GOAL-DIRECTED IMITATION IN PRE-SCHOOL AND ELEMENTARY SCHOOL CHILDREN

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ABSTRACT

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Imitation is a fundamental way of acquiring knowledge in human development. In their theory of goal-directed imitation (GOADI), Wohlschläger et al. (2003) divide the representation of observed movements into hierarchically organized aspects the highest of which is usually the goal. In a face-to-face imitation task young children usually copy the (spatial) goal of the body movement in terms of perceptual mirror symmetry rather than match them conceptually onto their own body, as adults do. We refer to these imitation schemes as "mirroring" and "matching" respectively. In the present study, we investigate the effects of age

and perspective of the child with respect to the experimenter (0°, 90°, 180°) in two imitation tasks, a hand-to-ear and a cup-grasping task. Moreover, we evaluate the developmental changes in the imitative behavior of children from a dynamical systems perspective. Children were supposed to imitate the movements of the experimenter. Tasks were conducted on 4.5- to 11-year-old Iranian pre-school and elementary school children (81 female, 84 male). Imitation scores for the spatial goal were analyzed in terms of mirroring or matching. Imitation schemes varied according to age and perspective in both tasks. Overall, older children's imitations of movements were more adult-like as established by an adult Iranian control group than those of the younger ones. They rather matched than mirrored observed movements. In the 180° and 90° conditions the mirroring scheme was predominant, but in 0° matching was predominant. GOADI was confirmed; however it was qualified by the child's perspective on the experimenter. Children's imitations showed a non-linear shift from perceptually-based mirroring to conceptually-based matching of observed movements onto their own body. This shift happens between 6 and 8-9 years of age. The amount of matching depends not only on age but also on control parameters such as spatial perspective, task demands, and exposure.

Keywords: Imitation; Ideomotor Principle; Action Perception; Action Generation; Dynamic Systems Approach

ÖZ

OKUL ÖNCESİ VE İLKÖĞRETİM ÇAĞINDAKİ ÇOCUKLARDA
AMACA YÖNELİK TAKLİT

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İnsan gelişiminde taklit bilgi edinmenin temel bir yoludur. Amaca yönelik taklit (GOADI) teorisinde Wohlschläger ve diğerleri (2003) gözlemlenen hareketlerin temsilini en üstte amacın yeraldığı hiyerarşik olarak organize olmuş unsurlara böler. Yüz yüze taklit görevinde küçük çocuklar genellikle vücut hareketinin (uzaysal) amacını yetişkinler gibi kavramsal olarak kendi vücutlarıyla eşleştirmek yerine algısal ayna simetrisi açısından kopyalar. Bu taklit şemalarına sırasıyla "eşleştirme" ve "yansıtma" adını veriyoruz. Bu çalışmada elden-kulağa ve bardak kavrama görevlerinde çocuğun yaşının ve uygulayıcıya gore görüş açısının (0°, 90°, 180°) etkisini araştırıyoruz. Ayrıca, çocukların taklit davranışında gelişimsel değişimleri dinamik sistemler bakış açısıyla

değerlendiriyoruz. Çocuklardan uygulayıcının hareketlerini taklit etmesi bekleniyordu. Görevler 4.5-11 yaş arası İranlı okul öncesi ve ilköğretim çağındaki çocuklar üzerinde yürütüldü (81 kız, 84 erkek). Uzaysal amacın taklit skorları yansıtma ve eşleştirme açısından analiz edildi. Taklit şemaları her iki görevde de yaşa ve görüş açısına göre farklılık gösterdi. Genel olarak hareketlerin büyük çocuklar tarafından yapılan taklitleri küçük çocuklarınkine kıyasla yetişkinlerinkine daha yakındı. Gözlemlenen hareketleri yansıtmak yerine eşleştirdiler. 180° ve 90° durumlarında yansıtma baskınken 0°'de eşleştirme baskındı. GOADI doğrulandı; ancak çocuğun uygulayıcıya göre görüş açısı tarafından sınırlandırıldı. Çocukların taklitleri, gözlemlenen hareketleri algısal-tabanlı yansıtmaktan kendi vücutlarına kavramsal tabanlı eşleştirmeye doğru doğrusal olmayan bir kayma gösterdi. Bu kayma 6 ve 8-9 yaş arasında gerçekleşmektedir. Eşleştirme miktarı yalnızca yaşa değil uzaysal perspektif, görev talepleri ve maruziyet gibi kontrol parametrelerine de bağlıdır.

Anahtar Kelimeler: Taklit; Ideomotor Prensibi; Eylem Algısı; Eylem Üretimi; Dinamik Sistemler Yaklaşımı

To my love, Amir Reza

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I do not know whether I can thank my dear parents for all their kind support during my education or not. I cannot forget the days that I was hopeless and my mother held my hands and encouraged me to continue. I cannot forget my father's support during all the days of my education. They mean the world to me.

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LIST OF ABBREVATIONS

ANOVA	Analysis of Variance
DF	Degree of Freedom
M	Mean
NE	Near-Hand-To-Ear
OE	On-Hand-To-Ear
SD	Standard Deviation
SE	Standard Errors

CHAPTER 1

INTRODUCTION

Development as a process which changes over time indicates properties of nonlinear complex dynamic systems (van Geert 2009). In addition, the dynamic system of development consists of many components which interact with each other as well as with the environment. Because this dynamic system self-organizes over different timescales, the whole system works coherently. The aim of this study is to investigate the effects of different factors on children's imitation performance with regards to traditional and dynamical points of view. Imitation has a very critical role in the development of learning for human and non-human species. Although imitation has been evaluated broadly for the past decades a lot is still unknown about the mechanism underlying it that should be investigated.

In a dynamic systems perspective, imitation is also subject to system-external influences, among them control parameters such as working memory constraints and conceptual/language development. Scientists have estimated that the age in which working memory capacity increases considerably is six to seven years of age (Gathercole et al., 2004). Likewise, language development will help children to switch from a perceptually-based to a conceptually-based imitation behavior. Consequently, the pattern of imitation in children in this age range should be different from that of younger children, in terms of mirroring and matching between perception and action. Briefly, "mirroring" refers to copying the (spatial) goal of the body movement in terms of perceptual mirror

symmetry and "matching" refers to conceptually mapping the body movement onto the subject's own body. These terms will be explained in more detail below. If we consider the age between six- and seven-year-old as a bifurcation region in which the imitation in children will switch to a different regime, consequently, we can find out some characteristics of the dynamic systems in imitation as well. In fact, imitation is a process which develops in stages; this entails the fact that all of the components of this stage-base system should work coherently, or, in other words, imitation as a dynamic system should be self-organizing. These expectations will be evaluated with novel empirical data that we analyzed in this study.

In a previous pilot study which was carried out with 33 four and five years old children, Fallahzadeh et al. (2009) investigated the effects of different perspectives between the child and the experimenter in two separate imitation tasks, i.e. hand-to-ear and cup-grasping tasks on children's imitation. In this study, the experimenter demonstrated six different gestures to the child, i.e. right-ipsi (the right hand moves to the right ear or cup), left- ipsi (the left hand to the left ear or cup), right-contra (the right hand to the left ear or cup), left-contra (the left hand to the right ear or cup), both-ipsi (the right hand to the right ear or cup and at the same time the left hand to the left ear or cup) and both-contra (the right hand to the left ear or cup and at the same time left hand to the right ear or cup). The results confirmed the GOADI theory, namely that goal-directed mirror movements were most common. In addition, the results showed that there is no significant difference between four- and five-year-old children in their imitation, although five years old showed more adult-like patterns. Children showed dominantly mirroring in the 180 and 90 degrees conditions and matching in the zero degree condition.

The aim of this thesis was to investigate the effects of different perspectives on children imitation. Furthermore, we wanted to find the critical age, in which a shift occurs between mirroring and matching in children's imitation. Mirroring shows a kind of symmetry between the perception of the child and their actions.

When mirroring shifts to matching, this is also evidence of shifting from more perceptual properties to more conceptual properties in children's imitations. Estimating the age of this shift is important for us in this study. Moreover, in the pilot study, there was just one situation for the zero condition, i.e. the experimenter sat on the right-hand-side of the child but in this study I investigated the zero degree condition from both sides (right and left) for a full picture. Moreover, in the present study we investigated the effects of three separate tasks, i.e. a hand-to-ear task (e.g., "on-ear" and "near-ear") and a cup-grasping task, on 165 Iranian children's imitation of five age groups from 4.5 to 11 years of age. In the "on-ear" task, the movements terminated at the body, in this case, on the ears and in the "near-ear" task, the movements terminated near to the ears without making contact with them. In the cup-grasping task, children were supposed to grasps the cups that were placed in front of them on the table. The experiment was carried out in Iranian kindergartens and boys' and the girls' elementary schools since children attend separate schools in Iran. In this study, the experimenter demonstrated four blocks consisting of six different gestures to the child in each task (i.e., RI, LI, RC, LC, BI, and BC). The order of the movements in each block was randomly different from other blocks. Moreover, the order of the tasks was different for children. Children were supposed to imitate the movements of the experimenter. In addition, an adult control group consisting of 22 Iranians (12 female and 10 male) between 17.5 and 34 years of age was tested.

In general, children predominantly imitate the goal: They mainly match and mirror the model's actions but very rarely imitate the effectors. Moreover, we found the main effects of tasks (i.e., on-ear, near-ear and cup-grasping), blocks (i.e., four blocks), conditions (i.e., zero-right, zero-left, 90 and 180 degrees) and age-group (i.e., five age groups). A qualitative nonlinear developmental shift between mirroring and matching occurs which, in addition, is qualified by the conditions. For 0°, matching strongly increases between 6 and 7 years of age; for 90°and 180° between 7 and 8-9 years of age. More matching occurs for cup-grasping than for on-ear and near-ear, especially in the 0° conditions. Thus,

children from 4.5 to 11 years move from more perceptually ("mirroring") to more conceptually ("matching") based imitation of human goal-directed actions. This nonlinear pattern indicates that cognitive development can be conceived of as a dynamic system. A shift of order parameters (mirroring and matching) depends not only on age-related changes but also on control parameters such as spatial perspective (0°vs. 90°and 180°), task (cup grasping vs. on-ear vs. near-ear), and repeated exposure (across blocks).

The main results of this study were presented in form of a talk in Tehran (3th International Conference of Cognitive Science, Tehran, Iran, 03-05 March 2009) and also, in form of poster presentations in Tehran (4th International Conference of Cognitive Science, Tehran, Iran, 10-12 May 2011) and in Bergen (15th European Conference on Developmental Psychology, Bergen, Norway, 23-27 August 2011).

CHAPTER 2

LITERATURE REVIEW

2.1 Imitation in child development: theoretical models and empirical findings

In this section, first of all we review the articles in which imitation is traditionally investigated and then, we will review those articles which are related with dynamical approaches in cognitive science and particularly, developmental psychology.

During the last decades, imitation has been investigated through many different aspects. Many investigations have been carried out to find out whether imitation is learned (Hayes & Watson, 1981; Piaget, 1962) or innate (Meltzoff, 2002; Meltzoff & Moore, 1977). Moreover, the mechanism underlying the imitation process in human beings and animals has been investigated broadly.

Meltzoff (1995) investigated whether the child can understand the intentions of adults in imitation tasks or not. In his account, he differentiates between mentalism and a representational model of mind. He has defined the ages that a child can be considered as a mentalist or a representationalist. He argues that children between 2.5-3 years of age are mentalists and that they can be considered as representationalists by the age of 3-5 years. In addition, he has stated that one can show the properties of being a mentalist without being a representationalist, but adopting the representational model of mind occurs after mentalism. In other words, when a child is considered as a mentalist, s/he can understand the fact that there is something like "mind" and each person has

her/his own mind and psychological states. After the child understands the existence of the mind, s/he can understand that the intentions and the desires of people underlie their behavior. Moreover, the child is considered as a representationalist when s/he understands that there is an active relation between the mind and behavior of a person. Meltzoff (1995), in his study, has carried out two experiments in order to find out whether 18-month-old children can understand the intentions of the adults or not. In addition, he has tested the differences between 18-month-old children's responses when they were confronted with the act of an inanimate device carrying out a movement versus a human actor. He found that the 18-month-old child is able to understand the intentions of the adults who demonstrated an intention to perform one specific act. Moreover, he stated that the 18-month-old child can distinguish between the goals and intentions of the humans versus an inanimate device. For instance, although the adult does not finish her/his intended act, the child still continues to perform it completely. Yet, when an inanimate device is considered, children neither imitate nor complete the act.

Meltzoff & Keith Moore (1994) proposed that imitation is based on the theory of Active Intermodal Mapping (AIM). Based on the AIM theory, children's imitations are a goal-directed process. Children can map the perceived movements of others onto their own movements with respect to the movement goals. A detailed model of the AIM theory, provided by (Meltzoff & Moore, 1997), demonstrated how a child can imitate the perceived facial act of adults. Figure 1 demonstrates a conceptual scheme of the AIM theory (Meltzoff & Moore, 1997). They claim that because imitation is innate, there is an innate link between perception of others' actions and perception of own actions, as indicated by the "equivalence detector" in the model. Hence, there is a common "supramodal representation of acts", in terms of perception and production. Moreover, based on the AIM theory, children have the ability to correct their imitative responses, as indicated by the "proprioceptive" loop in the model.

Although the issue whether imitation is innate or learned is still controversial it can be stated that imitation is a critical device for learning in human beings. Having this powerful device, infants can gain experience interacting with the environment. Imitation provides a kick-start into further development. It can be conceived of as an interface between an innate program and learning from experience. In our study, it will be shown that some external features that require experience may cause different imitation responses.

There is also neurological evidence which supports the isomorphism of observed and motor actions (Rizzolatti & Craighero, 2004). Results from animal studies show that mirror neurons in the F5 premotor area of the monkeys discharge when their motor programme acts and also when they just observe another monkey's actions. Recent studies show that the mirror-neuron system in humans has more features than the one in monkeys. Rizzolatti & Craighero (2004) have reported that the mirror-neuron system in humans will be activated even when they observed an intransitive action of others, that is, an action without a goal object while this is not the case with the mirror-neuron system in monkeys (Fadiga et al. 1995; Maeda et al. 2002; Patuzzo et al. 2003; as cited in Rizzolatti et al., 2004). In addition, it is reported that the mirror-neuron system in humans has the ability of coding the movements forming an action in terms of the actor's intentions. All this evidence confirms the fact that the mirror-neuron system plays a critical role in humans' imitation processes. Moreover, the results of many animal studies showed that tactile and visual stimulations have effects on the neurons in the parietal cortex (Bremmer et al., 2001; Graziano et al., 2000; Graziano, 1999; Iriki et al., 1996; as cited in Schaefer et al., 2009). In addition, the results of Schaefer et al. (2009) showed that different viewing perspectives of the touched hand have significant effects on the somatosensory cortices.

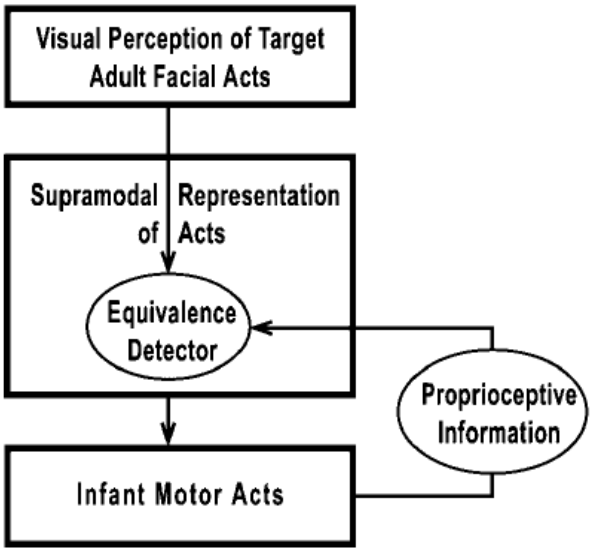

Figure 1 The AIM hypothesis for how infants perform facial imitation. Original figure from Meltzoff & Moore (1997, P.180).

Carpenter, Akhtar, & Tomasello (1998), investigated whether children already before the age of eighteen months can distinguish between accidental and intentional actions of others or not. In their study, they have used verbal words to mark accidental and intentional actions, i.e. "There!" for intentional and "Woops!" for accidental actions. The results of their experiment show that infants reproduce intentional actions more often than accidental actions. Moreover, fourteen- through eighteen-month-old children distinguish and imitate intentional actions of the adults rather than accidental ones. As a consequence, Carpenter et al. claim that imitation is not an accidental reaction to what is shown to the child by the adults Perra & Gattis (2008) propose a mediated mapping account. They claim that imitation in humans is not a mere mapping of the observed actions to a motor programme, rather, during the imitation process the relation between perceptions and actions is mediated by cognitive processes. We can consider this fact as evidence for children's understanding of adults' intentions during imitations tasks.

