, respectively; see Figure 4.6). No difference was found among the latter three conditions.

Furthermore, the analyses of simple main effects indicated that there were significant differences in the proportion of adult-manipulation control acts reproduced as the first acts among the three age groups in the Adult-Manipulation condition, $F(2, 108) = 50.38$, $p < 0.001$. Post hoc Tukey HSD tests showed that in the Adult-Manipulation condition, the 41-month-old group reproduced the demonstrated control acts as the first acts more often than the 31- and 19-month-old groups, $p < 0.005$ and $p < 0.001$, respectively (see Figure 4.3). There was no difference between the 31- and 19-month-old groups.

Adult-manipulations control acts produced at first and second actions combined

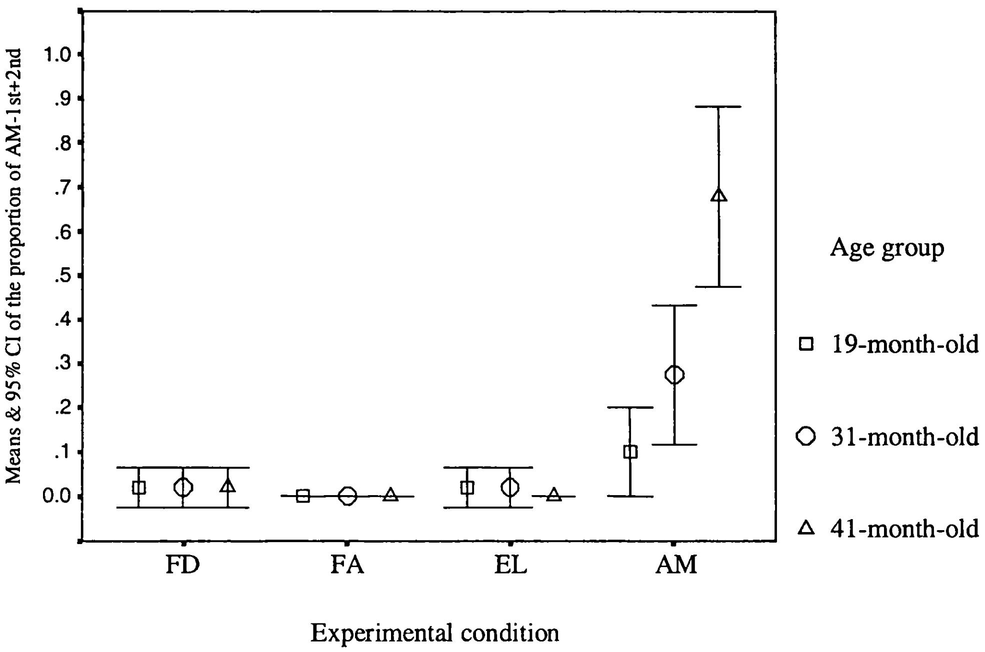
There was a main effect of age, $F(2, 108) = 14.46$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 61.46$, $p < 0.001$. The main effects were subject to a higher-order age × condition interaction, $F(6, 108) = 16.01$, $p < 0.001$. The analyses of simple main effects revealed that there was a significant difference in the proportion of adult-manipulation control acts reproduced as the first and second acts combined as a function of condition within each of the 31- and 41-month-old groups, $F(3, 108) = 12.12$, $p < 0.001$, and $F(3, 108) = 79.92$, $p < 0.001$, respectively. Post hoc Tukey HSD tests showed that either the 31-month-olds or the 41-month-olds in the Adult- Manipulation condition reproduced the demonstrated control acts as their first and second acts combined more frequently than they did in the Full-Demonstration, Failed-Attempt, and Emulation Learning conditions (all, $p < 0.001$, in each of the 31- and 41-month-old groups; see Figure 4.7). No difference was found among the latter three conditions.

Furthermore, the analyses of simple main effects revealed that there were significant differences in the proportion of adult-manipulation control acts reproduced as the first and second acts combined among the three age groups in the Adult-Manipulation condition, $F(2, 108) = 62.37$, $p < 0.001$. Post hoc Tukey HSD tests indicated that in the Adult-Manipulation condition, the 41-month-old group reproduced the demonstrated control acts as the first and second acts combined more often than the 31- and 19-month-old groups (both, $p < 0.001$; see Figure 4.7). There was no difference between the 19- and 31-month-old groups.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.6. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first actions coded in the category of Adult Manipulation (AM-1st) as a function of age × condition.



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

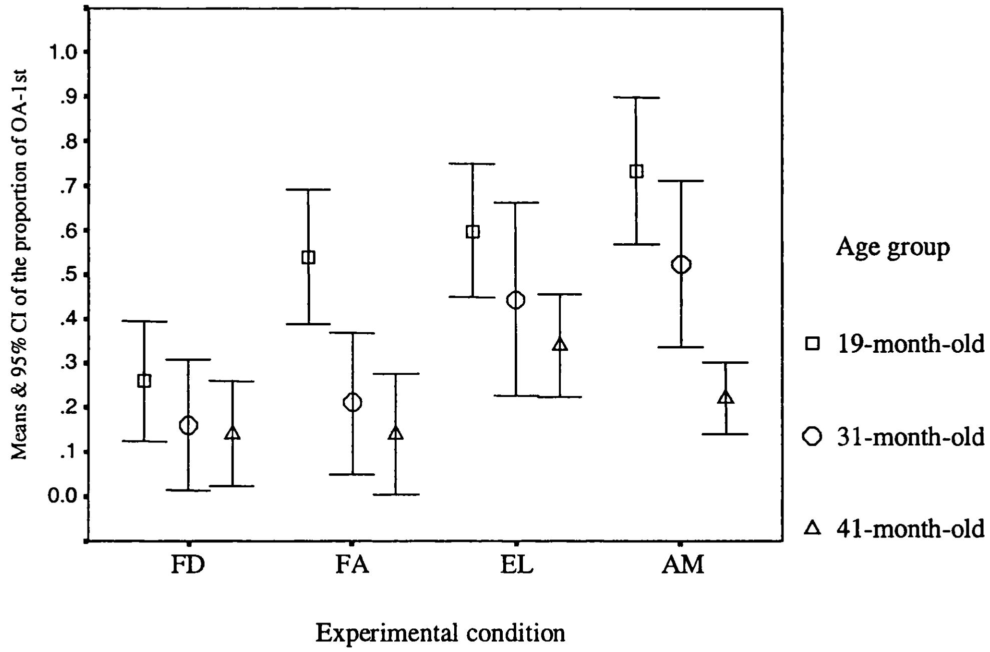
Figure 4.7. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first and second actions combined coded in the category of Adult Manipulation (AM-1st+2nd) as a function of age × condition.

4.3.2 Subsidiary analyses

Other acts produced at first action

There was a main effect of age, $F(2, 108) = 23.85$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 13.91$, $p < 0.001$. The main effects were subject to a marginally significant higher-order age × condition interaction, $F(6, 108) = 2.04$, $p = 0.067$. The analyses of simple main effects revealed that there was a significant difference in the proportion of other acts produced as the first acts as a function of condition within each of the 19- and 31-month-old groups, $F(3, 108) = 9.09$, $p < 0.001$, and $F(3, 108) = 7.27$, $p < 0.001$, respectively. For the 19-month-old group, pairwise comparisons using Tukey HSD tests showed that the 19-month-old children in the Full-Demonstration condition had a lower level of irrelevant other acts as their first acts than those that they had in the Failed-Attempt, Emulation-Learning, and Adult-Manipulation conditions, $p < 0.03$, $p < 0.005$, and $p < 0.001$, respectively (see Figure 4.8). For the 31-month-old group, follow-up Tukey HSD tests showed that the 31-month-old children in both the Full-Demonstration and Failed-Attempt conditions had a lower level of other acts as their first acts than that that they had in the Adult-Manipulation condition, $p < 0.01$ and $p < 0.04$, respectively (see Figure 4.8). No difference was found between the Emulation-Learning and Adult-Manipulation conditions. Neither were any differences among the Full-Demonstration, Failed-Attempt, and Emulation-Learning conditions.

Furthermore, the analyses of simple main effects revealed that there were significant differences in the proportion of other acts produced as the first acts among the three age groups within each of the Failed-Attempt and Adult-Manipulation conditions, $F(2, 108) = 10.21$, $p < 0.001$, and $F(2, 108) = 15.31$, $p < 0.001$, respectively. In the Failed-Attempt condition, follow-up Tukey HSD tests showed that the 19-month-old group produced more various other acts as the first acts than the 31- and 41-month-old groups, $p < 0.004$ and $p < 0.001$, respectively (see Figure 4.8). The 31- and 41-month-old groups did not differ. In the Adult-Manipulation condition, the 19- and 31-month-old groups did not differ from each other, and both of them had a higher proportion of other acts as the first acts than the 41-month-old group, $p < 0.001$ and $p < 0.009$, respectively (see Figure 4.8).



Note. FD = Full-Demonstration; FA = Failed-Attempt; EL = Emulation-Learning; AM = Adult-Manipulation.

Figure 4.8. Means and 95% CI of the proportion of 19-, 31-, and 41-month-old children's first actions coded in the category of Other Act (OA-1st) as a function of age × condition.

Using a finger to activate the beeper in the object set of box and stick

Table 4.2 illustrates the number of children using the stick or their finger to activate the beeper in the object set of box and stick across each of the three age groups. In the Emulation-Learning condition, the children observed the initial and end states of the object sets but not seeing the experimenter transform the object sets (by using a screen). Thus, the Emulation-Learning condition was compared with the other three conditions combined on the basis of whether they witnessed the experimenter's manual contact with the stick during the modelling phase. The number of children using the stick or their finger to activate the beeper as their first act or first and second acts combined from the 2 × 2 cross tables was analysed using χ^2 tests. There was a reliable difference in the number of children using the stick or their finger to activate the beeper as their first act between the Emulation-Learning condition and the three other conditions combined within the 41-month-old group, $p < 0.03$ (Fisher's exact test). As regards the first and second actions combined,

Table 4.2. Number of 19-, 31-, and 41-month-old children using a finger or stick to activate the beeper in the object set of box and stick.

Action / Age / condition	First action		First and second actions combined	
	Stick	Finger	Stick	Finger
19-month-old Full-Demonstration Failed-Attempt Adult-Manipulation	7	2	7	2
Emulation-Learning	1	3	1	6
31-month-old Full-Demonstration Failed-Attempt Adult-Manipulation	14	1	15	4
Emulation-Learning	4	2	4	4
41-month-old Full-Demonstration Failed-Attempt Adult-Manipulation	14	0	16	0
Emulation-Learning	1	2	1	4

significant differences were found within each of the 19-, 31-, and 41-month-old groups, $p < 0.05$, $p < 0.06$, and $p < 0.001$, respectively (Fisher's exact test).

Object parts children first touched

Table 4.3 presents the means of the proportion of object parts children first touched, according to whether the touched parts were consistent with, or different from those the experimenter first touched, or whether they started by taking hold of more than one part, or did not respond at all. With regard to the proportion of first-touched object parts which were consistent with those the experimenter first touched, 3×4 (age $\times$ condition) analyses of variance yielded a main effect of age, $F(2, 108) = 10.22$, $p < 0.001$, and a main effect of condition, $F(3, 108) = 6.13$, $p < 0.001$. Follow-up Tukey HSD tests showed that collapsing over age groups, the children in the Full-Demonstration and Failed-Attempt conditions followed the parts of the objects which the experimenter first touched more frequently than they did in the Emulation-Learning condition, $p < 0.001$ and $p < 0.01$, respectively. No difference

Table 4.3. Means of the proportion of parts of objects 19-, 31-, and 41-month-old children first touched in the response period.

Touched part Age / condition	Consistent with the model *Mean (SD)*	Differing from the model *Mean (SD)*	Touching more than one part *Mean (SD)*	No response *Mean (SD)*
Full-Demonstration				
19-month-old	.80 (.21)	.16 (.16)	.04 (.08)	.00 (.00)
31-month-old	.94 (.14)	.04 (.08)	.02 (.06)	.00 (.00)
41-month-old	.94 (.10)	.06 (.10)	.00 (.00)	.00 (.00)
Failed-Attempt				
19-month-old	.82 (.18)	.06 (.10)	.08 (.14)	.04 (.08)
31-month-old	.85 (.23)	.09 (.20)	.07 (.11)	.00 (.00)
41-month-old	.90 (.14)	.10 (.14)	.00 (.00)	.00 (.00)
Emulation-Learning				
19-month-old	.60 (.23)	.34 (.27)	.06 (.14)	.00 (.00)
31-month-old	.62 (.19)	.24 (.16)	.15 (.14)	.00 (.00)
41-month-old	.90 (.14)	.08 (.10)	.02 (.06)	.00 (.00)
Adult-Manipulation				
19-month-old	.64 (.20)	.22 (.26)	.12 (.14)	.03 (.08)
31-month-old	.86 (.17)	.08 (.10)	.07 (.11)	.00 (.00)
41-month-old	.86 (.23)	.08 (.17)	.06 (.14)	.00 (.00)

was found between the Emulation-Learning and Adult-Manipulation conditions. Neither were any differences among the Full-Demonstration, Failed-Attempt, and Adult-Manipulation conditions. On the other hand, collapsing over conditions, the 31- and 41-month-old groups did not differ in the tendency to touch the same parts of the object sets as those the experimenter first touched. Both the 31- and 41-month-old groups started by acting on such object parts more frequently than the 19-month-old group, $p < 0.04$ and $p < 0.0001$, respectively.

The previous analyses were complemented by 3×4 (age $\times$ condition) ANOVAs on the proportion of first-touched object parts which were different from those the experimenter first touched. These yielded a main effect of age, $F(2, 108) = 5.27$, $p < 0.007$, and a main effect of condition, $F(3, 108) = 4.59$, $p < 0.005$. Follow-up Tukey HSD tests showed that collapsing over age groups, the children in the Emulation-Learning condition started by acting on the parts of the objects which were not first touched by the experimenter more frequently than they did in the Full-

Demonstration and Failed-Attempt conditions, $p < 0.01$ and $p < 0.008$, respectively. No difference was found between the Emulation-Learning and Adult-Manipulation conditions. Neither were any differences among the Full-Demonstration, Failed-Attempt, and Adult-Manipulation conditions. On the other hand, collapsing over conditions, the 19-month-old group started by acting on the parts of the object sets which were not first touched by the experimenter more often than the 41-month-old group, $p < .006$. The 31-month-old group differed from neither of the 19- and 41-month-old groups.

Latency to produce target acts

Table 4.4 displays the means of the latency to produce the target acts as the children's first acts, first and second acts combined and overall performance in the 20-second response period. As in the preceding analyses, 3 ×4 (age × condition) ANOVAs were performed on the data. Counting the children's first acts only, there was a main effect of age, $F(2, 93) = 7.04$, $p < 0.001$. Post hoc Tukey HSD tests showed that collapsing over conditions, both the 31- and 41-month-old groups took a shorter latency to produce the target acts as their first acts than the 19-month-old group, $p < 0.03$ and $p < 0.004$, respectively. No difference was found between the 31- and 41-month-old groups.

Counting the children's first and second acts combined, there was a main effect of age, $F(2, 98) = 6.04$, $p < 0.003$, and a main effect of condition, $F(3, 98) = 5.81$, $p < 0.001$. The main effects were subject to a higher-order age × condition interaction, $F(6, 98) = 2.42$, $p < 0.03$. The analyses of simple main effects revealed that there was a significant difference in the latency to produce the target acts as the first and second acts combined as a function of condition within the 19-month-old group, $F(3, 98) = 7.74$, $p < 0.001$. Follow-up Tukey HSD tests indicated that the 19-month-old children in the Failed-Attempt condition took a shorter latency to produce the target acts at their first and second acts combined than they did in the Emulation-Learning and Adult-Manipulation conditions (both, $p < 0.03$). No difference was found between the Full-Demonstration and Failed-Attempt conditions. Neither were any differences found among the Full-Demonstration, Emulation-Learning, and Adult-Manipulation conditions.

Table 4.4. Means of the latency for target acts produced at first action (TA-1st), first and second actions combined (TA-1st+2nd), and during 20 seconds of the response period (TA-20 sec).

Latency (sec) / Condition / age	TA-1st *Mean (SD)*	TA-1st+2nd *Mean (SD)*	TA-20 sec *Mean (SD)*
Full-Demonstration			
19-month-old	5.04 (2.00) n= 10	5.12 (3.07) n = 10	5.41 (2.61) n = 10
31-month-old	3.28 (1.26) n =10	3.75 (1.32) n = 10	3.75 (1.32) n = 10
41-month-old	3.20 (1.14) n = 10	4.30 (1.56) n = 10	4.30 (1.56) n = 10
Failed-Attempt			
19-month-old	3.65 (1.41) n= 9	3.68 (1.41) n= 9	5.91 (2.27) n = 9
31-month-old	4.38 (2.08) n= 10	4.96 (1.97) n = 10	5.28 (2.15) n = 10
41-month-old	3.30 (1.50) n = 9	4.35 (2.21) n = 9	4.55 (2.17) n = 9
Emulation-Learning			
19-month-old	6.05 (3.71) n = 9	7.85 (3.33) n = 10	8.03 (3.12) n = 10
31-month-old	4.67 (1.71) n= 10	5.26 (1.65) n = 10	6.81 (3.17) n = 10
41-month-old	3.58 (1.07) n = 10	4.05 (1.04) n = 10	4.66 (2.03) n = 10
Adult-Manipulation			
19-month-old	6.65 (2.81) n= 4	8.90 (4.62) n = 5	10.91 (5.06) n = 7
31-month-old	2.45 (1.12) n= 7	5.16 (2.43) n = 10	7.05 (3.15) n = 10
41-month-old	3.82 (1.74) n = 7	4.33 (1.56) n = 7	7.46 (3.39) n = 8

Note. "n" is the valid number of children.

Furthermore, the analyses of simple main effects revealed that there were significant differences in the latency to produce the target acts as the first and second acts combined among the three age groups in each of the Emulation-Learning and Adult-Manipulation conditions, $F(2, 98) = 6.62$, $p < 0.005$, and $F(2, 98) = 4.43$, $p < 0.04$, respectively. Follow-up Tukey HSD tests showed that in the Emulation-Learning condition, both the 31- and 41-month-old groups took a shorter latency to produce the target acts as the first and second acts combined than the 19-month-old group, $p < 0.04$ and $p < 0.002$, respectively. There was no difference between the 31- and 41-month-old groups. In the Adult-Manipulation condition, although the analyses of simple main effects yielded a significant statistic, follow-up Tukey HSD tests did not reveal reliable group differences among the three age groups.

Finally, when all target acts produced in 20 seconds of the response period were considered, there was a main effect of age, $F(2, 101) = 7.20$, $p < 0.001$, and a main effect of condition, $F(3, 101) = 10.68$, $p < 0.001$. Follow-up Tukey HSD tests showed that collapsing over the age groups, the children in the Adult-Manipulation condition took a longer latency to produce the target acts in the 20-second response period than they did in the Full-Demonstration and Failed-Attempt conditions (both, $p < 0.001$). There was no difference between the Full-Demonstration and Failed-Attempt conditions. The children in the Full-Demonstration condition took a shorter latency to produce the target acts in the 20-second response period than that the children in the Emulation-Learning condition took, $p < 0.03$. No difference was seen between the Emulation-Learning and Adult-Manipulation conditions. On the other hand, collapsing over conditions, the 19-month-old group took a longer latency to produce the target acts in the 20-second response period than the 31- and 41-month-old groups, $p < 0.03$ and $p < 0.003$, respectively. The 31- and 41-month-old groups did not differ from each other.

4.4. Discussion

In Experiment 3, Experiment 1 was extended with two novel age groups of 31- and 41-month-old children. The adequacy of Meltzoff's Failed-Attempt paradigm was examined on the basis of the hypothesis that older children would differentially imitate the target acts as their first acts equally well in both the Full-Demonstration and Failed-Attempt conditions as a consequence of their apparently superior ability to understand the intentional acts of others. Across the four conditions, the 31- and 41-month-olds brought about more target acts than the 19-month-olds, but no significant age × condition interaction indicated that the differences related to age were subject to a specific condition. Thus, no evidence of imitation was found in the Failed-Attempt condition with regard to either 31- or 41-month-old children's performance on target acts at the first act. Whatever scoring strategy was adopted, neither of the two older groups in the Failed-Attempt condition was capable of producing the target acts as frequently as they did in the Full-Demonstration condition. Although previous research using verbal measures has shown that 3-year-olds are able to distinguish intended acts from unintended acts (Shultz & Wells, 1985; Shultz, Wells, & Sarda, 1980; Yuill, 1984), the 41-month-old children in the Failed-Attempt condition did not differentially reproduce the target acts that the demonstrator judged to be the intended subsequent but unfulfilled outcomes. Did the findings suggest that the older children, like the younger ones, also had problems in reading the intentions underlying the demonstrated failed attempts? It appears that the results could not simply be interpreted in terms of an inability to read the intended subsequent but unfulfilled target acts implied in Meltzoff's Failed-Attempt format. The pattern of findings concerning children's reproduction of two other types of demonstrated acts—Failed Act and Adult Manipulation—might help clarify the relevant issues.