Bekkering, Wohlschlager, & Gattis (2000), claim that imitation is a goal-directed process in children. They have carried out a series of experiments to find out whether the presence or absence of goals change the imitation results in pre-school children. They conceive of imitation as consisting of decomposition and reconstruction. In other words, when a child perceives an act, s/he decomposes this act into several segments. This segmentation is more often based on the perceived (spatial) goals rather than on the motor segments. When the child wants to imitate (re-enact) the perceived movements, the goals play an important role in her/his construction. Bekkering et al. (2000) also suggest that the goals in the child's imitation process are ordered hierarchically. They found that when the goals (e.g. dots on the table, ears) are present, the number of errors in responding to contra-lateral movements is higher as compared to the situation where the goals are absent. For instance, when the goals are present, the child will respond to contra-lateral movements often with ipsi-lateral movements. The reason for this is that, when the goals are present, reaching the goals is hierarchically higher than correctly imitating the movements of the hands. On the contrary, when the goals are absent, the movements of the hands will be considered as the main goal and then the child imitates the hands' movement more correctly. Later, Bekkering with his colleagues Wohlschläger and Gattis proposed their theory of goal-directed imitation in 2003 which will be reviewed further in this chapter.

Furthermore, Gleissner, Bekkering, & Meltzoff (2000) examined how three-year-old children code adults' actions in the imitation process. They investigated the effects of different factors on three-year-old children's imitation. In their experiment, they conducted a series of experiments in which the child should imitate twenty-four gestures made by an adult model. The gestures consist of the movement of one or two hand(s) terminating on some specific body part(s) (e.g. ear(s), knee(s)) or near these body part(s)). The results of their study indicated that children code, i.e, parse, the adult's actions before re-enacting them. In addition, they found that the number of errors which three-year-old children make during the imitation tasks is higher in contra-

lateral movements than ipsi-lateral movements. The number of errors which the child made during the imitation of the on-body-part movements was significantly higher than the number of the errors of near-body-part movements. Handedness and sex of the child does not have any effect on the child's correct response. All of these results confirm the fact that imitation in young children is goal-directed and that children are able to code, i.e., parse the adults' actions into goals and sub-goals which are hierarchically organized.

Wohlschläger, Gattis, & Bekkering (2003) in their study conducted a series of experiments to examine the mechanism underlying imitation in children and adults. They argue that the theories of direct-mapping in human (e.g., AIM) cannot be considered for all kinds of complex imitative behaviors since they just consider the inter-modal sensorial level; rather, another kind of theory is needed which could justify all the results which are proved by different imitation studies during the decades with respect to the higher cognitive system level. In this regard, they point out Meltzoff's (1995) study in which 18-month-old children showed understanding of the model's intention(s) in their responses. Moreover, they refer to findings that show that even six-month-old infants encode goals when they react to the observed movements (Woodward, 1998; Woodward & Sommerville, 2000; as cited in Wohlschläger et al., 2003). They emphasize that the absence or presence of goals has a critical role in children's imitation in the way that it is the goals that are predominantly imitated. In addition, children imitate the movements of the model more correctly when the goal(s) is absent (as in the "near-ear" condition, for example) or there is a singular clear goal (Wohlschläger et al. 2003, P.502).

Consequently, based on their investigations on the results of the previous imitation studies and also by considering the different high level cognitive aspects, they have proposed the theory of goal-directed imitation (GOADI). First, they carried out a similar experiment to Bekkering et al. (2000), in order to evaluate the GOADI theory. The results were the same and were interpretable by their proposed theory. In further tasks, they replaced the dots as

spatial goals with replaceable objects, cups. In the cup-grasping task, six gestures were shown to children and adults (left-ipsi, right-ipsi, left-contra, right-contra, both-ipsi, both-contra). Children showed more mirroring responses in their imitation of the ipsi-lateral movements (that is, they produced mirror-like movments, e.g., right-ipsi when the experimenter showed a left-ipsi gesture). (Examples of these movements will be provided in the methods section below.)

The results of all the imitation tasks they carried out, confirm the goal-directed imitation theory. Based on this theory, when the imitator perceives the act, s/he decomposes it into the different aspects as mentioned above. Some of these aspects are chosen as the goals, all the goals are organized hierarchically. Then, dependent on the selected goal(s), the corresponding motor programme will be activated. This theory underlies imitation in animals and humans (children and adults) alike and argues that the differences in imitation between animals and humans occur just because of the differences in their working memory capacities. The results also reveal that with respect to the ideomotor principle, the motor programme preferentially re-enacts higher order goals. The ideomotor principle states that there is a tendency to automatically enact observed movements due to a common representation of perception and action codes (Prinz, 1997; A. Stock & Stock, 2004). As a consequence, they believe that imitation and all the imitative responses can be modulated with regard to the GOADI. Moreover, they note that the theory of goal-directed imitation is important since it refers to the goal(s) of the imitator which will match those goals of the model, which is actually the meaning of the imitation process.

Following this proposed theory they have designed some experiments which test the different assumption of this theory and in general, the accuracy of the GOADI. The first thing that they examined was the issue about goal selection. They wanted to examine the point whether children do select the goal(s) in their imitation or whether there is a deficit in their perceptual system that prevents them from perceiving the other movements besides the goals. The results of

their studies showed that not only there is not any perceptual deficit in children but also they choose the goals cognitively according to some hierarchical order. The other assumption that should be examined was the one related to the ideomotor principle and its role in imitation. For an explanation of the ideomotor principle, they refer to the idea of William James on voluntary actions (Prinz, 1990; as cited in Wohlschläger et al. 2003) in which the motor system, via the motor programme, causes an action just by somebody thinking about that action's effect. In order to examine this part of the GOADI theory, they designed two kinds of experiments: in one the adult pointed to the object(s) and in the other the adult grasped the object(s) and in both of them the child was supposed to imitate the adult's movement. They hypothesized that if the ideomotor principle assumption in their theory was correct, then the number of errors in these experiments and the standard experiment which was carried out in Bekkering et al. (2000) should be the same. The results of these two experiments confirmed their assumption, since in both of them eliciting the motor programme in children was directly related with the goal(s) and sub-goal(s) chosen by children. Moreover, in these experiments they observed an unexpected kind of movement of the children, namely in the bimanual contra-lateral movements, some of them first grasped the cup by ipsi-lateral movements, and then crossed their hands while lifting the cups. They claim that this result besides other observation is an obvious sign of the children selecting goal(s) and sub-goal(s) and of the fact that they decompose the observed movements: hey first grasp the cups as the main goals and then cross their hands as the sub-goal.

Then, they examined adults' imitation since general validity is a part of the GOADI theory also. Remember that GOADI is based on the assumption that imitation in children, adults and animals does not vary so much. In several adults' imitation studies which were more difficult in comparison to the children's imitation tasks, they examined the effects of objects, effectors, movement path and finally treatment in order to know whether adults show the same kind of errors as children or not. The results confirmed the fact that adults

as well as children do decompose the observed model's movements and the goals which were the objects in their experiments occupy the highest hierarchical position in their imitation responses. They conclude from these results that their GOADI theory widely encompasses different imitative behaviors in children and adults unlike active intermodal mapping theory (AIM) which interprets different imitation responses mainly based on the direct-matching imitation. They think the AIM theory with its "direct-mapping" approach cannot justify the fact that younger children have the tendency to imitate in the mirror-like fashion while older children transpose the right and left side in their imitation (Swanson & Benton, 1955; Wapner & Cirillo, 1968; as cited in Wohlschläger et al., 2003) because then, it can be concluded that imitation in younger children is less direct or can be considered as "direct-mirroring" instead of direct-mapping (Wohlschläger et al., 2003). Thus, GOADI theory has the dynamical features in it, since, based on this theory, the imitator can use her/his desired goal(s) despite the different size of limbs and body between imitator and the model. Last but not least about the GOADI there is the teaching issue. On account of this theory goals are mostly imitated, so, Wohlschläger et al. (2003) emphasize the point that the contents that are taught to children by imitation, should be clearly related to the end goals rather than to the means in order to obtain more effective results. In the following, the articles related to dynamical view are reviewed.

2.2 The dynamical approach to cognitive development

Imitation is a mechanism through which, among others, a child acquires knowledge – she learns. Therefore, as pointed out in the previous section, imitation is an important research area for studies in cognitive development. We discussed also already various theoretical models of imitative behavior. In this section, we want to present the broader conceptual framework in which we embed the present study, namely dynamical systems.

Van Geert (2000) presents the dynamic properties of development, starting with the principles of dynamic systems theory. On a global level he states that ”dynamical systems theory is antireductionistic in that it allows us to select a level of description and explanation and take for granted whatever precedes that level”(van Geert, 2000, p.64). According to him, a dynamic systems model should consist of a minimal number of variables and should perform in one dimension, namely time. For example, in order to provide a dynamic systems model of development, in the sense of van Geert (2000), we just need a single variable which can be a specific skill or integration of some developmental changes as a unique variable that we track over time. He also notes that, although development is a progressive phenomenon, a dynamic systems model may consist of regressions as well. In addition, these regressions can be considered as a preparatory phase before a leap forward in such systems.

Van Geert (2000, p.64) claims that development is “really” or “essentially” one-dimensional. He has used Piaget’s and Vygotsky‘s general developmental mechanisms in his model of dynamic systems (Van Geert, 1998). This model includes a dual dynamic principle which consists of a conservative force and a progressive force. The conservative force strengthens the current event or procedure and prevents performing novel acts by consolidating a current procedure. On the other hand, the progressive force helps to strengthen internal procedures. Based on these general developmental mechanisms he defines the model’s assumption (van Geert, 2000). He assumes that each particular internal procedure can affect the procedure in the future. After the child performs an act, the future performance of the same act will be different from the first one. He mentions the novelty of action as a factor which changes the internal procedure, i.e., it is hard to do a new task even though it is more interesting. But, as van Geert (2000, P.66) explains the novelty can be optimized by familiarity which lead to “accommodatable novelty”. He states that every current event makes the novel procedure more familiar and thus, easier to perform. Thus, based on the second assumption of this dynamic model the current familiar procedure can affect the future novel procedure in the way that the prospective novel

procedures seem increasingly easier and similarly or even more likely to be performed than old procedures.

The last assumption of van Geert's model is that every procedure and event can be considered as the input of this model. Figure 2 illustrates the three outcomes of Van Geert's (1998) dynamic model of development. In this model, as mentioned before, the conservative and the progressive forces are considered as the particular variables as well as the adaptation in the environment. In this model, three situations are evaluated. In the first one, the conservative and the progressive forces are both strong and the environment has less effect as an input. In this case, the output of the model is four stepwise and discontinues stages. Moreover, since the model is balanced based on the assimilatory (the conservative force in the model) and accommodatory (the progressive force in the model) parameters as its input, van Geert (1998) claims that this 4-stages developmental pattern covers Piaget's claim also, namely that in the case of absense of assimilation and presence of accommodation the input will be imitated (van Geert, 1998, P.652). In this situation the child explores the environment him/herself without any educational input from the environment which leads to this pattern of stepwise transitions from each stage to the next, as shown in the top panel of Figure 2. If the strength of the current activated procedures is in competition with the internal procedures that are different from the current activated procedure, the model's output will be like co-existing bands located on different levels, as shown in the middle panel of Figure 2. As van Geert (2000) explains if the competition between these two inputs be reduced then the output of the model will be like co-existing bands on distinct levels. As an example in this regard, van Geert (2000, P.67) mentions the situation in which a child is asked to spell the word "wooster". The child can benefit from an analogy strategy by remembering the spell of the word "rooster" and replace the "r" with the "w". Or, the child can remember the meaning of the word from a book that he/she has read before and then remember how the word was spelled in that book. The different strategies that the child can use in order to spell the word "wooster" can be considered as co-

existing bands which form the second outcome type of this dynamic model. In the third situation, the environment has the critical role in child's development as a beneficial and strong input to the model. In this case, the model produces an S-shaped curve, as shown in the bottom panel of the Figure 2. According to van Geert (2000), in the standard view, only the development of the child in the different positions is considered but in the dynamic model of the development, the developmental change in each individual is evaluated as well as the different positions of the child. Thus, the random interactions of the individual with the environment beside the internal changes of the child lead to this S-shape output of the dynamic model.

Smith & Thelen (2003) also consider it a fact that development is a dynamic system. They discuss self-organization and emergent properties of dynamical systems such as development. They consider complexity as the first assumption of dynamical systems: they consist of many components which work individually but the whole system works coherently in relation with the complex environment around it. In addition, they assume timescales as the second assumption of dynamical systems. They note that change or development of a dynamic system occurs over different timescales which interact with each other.

As a paradigmatic case of cognitive development, Smith & Thelen (2003) investigated the A-not-B error in terms of a dynamical approach. In the A-not-B task an object is hidden in two different locations under two lids beside each other. The experimenter shows the child that the object is under the A location several times. Then, the experimenter changes the place of the object from A to B such that the child can see this dislocation clearly. Eight- to ten-month-old infants, after a short delay, reach to the object in A location although they had seen that the object was hidden in the B location Twelve-month-old infants reach to the correct location, B.

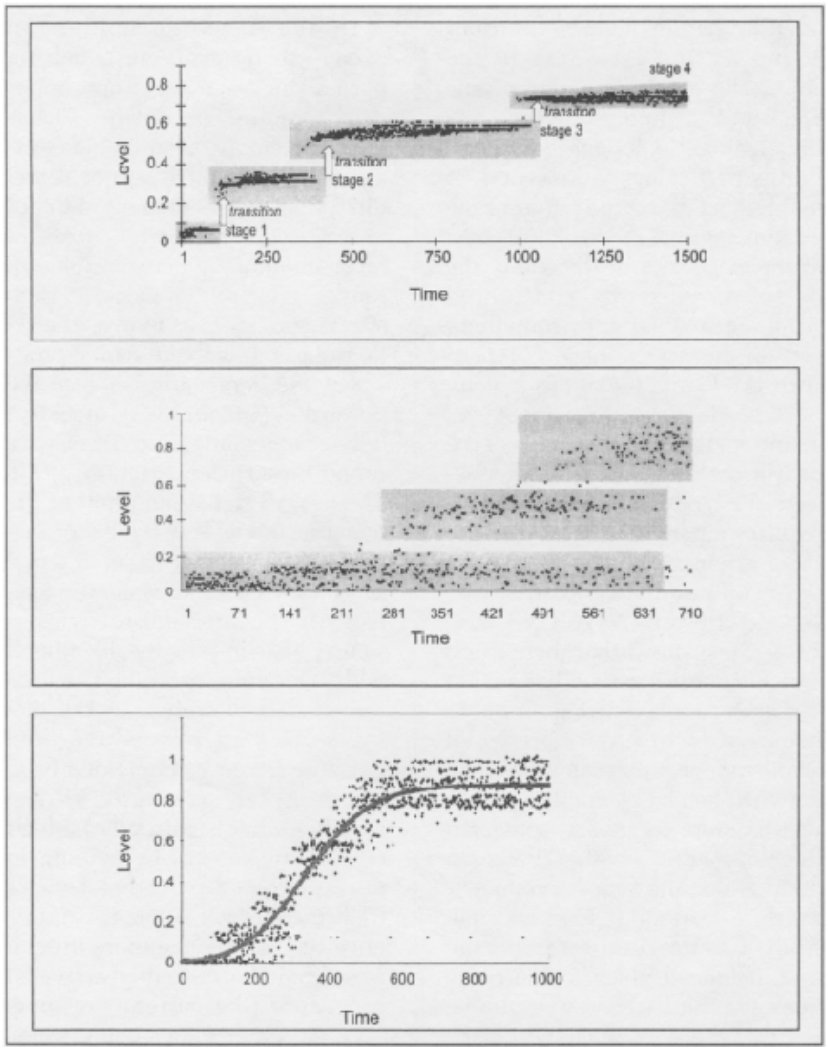

Figure 2 Three outcomes of the dynamical model: stepwise change with discontinuous shifts (top panel), co-existing bands of performance levels (middle panel), and S-shaped growth (bottom panel). Dots correspond to developmental levels of (simulated) activities over the course of months or years. The gray-shaded areas correspond to coherent levels, or stages. Original figure from van Geert (1998; as cited in van Geert, 2000, p.66).

According to Smith and Thelen (2003), there are many classical developmental accounts which explain the results of the A-not-B task but all of them investigate the issue with a single cause. Contrary to these single cause explanations, Smith and Thelen (2003) account for the results in terms of multicausality of the dynamic system of development. Thelen, Schöner,

Scheier, & Smith (2001) propose a dynamic model of the A-not-B task which is a one-dimensional model and which demonstrates different factors (the task set-up, the current perception, the memory of the object's previous location, the arm with which the child reaches, the temporal delay, etc.) which influence the child's decisions to reach to which object. They conclude that self-organization and complexity of the system are crucial in the explanation of the main effects on the A-not-B error. In addition, they believe that each child (i.e. 10- and 12-month-olds) is a complex dynamic system and this can explain the shifting of the A-not-B response from 10-month-olds to 12-month-olds as well as many causes which affect these complex dynamical systems.

Van Geert (2009) indicates the different aspects of human development with respect to the properties of nonlinear dynamical systems (NDS). He argues that human development can be considered as a main example for NDS. In addition, he mentions some general principles of development, by taking up Piaget's stage theory of development. Afterwards, van Geert (2009) claims that the human developmental process during the defined stages (e.g., newborn, toddler, schoolchild, adolescent and adult) confirms the fact that development is a nonlinear system.

According to van Geert (2009, p.243), a dynamic system is a system in which one state changes to another state in time, as shown in the two equations in (1) and (2). In fact, equation (2) is similar to equation (1). The only difference lies in the form of these two equations. As shown in (1), in a dynamic system, state y at time $t+1$ equals the function f of state y at time t and so forth. In addition, equation (1) demonstrates the recursive relationships between each state in the dynamic system and its predecessor.

(1) $y_{t+1}=f(y_t)$

(2) $\Delta y/\Delta t=f(y)$

Based on equation (2), the change of the system (Δy) over some amount of time (Δt) is a function f of the state of y. The most important property of this equation is recursive relationship in which y_t leads to y_{t+1}, and accordingly y_{t+1} leads to y_{t+2} and so on. Contrary to dynamic systems, states of a static system do not change in time. Rather, the value of the variable y is dependent only on the value of the independent variable x, as shown in (3).

$$(3) \qquad y_i = f(x_i)$$

A dynamic model, on the other hand, is recursive over time. Each state is related to its previous state. Conversely, the static model describes a population consisting of independent individuals. Each state is related to one individual at a particular time. Moreover, a complex system is a system which consists of many interactive components. The complex system changes over a period of time but all of its features work in a coherent manner as a unique system (van Geert, 2009). This system has nonlinear characteristics as well, because the action of the whole system is more than the sum of the action of each feature.

Van Geert (2009) explains the dynamics of long-term and short-term changes during the life span. He states that "the hallmark of development in a complex system is that *all changes of the system* occur through *information* that is *moderated through the system*. Changes are both short-term and long-term changes" (Van Geert, 2009, p.250). In this view, "system" means any complex system and "information" anything which affects the system or moderates its performance. "Moderating" can have the meaning of adaptation of information inside a system or through interacting with other systems. Based on van Geert's explanation of long-term change, a dynamical system consists of interdependent features which interact with each other. Moreover, this system has interactional relation with the other systems in the environment.

In addition, Van Geert (2009) mentions the dynamics of actions in order to demonstrate the dynamics of short-term changes. Long-term dynamics

encompass short-term dynamics as well. There are a lot of factors which have effects on the dynamics of actions (i.e., intentions, goals, emotions).

Steenbeek & Van Geert (2008) provided a circular causality model which shows the relation and interaction between the short- and long-term time scales of action in terms of the order and the control parameters, as shown in Figure 3 (as cited in van Geert, 2009, p.255). A control parameter is a parameter 'to which the collective behavior of the system is sensitive and that moves the system through different collective states' (Thelen & Smith, 1994, p. 62; as cited in Steenbeek & Van Geert, 2008, P.256). Order parameters are ways of describing and distinguishing different forms of collective states, i.e. 'dominant modes' (Haken, 1977; Thelen & Smith, 1994, P.55; as cited in Steenbeek & Van Geert, 2008, p.256). In other words, an order parameter is any stable, i.e., orderly, behavior of a dynamical system whereas control parameters are continuously varying parameters that control an order parameter. Order and control parameters interact with each other in cycles on various time scales. For instance, in order to explain the imitation process based on this model, if we assume the actions of the child as the short-term order parameters, these may constitute control parameters on the long-term time scale, as in the case of an infant's experience of the imitating of tongue protrusion, the classical example of Meltzoff & Moore (1977). Then, these control parameters constitute order parameters at the long-term level, again, i.e., the child's knowledge of imitation of tongue protrusion or her/his skill in the imitation of tongue protrusion or any other imitation tasks. Then, these order parameters at the long-term level constitute control parameters at the short-term level, i.e., imitation tasks in which the child has to understand the intention of the adults, and so on.

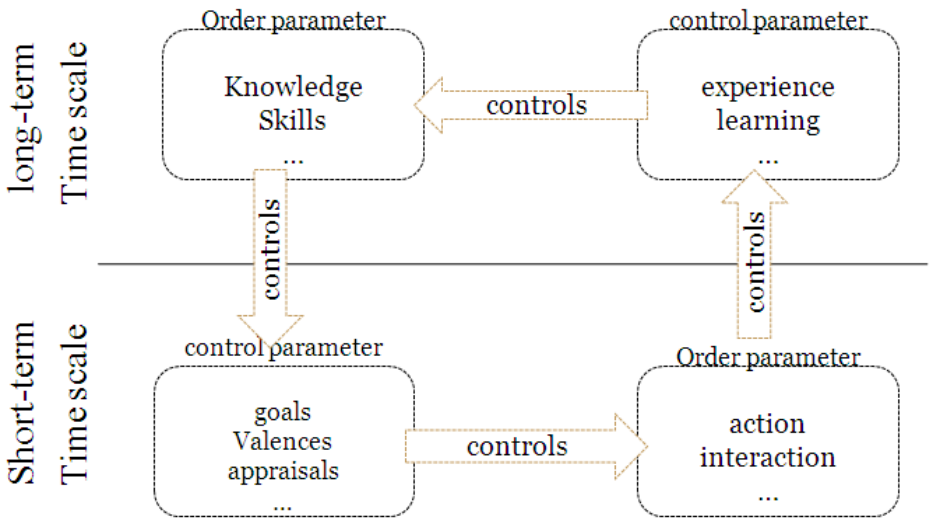

Figure 3 Cyclical relationships between order and control parameters on the short-term scale of action and long-term time scale of development. Original figure from van Geert (2009, p.255).

In addition, Van Geert (2009) asserts that when we consider development as a process which occurs in different stages, this issue entails the fact that all the components of this stage-base system should work coherently. In other words, this system should have the property of self-organization, which is a property of complex systems. However, it is a doubtful issue whether transitions between the various stages of development are continuous or discontinuous. Furthermore, classical and more modern stage theories of development differ in their conception of a stepwise vs. "fuzzy" stepwise form of development.

The developmental dynamics can be considered as the result of short-term changes of each component. These short-term changes generally have effects on the endo- and exo-systems as well. In fact, the endo-system is an individual (everything related with the brain and the body of an individual) and the exo-system is the environment which the individual is related with. In sum, van Geert (2009) argues that development is nonlinear, dynamic and complex with self-organizing and recursive properties. However, current developmental psychology (still) has a tendency to simplify these properties as a linear system.

According to Tschacher et al., (2003), self-organization can be considered as a basic explanation for a complex system's behaviors such as the cognitive system. In addition, they argue that psychological systems should be investigated with consideration of the continued interaction of the system with the environment. They think that traditional psychology approaches which only considered the stimulus and the response of the systems are not efficient in order to do justice to complex systems (Tschacher & Scheier, 2003; Thelen & Smith, 1994; as cited in Tschacher et al., 2003). In addition, they use the term "gradients" for the control parameters that affect the complex systems from outside the system. It is along those gradients that dynamical systems move and ultimately find their stable solutions, i.e., converge onto their order parameters. In general, they consider the components of a system, the environment and the gradients together in order to investigate a complex system's behavior and they consider all these as a strong support for self-organization.

Lastly, Maruyama et al. (2006) claim that imitation in infants is dynamically affected by the behavioral history and the context of the task. They investigated the perseverative errors in an imitation task and found that several factors and the dynamic interactions between them including the task context, the behavioral history and familiarity with the types of the actions used in the task affect infants' imitation performance.

Gathering all these facts about imitation and dynamic systems, we considered several independent variables as important in this study. Indeed, if we had a dynamic systems model for imitation, all these variables would go into the differential equation of this system, however, we do not offer a model here. As noted earlier, the interaction of some variables that interact with each other in complex way leads to a particular behavior of the dynamic systems. Therefore, we tried to come up with some internal and external variables that may modulate the child's imitative behaviors. These variables and the specific explanation for considering each of them with regard to the dynamic point of view are noted in the following:

Age: We consider age in the group of our independent variables; however, it is actually a carrier variable which mainly indicates the development. Moreover, the range of different ages was spread wide in order to comprise imitative behaviors differences, specifically, mirroring and matching, in different age groups. Thus, we will be able to estimate the age in which the shift between these two order parameters occurs.

Task: We expected major differences between the tasks that involve objects (e.g. cups, ears) and the tasks without objects. These tasks vary with respect to the action goal, i.e., the goal object of the movement. As known from the literatures (Wohlschläger et al., 2003; Gleissner et al., 2000), the near-ear task leads to a fewer amount of errors in comparison with the on-ear task. Although, the on-ear task with the body part goal and the cup-grasping with the physical objects may show similar results.

Perspective: We considered different perspectives between the experimenter and the child as an external variable that may modulate the child's response with respect to his/her choice of matching or mirroring. As we reviewed, the perspective has not been systematically varied in the literature before. Usually the experiments are carried out in 180 and zero conditions. In the present study, we considered two zero degree conditions since they may facilitate matching responses, especially in the younger children, due to the simple parallel shift that the child has to mentally carry out between the position of the experimenter and her/his own position. In this case, the conceptual burden is very low because perceptual and conceptual symmetry coincide. In the case of 180 and 90 degrees, matching does not result in the same kind of mirror-image perceptual symmetry but only in a diagonal kind of symmetry. Thus, we considered these three perspective conditions which put children in different situations which can affect their imitative behavior. The 90° condition was invoked as an intermediate position between 0° and 180° in order to see with which of those two alternatives they pattern: more with the 0° or more with the 180° condition or perfectly in between? This position is particularly interesting

for a dynamic systems approach because spatially it is exactly in between 0° and 180°; however, the results may not be an exact average between these two conditions. Rather, the 90° position may pattern with one of them more than with the other, i.e., although the variation is continuous, the result may be discrete.

Block: The findings of the other studies did not provide any information aboutany significant differences between different blocks although children, as in our study, were repeatedly exposed to the same movements (Wohlschläger et al., 2003). Here, we considered four blocks in our study in order to obtain more reliable data. Moreover, from a dynamic view the short-time scale (as exemplified in the blocks) is as important as the long-time scale (as exemplified in the age variable). Lastly, this variable is important in a dynamic view since it may reveal some "micro"-development going on on the short time scale of each task which may even affect the "macro"-development across age.

After evaluating the reasons of invoking the above mentioned independent variables in our study with regard to dynamical systems, in the following we explain the choice of our dependent variables, namely, "matching", "mirroring" and at the lower level "imitation of the effector" and "other" movements. We concentrated on matching and mirroring and on the factors that affected these imitative behaviors in children from mirroring in the younger children to matching in the older ones. However, as reviewed, mirroring itself is considered as a proper child imitative behavior, specifically in the studies of Wohlschläger et al. (2000; 2003). We considered matching and mirroring separately as two different forms of our dependent variable since matching requires a more high-level, abstract conceptualization of the relation between the model and the imitator in terms of bodily identity than mirroring, which is based on lower-level, perceptual strategies, e.g., mirror symmetry. Since matching is rather more conceptual than mirroring, it may require some abstract conceptual language abilities to develop before. It should be mentioned that, we do not mean language in the sense of the lexicon or grammar, but in terms of concepts.

In particular, the deictic or indexical concepts like “me-you”, “left-right”, “here- there” need to be established. All these linguistic concepts may affect the children’s imitation specifically in different perspectives. The challenge of matching is that they have to preserve the higher-order conceptual invariance (“the experimenter’s right hand corresponds to my right hand”) and to sacrifice the lower-order perceptual invariance (the mirror symmetry).

As mentioned earlier, without doubt, human development can be considered as a nonlinear complex dynamical system. In other words, development is changing from one situation to another, more mature situation or state or sometimes also to a seemingly less mature state, as in U-shaped development. The complexity of this system increases over time but all of its components work interdependently and the system remains coherent. Moreover, if we want to argue that development is a nonlinear complex dynamical system then imitation is a suitable mechanism to look at. This is because, as mentioned earlier, it is a fundamental way for acquiring different skills and knowledge in various domains, motor, cognitive, emotional. Thus, it may serve as a bootstrapping mechanism for entering, e.g., a cognitive, domain that would otherwise not be accessible to the infant. For this reason imitation can be considered as a suitable area to investigate cognitive development from a dynamical perspective.

In sum, the independent variables (e.g. task, block, age, condition) as the control parameters in a dynamic system and their effects on the dependent variables (e.g. matching and mirroring) as the order parameters are directly related to a dynamic systems approach to understand the mechanism underlying imitation.

CHAPTER 3

METHOD

3.1 Participants

The experiments were carried out with 165 children (81 female and 84 male). There are five age groups in this study: 4.5-5.5, 6, 7, 8 - 9 and finally, 10 - 11 years of age. Therefore, our study is cross-sectional. The experiment was carried out in Iranian kindergartens and elementary schools. Iranian elementary schools consist of one pre-school grade and five elementary grades. Six-year-old children study in pre-school grade which is a sort of adaptation to the school and then, seven-year-old children start the first grade of elementary school. In this study, the children of grades 2 and 3 were considered as the 8-9-age-group and children of grades 4 and 5 were considered as the 10-11-age-group. The descriptive statistics for the various age and gender groups are shown in Table 1, Table 2 and Table 3, respectively.

There are separate elementary schools for girls and boys in Iran. Therefore, the children were recruited from two kindergartens, one female elementary school and one male elementary school in Tehran which is the capital city of Iran. The children were chosen randomly from the roster of the schools and the kindergartens with respect to their ages.

Table 1 Descriptive Statistics for the children group

	N	Minimum	Maximum	Mean	Std. Deviation
Age of the subjects in years	165	3.79	11.15	7.2566	1.98556

Table 2 Age value for different age groups

Age Groups	N	Mean	Std. Deviation
kindergarten	33	4.7682	.54424
Six	32	5.9078	.31515
seven	32	6.9141	.36781
eight and nine	36	8.3103	.63330
ten and eleven	32	10.3288	.49086

Table 3 Age value for different gender groups

gender	N	Mean	Std. Deviation
male	84	7.3532	1.86565
female	81	7.1564	2.10970
Total	165	7.2566	1.98556

There is one adult Iranian control group in this study. It consists of 22 adults (12 female and 10 male) between 17.47 and 34.00 years of age. The females were randomly chosen from a cooking and food decoration class in a cultural center in Tehran, Iran. The Iranian male control group was randomly chosen from a mixed family class of young people. Table 4 shows some descriptive statistics for the Iranian control group. Table 5 shows the age values for the two gender groups of Iranian adults.

Table 4 Descriptive Statistics for the Iranian control group

	N	Minimum	Maximum	Mean	Std. Deviation
Age of the subjects in years	22	17.47	34.00	25.3095	4.86531

Table 5 Age value for different gender groups of adults

gender	N	Mean	Std. Deviation
male	10	22.8930	5.08141
female	12	27.3233	3.78571
Total	22	25.3095	4.86531

3.2 Experiment

3.2.1 Tasks

This study consists of two tasks, hand-to-ear and cup-grasping (cf. Gleissner et al. 2000; Wohlschläger et al. 2003). The reason, why we conducted two different tasks was that in the classical hand-to-ear task the goal is a body part, which is not directly visible, however in the cup-grasping task the goal is a fully visible external goal object. Including both cases, we wanted to arrive at some general results with respect to the nature of the goal.

3.2.1.1 Hand-To-Ear Task

In the hand-to-ear task we did not use any special materials. All the gestures were movement(s) of the hand(s) to the ear(s). The hand-to-ear task had two different demonstrations in this study. In one, which we refer to as *on-ear* demonstration (OE), the gesture(s) terminates at the ear(s). The second demonstration is the *near-ear* task (NE) in which the hand(s) does not make contact with the ear(s) but halts near the ears.

3.2.1.2 Cup-Grasping Task

In the cup-grasping task, we used two different pairs of two identical cups. One pair of cups was placed on the table in front of the child and another pair in front of the experimenter. In the cup-grasping task the experimenter grasped the cup(s) with one or both hand(s) and the subject was supposed to grasp the cup(s) in front of him- or herself accordingly.