Overall, the findings of Experiment 3 revealed a developmental lag in children's abilities to imitate demonstrated acts of various types. Despite age differences in the number of target acts produced across the four conditions, the children in the Full-Demonstration condition were most likely to produce the target acts as their first acts. None of 19-, 31-, and 41-month-old children in any of the other three conditions were found to produce the target acts as their first acts as frequently as they did in the Full-Demonstration condition. No evidence indicated that the 19-month-olds could imitatively copy the demonstrated failed attempts in the Failed-Attempt condition or the non-afforded control acts in the Adult-Manipulation condition. Similar to the 19-month-olds, neither did the 31-month-olds in the Failed-Attempt condition imitatively copy the observed movements. The only evidence for imitation taking place in the Failed-Attempt condition came from the 41-month-old group who reproduced more of the observed movements as their first acts than they did in the other three conditions. In the Adult-Manipulation condition, there was evidence of imitation in both the 31- and 41-month-olds' reproduction of the non-afforded control acts. Both the 31- and 41-month-olds in the Adult-Manipulation condition reproduced the observed movements more often than they did in the other three conditions. Overall, the 19-month-old children's performance in imitation of acts on objects was most liable to constraints of types of demonstrated act. Among the three types of demonstrated act—Target Act, Failed Act, and Adult Manipulation—the only evidence for imitation taking place as the 19-month-olds' first acts was revealed as their tendency to produce the target acts observed in the Full-Demonstration condition. The 31-month-olds were found to imitatively copy the target acts in the Full-Demonstration condition and the non-afforded control acts in the Adult-Manipulation condition. By contrast, the type of demonstrated acts did not affect the 41-month-olds' performance in imitation of acts on objects. The 41-month-olds differentially reproduced the observed movements according to how such movements had been actually modelled by the experimenter.

The findings considered above raised several critical questions about the adequacy of Meltzoff's Failed-Attempt paradigm for exploring children's ascription of intentions to the model in imitation of acts on objects. Why did only the 41-month-olds exhibit the behavioural tendency to copy the observed acts from seeing the failed-attempt model? Counter to the predictions for Experiment 3, the older children in the Failed-Attempt condition did not succeed in producing the intended subsequent but unfulfilled target acts as their first acts as a result of a greater ability to understand unfulfilled intentions. On the contrary, it seems that the observed outcomes of the demonstrated failed attempts could be interpreted as the intended outcomes by the 41-month-old children and consequently they tended to copy such acts. This interpretation retains the intentional hypothesis that copying the demonstrated failed attempts was guided by attribution of intention to the model and only the 41-month-olds' imitative performance in the Failed-Attempt condition gave credence to this hypothesis. In addition, the developmental constraint on children's ability to copy demonstrated acts of various types as indicated in the present study might relate to such an ability required for intentional understanding in imitation of acts on objects. Meltzoff (1995) and Bellagamba and Tomasello (1999; also Tomasello, 1999) maintained that 18-month-olds did not replicate the observed acts literally after seeing the failed-attempt model because they were able to re-enact the intended but unfulfilled target acts that they understood that the model was attempting to achieve. On the basis of the intentional hypothesis considered above, the evidence of imitation for 41-month-old children's reproduction of the observed acts in the Failed-Attempt condition could challenge Meltzoff's and Bellagamba et al.'s view that the observed outcomes of the demonstrated failed attempts were unintended and not likely to influence children's imitative performance. Moreover, except in the Full-Demonstration condition, there was no evidence showing that any of the 19-, 31-, and 41-month-old children in the Failed-Attempt condition imitatively copied the target acts as their first acts. Thus, an inability to decode the target acts that the demonstrator judged to be the intended subsequent outcomes does not appear sufficient to account for why the 41-month-olds in the Failed-Attempt condition differentially copied the demonstrated failed attempts rather than the target acts presumably intended.

Might it be the case that none of the 19-, 31-, and 41-month-old children in Experiment 3 were influenced in their imitative performance by attribution of intention to the model from seeing the failed-attempt model? That is, could the evidence for 41-month-old children's replication of the demonstrated failed attempts suggest that they literally copied what the model did without necessarily interpreting the observed acts as intended? In contrast to the intentional hypothesis, the second hypothesis is that the 41-month-olds in the Failed-Attempt condition copied the observed acts more than did the 19- and 31-month-olds because the 41-month-olds were less susceptible to the affordances of the objects and were more able to attend to and copy the modelled sequences of movements. This might also explain why the 19- and 31-month-olds were not as likely to reproduce the demonstrated failed attempts as the 41-month-olds were. In the following discussion, the adequacy of Meltzoff's Failed-Attempt paradigm for exploring the concept of intention will be examined in relation to the foregoing two hypotheses highlighted by the results of Experiment 3. Did the 41-month-old children in the Failed-Attempt condition reproduce the observed movements as a result of their ability to read the observed outcomes of the demonstrated failed attempts as intended, or did they do so without attribution of intention to the model?

Imitating demonstrated failed attempts

As stated by the intentional hypothesis, a possibility immediately suggesting itself is that the 41-month-olds in the Failed-Attempt condition copied the observed acts as a result of their interpretation of the demonstrated failed attempts as the outcomes intended by the model. Methodologically, the goals involved in Meltzoff's Failed-Attempt format might call for different interpretations other than the target acts that the experimenter judged to be the intended but unfulfilled subsequent outcomes. As suggested in Section 1.5.1, it is possible that the target acts were not the only goals to which the acts demonstrated in the Failed-Attempt condition could be attributed. Several relevant findings in the present study contribute to the above likelihood.

First, the majority of 41-month-olds in the Failed-Attempt condition exhibited a proclivity to emulate the target acts whilst also imitatively copying the observed demonstrated acts. Whereas overall the children in the Failed-Attempt condition produced the target acts less often than they did in the Full-Demonstration condition, the 31- and 41-month-old groups brought about the target acts more than did the 19-month-old group across the four conditions. This gives rise to the possibility that the older children, before the demonstration, knew that the objects could be used to produce such acts. However, only the 41-month-olds were found to copy the observed acts in the Failed-Attempt condition, in spite of the substantial influence of observing the failed-attempt model on their tendency to emulate the target acts as compared with that of observing the adult-manipulation model. Further, the analysis of other acts produced at the first act in the Failed-Attempt condition showed that the 41-month-olds brought about fewer of other acts as their first acts than the 19-

month-olds. In contrast to the 19-month-olds, the 41-month-olds appeared less likely to be engaged in a kind of trial-and-error by producing other acts of various types as their first acts. This provides additional support for the 41-month-olds' tendency to produce both the target acts and observed movements in response to the failed-attempt model. It seems that the 41-month-olds in the Failed-Attempt condition readily either produced the target acts in the light of the object affordances or copied the modelled acts that had been observed. These findings suggest that Meltzoff's Failed-Attempt format had potential for offering children an implicit contrast between observed and object-afforded outcomes as alternative interpretations of what the experimenter was intending to achieve subsequently. Although the data do not directly support the hypothesis that the 41-month-olds were reading the demonstrated failed attempts as intended, their production of target acts and failed attempts in the Failed-Attempt condition at least suggests that they were responding to both the object affordances and observed movements involved in the failed-attempt display.[1]

Second, from the 41-month-old children's perspective, the failed-attempt model appeared to involve contradictory information about the observed outcomes of the demonstrated failed acts and the affordances of the objects. As can be seen in Table 4.1, the 41-month-olds in the Failed-Attempt condition had on average 4.3 first acts (out of 5) falling within the categories of Target Act and Failed Act as compared with 1.9 (out of 5) that the 19-month-olds had. By contrast, the 41-month-olds in the Full-Demonstration condition had on average 4.2 first acts (out of 5) exclusively falling within the category of Target Act as compared with 3.0 and 3.9 (out of 5) that the 19- and 31-month-olds produced, respectively. For the 41-month-olds, the inputs given in the full-demonstration model appeared to involve much less contradictory information about the outcomes that the experimenter intended to

[1]This interpretation differs from the findings of Nagell, Olguin, and Tomasello (1993), who demonstrated that in a rake-using task the 3-year-olds emulated the target act (flipping the rake then pulling the toy) in both the no-model and partial-model (pulling the toy without flipping the rake) conditions, and did not imitate the inefficient method observed in the partial-model condition. On the contrary, the 2-year-olds in the partial-model condition imitated the inefficient method observed. These researchers suggested that the 3-year-olds did not differentially imitate the demonstrated method, because they were dexterous with this level of skill required for the rake-using task and did not seem to rely on the information given in the demonstration.

achieve than those given in the failed-attempt model. In a sense, the 41-month-olds did not participate in exploratory activities after observing the failed-attempt model as compared with the 19-month-olds, because the 41-month-olds rarely produced acts other than the target acts and failed attempts in such circumstances. That is, it is possible that the 41-month-olds' performance in the Failed-Attempt condition was guided by ascription of two potential goals inherent in Meltzoff's Failed-Attempt format: the target act that the model judged to be the intended but unfulfilled subsequent outcome, and the observed outcome of the demonstrated act. As only the 41-month-olds showed the tendency to produce both the target acts and observed movements in the Failed-Attempt condition, the finding might imply a developmental constraint on children's possession of abilities for detecting the contradictory information inherent in Meltzoff's Failed-Attempt format.

Third, the 41-month-olds' adoption of a strategy of reproducing the observed acts in the Failed-Attempt condition implies that their performance in imitation of acts on objects was not reliant on cases where the observed outcomes of the demonstrated acts specified both the affordances of objects and the goals of the model. In Experiments 1 and 2, it was suggested that the 19- and 17-month-olds reproduced many fewer of the observed acts in the Failed-Attempt condition perhaps because copying the demonstrated failed acts would not elicit the dynamic affordances of the objects that they found out during observation of the demonstration. Additionally, the demonstrated failed attempts were similar and relevant to the target acts as compared with the non-afforded control acts and likely to divert children's attention from the acts that were actually demonstrated to the target acts that specified the object affordances. Under this view, the finding of Experiment 3 that the 19- and 31-month-olds did not adopt a strategy of reproducing the observed acts in the Failed-Attempt condition may be interpreted as their problems in reading the demonstrated failed attempts as "to be copied". It might be that the 19- and 31-month-olds were not aware that indeed the experimenter meant to perform the unconsummated target acts. Alternatively, it is possible that the 41-month-olds were aware of such an intentional stance of the experimenter and thus read the demonstrated failed attempts as "to be copied". This might explain why the 41-month-olds used a strategy of reproducing the observed acts in the Failed-Attempt condition. If adopting a strategy of reproducing the observed acts in the

Failed-Attempt condition required a particular form of social understanding, apparently only the 41-month-olds' performance could justify the attribution of such a kind of social understanding.

Imitating non-afforded control acts

There is evidence of imitation for both the 31- and 41-month-olds' reproduction of non-afforded control acts in the Adult-Manipulation condition. Both the two older groups reproduced the observed control acts more often in the Adult-Manipulation condition than in the other three conditions. By contrast, no evidence indicated that the 19-month-old group differentially produced the observed control acts in the Adult-Manipulation condition. On the contrary, the 19-month-old group brought about fewer of such acts than the 31- and 41-month-old groups. Why did the 19-month-olds not imitatively respond to the observed control acts in the Adult-Manipulation condition? Does that suggest that imitating the non-afforded control acts, like imitating the demonstrated failed attempts, also required advanced cognitive skills, which the 19-month-olds have not acquired? There are two possible explanations for the present findings.

First, it appears that the 19-month-old children's imitation of acts on objects was confined to occasions when the observed outcomes of the demonstrated acts were of certain kinds, for example in the Full-Demonstration condition where the observed outcomes specified the affordances of the object sets. In Experiment 3, while across age groups the children in the Adult-Manipulation condition produced fewer target acts than they did in the other three conditions, both the 31- and 41-month-old groups were found to imitatively copy the non-afforded control acts. Consider the finding, pointed to earlier, that the 41-month-olds adopted a strategy of reproducing the observed acts in the Failed-Attempt condition as contrasted with the 31- and 19-month-olds, who did not differ from each other. It is important to note that reproduction of the observed acts was a strategy that the 31-month-olds adopted in the Adult-Manipulation condition, but not in the Failed-Attempt condition. This suggests that the 31-month-olds tended to use such a strategy in response to the adult-manipulation model when the observed acts were not likely to induce them to emulate the affordances of the objects. Under this explanation, it might be that the affordances of the objects involved in the failed-attempt model were so explicit as to prevent the 31-month-olds from using a strategy of reproducing the observed acts. Among the three age groups, only the 41-month-olds were found to imitatively copy the observed acts in both the Failed-Attempt and Adult-Manipulation conditions. This might suggest that in contrast to the 31- and 19-month-olds, the 41-month-olds possessed abilities for refraining from the tendency to emulate the affordances they learned from seeing the failed-attempt model. However, in contrast to the 31-month-olds, the 19-month-olds' production of demonstrated control acts in the Adult-Manipulation condition did not appear to benefit from the diminution of the affordances involved. Therefore, the 19-month-olds' ability to imitate acts on objects was restricted in the sense that their performance was highly reliant on cases where the observed outcomes of the demonstrated acts specified what the objects afforded, as in the Full-Demonstration condition.

Second, among the three age groups, the 41-month-old children appeared less likely to be influenced by the types of demonstrated acts in their adoption of a strategy of copying the observed acts. In the Full-Demonstration condition, the demonstrated acts resulted in the observed outcomes that specified both the affordances involved and goals of the model. It is not surprising that exposure to the full-demonstration model elicited most target acts. One other finding worth emphasizing is that both the 19- and 31-month-olds produced fewer other acts as their first acts in the Full-Demonstration condition than in the Adult-Manipulation condition, whereas the 41-month-olds produced other acts as their first acts equally infrequently across the four conditions. This suggests that the 41-month-olds were as likely to adopt a strategy of reproducing the observed acts in response to the demonstrated acts of various types as they were in response to the fully modelled target acts. In the Adult-Manipulation condition, while the 19- and 31-month-olds exhibited a proclivity to explore the objects by producing a wide range of other acts as their first acts, the 41-month-olds directly reproduced the demonstrated control acts as their first acts. In the Failed-Attempt condition, as indicated earlier, the 41-month-olds displayed a tendency to imitatively copy the observed movements while they were also likely to emulate the target acts. Such a conflict between the two differing ways of responding implies that in the Failed-Attempt condition the 41-month-olds were making efforts to refrain from being induced to emulate the target acts on the one hand, and to copy the observed acts with fidelity on the other hand. It is important to emphasise again that the contrast between the two differing behavioural strategies employed by the 41-month-olds possibly revealed the contradictory information given in Meltzoff's Failed-Attempt format.

On the other hand, if imitation consists of copying novel or improbable acts as defined by Thorpe (1963), it appears that only the 41-month-old children's imitative performance in Experiment 3 could be qualified as imitation under Thorpe's definition. As discussed in Section 1.4.1, the target acts involved in Meltzoff's Failed-Attempt paradigm were novel in the sense that the infants in Meltzoff's (1995) study did not produce them spontaneously in either the baseline or the adult-manipulation group. Similarly, the demonstrated failed and non-afforded control acts could be of high novelty and justify in themselves the acts to be imitated, because it seems unlikely that children would spontaneously generate these acts without seeing them done by a model.

Interestingly, there seems to be a parallel between the findings discussed above and those of early symbolic play that children younger than 3 years have difficulty using objects of incompatible functions for substitution in a pretending situation (Elder & Pederson, 1978; Jackowitz & Watson, 1980; Pederson, Rook-Green, & Elder, 1981). In one experiment, Elder and Pederson (1978) found that 2 ½-year-olds' play in a pretending situation were reliant on the similarity between the substitute objects and their reference objects. 3 ½-year-olds were able to pretend using substitute objects similar or dissimilar to the reference objects, for example, combing their hair with a flat piece of wood or a rubber ball. In another experiment, Pederson, Rook-Green, and Elder (1981) asked 2 ½- and 3-year-olds to perform familiar acts (e.g., drinking from a cup or talking on the telephone) with substitute objects differing in function and likelihood of eliciting a manipulative response, such as combing their hair with a toy watch or a tennis ball. Pederson et al. showed that 2 ½-year-olds found it more difficult to perform the requested acts when the substitute objects were likely to elicit manipulative responses (e.g., drinking from scissors) than when the substitute objects had a low likelihood of eliciting such responses (e.g., drinking from a dustpan). However, 3-year-olds could perform equally well whatever substitute object is used. It was suggested that 2 ½-year-olds have difficulty in inhibiting manipulative responses incompatible with the pretending acts.

The findings of early pretend play provides additional support for the author's assertion that reproduction of the observed acts as a behavioural strategy in the Failed-Attempt condition requires a special form of social understanding that only children older than 3 years of age have developed. It is possible that such a kind of social understanding has a close relation both to children's ability to imitate acts of various types on objects and their use of inappropriate dissimilar objects to substitute for realistic prototypical objects in a pretending situation. The notion of object-elicited manipulative responses, specified in research on pretend play, is a parallel case to that of object affordances of particular interest here. It is very likely that the 41-month-olds imitatively copied the observed acts in the Failed-Attempt condition just as the 3-year-olds in Pederson et al.'s (1981) study used objects of incompatible functions for substitution, because both cases required that the children performed the demonstrated or reference acts whilst refraining from the influence of the afforded properties of the objects. On the other hand, the 2 ½-year-olds in Pederson et al.'s (1981) study had difficulty using objects with a high likelihood of eliciting manipulative responses for substitution just as the 31-month-olds in the Failed-Attempt condition did not imitatively reproduce the failed acts observed because they probably had difficulty inhibiting their tendency to bring about the object-afforded acts. On the contrary, the 31-month-olds differentially replicated the non-afforded acts in the Adult-Manipulation condition just as the 2 ½-year-olds in Pederson et al.'s (1981) study could use objects with low likelihood of eliciting manipulative responses to substitute the referent objects. Thus, the pattern of findings of Experiment 4 indicated a linkage between children's performance in early pretend play and their abilities to imitate demonstrated acts on objects of various types.

Imitating vs. mimicking failed attempts?

It might be possible to explain the 41-month-olds' use of the copying strategy in the Failed-Attempt condition without assuming that they imitatively learned the desired causal relations between the demonstrated failed attempts and the observed outcomes of these acts as a result of ascription of intention to the model. This explanation retains the hypothesis that the 41-month-olds' behavioural tendency to reproduce the observed acts in the Failed-Attempt condition was simple mimicry. According to Tomasello (1996), mimicry refers to a case where the observer copies the model's behaviour on the sensory-motor level without cognitively understanding the relations between the observed behaviour and the outcome that the behaviour is designed to produce. Did the 41-month-olds in the Failed-Attempt condition interpret the observed outcomes as intended in their reproduction of the demonstrated failed attempts, or did they simply copy the observed movements without knowing that these acts were modelled on purpose?

It is possible that the 41-month-olds in the Failed-Attempt condition mimicked the observed movements with no understanding of the model's intended goals. However, this seems unlikely given the author's impression when coding their responses from the videotapes. For example, these children often looked up to the experimenter and smiled after reproducing the demonstrated failed attempts just the same as they did after producing the target acts in the Full-Demonstration condition. It seems that they looked to the experimenter to check whether they reproduced what the adult was actually focused on. If the 41-month-olds in the Failed-Attempt condition merely mimicked the experimenter, they were not supposed to have behaved in this way. That is, if the 41-month-olds' reproduction of the demonstrated failed attempts were solely influenced by the observed movements, it is not necessary for them to seek or wait for the adult's behavioural response after copying such acts.

In addition, the mimicry hypothesis would make the 41-month-olds' production of target acts and failed attempts in the Failed-Attempt condition difficult to interpret. The 41-month-olds in the Failed-Attempt condition did not exclusively produce the demonstrated failed acts. They emulated the target acts whilst also showing a tendency to imitatively copy the observed movements. They also displayed a tendency to imitatively copy the observed movements in the Adult-Manipulation condition, but were not as likely to produce the target acts as they were in the Failed-Attempt condition. If the 41-month-olds were using the strategy of mimicry in response to demonstrated acts of various types, it could not explain why they produced more target acts in the Failed-Attempt condition than in the Adult-

Manipulation condition. That is, if the 41-month-olds merely mimicked the demonstrator's failed attempts, they should have brought about the target acts equally infrequently in both the Failed-Attempt and Adult-Manipulation conditions and employed the behavioural strategy of mimicry with consistency.