3.2.2 Experiment environment

The experiments were carried out in different places with regard to the children groups and the adult control group. For the children groups, the experiment was carried out in a specific room at the kindergartens and the schools. Each child sat in front of a rectangular table.

We considered three perspective conditions between the child and the experimenter which were zero, 90 and 180 degrees. The zero condition had two variants. In the first one, the experimenter was sitting at the right-hand-side of the child and in the other situation the experimenter was sitting at the left-hand-side of the child. We refer to the former as zero-right condition and to the latter as zero-left condition. Therefore, the experiment consisted of four conditions in total: zero-right, zero-left, 90° and 180° (see Figure 4). In each of these conditions one video camera was in front of the child in order to record the child's head, torso and the top part of the table in front of the child and the experimenter. But note that there was a difference in recording the experiment with the camera between the girls' and the boys' schools based on their regulations. Thus, we could not record the experiments for all the girls in their school. In the boys' school and in the kindergartens there was no problem to record the experiment.

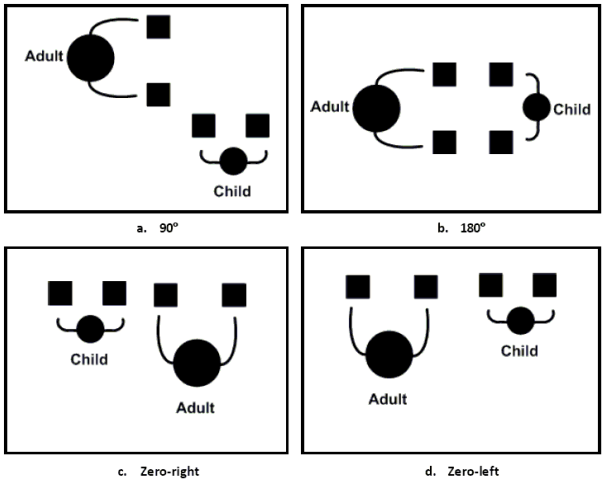

Figure 4 Four perceptual perspectives of the imitator towards the experimenter. 1. a 90 degrees condition. 1. b 180 degrees condition. 1. c zero-right condition and 1. d zero-left condition.

3.2.3 The experimenter gestures

Six main gestures were defined in this study based on the path of the movement of the hand(s) to the ear(s) or to the cup(s) (cf. Gleissner et al. 2000; Wohlschläger et al. 2003). These movements consist of right-ipsi (the right hand to the right ear or cup), left- ipsi (the left hand to the left ear or cup), right-contra (the right hand to the left ear or cup), left-contra (the left hand to the right ear or cup), both-ipsi (the right hand to the right ear or cup and at the same time the left hand to the left ear or cup) and both-contra (the right hand to the left ear or cup and at the same time left hand to the right ear or cup).

As mentioned before, in the hand-to-ear task, we had considered two kinds of movements of the hand(s) to the ear(s) (cf. Gleissner et al. 2000). In the *on-ear* demonstration (OE), the hand(s) touched the ear(s) and in the *near-ear* demonstration (NE), the hand(s) did not make contact with but halted shortly beside the ear(s) (see Figure 5).

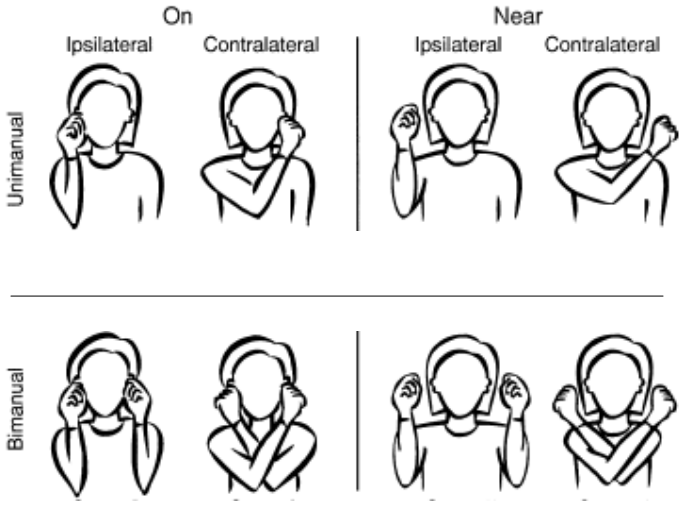

Figure 5 Samples of four gestures in the hand-to-ear task. The left gestures show the on-ear demonstration. The right gestures show the near-ear demonstration. The two top pairs show right-ipsi and right-contra gestures, respectively. The two pairs below show both-ipsi and both-contra gestures, respectively. Original figure from Gleissner et al. (2000, P.408).

3.2.4 Design

The children from each age group were assigned randomly to each of the four perspective conditions. The numbers of girls and boys from each age group that participated in each of the four perspective conditions are shown in Table 6. The *near-ear* and *on-ear* tasks were carried out for each child as well as the cup-grasping task. Moreover, the order of the *on* and *near-ear* tasks were counter-balanced as was the order of the cup-grasping task with respect to the hand-to-ear tasks. Each child was assigned to one of the following four orders of the tasks which are shown in Table 7.

Table 6 Number of children in the four conditions based on different age groups and gender

gender	condition of task	age as dummy					Total
		kindergarten	Six	seven	eight and nine	ten and eleven	
male	zero-left	3	4	4	6	4	21
	zero-right	3	4	4	6	4	21
	90	4	4	4	4	4	20
	180	6	4	4	4	4	22
female	zero-left	5	4	4	4	4	21
	zero-right	5	4	4	4	4	21
	90	4	4	4	4	4	20
	180	3	4	4	4	4	19

Table 7 Different orders of the three tasks

1	On-ear, Near-ear, Cup-grasping
2	Near-ear, On-ear, Cup-grasping
3	Cup-grasping, Near-ear, On-ear
4	Cup-grasping, On-ear, Near-ear

Furthermore, we considered four blocks of presenting gestures to each child in each of the three tasks (i.e. *near-ear*, *on-ear* hand-to-ear tasks and cup-grasping task). Each block consisted of the six RI, LI, RC, LC, BI, BC movements. The order of these movements in each block was as shown in Table 8.

Table 8 Order of the movements in the different blocks

	1st	2nd	3rd	4th	5th	6th
Block 1	RI	RC	LI	LC	BI	BC
Block 2	BI	LI	RI	LC	RC	BC
Block 3	RC	LC	RI	LI	BC	BI
Block 4	BC	LC	LI	RC	RI	BI

In order to analyze the data, we defined four different responses of the children to the movements which are the four possible forms of the dependent variable in this study. The first and most important form of the dependent variable is conceptual "matching" leading to RI imitation of a RI model's hand movement

in all the conditions and tasks. It means that the hand that the child is reaching the goal with is exactly matched with the hand of the experimenter. If the experiment uses her right hand, the child would also use her right hand. The second form of the dependent variable is perceptual "mirroring" leading to LI imitation of an RI model. We considered a child movement as a mirror action when the child's hand and the reached goal were exactly opposite (i.e., mirror-symmetric) compared with the experimenter's hand and reached goal. For example, when the experimenter showed a right-contra movement (the right hand to the left ear or cup) the child replied with left-contra movement (the left hand to the right ear or cup). However, there was a kind of child response in which the child chose the same hand as the experimenter's hand but to the opposite ear or cup. We named this kind of dependent variable "effector" since the child used the correct effector, which is the hand in this experiment. For example, the child moved her/his right hand to the left ear or cup (right-contra) in response to right-ipsi movement of the experimenter (the right hand to the right ear or cup) or *vice versa*. The forth form of the dependent variable which is named "other" consists of all the cases which cannot be grouped under matching, mirroring or effector. Moving the left hand to the right ear or cup (left-contra movement) as a response to the experimenter who is moving her right hand to the right ear or cup (right-ipsi movement) is an example of this condition. These four imitative responses in the 180° condition are shown in Figure 6. Moreover, in order to show how we arrived at the counts of the various forms of the dependent variable, Figure 7 presents six-year-old children's responses (in percentage) to the experimenter's movements in the first block of the on-hand-to-ear task in the 180º condition. An example of "matching" is shown with the solid rectangle leading to BI imitation of a BI model. The left-ipsi imitation of the children as response to the right-ipsi model of the adult which is considered "mirroring" is shown with the square dot oval. The "effector" imitation is shown by the long dashed dotted rounded rectangle, where a right-contra movement of the adult is replied with a right-ipsi movement by the children. The solid triangle shows an "other" movement

which in this case is a right-ipsi movement of the child as a response to a left-contra movement of the experimenter.

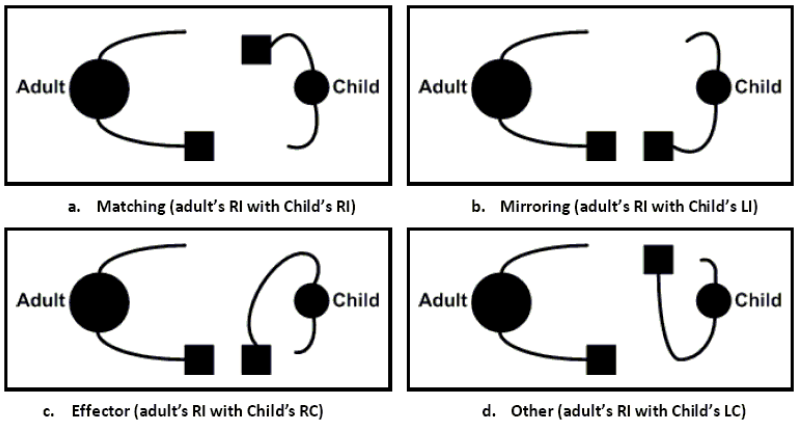

Figure 6 Four imitative responses in 180°: Matching, mirroring, effector and other imitation responses.

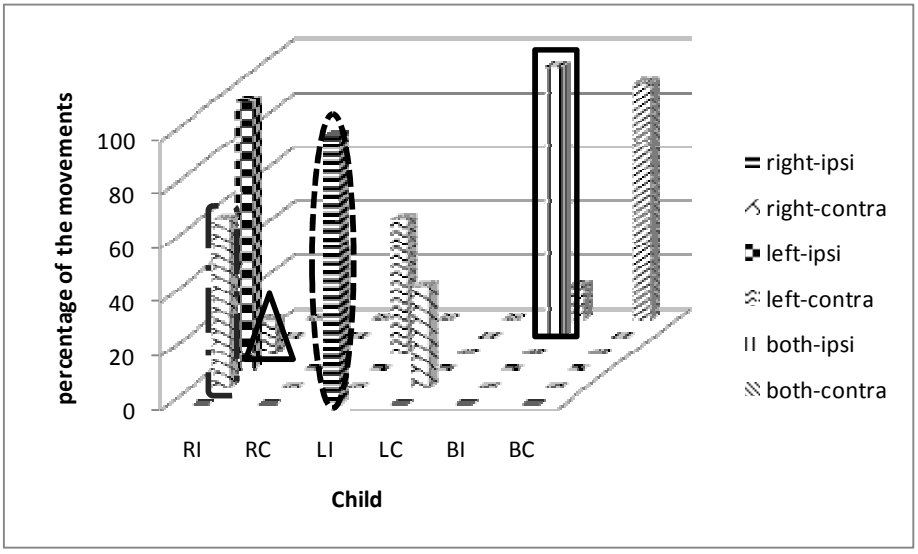

Figure 7 Samples of matching, mirroring, effector and other forms of the dependent variable in the first block of 6-year-olds' responses in the OE task, 180º.

Note that in terms of the descriptive statistics all four forms of the dependent variables will be reported, as in stacked bar graphs so that the amount of matching, mirroring, effector and other responses can be inspected directly. However, the inferential statistical analyses will only be run for the major dependent variable, i.e., matching.

3.2.5 Procedure

Consent was obtained from the kindergartens and schools directors based on their regulations. The experiment took place on a work day at the schools and the kindergartens. The teachers were informed in advance about the students chosen from the list so that they could come out of the class to participate in the experiment. After each child returned to her/his class the teacher called the next one to go out and so on. When the child came out of the classroom, one of the experimenters who ran the experiment during the study escorted her/him to the specific room of the experiment. We refer to this experimenter as "experimenter 1". Experimenter 1 talked with the child in a friendly manner during walking in the corridor from the child's class to the experimental room. Experimenter 1 introduced herself to the child when she/he came out of the class. Then she asked the name of the child and told her/him that they were going to another room to do something which was like a simple game. The dialog between the child and experimenter 1 was adapted to the child's age. The younger children needed more kindness to be comfortable and the older ones needed some specific information in order to know where they were going with the experimenter. During the time that experimenter 1 was escorting the child to come back to her/his class and bringing another student, another experimenter had positioned the chairs depending on the perspective between the child and experimenter 1. We refer to that second experimenter as "experimenter 2". When the child came to the room experimenter 1 led her/him to sit on that specific chair which was positioned before by experimenter 2. The child was sitting on that specific chair until the end of the test. In other words, each child

was tested in only one perspective condition and with the three kinds of tasks. Experimenter 1 introduced experimenter 2 to her/him. She spoke about some general things so that the child would become familiar with the environment and the experimenters. Then experimenter 1 asked the child some questions as cited below:

1- Identity: “What is your name and family name”?

2- Number of siblings: “How many brothers and sisters do you have”?

3- Birth order: “Are you the oldest/middle/youngest among your siblings”?

The answers to these questions were noted down by experimenter 2. The birth date of the children and the level of their parents’ education were asked from the staff of the school that was responsible for this information. (Only the director of the girls’ school refused to provide that information to us.) Experimenter 1 had not talked about the tasks so far. When experimenter 1 felt that the child was ready, she asked the child “Do you want to start?” and if s/he said “yes”, experimenter 1 started the tasks.

For the female students the procedure was a little bit different from the male students. The female children had to wear a scarf at school. However, in the hand-to-ear task it was critical that the child’s and the experimenter’s ears be visible. Thus, one special way of wearing the scarf was planned for those female students which participated in the hand-to-ear task. In this way the female child’s ears appeared without revealing her hair. Experimenter 1 wore the same kind of scarf as the female children during the experiment at the boys’ and girls’ schools and kindergartens as well as in the experiment with the Iranian adult control group. After the girl was familiar with the environment and the experimenter, experimenter 1 asked “Can I ask you to wear your scarf like me?” and then experimenter 1 showed the child to change the way of wearing her scarf and if she could not manage it, experimenter 1 helped her. Then, if the child was ready, the experiment was started.

As explained in the Design part (1.2.4), there was a counterbalanced order for the three tasks. Each child started and continued her/his task based on the order that the experimenter had decided on before. In the following, we describe the case for *on-ear* first and *near-ear* second and *cup-grasping* third. During all the three tasks, the experimenter had a very small piece of paper on the table near to herself on which the six movements in each of the four blocks were written. It helped the experimenter to do the movements and the tasks in the right order. First of all, experimenter 1 told the child "please do what I do" and then she started with the *on-ear* task. Experimenter 1 demonstrated the six movements according to the schedule in Table 9 in four blocks. In each block, experimenter 1 showed the RI, LI, RC, LC, BI, BC gestures to the child. When the experimenter had completed each of these movements, she waited for the child's response to the gesture. After the experimenter finished the first block of the six gestures she started the second block of these six gestures with the new order, until the four blocks were finished. The responses of the child were noted down by experimenter 2 in parallel. In the analysis part, the average score of the child's response to the same gesture was considered as her/his response to that specific gesture.

When the four blocks of the *on-ear* task finished, the experimenter gave a short break to the child. Before the next task was started, the experimenter told the child that the movements are similar to the previous task and that they should again do what she will do. Then, when the child was ready, the experimenter started the four blocks of the *near-ear* task. In this task the experimenter demonstrated the six gestures in a way that the hand(s) did not make contact with the ear(s). For instance, in the right-ipsi gesture, the right hand, as if it was grasping something, was in the air 10 cm beside the ear and the palm of the hand was facing the side of the face (see Figure 2, right hand side). When the experimenter finished the first block of the six gestures, she continued until the four blocks were finished. Then, like in the previous section, the experimenter gave the child the second short break for her to become ready for the next task which, in this case, is the *cup-grasping* task.

As mentioned before, the order of the cup-grasping and the hand-to-ear grasping tasks were counter-balanced. The experimenter brought two different pairs of two identical cups. She put the first pair of cups on the table in front of the child and the second pair in front of herself. The experimenter grasped the cup(s) with the six gestures. For instance, in the both-contra gesture the experimenter grasped the right cup with her left hand and at the same time she grasped the left cup with her right hand. For each gesture, after the experimenter grasped the cup(s) she was keeping her hand(s) in that place until the child responded with her/his own gesture. This task had four blocks as the previous tasks and the order of these six gestures within each block was varied according to Table 9.

After completion of all three tasks, the child was asked a short question in order to find out why s/he replied to a certain movement with her/his particular gesture. Therefore, after the last movement of the third task had been imitated by the child, experimenter 1 repeated one of the one-handed gestures (e.g., RI, RC, LI or LC) and waited until the child responded to that movement. The kind of task for this repetition movement depended on whatever was the third task for each child. For instance, if the third task for a child was cup-grasping, the experimenter repeated one of the above movements by grasping the cup. When the child did the movement, experimenter 1 asked her/him to hold her/his hand in that situation and experimenter 1 also held her hand in that situation and immediately asked the child "what was your reason that you responded to this particular movement of mine with this kind of hand movement that you did?" Moreover, after this question experimenter 1 told the child that "your response was alright, I just wanted to know what your reason was." Experimenter 1 added this second sentence to her explanation in order to make the child feel sure that her/his movement was correct. The answer of this question also was noted down by experimenter 2.

After the experiments were finished, experimenter 1 conducted a short test in order to determine the hand dominance of the child. This test was the same as in

Gleissner et al.'s (2000) imitation tasks, namely it "consisted of five different activities which the child performed three times each: kicking a ball with the foot, throwing a ball with one hand, knocking on a piece of wood with a plastic hammer, drawing with color pencils on papers, and eating fruit loops out of a bowl." (Gleissner et al. 2000, P.409). Carrying out the handedness test took around 3-5 minutes.

When the three tasks plus the handedness test had been carried out, the child was presented with some chocolate as an award. Experimenter 1 escorted the child to her/his class and brought the next child to the experiment room. It took around 15-20 minutes in order to complete the whole experimental procedure from bringing the child into the room to her/his leaving. The flowchart of the experimental procedure is shown in Figure 8.

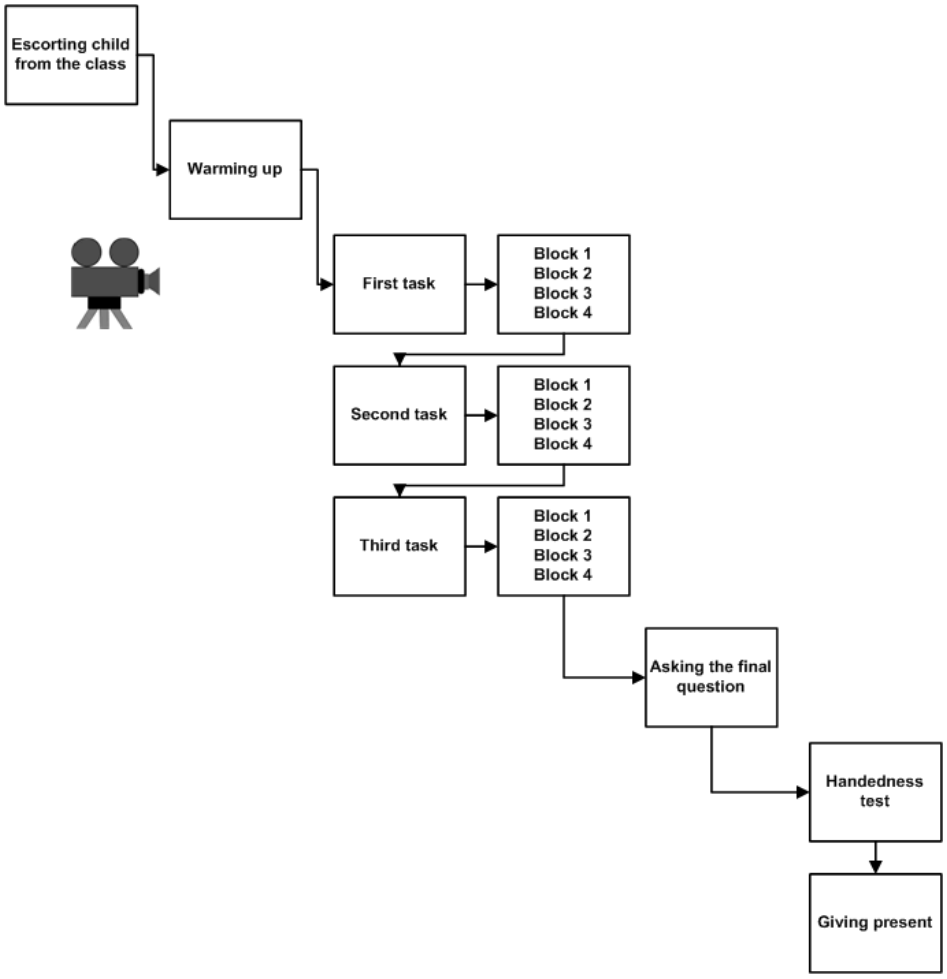

Figure 8 The flowchart of the experimental procedure

The adult Iranian subjects agreed to participate in the study by oral consent. The experiment procedure was almost the same as for the children group with some exceptions. First of all, there was no handedness test for the adult control group. Instead of the handedness test, the experimenter asked the adult about her/his dominant hand. The answer of the adult subject about her/his dominant hand was considered later in the analysis. Moreover, they agreed to participate in the experiment voluntarily. Then, experimenter 2 asked the questions about the subject's education, number of siblings, handedness and date of birth. Then, experimenter 1 explained the tasks to the subject. Because the tasks may seem

easy and funny to adults, experimenter 1 explained to all the adult subjects that they are the control group for a child experiment and the movements may therefore seem funny to them. Then the experimenter turned on the camera and started the first task. The ordering of the blocks and the tasks and the procedure of running the experiment for the adult control group was exactly the same as for the children group.

Because women should wear a scarf in Iran, experimenter 2 explained to them that they needed to change the manner of wearing their scarf and demonstrated how by changing her scarf in a way such that the two ears appeared without showing their hair. Besides, there was no video recording for the Iranian women control group because except one woman the others did not agree to their experiment being recorded. However, the experiment of the entire Iranian men control group was video-recorded.

CHAPTER 4

RESEARCH QUESTIONS AND HYPOTHESES

From the previous presentation and discussion of the literature the following research questions and hypotheses are derived:

RQ1- Are goals mostly imitated? Do the results confirm the GOADI theory?

RQ2- Is the amount of matching different in the three different tasks?

RQ3- When the experimenter demonstrates the gestures which terminated *on* or *near* the body (the ear), how do these changes within the gestures' endpoints affect the results?

RQ4- What is the effect of the two different imitation tasks, i.e. body-related versus object-related, on the results?

RQ5- Does subjects' imitative performance vary across the four blocks of each task?

RQ6- What is the age of shifting from mirroring to matching? What are the quantitative and qualitative imitation differences between the different age groups?

RQ7- What is the effect of different perspectives in imitation? Is imitation influenced by the perceptual perspective of the imitator towards the model in zero, 90 and 180 degrees?

RQ8- Does imitation in the 90° condition differ from imitation in the 180° condition? Or, does the intermediate perspective of 90° cause similar effects as in the 180° condition?

RQ9- Is there a significant difference within the two situations of the zero degree condition? If the experimenter sits at the right-hand-side of the child or at the left-hand-side, does it change the results? Is it related with the handedness of the child?

My hypotheses, based on my research questions, are listed below:

H1- The results are supposed to confirm the goal-directed theory of imitation. Based on this theory, the perceived act will be decomposed into separate aspects which are hierarchically organized. The higher ordered goal will be mostly imitated.

H2- The amount of matching is different for the three tasks.

H3- In the *near* demonstration of the hand-to-ear task, the child will make fewer errors than in the *on* demonstration of the hand-to-ear task. In the *near* demonstration, the absence of the terminal point(s) helps the child to choose the correct effectors (hand(s)) so that the child will make fewer errors. “Fewer errors” here means “less mirroring”.

H4- There is no significant difference between the imitation of the body parts or the physical objects. The child will choose the body parts or physical objects as the main goals.

H5- Blocks might reveal learning effects during the tasks such that matching rates increase across blocks.

H6- The shift between mirroring and matching will occur after the age of eight years.

H7- Perspective modulates matching rates.

H8- The results of 90 and 180 degrees will be very similar to each other (e.g. dominantly mirroring in the specific ages), but in the zero degree condition, the results will show dominantly matching, even in the younger children.

H9- There is no significant change between the two situations of the zero degree condition. We think in both of them, children will dominantly match the gestures. However, imitation of the gestures on the invisible side of the experimenter might differ from imitation of the gestures on the visible side. These differences will be complementary in both zero conditions.

CHAPTER 5

RESULTS & SPECIFIC DISCUSSION

First of all in this chapter, we state the results of the children and then, we present the results of the adults control group. For both children and adults, first, descriptive statistics, then inferential parametric statistics (ANOVA), and then non-parametric statistics will be presented. Along with the various results we will provide a specific discussion of each of them, however, spare the general discussion for chapter 6. It should be noted that the two bi-manual gestures, i.e., both-ipsi and both-contra, were excluded from the analysis since in these two cases, children's imitative behavior was almost perfect (see Figures 14 and 15). Hence, the following inferential statistical analyses are based exclusively on the four uni-manual gestures, i.e., right-ipsi, right-contra, left-ipsi and left-contra (cf. also Wohlschläger et al. 2003, for identical procedures).

5.1 Children:

5.1.1 Descriptive Statistics:

The descriptive statistics and the age values for the different child age groups and for the adult control group had already been shown in section 3.1. Moreover, Table 9 shows the mean percentages and standard deviations of matching, mirroring, effector and the other responses for all ages, conditions with the average of four blocks in the on-hand-to-ear task. We present this table

as an example to show on which descriptive data the following inferential statistics were based. The mean percentages and standard deviations in the same condition as Table 10 for the near-hand-to-ear and the cup-grasping tasks are shown in Table 28 and Table 29 respectively which are in the appendix A.

Table 9 The M percentages and SDs of matching /mirroring/effector/other across all ages, conditions and blocks in On-Hand-To-Ear task (Children).

Age Groups	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
kindergarten	zero-left N=8	Mean	.2422	.3828	.2969	.0781
		Std. Deviation	.30148	.19318	.10953	.05540
	zero-right N=8	Mean	.3594	.4141	.1641	.0625
		Std. Deviation	.22097	.14149	.17014	.04725
	90 N=8	Mean	.0469	.6250	.3047	.0234
		Std. Deviation	.07281	.13363	.19027	.03235
	180 N=9	Mean	.0417	.7292	.1736	.0556
		Std. Deviation	.08268	.23799	.09772	.10572
	Total N=33	Mean	.1686	.5436	.2330	.0549
		Std. Deviation	.22830	.22937	.15410	.06767
six	zero-left N=8	Mean	.2813	.5234	.1563	.0391
		Std. Deviation	.17678	.16683	.09449	.06629
	zero-right N=8	Mean	.2109	.6094	.1406	.0391

Table 9 (Cont.)

Age Groups	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
		Std. Deviation	.14917	.17279	.08011	.06629
	90 N=8	Mean	.0156	.8047	.1719	.0078
		Std. Deviation	.02893	.18126	.17279	.02210
	180 N=8	Mean	.0078	.8203	.1641	.0078
		Std. Deviation	.02210	.13950	.14149	.02210
	Total N=32	Mean	.1289	.6895	.1582	.0234
		Std. Deviation	.16493	.20360	.12192	.04957
seven	zero-left N=8	Mean	.6953	.2266	.0625	.0156
		Std. Deviation	.36663	.29869	.08839	.04419
	zero-right N=8	Mean	.5781	.3672	.0391	.0156
		Std. Deviation	.36558	.33146	.06629	.04419
	90 N=8	Mean	.0859	.8672	.0469	.0000
		Std. Deviation	.17339	.18431	.04419	.00000
	180 N=8	Mean	.0625	.8359	.0625	.0391
		Std. Deviation	.08183	.20027	.10022	.07423
	Total N=32	Mean	.3555	.5742	.0527	.0176

Table 9 (Cont.)

Age Groups	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
		Std. Deviation	.39029	.37916	.07465	.04824
eight and nine	zero-left N=10	Mean	.7938	.1938	.0125	.0000
		Std. Deviation	.34112	.32469	.02635	.00000
	zero-right N=10	Mean	.6813	.2938	.0250	.0000
		Std. Deviation	.24729	.23579	.03227	.00000
	90 N=8	Mean	.0313	.9297	.0313	.0078
		Std. Deviation	.04725	.11298	.06682	.02210
	180 N=8	Mean	.2500	.6328	.0547	.0625
		Std. Deviation	.41323	.44876	.11298	.12045
	Total N=36	Mean	.4722	.4826	.0295	.0156
		Std. Deviation	.42190	.41123	.06424	.06046
ten and eleven	zero-left N=8	Mean	.8359	.1484	.0078	.0078
		Std. Deviation	.23130	.22395	.02210	.02210
	zero-right N=8	Mean	.9297	.0547	.0078	.0078
		Std. Deviation	.17499	.13126	.02210	.02210
	90 N=8	Mean	.4375	.5234	.0313	.0078
		Std. Deviation	.46170	.42775	.05786	.02210
	180 N=8	Mean	.5313	.4531	.0156	.0000
		Std. Deviation	.47481	.46621	.04419	.00000

Table 9 (Cont.)

Age Groups	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
	Total N=32	Mean	.6836	.2949	.0156	.0059
		Std. Deviation	.40159	.38207	.03889	.01851
Total	zero-left N=42	Mean	.5804	.2902	.1027	.0268
		Std. Deviation	.38037	.27808	.13083	.05004
	zero-right N=42	Mean	.5580	.3452	.0729	.0238
		Std. Deviation	.33992	.27234	.10596	.04568
	90 N=40	Mean	.1234	.7500	.1172	.0094
		Std. Deviation	.26648	.27225	.15962	.02260
	180 N=41	Mean	.1753	.6951	.0960	.0335
		Std. Deviation	.33255	.33894	.11784	.08040
	Total N=165	Mean	.3633	.5163	.0970	.0235
		Std. Deviation	.39187	.35415	.12957	.05406

Furthermore, for the four independent variables (i.e. age groups, conditions, blocks and tasks), we have provided bar charts which show how the amount of matching, mirroring, effector imitation and other movements' imitation developed over these variables. It is clear that each of these bar charts is provided based on one of these four independent variables but collapsing over all the others. For instance, Figure 9 shows how the amount of matching, mirroring, effector and other movements (as four dependent variables) changes over the five age levels. It clearly can be seen that the amount of matching is

gradually increasing over the five age levels and the only exception are the six-year-old children whose matching rate is lower than that of the previous age group (i.e., kindergarten). The other aspect which can see from Figure 9 is that children of lower ages use different responses in their imitation. For example, we can see more effector and other movements' imitation in kindergarten children but the rate of these responses decreases as age increases.

In addition, the development of the four dependent variables over the four different perspective conditions is shown in Figure 10. As this figure shows, children predominantly match in the zero-degree conditions in contrast to 180° and 90° conditions in which children predominantly mirror. The effector responses were higher in the 90 condition as compared to all the other conditions.

Furthermore, as Figure 11 shows, the children's imitation performance in terms of matching, mirroring, effector and other movements is variable over the four blocks. Moreover, the amount of matching is highest in the cup-grasping task and lowest in the on-ear task as Figure 12 shows.

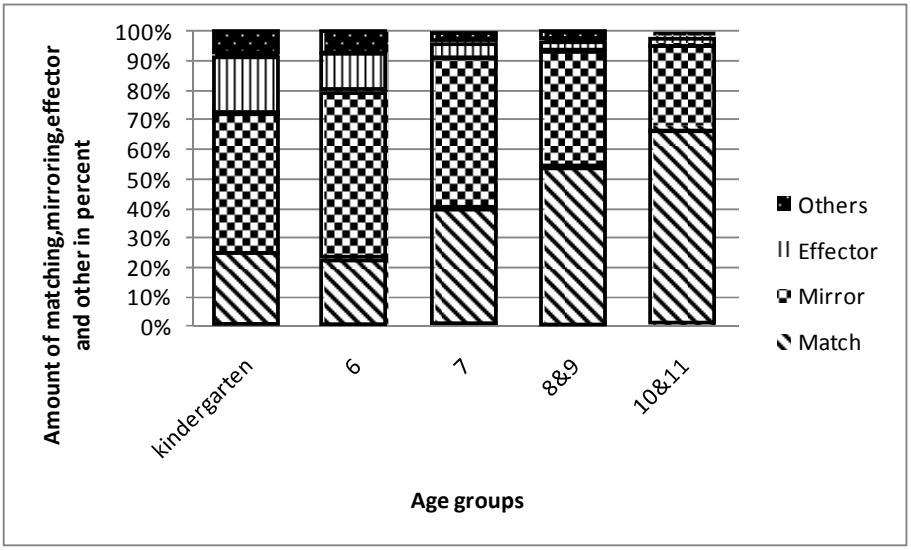

Figure 9 Development of matching, mirroring, effector and other movements' imitation over different age groups (Children).