Although the influence of object affordances was stronger in the Failed-Attempt condition than in the Adult-Manipulation condition, it might be argued that the 41-month-olds produced the target acts and failed attempts in the Failed-Attempt condition as a result of the influences of object affordances and observed outcomes and these influences did not necessarily constitute the contradictory information. That is, the 41-month-olds' tendency to emulate the target acts whilst imitatively copying the demonstrated failed attempts might not necessarily imply that the affordances of objects and the observed outcomes involved in the failed-attempt model contradicted with each other. However, if the affordances of objects and the observed outcomes involved in the failed-attempt model did not produce conflicting tendencies, why did the 31-month-olds imitatively reproduce the observed acts in the Adult-Manipulation condition but not in the Failed-Attempt condition? Similarly, why were only the 41-month-olds in the Failed-Attempt condition influenced by the observed movements? Further, it was noted that 60% (6 of 10) of the 41-month-olds in the Failed-Attempt condition on at least one occasion produced the target act followed by the failed attempt or the failed attempt followed by the target act as their first and second acts combined in a single trial. In contrast, only 20% (2 of 10) of the 31-month-olds and 20% (2 of 10) of the19-month-olds in the Failed-Attempt condition were found to do so. If the 41-month-olds' reproduction of the observed acts in such case was simple mimicry, it does not seem plausible that both object affordances and observed movements independently contributed to the two differing ways of responding exhibited by these children, while these influences were not producing conflicting tendencies. On the contrary, it is possible that the 41-month-olds were aware that the affordances of objects highlighted by the model and what the model was actually focused on might not match. In a sense, the 41-month-olds were not only less enslaved to the affordances of objects but also more sensitive to information relevant to the experimenter's behavioural intentions than younger children. As the acts presented in Meltzoff's Failed-Attempt paradigm were simple acts on objects, it is possible that the 41-month-olds would tend to interpret the observed outcomes of these acts as the demonstrator intending to bring about the unconsummated target acts rather than the consummated ones. Under this account, it is probable that the 41-month-olds used a strategy of copying the observed acts in the Failed-Attempt condition because they were sensitive to the demonstrator's underlying intentional stance when they observed him perform the unconsummated target acts. Therefore, a more plausible explanation would seem to be that the 41-month-olds in the Failed-Attempt condition possessed abilities for reading the observed outcomes of the demonstrated acts as intended, whilst still being under the influence of the affordances of objects.

Finally, additional support for the assertion that the 41-month-olds in the Failed-Attempt condition did not merely mimic the observed movements comes from the comparative studies that have explored the role of imitation in tool use between young children and non-human primates. For example, Whiten, Custance, Gomez, Teixidor, and Bard (1996), who tested children and chimpanzees in a situation involving an artificial fruit device, found that children of 2, 3, and 4 years copied the actions which they had witnessed with relatively high fidelity in comparison to the chimpanzee group, even though the action they reproduced was of limited benefit in task completion. Nagell, Olguin, and Tomasello (1993) reported a similar finding that in a rake-using task 2-year-olds often copied the method of the demonstrator even in the case of the less inefficient method, whereas the chimpanzees used either the same method or other methods which had never been observed in the demonstration. These findings are consistent with the results of Experiment 3. Although the 31-month-olds did not copy the observed acts in the Failed-Attempt condition, they were found to do so in the Adult-Manipulation condition. Despite the fact that all the three groups of children in the Failed-Attempt condition were engaged in a kind of emulation learning, the 41-month-olds showed a reliable tendency to imitatively copy the demonstrated failed acts under the influence of their learning about the affordances of objects. The 19- and 31-month-olds did not copy the observed acts in the Failed-Attempt condition, perhaps because the object affordances induced were so strong to detract from their tendency to adopt the behavioural strategy of copying the observed acts. If the 41-month-old children's reproduction of the observed acts in the Failed-Attempt condition was mimicry, that would seem to underestimate the role of other advanced cognitive skills such as behavioural inhibition in their imitative performance. Thus, the author concurs with Whiten and Custance's (1996) suggestion: "quite high-fidelity imitation of adults is such a powerful general-purpose strategy for children of these ages that occasional counterproductive overshooting of its application is a small price to pay" (p.306-307).

In a recent study, Want and Harris (in press b) investigated 2- and 3-year-old children's imitative performance in a trap-tube task involving complex acts on objects (using a stick to retrieve a toy from the centre of a narrow tube). The 2- and 3-year-olds were shown one of the four demonstrations: a correct demonstration, an incorrect followed by a correct demonstration, and two control demonstrations. The correct demonstration involved inserting a stick from the correct end of the tube to retrieve a toy. In the incorrect followed by the correct demonstration, the experimenter first failed to push the toy out from the centre of the tube by inserting the stick from the incorrect end of the tube and successfully retrieved the toy by making a second insertion from the correct end of the tube. The two control demonstrations mimicked the stick movements produced in the above two demonstrations, but did so with the stick being moved along the outer surface of the tube. Results indicated that all the 2- and 3-year-olds who could not spontaneously solve the trap-tube task at least attempted to retrieve the toy by inserting the stick into one side of the tube after observing the correct demonstration, but rarely did so after observing the two control demonstrations. By contrast, only the 3-year-olds benefited from observing the incorrect and correct demonstrations combined and were most successful in retrieving the toy from the tube. In addition, it was reported that the children did not differentially copy the observed acts after seeing the control demonstrations. Neither did they copy the sequence of the modelled incorrect and correct demonstrations combined. Want et al. suggested that by 3 years of age children copy the observed act only when they understand that the act is intended to bring about a desired causal effect by the model. Want et al.'s view is in line with that of Tomasello (1996) who maintained that imitation takes place as a result of the imitator's ability to understand the intentional relations between the act produced and the outcome that the act is designed to achieve.

Might Want et al.'s findings challenge the author's assertion here that the 3-

year-olds' reproduction of the observed acts in the Failed-Attempt condition was not mimicry? It is important to note that the children in Want et al.'s study were told the experimenter's goal (retrieving the toy from the centre of the tube) before the demonstrations. However, in Experiment 3, the children in the Failed-Attempt condition were not instructed that the experimenter was going to produce a certain outcome in the object set. It might be that the children in Want et al.'s study were not likely to copy the control demonstrations or the sequence of the modelled incorrect and correct demonstrations because they were not required to interpret the intended subsequent outcomes when observing these demonstrations and their explicit knowledge of the goal detracted any tendency to copy the control demonstrations. Similarly, this might also be the reason why the 3-year-olds in Nagell et al.'s (1993) study rarely copied the inefficient method observed in the partial-model, because they did not need to decode the goal involved (using the rake to retrieve an out-of-reach object) by themselves. In contrast, in Experiment 3, the children in the Failed-Attempt condition were required to use action information to generate inferences about the outcomes that the model was intending to achieve. It is probable that they were more uncertain about the desired causal effect of the demonstrated failed attempts than the children observing the demonstrated solutions to tool-using tasks in Want et al.'s and Nagell et al.'s studies. Thus, it does not appear that the 3-year-olds in the present study replicated the demonstrated failed acts with no grasp of the likely outcomes of these acts.

Summary

To sum up, the main findings of Experiment 3 suggest that 41-month-old children differentially imitated demonstrated acts of various types and did not selectively reproduce those acts that resulted in observed outcomes specifying object affordances. In contrast, 19- and 31-month-old children appeared likely to have problems in copying demonstrated acts when there was a lack of matched relation between the observed outcomes of these acts and the affordances of the objects. In the Failed-Attempt condition, whilst all the three groups of children exhibited a proclivity to emulate the target acts, only the 41-month-olds imitatively reproduced the observed movements. The main points derived from the previous discussion include: (1) As the goals underlying the demonstrated failed attempts might not be necessarily ascribed to the assumed target acts, the validity of Meltzoff's Failed-Attempt paradigm for modelling intended subsequent but unfulfilled outcomes could be challenged. (2) The contrast between two divergent behavioural strategies that the 3-year-olds adopted in the Failed-Attempt condition reveals the conflict of contradictory information about the demonstrator's acts and intentions involved in the modelling. The evidence of imitation for 3-year-olds' reproduction of the observed acts in the Failed-Attempt condition suggests that they not only read the demonstrated failed attempts as "to be copied" but also possibly interpreted such acts as the demonstrator intending to bring about them. (3) Developmental differences in the tendency to use a strategy of copying the observed acts regardless of the constraints of types of demonstrated acts might be related to children's behavioural inhibition, such as an ability to refrain from the influence of the affordances of objects they learned during observation of the demonstration. (4) In addition, the findings of Experiment 3 highlight a parallel between imitation of acts on objects and early pretend play.

Scoring issues

The pattern of differences in children's production of target acts obtained in each of the three scoring strategies (first action, combined first and second actions, and 20-second response period) is consistent. Overall, the 31- and 41-month-olds were superior to the 19-month-olds in the ability to perform the target acts. The differences owing to an age factor tended to suggest that the 19-month-olds were liable to a manipulation difficulty in solving the task. For example, only 1 child in the 41-month-old group and 2 in the 31-month-old group produced an act falling into the category of Unfinished Target Act, as compared with 8 children in the 19-month-old group producing such acts. On the other hand, overall the 19-month-olds took a longer latency to produce the target acts as the first action than the 31- and 41-month-olds, who did not differ from each other. In the Full-Demonstration and Failed-Attempt conditions where the inputs demonstrated were apparently more relevant to the target acts, the three age groups of children did not differ in the latency to produce the target acts at the first and second actions combined. Conversely, in the Emulation-Learning condition where the task required that the children devised their own behavioural strategies to reproduce the observed end results, the 19-month-olds took a longer latency to produce the target acts at the first and second actions combined than both the 31- and 41-month-olds. The latter two groups of children did not differ. Given limited inputs, it seems that the older children were quicker to respond on the affordances of the objects than the younger ones. That is, the 31- and 41-month-olds generally exhibited superior motor skills in completing the task.

It might be argued that the test materials the author replicated from Meltzoff's (1995) study were designed based on the level of difficulty required for young children and, very likely, the target acts were already in the behavioural repertoire of the two older groups of children. However, the results showed that overall the children differentially imitated the target acts as their first actions in the Full-Demonstration condition. There was no evidence that the children imitatively learned the target acts in the other three conditions. Moreover, the main effect of condition obtained in each of the three scoring procedures was not subject to a higher-order age × condition interaction. Although overall the 31- and 41-month-olds outperformed the 19-month-olds, the effect of the type of display on children's production of target acts across the four conditions was not dependent on age. Despite the likelihood that the test materials underestimated the older children's baseline abilities, the effect of the type of display on their differential reproduction of acts of various types observed was convincing. That is, whether the children imitatively responded to the observed acts in the Failed-Attempt and Adult-Manipulation conditions did not necessarily rely on whether they were skilful in manipulating the objects. Even if the 19-month-olds were liable to a manipulation difficulty in performing the target acts, that did not appear to hinder their tendency to imitatively respond to the target acts observed in the Full-Demonstration condition.

Next, it is interesting to note that overall the children in the Full-Demonstration and Failed-Attempt conditions started by manipulating the same object parts that the demonstrator first touched more frequently than they did in the Emulation-Learning condition. Although the children in the Full-Demonstration, Failed-Attempt, and Adult-Manipulation conditions followed the object parts they watched the demonstrator first touch equally frequently, they were not similar to each other in performance on target acts. Evidently, the children were not induced to elicit the target acts by merely being attracted to the object parts which the demonstrator first touched. On the other hand, overall the children in the Emulation-Learning condition, to the contrary, started by manipulating the differing object parts the demonstrator did not first touch more frequently than they did in the Full-Demonstration and Failed-Attempt conditions. Were the children in the Emulation-Learning condition more likely to induce various other acts at their first action, as they tended to start by manipulating the differing object parts the demonstrator did not first touch? The results showed that the 19-month-olds in the Emulation-Learning, Failed-Attempt, and Adult-Manipulation conditions produced various other acts at the first action more frequently than they did in the Full-Demonstration condition. However, for both the 31- and 41-month-olds, their production of other acts at the first action in the Emulation-Learning condition did not differ from that in any of the other three conditions. As overall, the 31- and 41-month-olds followed the same object parts the demonstrator first touched more frequently than the 19-month-olds, that may account for the 19-month-olds' frequent adoption of an exploratory strategy by way of producing various other acts on the objects as the first action.

Finally, the 3×4 (age $\times$ condition) analyses of variance adopted in the present study did not fully replicate the pattern of 19-month-olds' production of target acts among the four conditions obtained in each of the three scoring procedures in Experiment 1. A reason for this is that the variance contributing to the main effect of condition was tested on the basis of different error terms. In Experiment 1, the main effect of condition was assessed in comparison with the variance of error within the 19-month-old group, whereas in Experiment 3 it was examined in comparison with the general variance of error within the 19-, 31-, and 41-month-old groups combined. As the present study was concerned with whether there was a developmental constraint on children's ability to imitate the intended target acts in the Failed-Attempt condition, it does not appear to serve a purpose by performing one-way ANOVAs in each of the three groups in isolation. Thus, the 3×4 (age $\times$ condition) analyses of variance were chosen to assess the overall main effects of age and condition, and their interaction. In Experiment 1, the results showed that the 19-month-olds in the Full-Demonstration, Failed-Attempt, and Emulation-Learning conditions performed the target acts equally well when all the target acts they produced in the 20-second response period were considered. Alternatively, in

Experiment 3, the results indicated that overall the children performed better in the Full-Demonstration condition than in any of the other three conditions regardless of whichever scoring procedure was adopted. This did not contradict the evidence for imitation reported in Experiment 1: the 19-month-olds differentially imitated the target acts at the first action in the Full-Demonstration condition, but not in the Failed-Attempt or Emulation-Learning conditions. On the other hand, Experiment 3 provided additional evidence that the children's behavioural tendency to imitate the observed target acts in the Full-Demonstration condition was not age-related. On the contrary, the developmental constraint on the ability to imitatively respond to the acts observed in the Failed-Attempt and Adult-Manipulation conditions was confirmed. If one-way ANOVAs were adopted, the critical age $\times$ condition interaction would not be directly recognised.

Chapter Five

Imitating failed attempts:
Intententionally-failed vs. accidentally-failed attempts

Experiment 4

5.1. Introduction

Experiment 4 was the last in a series of studies designed to examine the methodological adequacy of Meltzoff's Failed-Attempt paradigm and to explore the role of understanding of intention in children's imitation of acts on objects. In Experiment 3, while the 19-, 31-, and 41-month-olds in the Failed-Attempt condition exhibited a proclivity to produce the afforded target acts, only the 41-month-olds also imitatively reproduced the demonstrated failed attempts. The finding provides evidence that Meltzoff's Failed-Attempt format involves inherent contradictory information about the apparently intended target acts and the demonstrator's underlying intentional stance, and indicates a conflict between the two behavioural strategies—production of target acts and observed movements—that the 41-month-olds adopted in the Failed-Attempt condition. Further, it was suggested that the 41-month-olds copied the experimenter's failed acts imitatively because they interpreted the acts actually demonstrated as the intended acts. In a sense, the 41-month-olds were probably aware that the experimenter failed to consummate the target acts on purpose. Thus, they could read the failed acts observed as intended and imitatively copy such acts in comparison to the 19- and 31-month-olds who did not read the failed acts observed as intended. The 41-month-olds' ability to imitate the failed attempts demonstrated apparently implies a particular form of social understanding that the 19- and 31-month-olds have not acquired. However, previous research has shown that children as young as 16 months of age could distinguish between intentional actions from unintentional actions as a result of imitatively reproducing more acts followed by the adult saying "There!" (Intentional) than acts followed by the adult saying "Oops!" (Unintentional) (Carpenter, Akhtar, & Tomasello, 1998). According to this account, it is possible that the 19- and 31-month-old children in Experiment 3 were not as sensitive as the 41-month-olds to the experimenter's underlying intentional stance in the Failed-Attempt condition because there were no salient cues guiding them to interpret the observed outcomes of the demonstrated acts as intended. If the acts observed in Meltzoff's Failed-Attempt format were followed by vocal markers of intentional acts (such as "There!"), would children under 3 years of age be able to use this information to copy the failed acts that have been actually observed? On the other hand, if vocal markers of accidental actions (such as "Oops!") followed these acts, would 3-year-olds avoid replicating the modelled failed acts with an understanding that the experimenter was not intentionally failing to consummate the target acts? Therefore, Experiment 4 was designed as a modification of Meltzoff's Failed-Attempt paradigm, and examined the main hypothesis that 17- and 39-month-old children could imitatively copy the failed acts explicitly marked as intended. The alterations made to Meltzoff's format aimed to diminish the contradictory information about the demonstrator's underlying intentional stance by highlighting the failed acts demonstrated with vocal markers of intentional and unintentional (accidental) events familiar to children in their everyday life.

Tomasello and colleagues have investigated children's ability to distinguish between intentional and unintentional action in imitation of acts on objects. In one experiment (Tomasello & Barton, 1994), the experimenter modelled a sequence of two novel actions with an apparatus after announcing her intention to carry out a target act on the apparatus. The target act was vocally marked as intentional ("There!") and the non-target one as accidental ("Oops!"), with the order of intentional and accidental action counterbalanced across sequences and conditions. For example, the experimenter told the child, "Let's meek Big Bird", and then performed the target action followed by "There!" and the other action followed by "Oops!". The child was then invited to play with the apparatus by herself. Tomasello and Barton (1994) showed that children as young as 2 years of age reproduced more actions vocally marked as intentional ("There!") than those vocally marked as accidental ("Oops!"). It was suggested that the children imitatively learned the novel word referring to the target act for an intentional action and not for an unintentional action

In another experiment, Carpenter, Akhtar, and Tomasello (1998) extended Tomasello and Barton's (1994) findings to 14- to 18-month-olds who could recognise and differentially imitate actions that were followed by the model saying "There!". Following Tomasello and Barton's (1994) paradigm, Carpenter et al. (1998) demonstrated for children a sequence of two novel actions, which elicited the same end result on the apparatus. For example, the experimenter made a toy appear from a blue wooden box by either pulling the handle up or spinning the wheel. One of the modelled actions was vocally marked as intentional ("There!"), and the other action was vocally marked as accidental ("Oops!). After observing the sequence of two modelled actions, children were then given a chance to play with the object in a spontaneous manner. Carpenter et al. showed that infants reproduced the intentional actions (those followed by "There!") to elicit the end results observed more frequently than the accidental actions (those followed by "Oops!"). This suggests that 1 ½-year-olds could be induced to reproduce the intended acts of others in an imitating situation as a consequence of their ability to distinguish between intentional and unintentional actions. The above finding parallels the evidence that as early as 18 months, infants can match goals and outcomes in learning first words, such as "there" referring to a match and "uh-oh" referring to a mismatch (Gopnik, 1982).

However, the preceding experiments in this thesis showed that the 18- and 19-month-olds' behavioural performance in the Failed-Attempt condition was not guided by ascription of intention to the adult because they reproduced neither target acts nor failed acts as their first actions. In Section 1.5.1, it was proposed that the acts demonstrated in Meltzoff's Failed-Attempt format might not be interpreted as the target acts that the adult judged to be intended, because there is no additional clue in the display about whether the adult fails to elicit the target acts intentionally or accidentally. The scenario thus entails an inherent incongruity between the observed outcomes of the demonstrated acts and the apparently "intended" target acts. Unless the failure to consummate the target acts was accidental, there would be the likelihood that children would interpret the demonstration as the adult failing to do so on purpose. This suggests that the 17- and 19-month-olds in the previous experiments were not as likely to be aware of the contradictory information entailed in the failed-attempt display as the 41-month-olds were. On the other hand, the 14- to 18-month-olds in Carpenter et al.'s (1998) study imitated acts followed by "There!" and not acts followed by "Oops!" perhaps because each of the two modelled actions was distinctly marked and thus diminished the contradictory information imposed on children's adoption of an imitation strategy. According to this account, would the 19- or 17-month-old infants in the Failed-Attempt condition improve their imitative performance if they were offered additional cues that the demonstrator's failure to consummate the target acts was accidental? Might it be the case that these younger children showed an increased tendency to copy the failed acts when they understood that the demonstrator was failing to bring about the target acts on purpose?

Therefore, the current study incorporated vocal markers of accidental and intentional actions such as those employed in the studies of Tomasello and colleagues into Meltzoff's Failed-Attempt format. The modifications aimed to diminish the contradictory information inherent in Meltzoff's format by vocally marking the modelled acts as intentionally or accidentally failed, and in this way, to examine the extent to which children would match intentional cues and intended outcomes through imitative performance. That is, Experiment 4 explored whether children in such circumstances were sensitive to vocal markers of intentional and accidental actions and as a result differentially elicited "intended" target acts and "intended" failed acts. To achieve the above purpose, 39- and 17-month-old children were shown one of three types of failed-attempt model: the demonstrations vocally marked as intentionally failed, the demonstrations vocally marked as accidentally failed, and the demonstrations not vocally marked. The two age groups were chosen for two reasons. On the one hand, among the three age groups in Experiment 3, only 41-month-olds displayed a reliable ability to reproduce the acts observed in the Failed-Attempt condition. As discussed, that might support the view that 41-month-olds were sensitive to the contradictory information related to the adult's underlying intentional stance. On the other hand, though debatable, previous research has demonstrated that 14- to 18-month-olds were able to distinguish between intentional and unintentional acts in an imitating situation and this specific age range is of particular interest in recent literature (Carpenter, Akhtar, & Tomasello, 1998;

Carpenter, Nagell, & Tomasello, 1998; Meltzoff, 1995). As all the children involved in the present study were speakers of Mandarin, the author used corresponding vocalisations in Mandarin ("Zha Bian!" and "Ou!") to substitute for the markers ("There!" and "Oops!") used in the studies of Tomasello and Barton (1994) and Carpenter, Akhtar, and Tomasello (1998) (see Section 5.2.4 for a description).