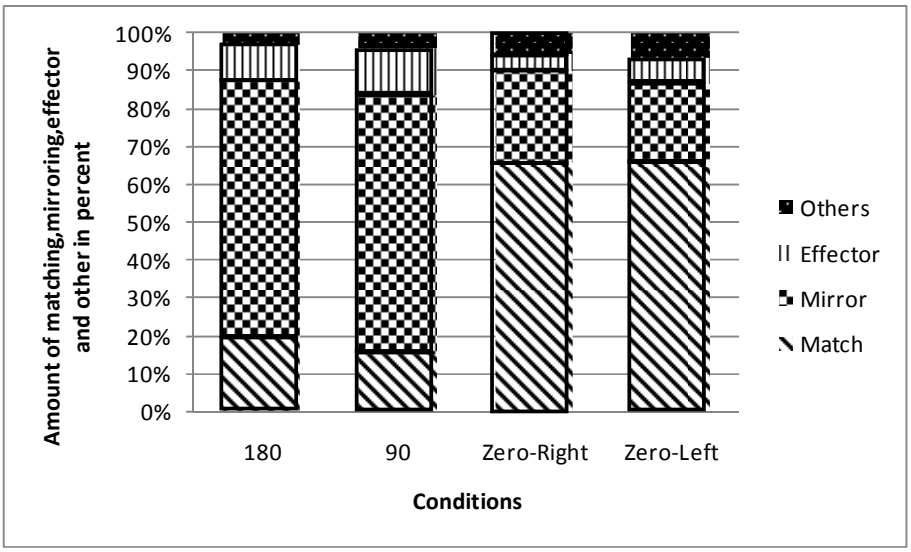

Figure 10 Development of matching, mirroring, effector and other imitation responses over different perspective conditions (Children).

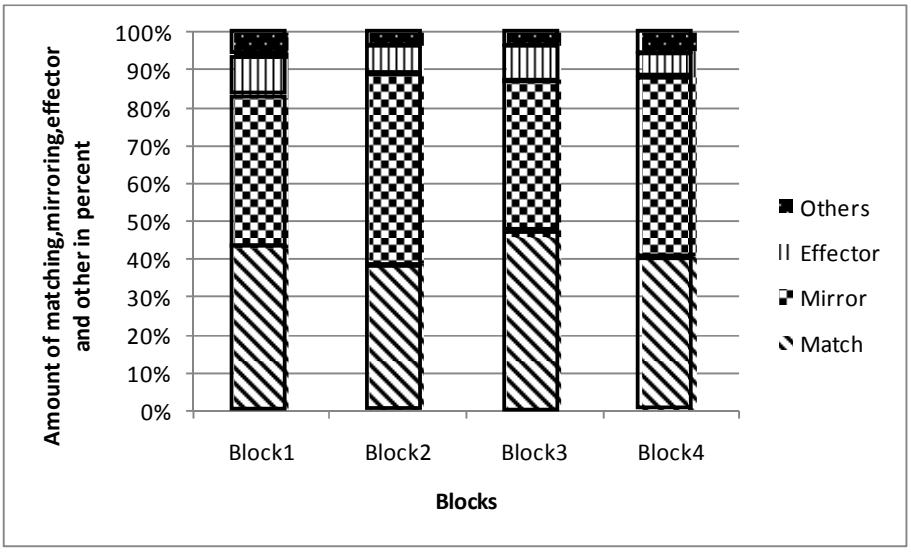

Figure 11 Development of matching, mirroring, effector and other movements' imitation over different blocks (Children).

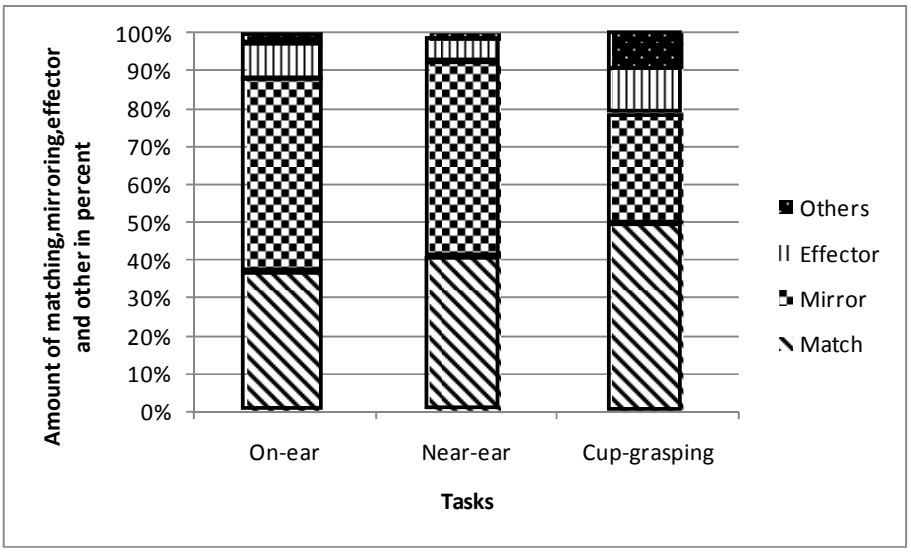

Figure 12 Development of matching, mirroring, effector and other movements' imitation over different tasks (Children).

Furthermore, we calculated the average responses of the children over the four blocks of each task for evaluating what movements the children did (e.g., RI, RC, LI, LC, BI, and BC), given what the model did. It should be mentioned that these averages are for all conditions and across all age groups as well as all the blocks. Figure 13 shows average percentages of the children's movements given the adult's movement in the on-ear task. As it can be seen clearly, children responded both-ipsi and both-contra movements of the model predominantly by both-ipsi (99.26%) and both-contra (93.75%), respectively. Moreover, this figure also shows that children in the on-ear task, predominantly respond to given ipsi-lateral movements by ipsi-lateral ones and given contra-lateral movements by contra-lateral ones. As Figure 14 shows, this pattern is repeated in children's imitation in the near-ear task, with an average of 99.70% both-ipsi and 99.39% both-contra in response to the model's both-ipsi and both-contra movements, respectively. The pattern of responses for the ipsi-lateral and contra-lateral movements was the same as what was explained earlier for the on-ear task before. Figure 15 shows a similar pattern in the cup-grasping task in which 99.54% of the both-ipsi movement was responded to by both-ipsi and

93.44% of the both-contra movement was responded to by both-contra movements. We will discuss children's movements in response to both-lateral movements further in Chapter 7.

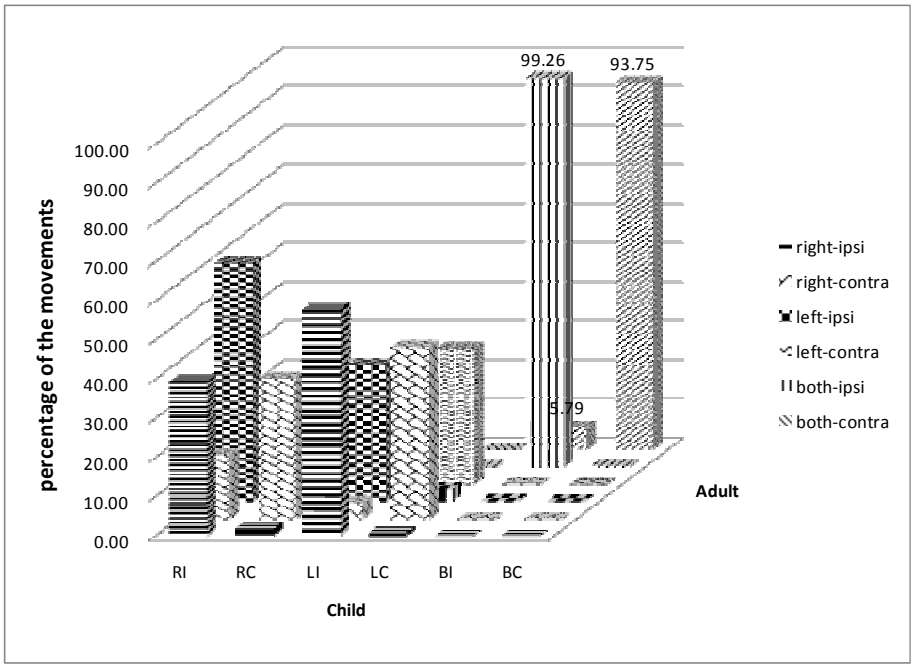

Figure 13 Average percentages of the children's movements given the adult's movement in the on-ear task.

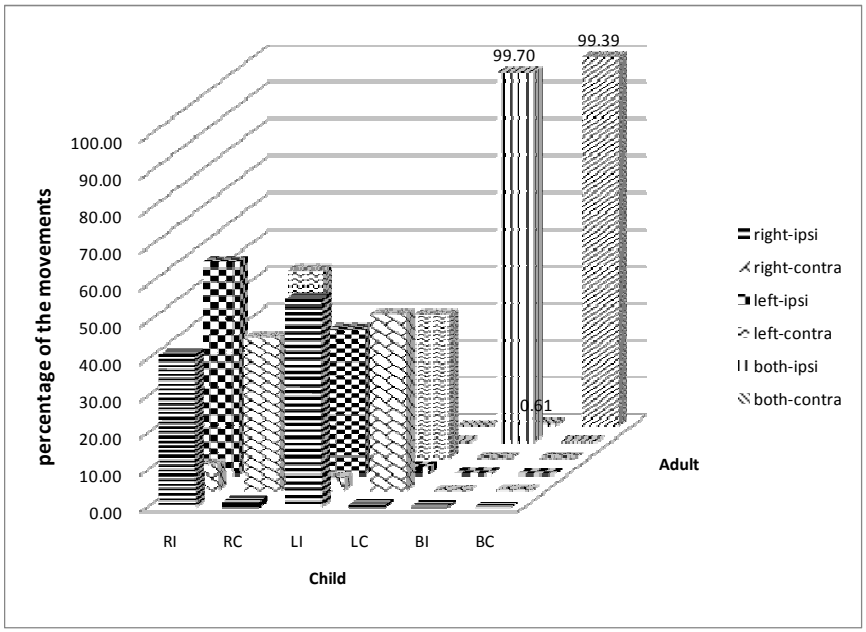

Figure 14 Average percentages of the children's movements given the adult's movement in the near-ear task.

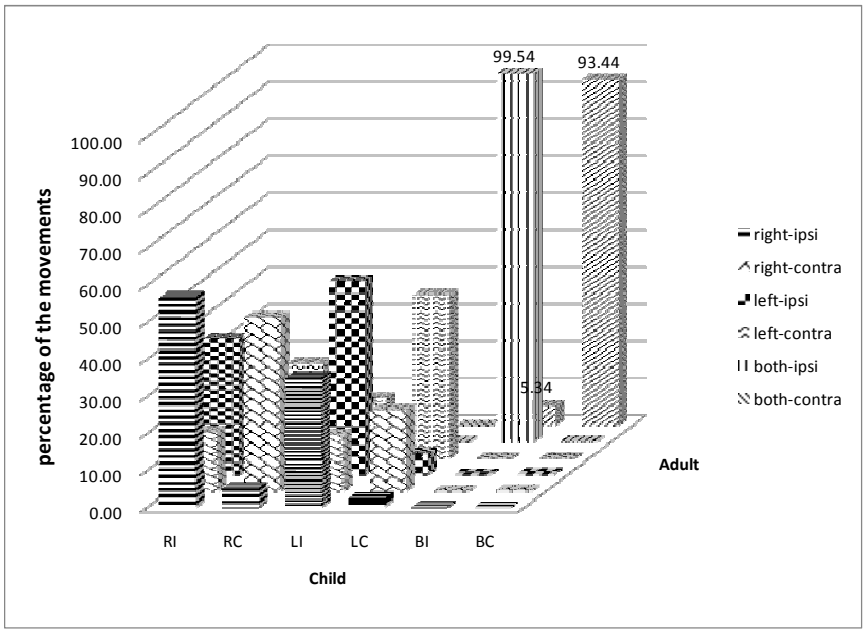

Figure 15 Average percentages of the children's movements given the adult's movement in the cup-grasping task.

5.1.2 Mixed ANOVA:

First of all, it should be mentioned that we did not consider gender as a specific variable besides the other main four variables (i.e. age, task, condition, and blocks) since we had not expected any gender differences, however, we tested for them to make sure there are not any. The results of the mixed ANOVA confirmed that there was not any main effect of gender ($F(1, 155) = 2.84$; $p > 0.05$, $\eta p2 = 0.02$). Thus, in the following analyses we have analyzed male and female subjects together which means all the analyses collapse over gender. Likewise, there was no significant handedness effect on children's imitation ($F(2, 124) = .25$; $p > 0.05$, $\eta p2 = 0.004$).

The main mixed ANOVA in this study is over different age groups and conditions, as between-subjects variables beside tasks and blocks, as within-subjects variables which, taken together, are our four independent variables. The amount of "matching" (in percentage) was considered as dependent variable. Since for all within-subjects variables the sphericity assumption was violated ($p < .05$), we report the Greenhouse-Geisser corrected df's and F-values.

Secondly, by considering matching as dependent variable, the results of simple contrasts for task and condition and repeated contrast for blocks and age groups are reported for each of the main effects and the interactions after reporting the df's and F-values as well as the means and the standard errors.

Lastly, the results of the Bonferroni post-hoc test for age groups, conditions, tasks and blocks are reported following the results of the contrasts for each of the main and interaction effects.

The variables that had main effects on the results are shown below:

- **Tasks**

The test statistics, the Means and Standard Errors:

It was found that different tasks (as within-subjects variable) have significant effects on the amounts of children's matching responses (F (1.70, 245.96) = 42.69; $p<0.001$, $\eta_p^2 = 0.23$). Children's mean percentage of matching was higher in the cup-grasping task in comparison with the near-hand-to-ear task and also, the mean percentage of matching in the near-hand-to-ear task was higher than the on-hand-to-ear task (OE (M=0.36; SE=0.02); NE (M=0.40; SE=0.02); Cup-grasping (M=0.49; SE=0.02), (see Table 10)). Figure 16 shows the mean values of matching in different tasks, along with error bars representing standard errors.

The results of the contrasts:

The on-hand-to-ear task was significantly different in comparison with the cup-grasping task (F (1, 145) = 63.65; $p<0.001$, $\eta p2 = 0.31$) and the near-hand-to-ear task was also significantly different from cup-grasping task (F (1, 145) = 34.97; $p<0.001$, $\eta p2 = 0.19$).

The post-hoc analyses:

- The hand-to-ear task was significantly different from the near-hand-to-ear task (P= .002) and also from cup-grasping task (P= .000).

- The near-hand-to-ear task was significantly different from the cup-grasping task (P= .000).

- As mentioned above, the cup-grasping-task was significantly different from both the hand-to-ear (P= .000) and the near-hand-to-ear (P= .000) tasks.

Table 10 The mean ranks and Standard Errors of matching for the three tasks.

Task	Mean	Std. Error
OE	.356	.021
NE	.397	.020
CUP	.494	.017

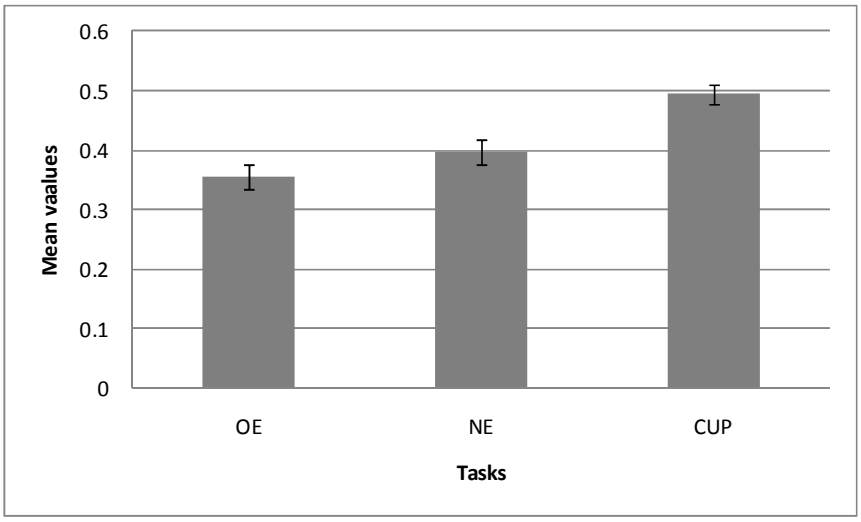

Figure 16 The mean values of matching in OE, NE and Cup-grasping tasks for children (Error bars represent SEs).

Discussion

In our hypothesis about the task, we had considered that the amount of matching is different for the three tasks which the results confirmed it. The three different tasks (i.e. OE, NE and Cup-grasping) had significantly affected the imitation in children. As shown in Table 11, more matching occurs for cup-grasping than for on-hand-to-ear and near-hand-to-ear, especially in the 0° conditions. Also, more matching occurs in the near-ear than in the on-ear task, in accordance with Gleissner et al. (2000). This may be because the goal representation needs fewer resources in these cases, leaving more resources for the cognitively more demanding matching strategy. According to the results shown in Table 15, the amount of matching was only higher in the 180° condition for the near-hand-to-ear task (M=.215) than for the cup-grasping task (M=.203). However, in general, cup-grasping had the highest amount of matching.

Moreover, the mean percentages which showed in Table 14 revealed that the amount of matching for cup-grasping task steadily increased with age. This increase in the amount of matching during age levels also occurred in OE and NE except for the six-year-old children in which the matching is a little bit decreased in comparison with the kindergarten children. Thus, these results confirmed that the older children, even in different tasks with different spatial end-points, do more matching.

Furthermore, the results showed less variability in children's responses in the cup-grasping task. They chose more matching as their responses especially in the zero-degree conditions and less other imitating responses such as effector or other movements. This result is important in a dynamical approach since we can interpret it with consideration of the dynamical factors that can cause these effects. Firstly, as a dynamical interpretation, we might argue with respect to the high rate of matching in the cup-grasping task that the children have the routine to do this in their life. Even in the kindergarten age-group, they have a habit to grasp cup(s) with their hand(s). It means that a pre-programmed motor

plan is activated which helps them to do better in the cup-grasping task in contrast to the on-ear and near-ear tasks which were completely novel for them. Another possible explanation is the visibility of the goal in the case of cup-grasping which may enhance its representational strength.

Another, minor point based on the observation of experimenter 1 during the task, may be of relevance for a dynamical approach because it reflects the role of motor routines as possibly modulating the responses comparing the two gender. Despite the overall similarity between the girls' and the boys' behaviour in the experiment, there is observational evidence that they responded somewhat differently in the near-ear task. When the experimenter was showing one of the six movements in the near-ear task with her closed hand, which somewhat resembled a fist hand, some of the boys responded with laughter and did the movements quickly with the strong fist hand(s) like in a fighting game. In addition, this attitude was seen especially in the both contra movements, where the two fist hands are crossed in front of the chest which, to some extent, looks like a personal defense which the boys commonly do in their games. Thus, from a dynamical point of view, it may be acknowledged that the boys are somehow more familiar with the movements of the near-ear task than the girls in who these reactions were not observed. Furthermore, the girls did the movements in such a way that the symmetry was preserved, especially in the 90° condition.

- **Blocks**

The test statistics, the Means and Standard Errors:

As mentioned before, four blocks were designed for each task. The results showed that blocks have a main effect on the imitation of the children (F (2.64, 383.51) = 10.19; $p<0.001$, η_p^2 = 0.07). This means that the order of carrying out the experiment in different blocks affects the imitation in children. Children's mean percentage of matching fluctuated over the four blocks (Block1 (M=0.43; SE=0.02); Block2

(M=0.38; SE=0.02); Block3 (M=0.45; SE=0.02); Block4 (M=0.40; SE=0.02), (see Table 11)). Figure 17 represents the mean values of matching over the four blocks, along with their standard error bars.

The results of the contrasts:

- Repeated contrasts represented the significant difference between Block1 and Block2 ($F(1, 145) = 10.91$; $p<0.05$, $\eta p2 = 0.07$), Block2 and Block3 ($F(1, 145) = 18.38$; $p<0.001$, $\eta p2 = 0.11$), Block3 and Block4 ($F(1, 145) = 14.94$; $p<0.001$, $\eta p2 = 0.09$).
- Moreover, a significant interaction effect of the on-hand-to-ear and cup-grasping tasks in block1 versus block2 was found ($F(1, 145) = 4.88$; $p<0.05$, $\eta p2 = 0.03$).
- Furthermore, we ran a polynomial contrast for blocks whose results revealed that there is a significant cubic trend between the four blocks ($F(1, 145) = 21.27$; $p<0.001$, $\eta p2 = 0.13$).

The post-hoc analyses:

- There was a significant difference between Block1 and Block2 (*P*= .007) but no significant differences between Block1 and Block3 (*P*= .266) and Block1 and Block4 (*P*= .338).

- There was significant differences between Block2 and Block1 (*P*= .007) and Block2 and Block3 (*P*= .000) but no significant difference between Block2 and Block4 (*P*= .615).

- There was a significant effect between Block3 and Block4 (*P*= .001).

- As mentioned above, there was a significant effect between Block4 and Block3 (*P*= .001) but no significant differences between Block4 and Block1 (*P*= .338) and Block2 (*P*= .615).

Table 11 The mean ranks and Standard Errors of matching for four blocks.

Block	Mean	Std. Error
1	.425	.018
2	.382	.021
3	.453	.018
4	.402	.019

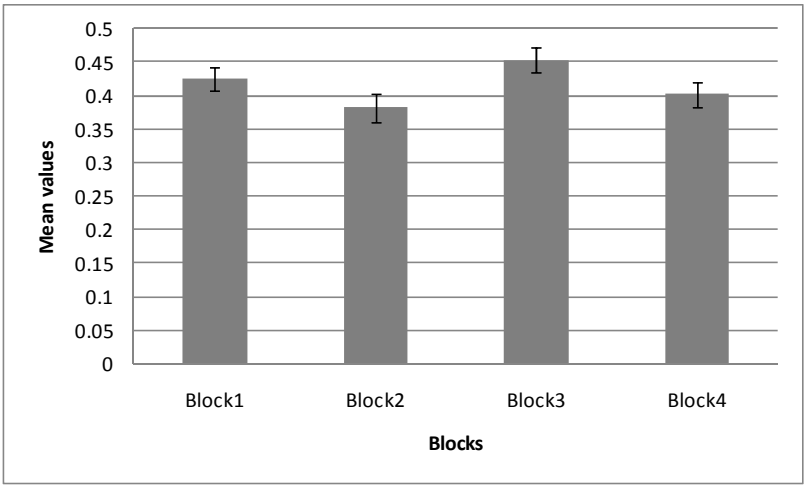

Figure 17 The mean values of matching over four blocks for children (Error bars represent SEs).

Discussion

As the results showed, the variable "block" affected children's imitative performance. The amount of matching and mirroring fluctuated across the four blocks which indicates a dynamic competition between them in the sense of two alternative order parameters (i.e. matching and mirroring). As Figure 18 shows, nothing is going on across the four blocks when the children do predominantly

mirroring in the lower age groups. But, in the higher age groups, when the conceptual matching increases and the mirroring comes in as a second option, this competition causes a zigzag pattern over the four blocks. This means that as soon as matching occurs in the children's imitative responses more regularly, the activation of these two order parameter across the four blocks will be started. The activation varies such that when matching is predominant in one block, mirroring as the other competitor increases in the next block and the continuing alternation between the two causes the zigzag shape in the older children's imitative performance over the four blocks.

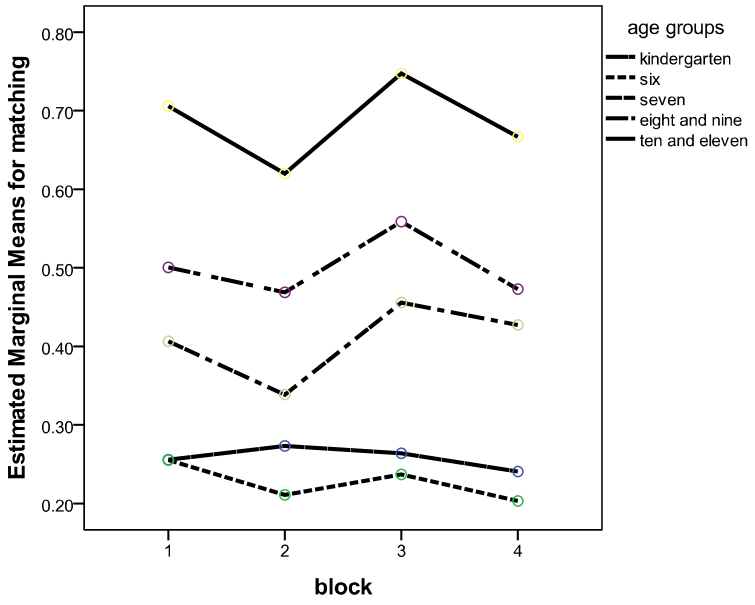

Figure 18 The amounts of matching for different age groups across the four blocks.

- **Age groups**

The test statistics, the Means and Standard Errors:

The results revealed that age had a significant effect on children's imitation and specifically, on the amount of matching in imitation ($F(4, 145) = 23.89$; $p<0.001$, $\eta_p^2 = 0.40$). Older children imitate more conceptually in comparison with younger children who imitate more perceptually. Moreover, children's mean percentage of matching increased across the five age levels except for the six years olds (Kindergarten (M=0.26; SE=0.04); six (M=0.23; SE=0.04); seven (M=0.41; SE=0.04); eight and nine (M=0.50; SE=0.04); ten and eleven (M=0.69; SE=0.04), (see Table 12)). Figure 19 represents the mean values of matching in the different age levels, along with error bars representing standard errors.

The post-hoc analyses:

- There was a significant difference in the amount of matching in children's imitation between kindergarten and eight- and nine-year-old children (*P*=.000) and between kindergarten and ten- and eleven-year-old children (*P*=.000) but no significant differences between kindergarten and six-year-old (*P*=1) and seven-year-old (P = .068) children.

- There were significant differences between six-year-old and seven-year-old children (*P*= .012) and between six-year-old and eight- and nine-year-old children (*P*=.000) and also between six-year-old and ten- and eleven-year-old children (*P*=.000) and as mentioned, no significant difference to kindergarten children (*P*=1).

- There was no significant difference between seven-year-old and eight- and nine-year-old children (*P*= .807) and a significant difference between seven-year-old and ten- and eleven-year-old children (*P*= .000).

- There was a significant difference between eight- and nine-year-old and ten- and eleven-year-old children (*P*= .007).

- As mentioned above, there were significant differences between ten- and eleven-year-old children and all other age levels.

Table 12 The mean percentages and Standard Errors of matching for the five age groups.

Age-group	Mean	Std. Error
kindergarten	.258	.038
six	.227	.039
seven	.407	.039
eight and nine	.500	.037
ten and eleven	.685	.039

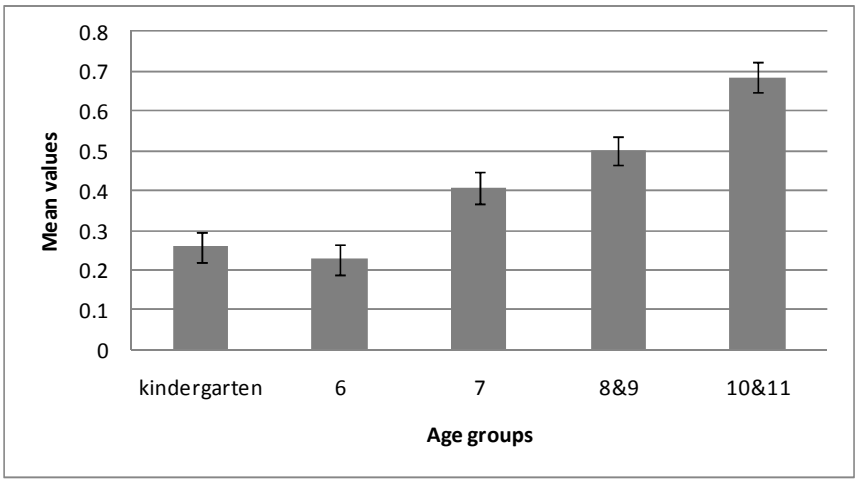

Figure 19 The mean values of percent of matching during the different age levels for children (Error bars represent SEs).

Discussion

In general, the results revealed that age significantly affects the imitation of the children; it shifts from more perceptual-based in younger children to more conceptual-based in older children, which confirmed our respective age hypothesis. Moreover, in the method part we mentioned that we tested subjects cross-sectionally and not longitudinally. This is because not only was a longitudinal study not feasible but also we did not expect any differences in the outcomes in comparison with a cross-sectional study. Furthermore, if we had run our study with the same children at different times, remembering the gestures may have had significant effects on children's imitation performance.

Moreover, in our hypothesis we had considered that the shift between mirroring and matching would occur after the age of eight years; this assumption also was confirmed to some extent, however, needs to be considered in combination with other variables. As the results showed, there is a sudden and steep increase in matching rates that may be considered as a qualitative nonlinear developmental shift between mirroring and matching. It is in addition, qualified by the

perceptual conditions. For instance, in the 0° condition, matching strongly increases between 6 and 7 years of age in all the three tasks (i.e. on-ear, near-ear, cup-grasping). Moreover, the shift between mirroring and matching for the 90° and 180° conditions occurred between 7 and 8-9 years of age (See Figures 20, 21 and 22).

Another form of non-linearity in the development of imitation in children can be seen nicely at the age of six years. As Figures 20, 21 and 22 show, six-year-old children in most of the three tasks and the conditions have a lower matching rate in comparison with kindergarten children. This fact was also confirmed in general by the mean percentage of the six-year-old children (M=.227) which was lower than that of the kindergarten children (M=.258). Except for this age (i.e. 6-years) all the other age groups show the normal developmental pattern which we expected, namely a monotonous increase in matching responses. We can interpret this non-linearity by considering the explanation that maybe the six-year-old children are faced with a kind of developmental "shock" when they enter elementary school. In a dynamical view, we may say that the environment of the school and the new educational phase temporarily pulled the children out of their regular developmental pattern. After adapting to it, which, according to our data, occurred at seven years of age, they caught up again. This "dip" is a nice illustration of a short-lived developmental non-linearity.

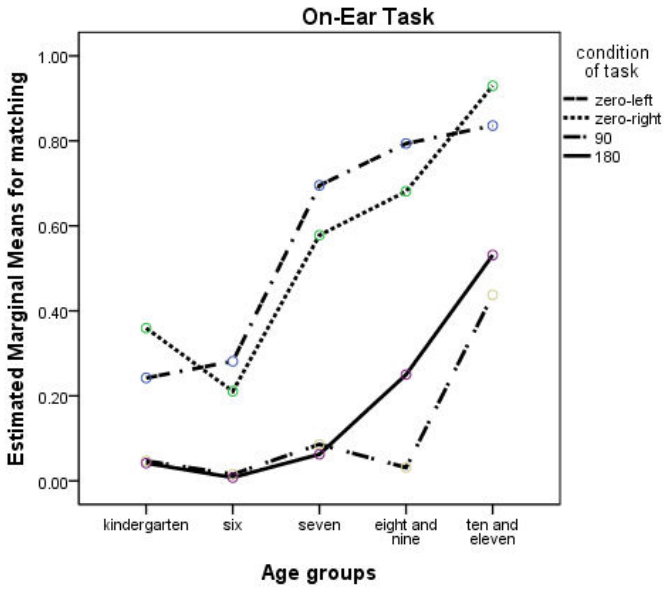

Figure 20 Amount of matching (in %) in different conditions of the on-ear task over the five age groups.

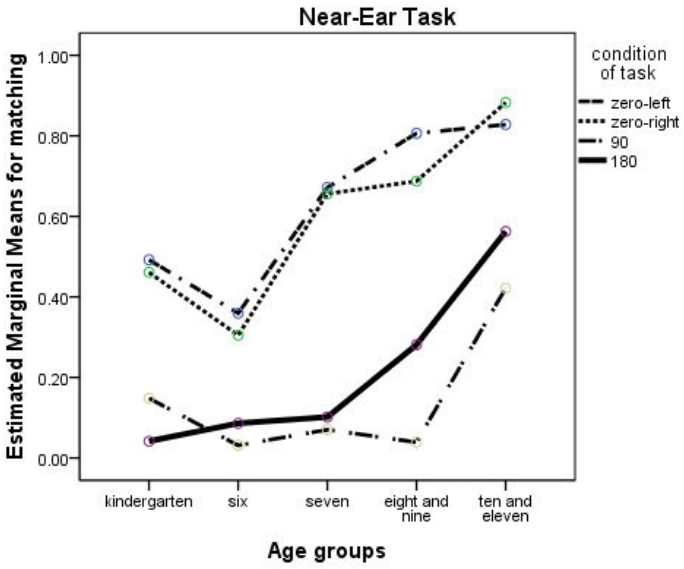

Figure 21 Amount of matching (in %) in the different conditions of the near-ear task over the five age groups.