Importantly, one main difference between the present study and Carpenter et al's study is that in Carpenter et al.'s study the adult demonstrated for children two differing forms of action leading to the same outcome, whereas in the present study the adult modelled an unfulfilled action leading to either the observed or intended outcome depending on the type of vocal marker used in the condition. Heyes (in press) has suggested that the children in Carpenter et al.'s study may have learned, before the demonstration, that rewarding outcomes are more likely to follow acts accompanied by the vocalisation "There!" than acts accompanied by the vocalisation "Oops!". In that case, it is arguable that children reproduced acts followed by the vocal marker "There!" as a consequence of ascription of intentions to the adult. By contrast, in the present study the acts demonstrated were unfulfilled actions that ensured that children would not selectively reproduce only the acts followed by the vocalisation "There!". For example, in the Failed-Attempt (by accident) condition where the failed acts were vocally marked as accidentally failed (saying "Oops!), the child was expected to be sensitive to this cue and elicit the target acts that the adult judged to be the intended outcomes. In the Failed-Attempt (by intention) condition where the failed acts were vocally marked as intentionally failed (saying "There!"), the child was expected to read the acts actually demonstrated as the intended acts and copy the failed acts instead of the target acts which were apparently more interesting than the failed acts. Note that the author considered the failed acts demonstrated as the intended acts in the Failed-Attempt (by intention) condition based on the previous findings that 41-month-olds reliably imitated such acts observed in the Failed-Attempt condition in Experiment 3. It has been suggested that 41-month-olds could read the unfulfilled acts demonstrated as the intended acts. Thus, the design of the present study was stringent in testing intention-sensitive imitation in the sense that the intended goal of an unfulfilled action was reliant on the intentional cue from the demonstrator. In contrast, in Carpenter et al.'s study the children were not expected to use the intentional cue to decode the goal underlying each of the two actions in the modelled sequence because both actions led to the same observed outcome.

Experiment 4 had three main hypotheses.

First, it was predicted that 39-month-olds would copy the failed acts more frequently when these acts were cued to be intentionally failed or not vocally marked than when these acts were cued to be accidentally failed. In Experiment 3, it was suggested that reproduction of the failed acts as a behavioural strategy is related to a special form of social understanding that only children of 3 years have developed. Additionally, previous research has shown that 3-year-old children have considerable understanding of intentional acts (Shultz, Wells, & Sarda, 1980) and unfulfilled intentional acts (Moses, 1993). Although there is no direct evidence that they also acquire understanding of intentionally unfulfilled act through verbal means, it is possible that in a live behavioural situation they would benefit from using an imitation strategy and copy the failed acts when they were marked as intentionally failed. On the other hand, Carpenter, Akhtar, and Tomasello (1998) have demonstrated that 1 ½-year-olds were capable of recognising an intended act as a person's intention in their imitative performance of acts on objects. However, Experiments 1 and 2 showed that the 19- and 17-month-olds copied the observed acts in the Failed-Attempt condition very infrequently. It is thus not clear that they would benefit from their understanding of intentional acts, thereby copying the intentionally failed acts.

A second hypothesis was that 3-year-olds would produce many more of the "intended" but unconsummated target acts when the failed acts were vocally marked as accidentally failed. In Experiment 3, the 41-month-olds in the Failed-Attempt condition exhibited a proclivity to produce the target acts as well as to imitatively reproduce the observed movements. It was suggested that they might be aware that the adult's failure to consummate the target acts was intentional and thus were more likely to replicate the failed acts than the younger children. It was thus likely that 39-month-olds would benefit from the cue that marked the failed acts as accidental, thereby avoiding reproducing the failed acts. On the other hand, no evidence from the previous experiments suggested that 19- and 17-month-old children's failure to imitatively produce the target acts as their first actions in the Failed-Attempt condition was related to their ability to decode the intended subsequent acts. It is interesting to examine whether they would take advantage of the vocal cue that marked the adult's failure to consummate the target acts as accidental, thereby improving their performance on target acts.

Finally, it was predicted that both 17- and 39-month-olds would display the same tendency similar to that they displayed in Experiment 3 to produce the target acts when the demonstrated failed acts were not followed by vocal cues.

5.2. Method

5.2.1. Participants

Thirty 17-month-old children (M = 17.2, SD = 1.3) and thirty 39-month-old children (M = 39.2, SD = 2.6) participated in the present study. There were 15 males and 15 females in the 17-month-old group; 19 males and 11 females in the 39-month-old group. All were ethnic Chinese in Taiwan. The children in the 17-month-old group were referred via the Department of Health Screening at Taipei Municipal Women's and Children's Hospital. The children in the 39-month-old group were recruited from three nurseries in greater Taipei district.

5.2.2. Test situation

The test situation followed a similar procedure to that used in Experiments 1~3. All sessions were videotaped. The 17-month-olds were tested individually at their own home. The 39-month-olds were tested in a room at their own nursery, with a worker present to make them feel comfortable with the experimenter. The worker sat behind the child, and was asked not to speak or act in any way that may affect the children's responses. The experimental setting for both home and school testing was identical to that which the author had set up in the previous experiments.

5.2.3. Test materials

The test materials were the same sets of five objects used in Experiments 1~3. They were replicas of the five objects in Meltzoff's (1995) study.

5.2.4. Experimental design

The children in both the 17- and 39-month-old groups were randomly assigned to one of the three conditions with 10 children per condition. With the addition of two variants of Meltzoff's Failed-Attempt format, there were three conditions: Failed-Attempt (neutral), Failed-Attempt (by accident), and Failed-Attempt (by intention). The alterations made were based on the adaptation of the vocal makers of intentional and accidental actions used in the studies of Tomasello and Barton (1994) and Carpenter, Akhtar, and Tomasello (1998). As all the participants in the present study spoke Mandarin as their first language, the vocal markers in Mandarin were chosen instead. The vocalisation "Ou!" substituted for "Oops" and "Zha Bian!" for "There!". Each of the vocalisations of "Ou!" and "Zha Bian!" was familiar to children speaking Mandarin in Taiwan, and had the corresponding meaning in Mandarin to that of "Oops!" and "There!" in English, respectively. The form of the acts watched by children in each of the three conditions was consistently modelled according to Meltzoff's Failed-Attempt format. In the Failed-Attempt (neutral) condition, the experimenter demonstrated the failed acts three times in each trial in the same way as in the Failed-Attempt condition in Experiments 1~3; that is, with a neutral expression and no accompanying vocal marker. In the Failed-Attempt (by accident) condition, the experimenter demonstrated the failed acts three times in each trial as in the Failed-Attempt (neutral) condition, but every time he failed to consummate a target act, the demonstration was immediately followed by the vocalisation "Ou!" ("Oops!"). In the Failed-Attempt (by intention) condition, the experimenter demonstrated the failed acts as in the Failed-Attempt (neutral) condition, but every time he failed to consummate the target acts, the demonstration was immediately followed by the vocalisation "Zha Bian!" ("There!"). The failure was repeated three times in each of the five trials, and then the object set was placed in front of the child. The order in which each of the five objects was presented was counterbalanced within the condition.

It is important to note that the experimenter exhibited an accompanying slightly disappointed facial expression when announcing that the failure to consummate the target acts was accidental, and an accompanying smiling face when announcing that he failed to bring about the target acts on purpose. The experimenter did not attempt to cue children by exaggerating his facial expression. Instead, he was saying "Ou!" ("Oops!") or "Zha Bian!" ("There!") just like the vocalisation was naturally said in an appropriate context in everyday life. In this way, the experimenter in the Failed-Attempt (by accident) and Failed-Attempt (by intention) conditions did not refrain from showing naturally accompanying facial expressions when uttering the vocal markers. On the contrary, the experimenter demonstrated the acts in the Failed-Attempt (neutral) condition with a neutral face and no accompanying vocal cue.

5.2.5. Scoring

The scoring followed the two-action strategy adopted in the preceding experiments. Each of the first and second actions that children produced in the 20-second response period across the five sets of objects was coded depending on whether it fell into one of the following categories: (1) Target Act, (2) Unfinished Target Act, (3) Failed Act, (4) Other Act, and (5) No Act. The operational criteria for scoring these categories were described in Experiment 1 (Section 2.2.5). For purposes of comparison between the present study and relevant previous research (Bellagamba & Tomasello, 1999; Meltzoff, 1995), target acts produced after the second action within 20 seconds were also independently coded. In addition, the following measures were recorded for subsidiary analyses: (1) the latency to produce the target acts, (2) the object parts that children first touched. The use of a finger to activate the beeper in the object set of box and stick was independently scored but not analysed, because the current study did not include the Emulation-Learning condition and the children in each of the three conditions had equal access to the experimenter's manual contact with the stick during the demonstration phase.

5.2.6. Inter-rater reliability

Children's responses were coded from the videotapes by the author. Inter-rater reliability was assessed for 40% of the data (4 children per condition) by a colleague who has been familiarised with the scoring system used in the preceding experiments. The reliability was established in three ways: (1) the children's first actions and (2) first and second actions combined falling into Target Act, Unfinished Target Act, Failed Act, Other Act, No Response, or the use of a finger to activate the beeper in the object set of box and stick; (3) the target acts produced within 20 seconds of the response period. For the 17-month-old group, the percentage agreement was 92%, (kappa = 0.86), concerning the children's first actions; 90% (kappa = 0.81), concerning the first and second actions combined; and 98%, (kappa = 0.97), concerning the target acts produced within 20 seconds of the response period. For the 39-month-old group, the percentage agreement was 93%, (kappa =

0.90), concerning the children's first actions; 88% (kappa = 0.82), concerning the first and second actions combined; and 100%, (kappa = 1.00), concerning the target acts produced within 20 seconds of the response period.

5.3. RESULTS

All participants in both the 17- and 39-month-old samples had a complete record of 5 trials. For purposes of comparison between Experiment 4 and the preceding experiments, the number of acts produced at first action and at first and second actions combined falling into each of the scoring categories was divided by 5 (the maximum number of acts coded falling into any category) to convert into a proportion. Tables 5.1 displays the means of the proportion of children's first actions, and first and second actions combined falling into each scoring category across the five different sets of objects, respectively. The main analyses included Target Act (first action, first and second actions combined, and overall performance in the 20-second response period), Failed Act (first action, first and second actions combined). The subsidiary analyses consisted of Other Act (first action), the latency to produce the target acts, and the object parts children first touched. The number of acts falling into Unfinished Target Act (first action, first and second actions combined) were not analysed, as only one child in the 39-month-old sample produced one such act. The data were subjected to 2 × 3 (age × condition) analyses of variance. Following these, pairwise comparisons were assessed using a Tukey HSD test.

5.3.1. Main Analyses

Target acts produced at first action

In 2 × 3 (age × condition) ANOVAs on the proportion of children's first acts coded in the category of Target Act, these did not reveal a main effect of age, $F(1, 54) = 0.05$, $p > 0.8$,or a main effect of condition, $F(2, 54) = 1.35$, $p > 0.2$. Neither was there a significant age × condition interaction, $F(2, 54) = 0.16$, $p > 0.8$.

Target acts produced at first and second actions combined

In 2 × 3 (age × condition) ANOVAs on the proportion of children's first and second actions combined coded in the category of Target Act, these did not yield a main effect of age, $F(1, 54) = 0.68$, $p > 0.4$, or a main effect of condition, $F(2, 54) = 0.30$, $p > 0.7$. The age × condition interaction was not significant, $F(2, 54) = 1.06$, $p > 0.3$.

Table 5.1. Means of the proportion of 17- and 39-month-old children's first actions and combination of first and second actions falling into each of the scoring categories.

Condition / Action / age	Failed-Attempt *(neutral)* *Mean (SD)*	Failed-Attempt *(accidentally failed)* *Mean (SD)*	Failed-Attempt *(intentionally failed)* *Mean (SD)*
TA-1st			
17-month-old	.32 (.14)	.24 (.16)	.34 (.19)
39-month-old	.38 (.29)	.22 (.22)	.30 (.33)
FA-1st			
17-month-old	.06 (.10)	.10 (.11)	.08 (.10)
39-month-old	.30 (.22)	.30 (.22)	.36 (.26)
OA-1st			
17-month-old	.54 (.16)	.60 (.23)	.58 (.22)
39-month-old	.32 (.23)	.46 (.19)	.34 (.27)
NO-1st			
17-month-old	.00 (.00)	.00 (.00)	.00 (.00)
39-month-old	.00 (.00)	.00 (.00)	.00 (.00)
TA (UN)-1st			
17-month-old	.02 (.06)	.06 (.10)	.04 (.08)
39-month-old	.00 (.00)	.02 (.06)	.00 (.00)
TA (F)-1st			
17-month-old	.06 (.10)	.00 (.00)	.00 (.00)
39-month-old	.00 (.00)	.00 (.00)	.00 (.00)
Total			
17-month-old	1.00	1.00	1.00
39-month-old	1.00	1.00	1.00

Note. TA-1st = target act produced at first action; FA-1st = failed act produced at first action; OA-1st = other act produced at first action; NO-1st = no act produced at first action; TA (UN)-1st = unfinished target act produced at first action; TA (F)-1st = use of a finger to activate the beeper at first action in the object set of box and stick.

Table 5.1. (Continued)

Action / age (Condition)	Failed-Attempt *(neutral)* *Mean (SD)*	Failed-Attempt *(Accidentally failed)* *Mean (SD)*	Failed-Attempt *(intentionally failed)* *Mean (SD)*
TA-1st + 2nd			
17-month-old	.38 (.15)	.42 (.15)	.46 (.27)
39-month-old	.46 (.30)	.30 (.24)	.34 (.34)
FA-1st + 2nd			
17-month-old	.10 (.14)	.12 (.14)	.22 (.20)
39-month-old	.50 (.33)	.48 (.23)	.54 (.33)
OT-1st + 2nd			
17-month-old	.78 (.20)	.80 (.16)	.84 (.13)
39-month-old	.38 (.22)	.54 (.21)	.48 (.29)
NO-1st + 2nd			
17-month-old	.06 (.13)	.00 (.00)	.00 (.00)
39-month-old	.24 (.28)	.10 (.19)	.16 (.35)
TA (UN)-1st + 2nd			
17-month-old	.06 (.13)	.12 (.14)	.06 (.10)
39-month-old	.00 (.00)	.02 (.06)	.00 (.00)
TA(F)-1st + 2nd			
17-month-old	.08 (.10)	.02 (.06)	.00 (.00)
39-month-old	.00 (.00)	.00 (.00)	.00 (.00)
REPEAT			
17-month-old	.54 (.28)	.52 (.21)	.42 (.24)
39-month-old	.42 (.22)	.56 (.26)	.48 (.29)
Total			
17-month-old	2.00	2.00	2.00
39-month-old	2.00	2.00	2.00
TA-20 sec			
17-month-old	.44 (.13)	.50 (.17)	.54 (.28)
39-month-old	.52 (.30)	.32 (.29)	.38 (.35)

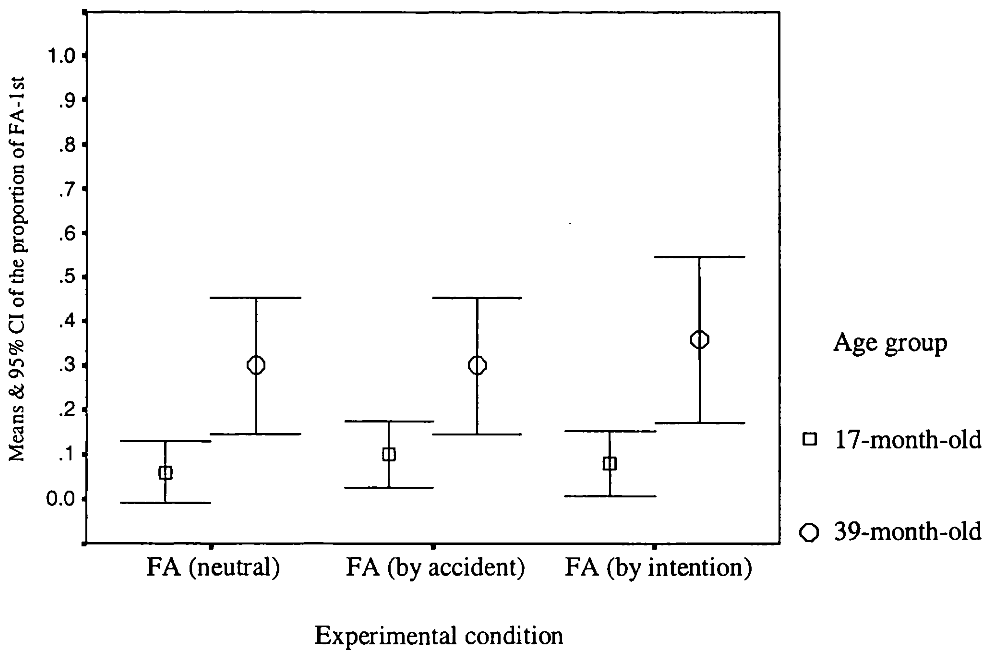
Note. TA-1st + 2nd = target act produced at first and second actions combined; FA-1st + 2nd = failed act produced at first and second actions combined; OA-1st + 2nd = other act produced at first and second actions combined; NO-1st + 2nd = no act produced at first and second actions combined; TA (UN)-1st+2nd = unfinished target act produced at first and second actions combined; TA (F)-1st + 2nd = use of a finger to activate the beeper in the object set of box and stick at first and second actions combined; Repeat = a scoring category repeatedly scored at first and second actions; TA-20 sec = target act produced during 20 seconds of the response period.

Target acts produced during 20 seconds of response period

As in the preceding analyses, there was no main effect of age and main effect of condition on the proportion of children's acts produced in the 20-second response period coded in the category of Target Act, $F(1, 54) = 1.62$, $p > 0.2$, and $F(2, 54) = 0.37$, $p > 0.2$, respectively. Also, there was no significant age × condition interaction, $F(2, 54) = 1.51$, $p > 0.3$.

Failed acts produced at first action

There was a main effect of age on the proportion of children's first actions coded in the category of Failed Act, $F(1, 54) = 26.75$, $p < 0.001$. There was no main effect of condition, $F(2, 54) = 0.25$, $p > 0.7$, and no significant age × condition interaction, $F(2, 54) = 0.25$, $p > 0.7$. Figure 5.1 shows that collapsing over conditions, the 39-month-olds were more likely to reproduce the demonstrated failed attempts as their first acts than the 17-month-olds.



Note. FA = Failed-Attempt.

Figure 5.1. Means and 95% CI of the proportion of 17- and 39-month-old children's first actions coded in the category of Failed Action (FA-1st) as a function of age.

Failed acts produced at first and second actions combined

There was a main effect of age on the proportion of children's first and second actions combined coded in the category of Failed Act, $F(1, 54) = 33.31$, $p < 0.001$. There was no main effect of condition, $F(2, 54) = 0.73$, $p > 0.7$, and no significant age × condition interaction, $F(2, 54) = 0.14$, $p > 0.8$. The results were the same as the analyses of such acts produced as the children's first acts. Figure 5.2 shows that collapsing over conditions, the 39-month-olds were more likely to reproduce the demonstrated failed attempts as their first and second actions combined than the 17-month-olds.

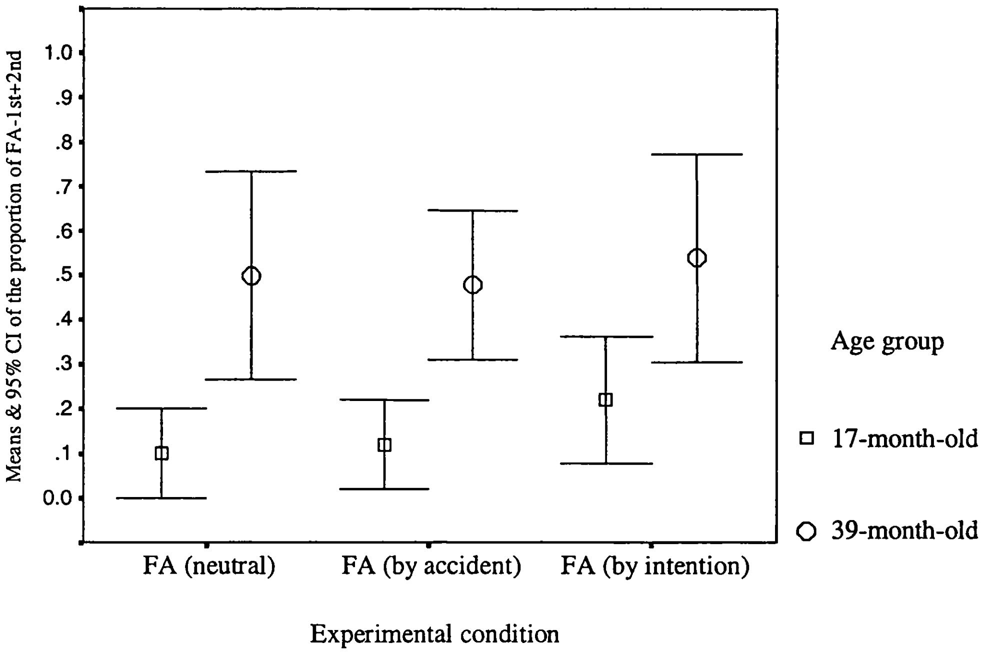
5.3.2. Subsidiary analyses

Other acts produced at first action

There was a main effect of age on the proportion of children's first acts coded in the category of Other Act, $F(1, 54) = 12.35$, $p < 0.001$. There was no main effect of condition, $F(2, 54) = 1.08$, $p > 0.3$, and no significant age × condition interaction, $F(2, 54) = 0.29$, $p > 0.7$. Figure 5.3 shows that collapsing over conditions, the 17-month-olds were more likely to produce other acts as their first acts than the 39-month-olds.

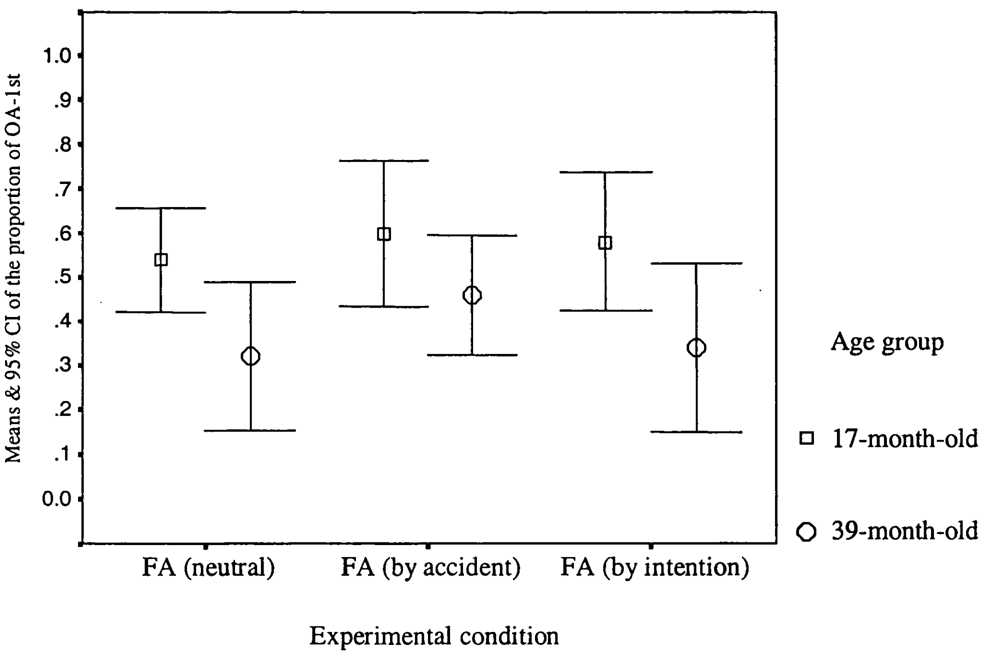
Object parts children first touched

Table 5.2 displays the means of the proportion of object parts that children first touched across the five sets of objects. The data are presented according to whether the children touched the same parts of the object sets as the experimenter, or different parts of the object sets from the experimenter, or touched more than one part at a time, or did not touch the object sets at all. In 2 × 3 (age × condition) ANOVAs on the proportion of first-touched object parts which were the same as those the experimenter first touched, these yielded a main effect of age, $F(1, 54) = 7.31$, $p < 0.009$. There was no main effect of condition, $F(2, 54) = 0.63$, $p > 0.6$, and no significant age × condition interaction, $F(2, 54) = 0.80$, $p > 0.4$. Collapsing over conditions, the 39-month-olds started by taking hold of the same parts of the objects as the experimenter more frequently than the 17-month-olds.



Note. FA = Failed-Attempt.

Figure 5.2. Means and 95% CI of the proportion of 17- and 39-month-old children's first and second actions combined coded in the category of Failed Act (FA-1^{st} + 2^{nd}) as a function of age.



Note. FA = Failed Attempt.

Figure 5.3. Means and 95% CI of the proportion of 17- and 39-month-old children's first actions coded in the scoring category of Other Action (OA-1^{st}) as a function of age.

Table 5.2. Means of the proportion of parts of objects 17- and 39-month-old children first touched.

Touched part / Condition / age	Consistent with the model *Mean (SD)*	Differing from the model *Mean (SD)*	Touching more than one part *Mean (SD)*	No response *Mean (SD)*
FA (neutral)				
17-month-old	.76 (.26)	.16 (.21)	.08 (.19)	.00 (.00)
39-month-old	.98 (.06)	.02 (.06)	.00 (.00)	.00 (.00)
FA (by accident)				
17-month-old	.82 (.27)	.10 (.14)	.08 (.19)	.00 (.00)
39-month-old	.88 (.14)	.10 (.14)	.02 (.06)	.00 (.00)
FA (by intention)				
17-month-old	.84 (.26)	.12 (.17)	.04 (.13)	.00 (.00)
39-month-old	.98 (.06)	.00 (.00)	.02 (.06)	.00 (.00)

Note. FA = Failed-Attempt.

On the other hand, 2 × 3 (age × condition) ANOVAs on the proportion of first-touched object parts which were different from those the experimenter first touched complemented the above analysis. These yielded a main effect of age, $F(1, 54) = 5.87$, $p < 0.02$. There was no main effect of condition, $F(2, 54) = 0.45$, $p > 0.6$, and no significant age × condition interaction, $F(2, 54) = 1.49$, $p > 0.2$. Collapsing over conditions, the 17-month-olds started by taking hold of the different parts of the object sets from the experimenter more often than the 39-month-olds.

Latency to produce target acts

Table 5.3 displays the means of the latency to produce target acts as the first acts, first and second acts combined, and overall performance during 20 seconds of the response period. The data were subjected to 2 ×3 (age × condition) ANOVAs. Counting the children's first acts only, there was a main effect of condition, $F(2, 43) = 3.72$, $p < 0.04$, and a marginally significant effect of age, $F(1, 43) = 3.65$, $p = 0.063$. The main effects were justified in a higher-order age × condition interaction, $F(2, 43) = 3.31$, $p = 0.054$. The analyses of simple main effects revealed that there was a significant difference in the latency to produce target acts as the first acts as a function of condition within the 17-month-old group, $F(2, 43) = 6.86$, $p < 0.01$. Follow-up Tukey HSD tests showed that the 17-month-old children in the Failed-Attempt (neutral) condition took a longer latency to produce the target acts as their

Table 5.3. Means of the latency for target acts produced at first action (TA-1st), first and second actions combined (TA-1st+2nd), and in the 20-second response period (TA-20 sec).

Condition \ Latency (sec)	TA-1st	TA-1st+2nd	TA-20 sec
FA (neutral)			
17-month-old	6.44 (3.00) n = 10	6.92 (3.49) n = 10	7.94 (4.29) n = 10
39-month-old	3.55 (1.75) n = 8	4.74 (1.94) n = 9	5.22 (2.69) n = 9
FA (by accident)			
17-month-old	3.55 (1.28) n = 8	7.99 (4.88) n = 10	8.97 (4.57) n = 10
39-month-old	2.80 (1.11) n = 7	5.45 (5.02) n = 9	5.49 (5.02) n = 9
FA (by intention)			
17-month-old	3.59 (1.44) n = 9	4.96 (2.14) n = 9	7.18 (5.05) n = 10
39-month-old	4.01 (2.07) n = 7	3.94 (1.99) n = 7	5.90 (5.87) n = 8

Note. "n" is the valid number of children.

first acts than they did in the Failed-Attempt (by accident) and Failed-Attempt (by intention) conditions (both, $p < 0.02$). No difference was seen between the latter two conditions. On the other hand, the analyses of simple main effects indicated that there were significant differences in the latency to produce the target acts as the first acts between the 17-and 39-month-old groups in the Failed-Attempt (neutral) condition, $F(1, 43) = 9.77$, $p < 0.01$. In the Failed-Attempt (neutral) condition, the 17-month-olds took a longer latency to produce the target acts as their first acts than the 39-month-olds.

Counting the children's first and second acts combined, there was a main effect of age, $F(1, 48) = 3.80$, $p = 0.057$. There was no main effect of condition and no age $\times$ condition interaction, $F(2, 48) = 1.74$, $p > 0.1$, and $F(2, 48) = 0.21$, $p > 0.4$, respectively. Collapsing over conditions, the 39-month-olds took a shorter latency to bring about the target acts as their first and second acts combined than the 17-month-olds.

Similarly, when all target acts produced in the 20-second response period were scored, there was a main effect of age, $F(1, 50) = 3.99$, $p = 0.051$. There was no main effect of condition and no age × condition interaction, $F(2, 50) = 0.13$, $p > 0.8$, and $F(2, 50) = 0.26$, $p > 0.7$, respectively. Collapsing over conditions, the 39-month-olds took a shorter latency to produce the target acts as their overall performance in 20 seconds of the response period than the 17- month-olds.

5.5. Discussion

Experiment 4 presents an attempt to modify Meltzoff's Failed-Attempt format and examined the hypothesis that children could distinguish between accidentally failed and intentionally failed attempts in a situation consisting of imitation of acts on objects. The alterations made to Meltzoff's format aimed to strengthen the cues given to the child about the experimenter's underlying intentional stance by vocally marking the acts demonstrated as intentionally or accidentally failed. In this way, children's reproduction of the target acts or demonstrated failed attempts was assessed as to whether they were using the accompanying vocal cue to represent the goals underlying the demonstrator's performance. Despite the modifications, neither of the 17- and 39-month-olds improved their performance on target acts as a result of the cue that marked the experimenter's demonstration as accidentally failed. Nor were they more likely to copy the demonstrated failed attempts from receiving the cue that marked the experimenter's demonstration as intentionally failed. However, similar to Experiment 3, the 39-month-old group was superior to the 17-month-old group in the ability to replicate the observed acts, but the groups did not differ in performance on target acts. That the 17-month-olds did not tend to adopt a strategy of reproducing the observed acts in response to the failed-attempt model was further supported by the finding that the 17-month-olds brought about a wide range of other acts as their first acts more frequently than the 39-month-olds. Overall, the pattern of findings concerning each of the 17- and 39-month-old children's production of the target acts and demonstrated failed attempts in the Failed Attempt (by accident) and Failed-Attempt (by intention) conditions was not different from that obtained in the Failed-Attempt (neutral) condition.

Assessing understanding of intentional action

Although neither of the 17- and 39-month-olds selectively reproduced the target acts or the demonstrated failed attempts according to the vocal cue about the demonstrator's intentional stance, it should be noted that the children in the current study appeared to be offered a more challenging task than that involved in Carpenter, Akhtar, and Tomasello's (1998) study. In Carpenter et al.'s study, 1 ½-year-olds' understanding of an intentional act was assessed in an imitating situation where the experimenter modelled a sequence of two different acts resulting in the same observed outcome, but only the act followed by the vocalisation "There!" was intended to produce the observed outcome. If children's imitative performance was guided by their understanding of the desired causal effect, they were expected to produce the observed outcome by copying the act followed by "There!", rather than the act followed by "Oops!". By contrast, in the present study, the experimenter modelled an unfulfilled action, which was the intended outcome itself when it was vocally marked as intentionally failed and referred to an intended but unfulfilled subsequent outcome when marked as accidentally failed. The use of an unfulfilled action in the demonstration could ensure that in either case the child would have to use the cue specifying the demonstrator's intentional stance to differentially produce the desired intended outcome. In other words, the scenario for Carpenter et al.'s study involved the same outcome resulting from an intentional and an unintentional action. As the results induced in both cases were identical and observed, the child was not expected to represent or imagine an intended subsequent outcome in some way. On the contrary, the child in Meltzoff's (1995) Failed-Attempt scenario was expected to both recognise the experimenter's unfulfilled act as intentional and re-enact the intended subsequent outcome underlying the unfulfilled act. The child's imitative performance in such a case was supposed to involve the type of cognitive skills required for interpreting or representing the intended subsequent outcomes that had not been observed.

The task in the current study was adapted from Meltzoff's Failed-Attempt format. The modified scenario involved an unfulfilled action being directed towards one of two potentially intended outcomes, whereas in Meltzoff's format the unfulfilled action was directed only to the target act that the demonstrator judged to be intended. Thus, the children in the present study were confronted with a more challenging task in the sense that they were required to reproduce the desired intended outcome by way of interpreting the cue specifying the model's intentional stance. That is, an action that on one occasion was a means to an end, would be an end in itself when the model intended it to be. If attention to the model were not a behavioural strategy that guided the child's imitative performance, the child would not be able to interpret the observed outcome of a demonstrated unfulfilled act as intended when the demonstrator did this on purpose. Similarly, if the child used a strategy to mimicry the acts produced by the model, they would not be able to use the cue, which marked the demonstrator's failure to consummate the target acts as accidental, to generate inferences about the intended subsequent but unfulfilled target acts. In this regard, the design of the present study, in comparison to that of Carpenter et al.'s (1998) study, more adequately addressed Meltzoff's view about 18-month-old children's understanding of intentional actions in imitation of acts on objects.

One other point worth emphasising is that the ability to distinguish intentionally failed versus accidentally failed attempts required for the current study might have been equated to the ability to distinguish intended versus unintended outcomes involved in Carpenter et al.'s (1998) study. In Carpenter et al.'s study, the child only needed to reproduce the observed outcome using the action modelled with the accompanying sound "There!". There was no such a situation where the results resulting from a sequence of two modelled actions were both vocally marked as unintended (saying "Oops!") that the child's interpretation of an unintended outcome could be assessed independently. How would the children in Carpenter et al.'s study respond if neither of the two modelled actions were vocally marked as intended?

In the author's experiences, it is quite rare for a child to produce no act at all after watching whatever type of action the experimenter had modelled. A clear example in the current study was that the 17-month-olds produced a range of other acts as their first acts compared to two times as many as the target acts as their first actions. It is plausible that even though children observe no intended outcome from the demonstration, the behavioural strategies they employed in such circumstances could reveal how they interpreted the demonstrated act from seeing it done by the model. In Experiment 3, for example, both the 31- and 41-month-olds in the Adult-Manipulation condition reproduced the non-afforded control acts more frequently than the 19-month-olds. The 41-month-olds in the Failed-Attempt condition exhibited two differing strategies of emulating the target acts and copying the observed acts in response to the contradictory information inherent in the scenario. Hence, in contrast to Carpenter et al's (1998) paradigm, the design of the present study was intended to provide a situation where the child was required to ascribe intentions to the model whose failure to fulfil the intended outcomes was accidental.

The scenario for the present study was based on the notion that if children were sensitive to the cue that marked the adult's failure as intentionally failed, they would copy the observed acts in preference to the target acts, and then emulation learning would not be the only strategy operating. Conversely, if children were sensitive to the cue that marked the adult's failure as accidentally failed, they would produce many more target acts than when they merely emulated these acts in the other two conditions. According to this account, the ability required for the current study not only entailed reproducing intentional action and intended outcome as in Carpenter et al.'s study, but also entailed refraining from the tendency to emulate the target acts when they were vocally marked as "not to be produced".

Recognising unfulfilled act as a person's intended act

In Experiment 3, the 41-month-olds in the Failed-Attempt condition displayed a behavioural tendency to emulate the afforded target acts while imitatively copying the acts actually demonstrated. This provides evidence that the acts observed in the failed-attempt display involved inherent contradictory information about the apparently "intended" target acts and the experimenter's underlying intentional stance. In Experiment 4, vocal markers of intentional and accidental actions were used to spell out the experimenter's intentional stance when demonstrating the failed attempts. Contrary to the author's prior predictions, the children did not differentially reproduce the target acts or the demonstrated failed acts according to the vocal markers. Neither the 17-month-olds nor the 39-month-olds improved their performance on target acts as a result of the cue that marked the demonstrations as accidentally failed. Nor did they benefit from the cue that marked the demonstrations as intentionally failed so as to copy the observed acts more frequently. The null results of Experiment 4 are thus difficult to interpret.

However, as in the preceding experiments, the 17-month-olds in Experiment 4 replicated few of the demonstrated failed acts: 0.4 (out of 5) at the first action across the three conditions, similar to the number produced by the 19- and 17-month-olds in the Failed-Attempt condition in Experiments 1 and 2, 0.3 (out of 5) in both studies. On the contrary, as in Experiment 3, the 39-month-olds in Experiment 4 exhibited a reliable ability to reproduce the failed acts: 1.6 (out of 5) at the first action across the three conditions similar to 1.7 (out of 5) produced by the 41-month-olds in the Failed-Attempt condition in Experiment 3. There are three reasons why this might be the case.

First, the 39-month-olds were supposed to be dexterous with the level of skill required for performing the task, and might be confused why the adult failed to consummate the target acts. Thus, they might not be motivated to choose a strategy of reacting to the vocal cue under these circumstances. In the Failed-Attempt (by accident) condition, the experimenter cued them to read the target acts as the intended subsequent outcomes, but the 39-month-olds were not more likely to produce the target acts than they were on the basis of emulation learning. They did not appear to use such a cue to interpret the unsuccessful event as accidental. Instead, whilst emulating the afforded target acts, reproduction of the acts observed was a strategy that the 39-month-olds chose to use across all three conditions. This suggests that the contradictory information about the apparently "intended" target acts and the experimenter's underlying intentional stance inherent in Meltzoff's Failed-Attempt format did not diminish as a consequence of the vocal cue. It appears that the 39-month-olds tended to interpret the adult's failure to consummate the target acts as intentional regardless of whatever way the experimenter cued them to read the observed acts as intentionally or accidentally failed.

In Section 1.5.3, the author has suggested that Meltzoff's Failed-Attempt paradigm is analogous to cases involving prior intention. For the 39-month-olds, it was not plausible that the adult failed in the task at this simple level while maintaining an intentional stance that he was attempting to bring about the target acts. If the adult planned to carry out the target acts prior to the demonstration, he should not have failed to produce them unless the failure was accidental. However, in the present study, even if the demonstrator vocally marked the failure as accidental, such an incongruity between action and intentional stance prior to acting did not appear to diminish. The 39-month-olds did not use the cue that marked the failed acts as "not to be copied" to produce more target acts. Similarly, they did not elicit less target acts as a result of the cue that marked the failed acts as "to be copied". It is thus possible that the unfulfilled action modelled in Meltzoff's Failed-Attempt format presupposes the demonstrator's inherent intentional stance prior to acting. If the adult did not hold a prior intention that he was not going to carry out the target acts, why should he have failed in the task at this skill level? Could 39-month-old children's reproduction of the failed acts imply that they read the acts observed with an awareness of the experimenter's underlying intentional stance? This is an interesting question worth addressing in future studies.

On the contrary, reproduction of the observed acts was not a strategy that the 17-month-olds consistently chose to use across the three conditions in Experiment 4. According to the account considered above, it is possible that the 17-month-olds were not as aware as the 39-month-olds that the act observed in the failed-attempt display presupposed the demonstrator's intentional stance prior to acting. In discussing the preceding experiments, it has been suggested that the 17-month-olds in the Failed-Attempt condition tended to produce the target acts in preference to the observed outcomes of the demonstrated failed acts because copying the observed acts would not result in the affordances of the objects highlighted by the demonstrated failed attempts. In the present study, the 17-month-olds in the Failed-Attempt (by intention) condition were not induced to replicate the demonstrated failed acts more frequently by the cue that marked such acts as "to be copied". They were as likely to emulate the target acts as they were in the other two conditions. On the other hand, the 17-month-olds in the Failed-Attempt (by accident) condition did not produce the target acts more frequently from receiving the cue that marked the failed acts as "not to be copied". Further, the 17-month-olds tended to elicit a range of other acts as their first acts compared to the 39-month-olds. This finding is in line with that reported in Experiment 3. This might suggest that the 17- to 19-month-olds were basing their behavioural strategies on either emulation learning or object exploration because they were not sensitive to the contradictory information inherent in the Failed-Attempt display. In this way, these younger children were not likely to adopt a strategy of copying the observed acts in response to the failed-attempt model, probably because they were not as aware as the 39- to 41-month-olds that the same action could result in different intended outcomes with the same object.

Meltzoff (1996, cited in Meltzoff, 1999) has also adopted a similar design to the current study to investigate 18-, 24-, and 36-month-old children's imitative performance in a situation where the adult demonstrated an unfulfilled action that was intended in one instance and unintended in the other. For example, the adult attempted to put a toy unsteadily on top of a shelf, but both the shelf and toy toppled down. In one condition, children watched the object fell and that was followed by the demonstrator's happy / fulfilled reaction (saying "Yeah! There!"). In the other condition, the same action was followed by the demonstrator's unhappy / unfulfilled reaction (saying "Uh-oh! Oh dear!"). Contrary to the findings of the present study, Meltzoff (1996) showed that the 36-month-olds displayed a significant and orderly response. For example, they put the toy unsteadily on top of the shelf when the unfulfilled action was marked as unintended (saying "Uh-oh! Oh dear!"), or made the toy topple off the shelf when the same action was marked as intended (saying "Yeah! There!"). On the other hand, similar to the findings of the present study, Meltzoff showed that neither of the 18- and 24-month-old groups differentially responded to the demonstrator's emotional and linguistic cues.

It is important to note that the test materials used in the present study consisted of simple acts on objects. It is possible that the 39-month-olds in the Failed-Attempt (by intention) condition did not copy the demonstrated failed acts more frequently than they did in the other two conditions because the materials involved were so likely to induce them to emulate the target acts. On the contrary, the 36-month-olds in Meltzoff's (1996) study copied the unfulfilled act more frequently when the act was marked as intended than when it was marked as unintended, perhaps because the task consisted of complex acts on objects and were more motivating to them. Further, the complex acts consisted of several steps of movement in sequence, and that might reduce the likelihood of inducing emulation learning. This may explain why the two types of vocal marker in the present study did not elicit systematic changes in children's behavioural performance, because the simple acts demonstrated were likely to induce emulation learning.

Second, a possible explanation concerns a developmental constraint of behavioural inhibition on children's performance in imitation of acts on objects. In Experiment 3, it has been demonstrated that reproduction of the acts observed was a behavioural strategy adopted by 41-month-olds but not 19- or 31-month-olds in the Failed-Attempt condition. In Experiment 4, the experimenter induced the 17-month-olds to reproduce the acts observed by vocally marking the observed outcomes of the demonstrated failed attempts as intended, but they replicated such acts as infrequently as they did when there was no accompanying vocal marker or the observed outcomes of the demonstrated failed acts were vocally marked as unintended. As in Experiment 3, this may be that young children had problems in copying the unfulfilled acts as these acts were actually demonstrated, as contrasted with Meltzoff's (1995) interpretation that 18-month-olds were not likely to reproduce the demonstrated acts because they could go beyond duplicating the observed acts literally. It might be argued that the 17-month-olds were able to recognise the observed outcomes of the demonstrated unfulfilled acts as the intended outcomes from receiving the vocalisation "There!", but they did not reproduce the observed acts because they were more interested in eliciting the affordances of the objects already highlighted by these acts. On the other hand, the 39-month-olds copied the observed acts in the failed-attempt display with consistency, perhaps because they were superior to the 17-month-olds in the ability to refrain from responding to the affordances of the objects. Even so, like the younger children, both Experiments 3 and 4 showed that 39- to 41-month-olds had a tendency to emulate the target acts after observing the failed-attempt display. Therefore, the developmental lag in children's imitative performance in Meltzoff's Failed-Attempt paradigm as shown in Experiments 3 and 4 was likely related to a more basic issue concerning their ability to inhibit the tendency to emulate the affordances involved.

This interpretation is in line with the author's impression of scoring the videotapes. At times the children in the 39-month-old group looked as if they were going to copy the failed action, but on the contrary they produced the target act by accident. More interestingly, they often corrected such a "mistake" immediately in the following response. For example, a child attempted to drop the loop next to the prong as the experimenter did, but the loop happened to rest on the prong after which she hastily released it. Soon after this "mistake", the child tried the second time with carefulness so that the loop did not cross the tip of the prong by accident. Similarly, for example, a child attempted to replicate the failed act that the experimenter produced with the dumbbell, but she unexpectedly split the dumbbell whilst slipping one of her hands off the cube because she was using too much outward force. The child learned to use the proper force and successfully slipped one hand off the cube without pulling the dumbbell apart at the second action. It appears to the author that these older children were exerting some control over their tendency to put the loop over the prong or split the dumbbell, otherwise they would accidentally produce the "target" acts rather than the failed acts. Overall, 40 % (12 of 30) of the 39-month-olds from the three conditions at least on one occasion produced the target act followed by the demonstrated failed act as the first and second acts in one trial as compared with only 13 % (4 of 30) of the 17-month-olds[1]. Hence, it is probable that the developmental constraint on children's ability to copy the acts observed in Meltzoff's Failed-Attempt paradigm had a relation to the ability to refrain from the influences of affordances of objects.

As in Experiment 3, it might be argued that the 39-month-olds produced the target acts and failed attempts across the three conditions because they were influenced by both the affordances of objects and the observed outcomes, and that does not necessarily imply that copying the observed outcomes required them to inhibit the tendency to emulate the target acts. If the affordances of objects and the observed outcomes involved in the failed-attempt model did not produce conflicting tendencies, it would be difficult to explain why the 31-month-olds copied the observed outcomes in the Adult-Manipulation condition but not in the Failed-Attempt condition. If the affordances of objects and the observed outcomes independently contributed to children's performance in the Failed-Attempt condition, the 31-month-olds should have been as likely to produce the target acts and failed attempts as the 41- and 39-month-olds in Experiments 3 and 4 had been. Furthermore, such a hypothesis would be difficult to explain the case considered above that the 39-month-olds in Experiment 4 made a following attempt to copy the demonstrated failed act to correct the target act produced at the first act.

Third, the adequacy of the technique of vocally marking actions for assessing children's understanding of intentional action may need to be reconsidered. Carpenter et al. (1998) adopted for their study this technique on the basis of the findings of Mumme, Fernald, and Herrera (1996). Employing a social referencing

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[1] In Experiment 3, 30 % (3 of 10) of the 41-month-olds in the Failed-Attempt condition on at least one occasion produced a target followed by a demonstrated failed act as the first and second acts in one trial as compared with 10 % (1 of 10) of the 31-month-olds and 0 % (0 of 10) of the 19-month-olds in the Failed-Attempt condition who did so.

paradigm, Mumme et al. (1996) tested 12-month-olds in a novel toy situation in which they watched their parents show facial or vocal expressions of happy, fearful, or neutral affect. There was no evidence that children's behaviour response varied with facial expressions alone. However, fearful vocal cues, but not happy vocal cues, alone were sufficient to elicit differential responding. Note that alternative vocal cues were adopted in the present study as well as Carpenter et al.'s (1998) study, instead of fearful vocal signals. Could the use of alternative vocal cues, of which the influences on children's behavioural regulation have not been tested, fail to elicit differential responding? There appears to be a gap in the application of Mumme et al.'s (1996) social referencing study to an imitating situation, because the intentional and accidental markers were probably not as sufficient to elicit appropriate behavioural responses as the negative vocal emotional cues were. This may explain why children in the present study did not behave differently toward vocally and non-vocally marked failed actions. Additionally, could the actor's vocal emotional expressions make the demonstrations look fun so that children were more motivated to respond? Although the results did not show that children would be more motivated to participate in the task when the actions that they had observed were vocally marked, it is a possible factor worth noting and investigating in future studies.

Summary

To sum up, beyond the attempt to present two modifications of Meltzoff's (1995) Failed-Attempt format, several constraints of object-related tasks on children's imitative performance inherent in such a paradigm were revealed by the results of Experiment 4. In general, the manipulation of vocal markers did not induce children's appropriate differential ways of responding. Methodologically, three possible explanations have been proposed. First, the skill level required for completing the task may not be motivating and attention to the vocal cue would not be a strategy that children chose to adopt in response to the adult's simple acts on objects. Second, the acts observed in the failed-attempt display had the potential for highlighting the afforded target acts and thus induced children to use a strategy of emulation learning. It is possible that the object-elicited affordances were so substantial as to prevent children from being sensitive to the vocal cues. Third, the method of vocally making actions appeared to be limited to cases where the intended outcomes were concurred with the observed outcomes of the demonstrated acts, such as in Carpenter, Akhtar, and Tomasello's (1998) and Tomasello and Barton's (1994) studies. In the current study, the same unfulfilled action resulted in two different intended outcomes. In one instance, the act itself was the intended outcome; in the other, it was supposed to lead to the intended subsequent outcome. Thus, the adult's intention had to be inferred by reasoning back to prior intention or forward to the intended subsequent but unfulfilled target act from observing the demonstration followed by the vocal cue. In this way, the children in the current study were offered a challenging task requiring recognition of intention as a person's representation of intended subsequent outcomes versus currently observed outcomes.

Theoretically, these findings strengthen two points suggested by the preceding experiments. First, developmental differences in children's adoption of a strategy of reproducing the observed acts in Meltzoff's Failed-Attempt paradigm challenge Meltzoff's (1995) theoretical account that children did not duplicate details of the behavioural form from seeing a person's failed attempts because they were more likely to re-enact what one intended to do than what one literally did. On the contrary, the present study strongly suggested that the constraints of behavioural inhibition abilities might account for this developmental lag. It may be that younger children have difficulty in reproducing the demonstrated failed attempts as a consequence of an inability to refrain from the behavioural tendency to bring about the results already in place. It is suggested that behavioural inhibition play a potential role in specifying the relations between imitation of acts on objects and understanding of intentional acts. Second, reproduction of the failed acts as a behavioural strategy of 39-month-olds showed two developmental implications. On the one hand, older children appeared to reproduce what they have observed as a general-purpose strategy in response to a situation involving uncertain information. On the other hand, whatever vocal cue the adult used to mark the unfulfilled act, older children appeared to understand that the acts observed in the failed-attempt model presupposed the demonstrator's intentional stance prior to acting. In contrast, younger children were not as sensitive as older children to such an incongruity inherent in the failed-attempt display. It appears that younger children's imitative performance was more reliant on the afforded properties of the objects that they learned during observation. This is likely to be the other reason why the 17-month-olds in the present study copied the demonstrated failed acts very infrequently.

Chapter Six

Summary and conclusion

In this chapter, results that emerged in the preceding series of experiments are reviewed and compared to previous studies. Theoretical implications for future studies are also discussed before coming to a conclusion about the methodological adequacy of Meltzoff's Failed-Attempt format as a paradigm to test children's understanding of intentional actions.

6.1. Review of results

Previous studies reviewed in the thesis have shown that children towards the end of the first year of life are able to replicate simple acts on objects by observation (e.g., Abravanel & Gingold, 1985; Killen & Uzgiris, 1981; McCabe & Uzgiris, 1983; Meltzoff, 1988 a, b). In these studies, the infants' imitative performance was assessed in situations where both the acts and the end results of the objects resulting from these acts were observed. Meltzoff's (1995) Failed-Attempt paradigm was the first to examine infants' imitative performance in relation to a person's intended subsequent acts in situations involving only unfulfilled acts and no observed salient outcomes from the objects. If 18-month-old children prove to be capable of imitating the adult's intended subsequent acts by observation of his failed attempts, this may suggest that they might possess the concept of the adult as an intentional agent. According to Barresi & Moore (1996), such a performance would possibly suggest that 18-month-old infants are capable of representing the adult's first person information about the intended subsequent but unfulfilled acts in the absence of the adult's comparable third person information about these intended acts. For that reason, it is important to examine the methodological adequacy of Meltzoff's Failed-Attempt paradigm, because it has led to the claim that 18-month-olds' imitation of acts on objects involves ascription of intentions to the adult (Meltzoff, 1995).

Full demonstration model

In Experiments 1 and 2, the 1 ½-year-olds after observing the full demonstration of the target acts reproduced on average 3.8 and 3.5 such acts across a series of five 20-second response periods. These findings are similar to those reported by Meltzoff (1995) and Bellagamba and Tomasello (1999) who used the same set of test materials and showed that exposure to the full demonstration of the target acts elicited on average 3.8 and 4.2 such acts out of five trials, respectively. In both Meltzoff's and Bellagamba and Tomasello's studies, exposure to the demonstrated failed attempts elicited a similar number of target acts as exposure to the full demonstration of the target acts. Experiments 1 and 2 showed that the above finding could be replicated only when all target acts produced during 20 seconds of the response period were counted. Under this analysis, however, exposure to the initial and end states of the target acts (the Emulation-Learning condition) or to the spatial contiguity of the target-relevant parts of the objects (the Spatial-Contiguity condition) induced a similar number of target acts as exposure to the full-demonstration model. However, counting the children's first actions only, their performance on target acts was most frequent after observing the full-demonstration model. This provides evidence for imitation taking place as the children's initial response to the full-demonstration model. If the children after observing the failed-attempt model were imitating the intended subsequent but unfulfilled target acts, they were expected to have reproduced these acts as directly as they did after observing the full-demonstration model. Thus, in Meltzoff's and Bellagamba and Tomasello's studies, the Full-Demonstration and Failed-Attempt groups performed equally well perhaps because the number of target acts was amplified by scoring the sequence of acts produced within the 20-second response period as a whole. It might be that children produced the target acts as acts subsequent to their first action within the 20-second response period because of the processes of emulation learning or reacting to spatial contiguity. Therefore, it is not clear that 1 ½-year-olds' performance on target acts in Melzoff's Failed-Attempt paradigm was guided by their understanding of the intended subsequent but unfulfilled target acts.

Failed attempt model

Overall, after observing the failed-attempt model, the 1 ½-year-olds in the present studies produced on average a slightly lower level of target acts within the 20-second response period: 2.2 (Experiment 1), 2.5 (Experiment 2), and 2.7 (Experiment 4) out of five trials, as compared with 4.0 and 3.6 reported by Meltzoff and Bellagamba et al, respectively. It might be argued that the preceding series of experiments did not faithfully replicate the scenario for Meltzoff's Failed-Attempt paradigm. However, the data concerning the levels of target acts produced by the 1 ½-year-olds in the Failed-Attempt condition of Experiments 1, 2, and 4 were replicated with remarkable consistency. The scenario has been at least replicated reliably within these experiments, even though its validity for demonstrating intended subsequent but unfulfilled acts has been left an open question because of some implicit demonstrated inputs of the afforded target acts and the demonstrator's underlying intentional stance. Another possibility is that the present studies adopted a more systematic scoring strategy in the sense that the sequence of different actions that children produced within the 20-second response period was parsed and independently scored. Each act scored was cross-checked by a range of types of response that the child could potentially produce according to strict behavioural criteria as contrasted with the dichotomous scoring method used in Meltzoff's and Bellagamba and Tomasello's studies. It might be that Meltzoff and Bellagamba and Tomasello overestimated the number of target acts produced by the children in the Failed-Attempt condition as their scoring procedure did not involve cross-checking the act with other types of response. Although the inter-rater reliabilities concerning the children's first acts and first and second acts combined coded were likely to be lower as a result of scoring more categories of responses, the findings of the present studies were more cautious. By contrast, the inter-rater reliability concerning children's production of target acts in the 20-second response period was excellent. Table 6.1 summarises the inter-rater reliabilities concerning children's first acts and first and second acts combined falling into the scoring categories in comparison to their overall production of target acts in the 20-second response period in the preceding studies.

Another factor that might affect 1 ½-year-olds' performance after observing the failed-attempt model would be their problems in decoding the target acts that the demonstrator judged to be the intended subsequent acts. Experiment 3 was designed to assess this possibility with the inclusion of two novel age groups of 2- and 3-year-

Table 6.1. Summary of the Inter-rater reliabilities obtained from the three scoring strategies in Experiments 1~4.

Scoring strategy	First action	First and second actions combined	Target acts produced In 20 seconds
Study	% (kappa)	% (kappa)	% (kappa)
Experiment 1			
19-month-old	87 (.78)	88 (.79)	100 (1.0)
Experiment 2			
17-month-old	92 (.86)	90 (.83)	97 (.93)
Experiment 3			
31-month-old	92 (.86)	87 (.79)	100 (1.0)
41-month-old	97 (.94)	92 (.88)	100 (1.0)
Experiment 4			
17-month-old	92 (.86)	90 (.81)	98 (.97)
39-month-old	93 (.90)	88 (.82)	100 (1.0)

old children. The older children were found to be superior to 1 ½-year-olds in their general ability to produce the target acts as their first acts, first and second acts combined, and overall performance in the 20-second response period. However, there is no evidence suggesting that the older children in the Failed-Attempt condition produced the target acts as a consequence of their ability to read the intended subsequent acts. No significant age × condition interaction was revealed and across the three age groups, the children in the Full-Demonstration condition reproduced most target acts at the first act. It is thus not clear that the slightly lower level of target acts produced by the 1 ½-year-olds in the present studies was due to a failure to decode the adult's intentions underlying the demonstrated failed attempts.

End state model

In Bellagamba and Tomasello's (1999) study, the demonstration (end state) condition in which the objects were set in their end states at the start of the presentation served as a control for the effect of observing the end states on infants' performance on target acts. Similarly, in Experiments 1 and 2, a novel condition of Emulation learning was designed to test the effect of observing the initial and end states of the object sets as an aspect of emulation learning. In Experiments 1 and 2, the 1 ½-year-olds after observing the initial and target states of the objects but without seeing the adult transform the objects produced on average 2.4 and 2.2 target acts over the five 20-second response periods, respectively. These findings are similar to that reported by Bellagamba and Tomasello who showed that exposure to the end states of the target acts only elicited on average 2.2 target acts out of five trials. In Bellagamba and Tomasello's study, this level of target acts elicited by exposure to the end states of the target acts was lower than exposure to the full-demonstration and the failed-attempt model. In contrast, when all the target acts produced within 20 seconds of the response period were counted, both Experiments 1 and 2 showed that exposure to the initial and target states of the objects elicited a similar effect on children's performance on target acts as exposure to the full-demonstration and the failed-attempt model. Counting the first actions only, however, exposure to the full demonstration produced a level of target acts higher than exposure to either the failed-attempt model or the initial and target states of the objects. As considered above, one factor that might account for the inconsistent findings of the present and Bellagamba and Tomasello's studies would be a bias resulting from the scoring procedure. In the present studies, the operational definition of performing the target acts consisted of strict behavioural criteria. For example, according to Meltzoff (1995), a target act was scored when the child put the loop over the prong so that it protruded through the loop. In Meltzoff's and Bellagamba and Tomasello's scoring system, however, it is not clear whether a target act would be assigned if the prong protruded through the loop but the loop was not released from the child's hand. On the contrary, special cases like this were clearly specified in the present studies. Further, in the present studies, the child's production of a target act was not only determined on the basis of inter-scorer agreement but also cross-examined by a full range of types of response that the child might potentially elicit. It is thus likely that the number of target acts was inflated in Meltzoff's and Bellagamba and Tomasello's studies as a result of a scoring bias.

Adult manipulation model

In Meltzoff's (1995) study, the 1 ½-year-olds in the Adult-Manipulation condition reproduced on average 2.6 of the demonstrated control acts over five 20-second response periods. The data obtained from Bellagamba and Tomasello's study and Experiment 1, by contrast, were relatively low: 1.3 and 0.5 (at the first and second actions combined), respectively. It appears that the findings concerning 1 ½-year-olds' proclivity to reproduce the demonstrated control acts vary greatly. One possibility is that the children in Experiment 1 reproduced many fewer of the control acts after observing the adult-manipulation model because only the first and second actions and not all acts produced in the 20-second response period were counted. However, it was the experimenter's strong impression that if the tendency to replicate control acts was not noticeable in the children's earliest acts, it is not likely that this might take place in their subsequent acts. Further, the findings of Experiment 3 showed that the 2- and 3-year-olds after observing the adult-manipulation model reproduced on average 1.1 and 2.7 of the control acts (out of five trials) as their first actions, respectively; 1.4 and 3.4 as their first and second actions combined, respectively. There is a considerable developmental lag in the ability to copy the type of demonstrated acts in the adult-manipulation model. This provides evidence that the number of control acts reproduced by the 1 ½-year-olds in Experiment 1 is very unlikely to have been considerably reduced by the scoring strategy. Another possibility, as discussed previously, is that in the present studies the scoring procedure involved the action scored being cross-examined by a range of types of response that the child might potentially produce. If an action did not satisfy the behavioural criteria for a certain type of action, it would rather be classified into Other Act. As a result, the number of acts falling within each scoring category would tend to be lower. It is possible that the children in Meltzoff's and Bellagamba and Tomasello's studies produced a higher level of control acts because they did not adopt strict behavioural criteria to rule out other types of response that resembled the demonstrated control acts but were more appropriately coded as producing irrelevant other acts.

Why were 1 ½-year-old children after observing the adult-manipulation model not as likely to reproduce the acts observed as a behavioural strategy as they were after observing the full demonstration of the target acts? Bellagamba and Tomasello suggested that lack of salient outcomes might depress children's tendency to imitate the non-afforded acts observed in the adult-manipulation model. Similarly, Devouche (1998) has shown that 9-month-olds' imitative performance in situations involving objects was facilitated by the affordances involved, such as a beeping sound. However, in Experiment 3, there is some evidence that in the absence of salient outcomes from the objects, the 3-year-old children after observing the failed-attempt or adult-manipulation model copied the acts that they had witnessed on the basis of a strategy of reproducing the observed acts. The 2-year-olds exhibited an imitative tendency to replicate the control acts after observing the adult-manipulation model, but were not found to imitatively copy the failed acts after observing the failed-attempt model. It appears that lack of salient outcomes was less likely to affect the older children's imitative performance in imitation of acts on objects. It is possible that reproduction of acts observed was not a behavioural strategy of the 1 ½-year-olds in the Adult-Manipulation condition in Experiment 1 because replicating the demonstrated control acts would not result in salient outcomes relevant to the affordances of the objects. In the same way, it might be that the 1 ½- and 2-year-olds in the Failed-Attempt condition reproduced few of the observed acts because copying the failed acts would not elicit object-afforded outcomes. Therefore, it is not surprising that the majority of children in Experiment 3 tended to produce the target acts within the 20-second response period after observing the failed-attempt model.

In one study, Meltzoff (1988a) demonstrated imitation of novel acts on objects in 14-month-old children. One of the test objects, of special interest here, was a box with a yellow panel that lit up when touched. The task required that the child imitated the act of an adult bending forward and touching the forehead to the light panel after a 1-week delay between the demonstration and the test session. Meltzoff showed that two-thirds of the infants reproduced the adult's head-touch behaviour when they returned to the laboratory and were given the box. There is reason to believe that this demonstrated act was an arbitrary act for 14-month-olds, however, it did elicit a salient end point in the object. Alternatively, a more plausible interpretation would be that the child was replicating the novel act of an adult to produce a strong affordance available from the object, rather than that the child was capable of imitating a non-afforded novel act. What would these children do if they watched the adult use the forehead to touch the panel but without activating the light device? Given the results of the present series of experiments, it is quite probable that young children might not be as likely to reproduce the head-touching behaviour as they were when the panel lights up. On the contrary, older children might stick to the strategy of copying what they see regardless of whether the act has elicited a salient outcome or not. If this were to be the case, Bellagamba and Tomasello's view that young children were likely to have difficulties in imitating acts that were not followed by salient outcomes from the objects would be relevant.

Vocally marked model

Infants' ability to distinguish intended from unintended acts was studied by Carpenter, Akhtar, and Tomasello (1998) using an imitation paradigm. Carpenter et al. showed that 16-month-old infants after observing a sequence of two modelled acts—one vocally marked as intentional and the other accidental—were likely to elicit the intentional act in preference to the accidental one. For example, after watching the experimenter elicit a toy from a newspaper recycler by intentionally pushing the hinge (saying "There!") or accidentally pulling the string (saying "Oops!"), the children tended make the toy appear themselves by pushing the hinge. It is important to note that Carpenter et al.'s design involved a scenario where the two acts in the modelled sequence resulted in the same salient outcome. A conceptual gap to be bridged between Carpenter et al.'s (1998) and Meltzoff's (1995) studies is that Carpenter et al.'s conclusion concerning children's understanding of an intentional act was subject to cases where there is currently available to them a fulfilled salient outcome. However, Meltzoff's theoretical concern was about children's understanding of an intended act when there is only the unfulfilled act and they were expected to generate inferences about the intended subsequent but unfulfilled act.

Experiment 4 was designed to attempt to incorporate Carpenter et al.'s technique of vocally marking demonstrated acts into Meltzoff's Failed-Attempt format and to explore children's ability to distinguish intentionally failed versus accidentally failed attempts in an imitating situation. The results did not extend Carpenter et al.'s findings to situations where there were only unfulfilled acts and no salient outcomes from the objects. Neither the 1 ½- nor the 3-year-old children were found to differentially replicate the demonstrated failed acts when these acts were cued to be intentionally failed. However, as in Experiment 3, 3-year-olds after seeing the failed-attempt model displayed a greater tendency to replicate the observed acts as compared with 1 ½-year-olds. It appears that lack of salient outcomes prevented 1 ½-year-olds not only from reproducing the non-afforded control acts but also the demonstrated failed acts. On the other hand, when the acts observed were cued to be accidentally failed, the levels of target acts produced by the 1 ½- and 3-year-olds were not different from what they had produced when the acts were cued to be intentionally failed or not vocally marked. It might be that the failed-attempt model was so likely to highlight the object-afforded target acts that emulation learning but not attention to the vocal marker was a strategy that they chose to respond to the demonstrated failed acts. Why was reproduction of acts observed also a strategy that 3-year-olds tended to choose? As will be discussed later, the author suggests that they might be induced to read the demonstrated failed acts as the intended acts as a consequence of their being aware of peripheral information about the adult's intentional stance prior to acting. It is possible that 3-year-olds copied what they saw with consistency regardless of whether the acts were cued to be intentionally or accidentally failed because they were aware that the adult had had a prior intention of producing the unfulfilled acts rather than the target acts.

6.2. Further implications

Before evaluating the methodological adequacy of Meltzoff's Failed-Attempt paradigm for assessing children's understanding of intention, it is helpful to highlight some important but less obvious implications for the present studies.

Behavioural inhibition

First, it is possible that the affordances invoked during observation of the failed-attempt model detracted from children's tendency to replicate the demonstrated failed acts. In Experiment 3, exposure to the failed-attempt model elicited more target acts than exposure to the adult-manipulation model. Whilst both the 1 ½- and 2-year-olds reproduced very few of the demonstrated failed acts, there is evidence that the 3-year-olds imitatively copied such acts. After observing the adult-manipulation model, 2-year-olds, like 3-year-olds, were found to replicate the demonstrated control acts on the basis of a strategy of reproducing the observed acts. In contrast, the 1 ½-year-olds did not reproduce these acts above chance levels. These findings suggest that the affordances involved in the failed-attempt model most likely detracted from the younger children's tendency to copy the observed acts as a behavioural strategy. It might be that the 2-year-olds imitatively copied the demonstrated control acts in the Adult-Manipulation condition because these acts were non-afforded and less likely to induce them to produce the target acts than the demonstrated failed attempts. On the other hand, the 3-year-olds copied the acts observed with consistency perhaps because they were superior to the younger children in the ability to refrain from the tendency to emulate under the influences of the object-elicited affordances. It appears that children younger than 3 years had more problems in understanding that an object could be manipulated in more ways than one. For example, a failed act that on one occasion was a means to a target act could be an end in itself if the adult cued it to be intended. In a sense, in situations involving objects young children's imitative performance was more likely to be guided by the presence of salient outcomes from the objects. The older children's response to the failed-attempt model might tell us that a failed act could render itself to an intentional interpretation. However, Meltzoff's imitation account of young children's understanding of intention has not specified age-related changes in relation to relevant aspects of social understanding, and, more importantly, the cognitive requirements for resolving the constraints of types of demonstrated acts on children's performance in imitation of acts on objects.

Object exploration vs. imitation

Second, it is possible that children older than 3 years benefit from reproducing what they have observed as a general-purpose strategy, and thus avoid understanding the model's intentions wrongly when there is ambiguity in the demonstrated inputs. In one sense, such a strategy saves children from exploring the objects by eliciting a range of other acts as their initial responses. Experiment 3 showed that the 3-year-olds produced other acts at first act relatively infrequently in the four conditions. In contrast, the 1 ½-year-olds produced other acts as the first actions in the Failed-Attempt, Emulation-Learning, and Adult-Manipulation conditions more frequently than in the Full-Demonstration condition. The 2-year-olds produced other acts as the first actions in the Adult-Manipulation condition more frequently than in the Full-Demonstration condition. In the Adult-Manipulation condition, both the 1 ½- and 2-year-olds produced more other acts as their first actions than the 3-year-olds. In the Failed-Attempt condition, the 1 ½-year-olds produced more other acts as their first actions than the 3-year-olds who did not differ from the 2-year-olds. All children produced few other acts at first act in the Full-Demonstration condition, because in such circumstances there is always available to them salient outcomes from the objects and no ambiguity about what subsequent acts would be carried out. Why did 1 ½- and 2-year-olds bring about other acts at first act so frequently after observing the adult-manipulation model? One possibility is that the affordances involved in the adult-manipulation model were not as explicit as the other types of model, and that this caused younger children to explore the objects by producing a range of other acts as their initial responses before they found out more object-afforded properties by themselves. In addition, lack of salient outcomes might facilitate their tendency to elicit other acts at first act at the same time as it depressed their tendency to copy the demonstrated control acts. Alternatively, children older than 3 years would rather reproduce the acts actually demonstrated instead of a range of other acts as their first acts, because it seemed a smaller cost to pay in comparison to the price if they produced the results already in place but misinterpreted the model's intentions (see also Whiten & Custance, 1996).

6.3. Methodological adequacy of Meltzoff's Failed-Attempt paradigm

Peripheral information about afforded target acts

In Experiments 1 and 2, it was argued that the main constraint on infant imitation as a paradigm for direct assessment of understanding of intention would be the affordances involved in the type of demonstrated action. For example, Devouche (1998) showed that 9-month-old infants reproduced acts that were accompanied with an object-afforded sound more frequently than the same acts that were accompanied with no object-afforded sound. It might be that infants were not likely to reproduce the latter acts because these acts did not interest them. Similarly, in Experiment 1, the 1 ½-year-olds in the Adult-Manipulation condition reproduced few of the control acts observed probably because copying such acts would not result in object-afforded outcomes. Might it be that the demonstrated control acts were arbitrary and attribution of no goals to the adult accounted for the infants' failure to imitate such acts? However, there is evidence of imitation for both the 2- and 3-year-olds' reproduction of such acts. The foregoing interpretation was thus not accepted.

Meltzoff's (1995) findings that 18-month-olds re-enacted the "intended" target acts in preference to the acts observed in the failed-attempt model could be challenged in the same way. It is possible that they copied the demonstrated failed acts relatively infrequently because copying these acts would not result in object-afforded outcomes, in marked contrasted to Meltzoff's assertion that they did not copy the adult's unfulfilled acts literally. Further, the findings of Experiment 3 showed that the 3-year-olds in the Failed-Attempt condition copied the failed acts on the basis of a strategy of reproducing the observed acts. It may be that they read the demonstrated failed acts as the intended outcomes. On the other hand, in Meltzoff's study, the evidence for children's understanding of the "intended" target acts in the Failed-Attempt condition came from the same tendency to bring about the target acts as that which they had in the Full-Demonstration condition. However, Experiments 1 and 2 provide powerful evidence that the 1 ½-year-olds' were basing their performance on target acts on different behavioural strategies in the Failed-Attempt and Full-Demonstration conditions. The children in the Failed-Attempt condition were responding to peripheral inputs about the affordances involved rather than the intentional aspect of the demonstrated acts. Below the author reviews some possible explanations and argues that 1 ½-year-old children's production of target acts in Meltzoff's Failed-Attempt paradigm may well be interpreted as emulation learning rather than reading intention.

Object affordances

A first possibility is that children's performance on target acts was enabled by their ability to emulate the knowledge of the affordances of the objects evoked during observation of the demonstrated failed attempts that were target-relevant as contrasted with the adult-manipulation control acts. As Want and Harris (in press a) recently suggested, 18-month-olds may be capable of emulating a model's action, and therefore emulation learning is difficult to rule out when tasks involve imitating simple acts on objects. Experiment 1 assessed children's tendency to emulate the acts for performing the target acts in the Emulation-Learning condition where they were presented with the end results of the target display without seeing the adult transform the object sets. Counting the children's first actions, the evidence of imitation for their performance on target acts took place only in the Full-Demonstration condition. The children in the Full-Demonstration condition also produced few other acts as their first actions compared to those in the other three conditions. However, when all target acts produced in the 20-second response period were counted, the children in the Full-Demonstration, Failed-Attempt, and Emulation-Learning conditions did not differ in the number of target acts produced.

This strongly suggests that the children in these latter two conditions were similar in the behavioural strategy that they used to produce the target acts as their subsequent actions. If the infants' performance in the Failed-Attempt condition was guided by an understanding of the intended subsequent but unfulfilled target acts, they should have brought about the target acts as their first actions as frequently as they did in the Full-Demonstration condition. It is thus likely that in Meltzoff's (1995) study the Full-Demonstration and Failed-Attempt groups performed equally well because his analyses involved the target acts produced as the children's subsequent actions that were independently contributed by their ability to emulate.

Then, there is reason to believe that 1 ½-year-olds were reacting to the affordances involved in Meltzoff's Failed-Attempt format rather than the intended subsequent but unfulfilled target acts.

Spatial contiguity

A second possibility is that children simply reacted to the spatial juxtaposition of the target-relevant parts of the objects involved in the demonstrated failed attempts and that acted as a potential effect of stimulus enhancement resulting in their performance on target acts. In Experiment 2 the role of stimulus enhancement in the target acts elicited by exposure to the failed-attempt display was further examined in the Spatial-Contiguity condition where the children observed the adult move the object set from the initial state to the particular setting of the target-relevant parts being juxtaposed. Neither the consummated nor the unconsummated target acts were demonstrated in this novel condition. As in Experiment 1, exposure to the target display elicited most target acts as children's first actions. None of the Failed-Attempt, Spatial-Contiguity, and Emulation-Learning groups produced the target acts as their first actions as frequently as the Full-Demonstration group. When all target acts produced in the 20-second response period were counted, the four groups did not differ from one another. Under this analysis, the non-imitative learning processes, such as emulation learning and stimulus enhancement, appear to influence children's subsequent actions. It is probable that in Meltzoff's study the Full-Demonstration and Failed-Attempt groups produced the target acts equally frequently because the combined effects of imitative and non-imitative learning processes were not teased apart in the sequence of actions children produced within 20 seconds of the response period. However, it is not clear that the 1 ½-year-olds in the Spatial-Contiguity condition were basing their performance simply on the contiguity of the target-relevant parts of the objects. In this condition children were induced to react to the particular setting of the target-relevant parts of the object being contiguous, but they also saw the track of movement when the experimenter moved the object set from the initial state to that setting. Exposure to the track of object movement might be sufficient to provide a basis for a possible kind of emulation learning. Thus, the spatial-contiguity model has not ruled out the possibility of emulation learning yet.

Finally, could the 1 ½-year-olds' ability to emulate account for the effect of exposure to the target display on their performance on target acts? It does not appear that imitation and emulation learning could be distinguished in the Full-Demonstration condition, because the target acts were fully observed and equivalent to the intended outcomes in such a case. Nevertheless, Experiments 1 and 2 consistently showed that exposure to the target display elicited more target acts as children's first actions than exposure to the other types of demonstration. Under this analysis, there is evidence of imitation for children's performance on target acts at the first action only in the Full-Demonstration condition. Why was imitation not a behavioural strategy characteristic of children's performance in the other conditions? It might be that the salient affordances of the objects augmented any tendency to copy the observed movements in the Full-Demonstration condition, but detracted with any such tendency in the other three conditions. However, this seems unlikely given the finding that the children in the Emulation-Learning condition observed the end results of the target acts but without seeing the experimenter transform the object sets, but produced the target acts at the first act less than they did in the Full-Demonstration condition. This shows that both the affordances of objects and observed movements were responsible for imitation taking place as the children's tendency to produce the target acts at the first act in the Full-Demonstration condition.

According to Barresi and Moore's (1996) theory, it may be that children's production of target acts in the Failed-Attempt and Emulation-Learning conditions was related to the ability to represent intentional relations at level 3 in which infants possess a concept of the adult as an intentional agent. For example, in the Failed-Attempt condition, the children were required to imagine the adult's first person information about the intended subsequent outcomes in the absence of the observed end results. Similarly, in the Emulation-Learning condition, they were required to imagine the adult's third person information about the acts for performing the target acts in the absence of the demonstrated acts. By contrast, in the Full-Demonstration condition, there was immediately available to the child both the first and third person information necessary for the representation of the matched intentional relations. Children's imitative performance in such a case was related to the ability to represent intentional relations at level 2 in which there is immediately available the matched object-directed activities between a child and an adult. Thus, the task requirements might explain why only the children in the Full-Demonstration condition imitatively copied the target acts as their first actions. Nevertheless, it is not clear whether they were basing their performance only on the basis of imitative learning

Peripheral information about the model's intentional stance prior to acting

At the outset of Experiment 3, it was proposed that the 1 ½-year-olds in Experiments 1 and 2 might not have acquired the ability to decode the target acts that the adult judged to be the intended subsequent outcomes in the Failed-Attempt condition. As 3-year-olds have considerable understanding of unfulfilled intention (Moses, 1993; Shultz, & Wells, 1985; Shultz, Wells, & Sarda, 1980), they might well imitatively reproduce the target acts in the Failed-Attempt and Full-Demonstration conditions equally well as a consequence of their ability to read the intended subsequent outcomes. Surprisingly, the results of Experiment 3 provide little support for this suggestion. Whilst the majority of children tended to produce the target acts in the Failed-Attempt condition, only the 3-year-olds also used an imitation strategy to copy the acts actually modelled. It was suggested that imitation of the acts observed was not a behavioural strategy used by the 1 ½- and 2-year-olds in the Failed-Attempt condition, because they might not be as aware as the 3-year-olds of the demonstrator's underlying intentional stance. In Experiment 4, the demonstrator gave children strong and salient vocal cues to the acts observed in the Failed-Attempt condition in such a way that in one instance the adult's failure was accidental and in the other it was intentional. Both the 1 ½- and 3-year-olds, however, were unmoved by the vocal cues. They did not use the cue marking the target acts as "intended subsequent outcomes" to produce these acts more efficiently than they did on the basis of emulation learning. Nor did they use the cue marking the failed acts as "intended outcomes" to copy the failed acts more frequently than they did when the acts were not vocally marked. Nevertheless, as in Experiment 3, a developmental lag in the ability to imitate the acts observed in Meltzoff's Failed-Attempt paradigm was compelling. These findings seriously challenge Meltzoff's (1995) view that 18-month-olds re-enacted the "intended" target acts through imitation instead of copying the unfulfilled acts literally. On the contrary, these findings suggest that a more complex form of social understanding might guide children's adoption of an imitation strategy to copy the unfulfilled acts in the Failed-Attempt condition. Thus, Meltzoff's Failed-Attempt format may be inappropriate for assessing infants' understanding of intended act through a behavioural re-enactment procedure.

On the other hand, 3-year-olds' reproduction of the acts observed in Meltzoff's Failed-Attempt format might show that they were responding to some inputs that were implicit in the display that younger children were not sensitive to. The format was thoughtfully designed to model a person's intended subsequent outcomes, but certain peripheral information accompanying the demonstrated acts has not been ruled out yet. As shown in the preceding experiments, one piece of peripheral information related to children's understanding of the intended but unconsummated target acts would be the affordances of the objects highlighted by the demonstrated failed acts. Another piece of peripheral information that might affect children's attribution of intended goals to the model was information about the adult's intentional stance prior to the demonstrations. Such a possibility has been discussed with relation to 3-year-olds' use of a behavioural strategy to copy the acts observed in the failed-attempt model. Before coming to a conclusion that 3-year-olds in Meltzoff's Failed-Attempt paradigm were induced to copy the acts observed by additional information about the demonstrator's underlying intentional stance, it is helpful to re-examine the possible explanations suggested previously.

Mimicking without intentional understanding?

A first possibility is that 3-year-olds merely mimicked the demonstrated failed acts without recognising the target acts as the adult's intended subsequent outcomes. However, the findings of the present studies are not in favour of this assertion. Direct evidence comes from the developmental lag that neither of 1 ½- and 2-year-olds exhibited the same tendency to use a copying strategy in response to the failed-attempt display as 3-year-olds. This shows that 3-year-olds were sensitive to certain additional information accompanying the demonstrated failed acts compared to other young children. In addition, if 3-year-olds were mimicking the demonstrated failed acts, reproduction of the acts observed would be a strategy that they consistently used in the Failed-Attempt and Adult-Manipulation conditions. That is, if 3-year-olds were not at all aware of the apparently intended target acts in the failed-attempt display, they would produce the target acts equally infrequently in these two conditions. However, like other young children, 3-year-olds produced the target acts in the Failed-Attempt condition more often than in the Adult-Manipulation condition. Thus, it does not appear that they just duplicated the demonstrated failed attempts at the motor-perceptual level. Further, whilst reproduction of observed acts was not a behaviour strategy that 1 ½- and 2-year-olds used in the Failed-Attempt condition, 2- and 3-year-olds were similar in their adoption of such a strategy in the Adult-Manipulation condition. This shows that the type of demonstrated act could influence children's tendency to choose a strategy of reproducing observed acts in their imitative performance. It is possible that various types of demonstrated act entailed varying peripheral information that the demonstrator was not aware of prior to the demonstration and probably did not expect children to decode. For example, the experimenter judged that the demonstrated failed attempts were performed to achieve the intended subsequent but unfulfilled target acts, but indeed he produced the consummate the target acts on purpose. Thus, it is possible that children would prefer to copy the failed attempts if they could read into peripheral information accompanying the demonstrations, such as the demonstrator's underlying intentional or motivational stance.

Prior intention

A second possibility is that 3-year-olds tended to copy the acts observed in the failed-attempt model because they were sensitive to peripheral information that induced them to read the failed acts as the intended outcomes. The findings of the present studies have given rise to suggestions of this interpretation. First, the demonstrated failed acts might not justify in themselves the adult's conception of the intended subsequent but unconsummated target acts. For example, 3-year-olds were supposed to be very dexterous with this skill level required for the tasks, and might be confused why the adult failed to complete the target acts. Such confusion might lead them to recognise the adult's underlying intentional stance. It is thus possible that they reproduced the unfulfilled acts because of their interpretation of these acts as the adult failing to bring about the target acts on purpose. By contrast, 1 ½- and 2-year-olds reproduced few of the failed acts, perhaps because they were not aware of such an incongruity implied in the scenario. Similarly, it has been suggested that 3-year-olds might understand more than the apparently "intended" target acts from seeing the failed-attempt display. Could they distinguish intentionally failed versus accidentally failed attempts? In Experiment 4, they did not show differential ways of responding, even though the demonstrator used salient vocal cues to mark his failure to complete the target acts as either accidental or intentional. It may be that the afforded target acts were so explicit that in any case, the adult's failure to bring about such acts would confuse 3-year-olds. Thus, regardless of whether the acts observed were vocally marked, they would attribute intentions of producing unconsummated target acts to the adult in addition to apparent intentions of producing intended subsequent target acts.

However, very little research has looked at children's understanding of intention at 3 years of age in an imitating situation. Using verbal methodologies, previous research has shown that 3-year-olds could distinguish intended action from mistake (Schultz, Wells, & Sarda, 1980) and understand unfulfilled intention (Moses, 1993). It is not clear whether they could distinguish intended action from fortuitous success or recognise intention as a person's representation of the intended subsequent action through verbal means (Astington, 1991). Although the extent to which 3-year-olds might possess some understanding of intentionally failed acts remains an open question, the provocative evidence from the present studies presents a potential non-verbal methodology of probing young children's knowledge of intention as compared to previous research in this respect. It is possible that in a live behavioural situation 3-year-olds would be more capable of taking advantage of action cues to consider the demonstrator's underlying intentional stance.

First person information about expenditure of force and energy

A third possibility is that 3-year-olds copied the acts observed in the failed-attempt display because they might not only read goals implied in target-relevant sequences of object movements but also the force that the experimenter actually exerted on the objects. According to Barresi and Moore (1996), children's understanding of an unfulfilled intentional action through imitation results from an ability to represent intentional relations at level 3 in their theory. At this level, children can create corresponding third person information when experiencing first person information about their own activities in relation to objects, and also represent or imagine first person information of the other by observing a person's activities. It is possible that the 3-year-olds in the present studies tended to reproduce the failed acts as contrasted with the 1 ½- and 2-year-olds because they could distinguish the adult's first person information such as force and energy expenditure accompanying the failed acts from that accompanying the adult's or their own production of the target acts. For example, in the dumbbell object set, in order to succeed in replicating the failed act, the child had to decrease the force when slipping one hand off the cube as the adult did in the display, or she would split the dumbbell into two halves instead. On the other hand, an unfulfilled intended action consists of both intention-in-action and prior intention that are causally self-referential (Searle, 1983). In 3-year-old's notion of intention, it might not be plausible that the demonstrated failed act was preceded by the adult holding in mind an intention of producing the target act prior to acting. If the adult had a prior intention of producing the target act, it is difficult to explain why he did not execute an intention-in-action involving the proper force and energy expenditure to fulfil this intention if not by accident. In Experiment 4, the demonstrated failed acts were marked as accidental by a salient vocal cue, but 3-year-olds did not improve their performance on target acts. This perhaps suggests that the adult's prior intention of performing the failed acts rather than the target acts was an inherent limitation of Meltzoff's Failed-Attempt format, particularly in a live behavioural situation. If the adult did not have a prior intention of bringing about the failed acts, why did he not consummate the target acts? It is thus possible that 3-year-olds replicated the failed acts with an awareness of such a prior intention of the demonstrator.

Inhibit tendency to emulate

Finally, a related possibility is that 3-year-olds copied the failed acts as a consequence of their ability to inhibit the tendency to produce the affordances involved. In Experiment 3, whilst 2-year-olds reproduced few of the failed acts demonstrated, they imitatively copied the non-afforded control acts in the Adult-Manipulation condition. It may be that the affordances involved in the Failed-Attempt condition were so strong as to prevent them from copying the observed acts.

That is, 1 ½- and 2-year-olds' problems in copying the observed acts in the Failed-Attempt condition might result from their difficulties in refraining the influence of the affordances they learned by observation. Developmental differences in children's use of an imitation strategy in such a case parallel those found in early symbolic play (Elder & Pederson, 1978; Jackowitz & Watson, 1980; Pederson, Rook-Green, & Elder, 1981). In contrast to 3-year-olds, younger children's problems in using objects of incompatible functions for substitution in a pretending situation appears to be their inability to inhibit object-elicited manipulative responses (Pederson, Rook-Green, & Elder, 1981). Although there is evidence suggesting that the executive function hypothesis have the potential for delineating autistic children's difficulties in imitation (Rogers, 1999), whether executive functions such as behavioural inhibition plays a role in typical children's imitation in object-related situations is not known. But it would be worth trying to find out the role of executive function in specifying the relation between imitation and understanding of intentional action in typical children.

In sum, there is strong reason to believe that 3-year-olds' reproduction of the demonstrated failed acts was not mere mimicry. The results of the present studies suggest that they might well understand certain peripheral information about the demonstrator's underlying intentional stance by observing the failed-attempt model. An inherent constraint on Meltzoff's Failed-Attempt format was the demonstrator's intention of performing the failed acts prior to acting. Children older than 3 years appear to be sensitive to the incongruity between such a prior intention and apparently intended target acts involved in such a circumstance. This interpretation is consistent with the view that 3-year-olds might possess a threshold understanding of theory of mind as a result of their ability to understand the motivational aspect, or even the epistemic aspect of intention (Bartsch & Wellman, 1989; Moses, 1993). In live behavioural situations, imitation appears to be so powerful a tool that 3-year-olds could use to learn a person's activities in relation to objects, not only third person information about sequences of bodily movement, but also first person information such as kinesthetic and proprioceptive changes during demonstration.

6.4. Limitations and suggestions for future research

Having evaluated the methodological adequacy of Meltzoff's Failed-Attempt paradigm for exploring how young children ascribe intentions to the model in imitation of acts on objects, let us turn to limitations of the present studies and look at the questions that they highlighted for future research.

One limitation of the present studies is that the scoring procedure did not provide a transparent method of demarcating the separation between the first and second acts produced within a very short period. The two-action scoring strategy was intended to distinguish the effects of imitative and non-imitative learning processes by scoring the first two distinct acts children produced in the 20-second response period. In this regard, the present studies present a more conservative methodology for assessing children's imitative performance as contrasted with previous research (e.g., Meltzoff, 1988a, 1995) in which the overall performance in the response period was scored. In the present studies, however, the separation between the first and second acts was determined according to behavioural criteria of preset scoring categories rather than sequences of parts constituting an intentional act. It is not clear that the segments coded as a distinct act by the rater could reliably reflect the child's initiation and completion of a goal. Further, the inter-rater reliability concerning the children's first acts or first and second acts combined falling into the scoring categories was not as high as that with respect to their overall production of target acts in the 20-second response period. This may be due to a disagreement with the parsing of the child's first and second acts. Baldwin and Baird (1999) have recently suggested that infants possess abilities for parsing others' action into units, and such action analysis on infants' part not only enables them to discover dynamic movement patterns but also guides their drawing inferences about others' intentions and goals. From my point of view, this suggestion could be addressed with respect to the establishment or modification of the two-action scoring strategy developed in the present studies. For example, it might be possible to describe the criteria for scoring a certain type of response as the sequence of bodily movements required for its initiation and completion. This might provide convergent validity for behavioural assessments of how infants ascribe intentions to others as a result of abilities to parse the observed acts into intentional units.

A second limitation of the present studies is that in Experiment 4 the reliability of the demonstrations was not assessed by a scorer rating the demonstrated acts as intentionally or accidentally failed. Note that while the three types of model used in Experiment 4 differed from each other with regard to whether the demonstrated acts were vocally marked as intentionally or accidentally failed or not vocally marked, the demonstrated acts involved in the three conditions were of the same format. It might be that neither of 1 ½- and 3-year-olds showed differential response to the vocal cues because their activities were guided by a visual similarity in the way in which these acts were performed by the experimenter. As has been done in Carpenter, Akhtar, and Tomasello's (1998) study, it is important to assess whether a naïve adult could distinguish between intentionally and accidentally failed attempts from seeing a tape of the demonstrations without using the experimenter's vocalisation (e.g., with the sound off). However, in Experiment 4 only the child's responses during the session were videotaped for the purpose of scoring. In addition, the author used the vocalisations in Mandarin ("Zha Bian!" and "Ou!") to substitute for those in English ("There!" and "Oops!") because the children tested in Experiment 4 were speakers of Mandarin. As the adaptability of Carpenter et al.'s paradigm has not been examined in Taiwan before, it might be necessary to clarify how children speakers of Mandarin use vocalisations of certain kinds to interpret the behaviour of others as intentionally or accidentally failed. It is not clear whether they refer to a match between intentions and outcomes as "Zha Bian!" and a mismatch as "Ou!", in learning first words. Therefore, the results of Experiment 4 would be less conclusive because of the above limitations.

Third, while in Experiment 2 the Spatial-Contiguity condition was designed to control for the possibility that the infants in the Failed-Attempt condition were induced to produce the target acts as a result of reacting to the contiguity of the target-relevant parts, the sequences of movement when the experimenter moved the object set from its initial state to the transitional state of the target-relevant parts being contiguous could have given rise to a differing aspect of emulation learning instead. A refined situation will be where the child observes the initial state of the object set and then the contiguity of the target-relevant parts but without seeing the experimenter transform the object set (e.g., using a screen). In this way, the possible effect to of emulation learning induced by observing the track of object movement in the Spatial-Contiguity condition might be ruled out.

Similarly, the findings of the present studies have suggested that the 1 ½- and 2-year-old children in the Failed-Attempt condition reproduced few of the demonstrated failed attempts because they might have problems in inhibiting their behavioural tendency to produce the afforded target acts evoked by observing the failed-attempt model. However, it is not clear how salient these afforded target acts were for children upon seeing the failed-attempt model. If emulation learning is seen as a factor detracting from children's attention to the form of the model's action, then it is important to assess the specific acts that children will spontaneously use with objects of differing properties after observing certain types of demonstrated acts. That is, there is a need to develop advanced controls to delineate the role of emulation learning in imitation of acts on objects in relation to the varying saliency of the affordances involved.

Furthermore, an inherent limitation of Meltzoff's Failed-Attempt format is that the demonstrated failed attempts presuppose the actor's intentional stance prior to acting. As the observed acts could be very strong cues to peripheral information about the motivational aspect of the adult's performance, a possible solution is to adopt a virtual situation (e.g., in the form of a videotape) rather than a live behavioural situation. In a face-to-face situation, the demonstrator has to use an expenditure of improper force and energy to demonstrate the unconsummated target acts and that could have cued older children to interpret the demonstrated failed attempts as the adult making mistakes on purpose. It might be possible for the adult to demonstrate the failed attempts in a lifelike manner on a film so that he could virtually use an expenditure of proper force and energy to make "accidental" mistakes. Such a virtual situation might diminish the incongruity of the actor's intentional stance prior to acting to the minimum.

Finally, to test the hypothesis that 3-year-old children's reproduction of the observed acts in Meltzoff's Failed-Attempt paradigm is not mimicry would require a situation in which the pattern of movements involved in the failed-attempt model are the same in two cases. In one instance, the adult performs the failed attempts in the same way as the demonstrator does in Meltzoff's Failed-Attempt paradigm. For example, the adult tries to pull the cubes of the dumbbell object set outwards, but one of his hands slips off the cube and thus the dumbbell does not come into two halves. In the other instance, the adult "actually" intends and fails to produce the target acts so that the observed movements are directed towards the intended subsequent but unfulfilled outcomes rather than the observed outcomes. For example, the adult performs the failed attempt with a glued dumbbell. He tries to pull the dumbbell apart just the same as he is producing the target act without decreasing the outward force when slipping one hand off the cube. Thus, the possibility that he fails to pull the dumbbell apart on purpose could be ruled out, because he is using the expenditure of force and energy required for producing the target act to perform this failed act. After observing one of the two demonstrations, the children in each case are presented with the dumbbell object set that is not glued. If the tendency of 3-year-olds to copy the observed movements in Meltzoff's Failed-Attempt paradigm were mimicry with no grasp of the adult's intentional stance, then they ought to copy the observed movements equally frequently in both cases. If, however, the intentional hypothesis that 3-year-olds' reproduction of the observed movements in Meltzoff's Failed-Attempt paradigm is guided by attribution of intention to the model were supported, then they ought to differentially produce the target act when the failed attempt is modelled with a glued dumbbell and copy the observed movements when the failed attempt is modelled with a dumbbell not glued.

6.5. Conclusion

Want and Harris (in press a) have recently raised the important question of the role of social learning processes in developmental studies of imitation of acts on objects in children. The authors suggest that the same question can now be addressed with the establishment of imitation as a paradigm for exploring the concept of intention in children. In summary, the extent to which Meltzoff's (1995) findings lead to an imitation account of infant understanding of intention was revealed as the constraints of the types of demonstrated acts on 1 ½-year-old infants' imitative performance. The present studies (a) provide evidence for the assertion that Meltzoff's (1995; also Bellagamba & Tomasello, 1999) results were based on a scoring method which was likely to involve the combined effects of imitation and emulation learning, (b) challenge Meltzoff's conceptual analysis of relations between imitation and the concept of intention, and (c) delineate the role of emulation learning and stimulus enhancement in the failed-attempt model.

An important methodological advance of the present studies was to score the first and second acts children produced within the 20-second response period. The evidence of imitation taking place as the child's initial response is compelling. The target acts produced as acts subsequent to the first act within the 20-second response period appear likely to be affected by their ability to emulate. When the same failed-attempt model was presented to 2- and 3-year-olds, a majority of 3-year-olds were found to imitatively copy the observed acts whilst they were also similar to other children in a tendency to produce the target acts. The failed-attempt model appears to involve certain peripheral information that induced 3-year-olds to imitate the demonstrated failed acts. By contrast, 1 ½- and 2-year-olds did not appear to be sensitive to such information implicit in the display. Further, although the demonstrated failed act was cued to be intentionally or accidentally failed, both 1 ½- and 3-year-olds were unmoved by vocal markers. It was suggested that the affordances involved in the failed-attempt model were so strong as to detract from children's attention to vocal markers as a strategy. However, 3-year-olds exhibited the tendency to copy the failed acts with consistency. It did not appear that they were simply mimicking the demonstrator. Alternatively, the actions in live behavioural situations could be very salient cues to the adult's underlying intentional stance. It might be that 3-year-olds imitatively reproduced the failed acts because they could read the adult's underlying intentional stance from the observed acts. In this view, an inherent limitation of Meltzoff's Failed-Attempt format would be the demonstrator's intention of avoiding consummating the target acts prior to acting. The results of the present studies suggest that 3-year-olds were probably sensitive to such an incongruity.

On the other hand, it is not clear that 1 ½-year-old infants' imitative performance involved using action information to generate inferences about the intentions of the model. While there is evidence of imitation that 1 ½-year-olds differentially reproduced the observed acts after observing the full-demonstration model, no evidence indicates that they used a strategy of reproducing the observed acts in response to the other types of model. This suggests that the observed outcomes of the demonstrated acts were likely to promote 1 ½-year-olds' imitative performance when the observed outcomes were of certain kinds.

Nonetheless, recent research in other developmental domains indicates that infants possess considerable abilities for intentional understanding by 18 months of age (e.g., Carpenter, Nagell, & Tomasello, 1998; Charman, Baron-Cohen, Swettenham, Baird, Cox, & Drew, in press; Tilden, Poulin-Dubois, & Desroches, 1997, cited in Poulin-Dubois, 1999). For example, Charman et al. (in press) found that joint attention, but not imitation, measured at 20 months predicted later theory-of-mind ability measured at 44 months. Charman et al. suggested that children engaging in imitation of acts on objects and joint attention are required to tune in to another's goals, while imitation is also more tied to the infants understanding of object properties than is joint attention. Using a novelty preference paradigm, Tilden et al. (1997, cited in Poulin-Dubois, 1999) showed that children as young as 18 months of age were sensitive to the congruity between people's emotional reactions and the outcomes of their desires. For instance, they could understand how a sad expression was related to the unfulfilled outcome of another's desire. Although there is reason to believe that 18-month-old infants have considerable intentional understanding, whether an ability to ascribe intentions to the model must play an essential role in their imitative performance remains controversial.

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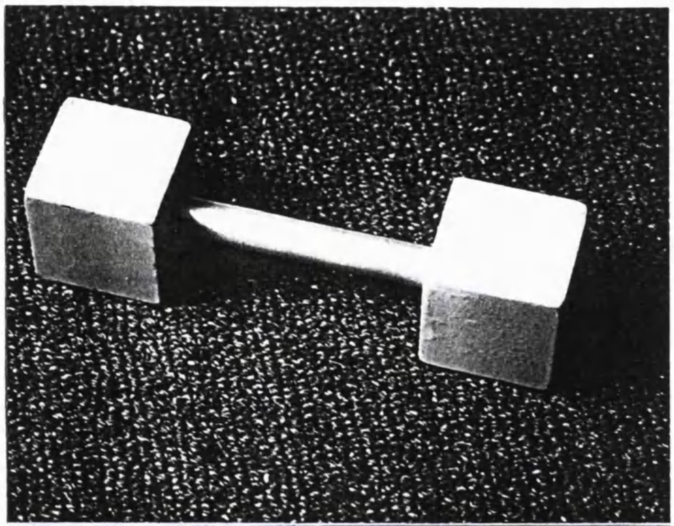
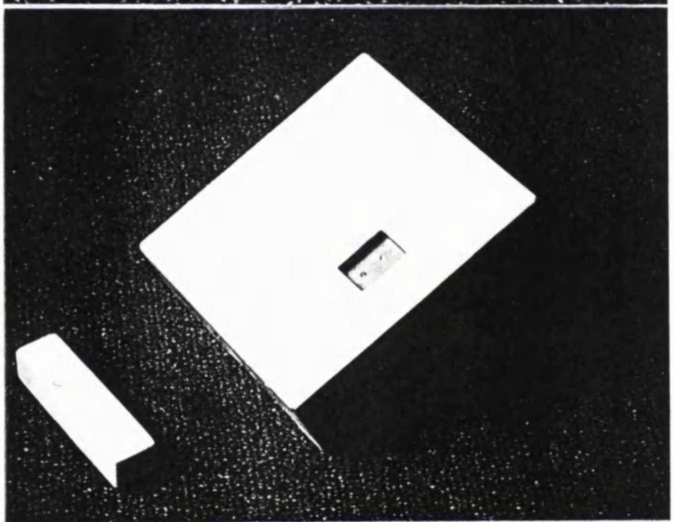
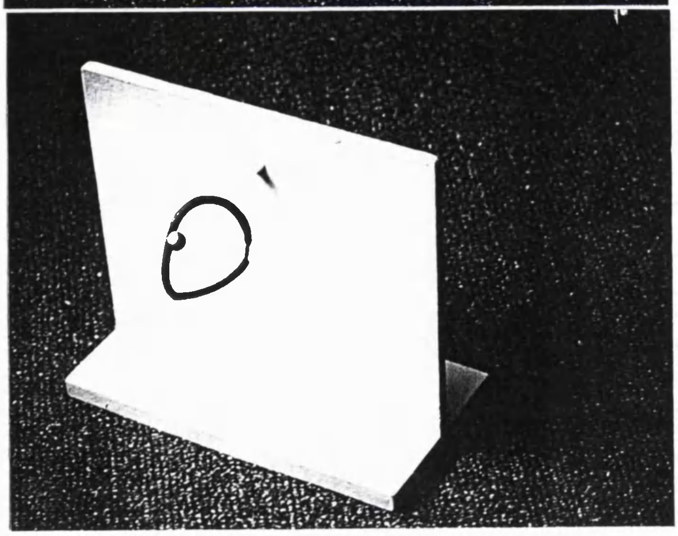
Appendix: Test materials



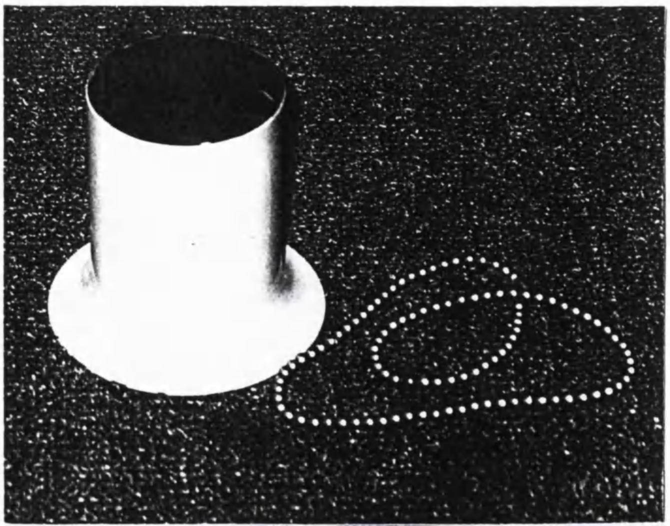
a. Dumbbell



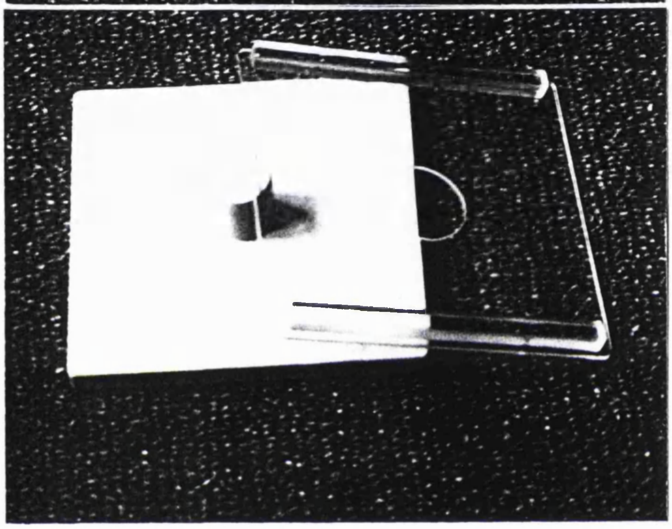
b. Box and stick



c. Prong and loop



d. Beads and cylinder



e. Square and dowel