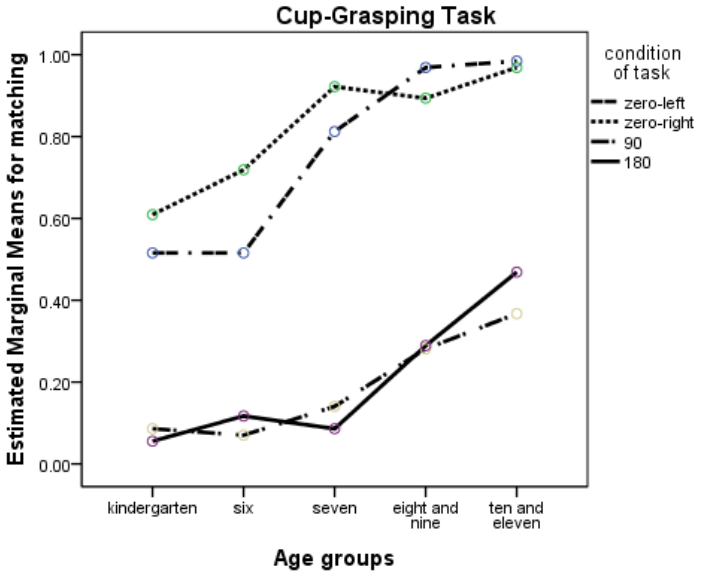

Figure 22 Amount of matching (in %) in the different conditions of the cup-grasping task over the five age groups.

- **Perspective conditions**

The test statistics, the Means and Standard Errors:

For the four perspective conditions in this study we found a significant effect on children's imitation ($F (3, 145) = 66.78$; $p<0.001$, $\eta_p^2 = 0.58$). Descriptively, children's mean percentage of matching was almost the same for the zero-left and zero-right conditions; however, these two conditions showed a much higher mean percentage of matching than the 90 and 180 degrees conditions. Moreover, children's mean percentage of matching in 180 degree was higher than in 90 degree (Zero-right (M=0.66; SE=0.03); zero-left (M=0.65; SE=0.03); 90° (M=0.15; SE=0.03); 180° (M=0.20; SE=0.03), (see Table 13)). Figure 23 presents the mean values of matching in the four different perspective conditions, along with error bars representing standard errors.

The post-hoc analyses:

- There was no significant difference between zero-left and zero-right degrees conditions (*P*=1) and significant differences between zero-left and 90 degrees (*P*= .000) and zero-left and 180 degrees (*P*= .000) conditions.

- There were significant differences between zero-right and 90 degrees conditions (*P*= .000) and zero-right and 180 degrees conditions (*P*= .000).

- There was no significant difference between 90 and 180 degrees conditions (*P*= 1).

- As mentioned above, 180° was significantly different to zero-left (*P*= .000) and zero-right (*P*= .000) degrees and was not significantly different to 90 ° (*P*= 1).

Table 13 The mean ranks and Standard Errors of matching for four conditions.

Condition	Mean	Std. Error
zero-left	.654	.034
zero-right	.658	.034
90	.152	.034
180	.199	.034

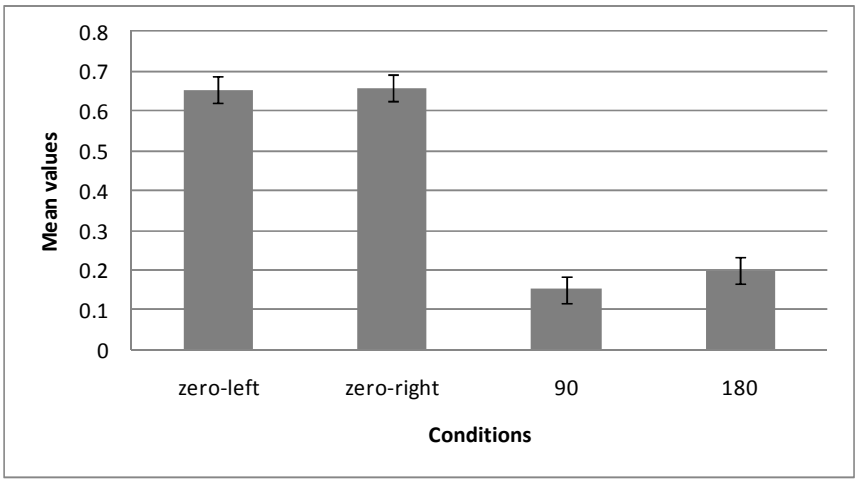

Figure 23 The mean values of matching in different conditions

for children (Error bars represent SEs).

Discussion

Overall, children's imitation in the four perspective conditions of the tasks (i.e. Zero-right, zero-left, 90° and 180°) was significantly different. Thus, the hypothesis that perspective modulates matching rates was confirmed.

More specifically, the zero-right and zero-left degrees conditions were not significantly different from each other in the amount of matching as we had considered in our hypothesis. The 0° conditions showed higher matching rates than 90°and 180°. This may be because in the 0° conditions matching can be achieved by a simple parallel shift between imitator and model whereas in 90° and 180° matching requires a more effortful contra-lateral switch. This means that when a younger child does matching in the zero-degree conditions it cannot be said that this child is imitating conceptually. Rather, this can be considered as a consequence of the parallel transformation which leads to, for instance, RI of the child to RI of the model in the zero-degree conditions. This finding is interesting from a dynamical point of view in the following sense. As internal

(e.g., conceptual) as well as external (e.g., spatial perspective) factors may lead to similar behaviors (responding to RI with RI) and as external factors may do so earlier in the development than internal ones, the external ones may function as a stepping stone or precursor towards the internal one. In other words, since a younger child has already experienced her/himself responding in a "mapping" kind of way in an "easier" spatial setting (the zero degree conditions) this might to some degree facilitate a mapping response in a more demanding spatial setting (the 90 and 180° conditions). Although merely on the motor level (responding with RI to RI) it is known from other tasks such as the A-not-B error also (Thelen et al. 2001) that such seemingly superficial external factors may play a role in children's later performance which then is more based on internal, cognitive factors.

Moreover, the 90º and 180º conditions yielded similar effects in children's imitation. As mentioned in the discussion part of the age groups, the shift between mirroring and matching in the 90° and 180° conditions occurs between seven and eight-nine years of age in comparison with the zero-degree conditions which show this shift between six and seven years of age (See Figure 20, 21, 22). Especially the 90° condition seems to be difficult for the younger children. Why might this be so? Firstly, the intermediate condition of 90° causes a more difficult to deal with perceptual symmetry which leads to less matching rates. Thus, it seems that matching in 90º can only be achieved through conceptually based imitating in contrast to the zero-degree conditions in which the matching could be considered as a parallel shift. This parallel shift, however, is not available in the 90° (and in the 180°) condition. Secondly, the lower matching rate in the 90º condition may be because of the little space between the experimenter and the child. In the 180 º and also in the zero-degree conditions there is enough space between the child and the experimenter whereas in the 90º condition they sit much closer together. This deficit in the space may affect the results of the 90º condition. Thirdly, the higher familiarity with the zero (and also with the 180°) perspective may cause a difference between these conditions and the 90º condition. Children usually learn the

simple life skills in 180° or even in zero degree perspectives and it is very rare that parents,teachers or even their friends teach or show them something in a 90° angle. So, this unfamiliarity with this perspective may lead to the observed results. Lastly, it seems that the children did more effector responses during the cup-grasping task in the 90° condition: For instance, the right-contra movement of the experimenter led to a right-ipsi movement of the child. It seems that in the specific task of cup-grasping where the cups are located in front of the child and the experimenter, this kind of response (i.e. effector) is the result of perceptual symmetry which occurs by considering the symmetry line between the two cups (see Figure 24).

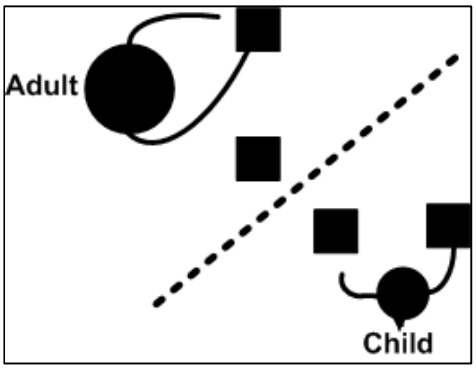

Figure 24 Perceptual symmetry occurs in the cup-grasping task, 90°, in the case of an "effector" response.

In the following, significant interactions between independent variables are presented. Mostly, there were 2-way interactions. Only one 3-way and one 4-way interaction occurred.

- **Task*Age-group**

The test statistics, the Means and Standard Errors:

The results showed that the interaction between different tasks and age groups has a significant effect ($F (6.79, 245.96) = 3.62$; $p=0.001$, $\eta_p^2 = 0.09$). The mean percentages and standard errors of matching for the two-way interaction of task and age-group are shown in Table 14.

The results of the contrasts:

The interaction between task and age groups for the on-hand-to-ear and cup-grasping ($F (4, 145) = 4$; $p<0.05$, $\eta p2 = 0.10$) and also near-hand-to-ear and cup-grasping ($F (4, 145) = 3.26$; $p<0.05$, $\eta p2 = 0.08$) tasks was found significant. Matching rates were highest in the cup-grasping task as compared to the hand-to-ear tasks and among those, the near-ear condition led to higher matching rates than the on-ear condition. This pattern holds until age 8-9 years, whereas in the 11-12 year old children, matching rates for the hand-to-ear tasks had caught up with those of the cup-grasping task.

Table 14 The mean ranks and Standard Errors of matching for age-group*task.

Age-group	Task	Mean	Std. Error
kindergarten	OE	.173	.046
	NE	.286	.044
	CUP	.317	.038
six	OE	.129	.047
	NE	.195	.045
	CUP	.355	.038
seven	OE	.355	.047
	NE	.375	.045
	CUP	.490	.038
eight and nine	OE	.439	.044
	NE	.454	.042
	CUP	.608	.036
ten and eleven	OE	.684	.047
	NE	.674	.045
	CUP	.697	.038

- **Task*Condition**

The test statistics, the Means and Standard Errors:

The interaction between different tasks and conditions was found significant ($F(5.09, 245.96) = 8.41$; $p < 0.001$, $\eta p2 = 0.15$). The mean percentages and standard errors of matching in the task*condition interaction are shown in Table 15.

The results of the contrasts:

Significant effects of interaction between different tasks and conditions were found for OE and cup-grasping tasks ($F(3, 145) = 10.77$; $p<0.001$, $\eta p2 = 0.18$) and NE and cup-grasping tasks ($F(3, 145) = 9.78$; $p<0.001$, $\eta p2 = 0.17$). Whereas in the 90° and 180° conditions, matching rates were uniformly low, they varied stronger among the tasks in the two 0° conditions.

Table 15 The mean ranks and Standard Errors of matching for condition*task.

Condition	Task	Mean	Std. Error
zero-left	OE	.570	.041
	NE	.632	.039
	CUP	.759	.034
zero-right	OE	.552	.041
	NE	.598	.039
	CUP	.823	.034
90	OE	.123	.042
	NE	.142	.040
	CUP	.189	.034
180	OE	.179	.041
	NE	.215	.040
	CUP	.203	.034

- **Block*Age-group**

The test statistics, the Means and Standard Errors:

The 2-way interaction between the four blocks and five different age groups had significant effect on children's imitation ($F(10.58, 383.51) = 1.86$; $p<0.05$, $\eta p2 = 0.05$). The mean ranks and standard errors of matching for the interaction of block and age-group are shown in Table 16.

The results of the contrasts:

The interaction of block and age-group was found significant only for Block2 versus Block3 ($F(4, 145) = 2.60$; $p<0.05$, $\eta p2 = 0.07$). Overall, the alternating pattern between matching and mirroring only occurred in the older children but not in the younger ones, due to their generally low matching rates.

Table 16 The mean ranks and Standard Errors of matching for age-group*block.

Age-group	Block	Mean	Std. Error
kindergarten	1	.256	.040
	2	.273	.046
	3	.264	.041
	4	.240	.042
six	1	.255	.041
	2	.211	.046
	3	.237	.041
	4	.203	.042
seven	1	.406	.041
	2	.339	.046
	3	.456	.041

Table 16 (Cont.)

Age-group	Block	Mean	Std. Error
	4	.427	.042
eight and nine	1	.501	.039
	2	.469	.044
	3	.559	.039
	4	.473	.040
ten and eleven	1	.706	.041
	2	.620	.046
	3	.747	.041
	4	.667	.042

- **Task*Block*Condition:**

Only one 3-way interaction reached significance, namelys the interaction between tasks*blocks*conditions (F (16.54, 799.39) =3.48; $p<0.001$, $\eta p2$ =0.07). The mean values and standard errors of matching for this three-way interaction are shown in Table 17.

The results of the contrasts:

The 3-way interaction of task and block and condition was significantly different for OE and cup-grasping for Block1 vs. Block2 (F (3, 145) = 6.73; $p<0.001$, $\eta p2 = 0.12$), Block2 vs. Block3 (F (3, 145) = 11.04; $p<0.001$, $\eta p2 = 0.19$), and Block3 vs. Block4 (F (3, 145) = 5.12; $p<0.01$, $\eta p2 = 0.10$). Moreover, the interaction of NE and the cup-grasping tasks was significantly different for Block1 vs. Block2 (F (3, 145) = 4.56; $p<0.01$, $\eta p2 = 0.09$), Block2 vs. Block3 (F (3, 145) = 5.85; $p<0.01$, $\eta p2 = 0.11$), and Block3 vs. Block4 (F (3, 145) = 6.89; $p<0.001$, $\eta p2 = 0.12$).

Table 17 **The mean ranks and Standard Errors of matching for condition*task*block.**

Condition	Task	Block	Mean	Std. Error
zero-left	OE	1	.541	.046
		2	.481	.053
		3	.683	.045
		4	.574	.047
	NE	1	.629	.048
		2	.589	.054
		3	.729	.049
		4	.580	.046
	CUP	1	.739	.040
		2	.819	.042
		3	.716	.043
		4	.764	.039
zero-right	OE	1	.616	.046
		2	.490	.053
		3	.544	.045
		4	.558	.047
	NE	1	.606	.048
		2	.553	.054
		3	.636	.049
		4	.599	.046
	CUP	1	.764	.040
		2	.856	.042

Table17(Cont.)

Condition	Task	Block	Mean	Std. Error
Zero-right	CUP	3	.871	.043
		4	.799	.039
90	OE	1	.169	.047
		2	.094	.054
		3	.125	.046
		4	.106	.048
	NE	1	.194	.049
		2	.106	.055
		3	.131	.050
		4	.138	.047
	CUP	1	.225	.040
		2	.113	.043
		3	.288	.044
		4	.131	.040
180	OE	1	.180	.046
		2	.156	.054
		3	.206	.045
		4	.174	.048
	NE	1	.187	.048
		2	.188	.054
		3	.274	.049
		4	.210	.046
	CUP	1	.247	.040
		2	.144	.042
		3	.229	.044
		4	.193	.040

Lastly, the results of the contrasts revealed a 4-way interaction of task, block, age-group and condition, for the near-hand-to-ear task vs. cup-grasping task and over Block3 vs. Block4 ($F(12, 145) = 2.22$; $p<0.05$, $\eta p2 = 0.16$).

5.1.3 Non-parametric tests:

The tests of normality for the combination of the three tasks and the five age groups revealed that the data were not normally distributed since the results of the Kolmogorov-Smirnov Test and Shapiro-Wilk Test were all $p < .05$ for all the age levels in all the tasks (i.e. OE, NE, Cup-grasping) (See appendix B for the normality tables and plots). Therefore, non-parametric tests were conducted for related (within-subjects) and unrelated (between subjects) variables. We ran these non-parametric test results in order to back up the parametric ANOVA-results.

The results of the non-parametric test showed that there was a main effect of task ($\chi^2(2) = 43.56$, $p < .001$) as the ANOVA-results had already shown before.

The results of the non-parametric test also revealed that there was a main effect of the on-hand-to-ear task across the four blocks, ($\chi^2(3) = 22.08$, $p < .001$).

Following up, in this general result for the OE task, age-wise analyses were conducted (with Bonferroni corrected level of significance of P=.01). It was found that the block effect was strongest for seven ($\chi^2(3) = 9.45$, $p = .024$) and for age ten and eleven ($\chi^2(3) = 11$, $p = .012$) (See Table 18).

Moreover, a main effect of the near-hand-to-ear task across the four blocks was found, ($\chi^2(3) = 10.20$, $p = .017$). By considering the Bonferroni corrected level of significance of P=.01, the block effect was marginally significant for seven-year-old children in the near-hand-to-ear task ($\chi^2(3) = 10.76$, $p = .013$) (See Table 19).

Lastly, the results of the non-parametric tests revealed that there was no significant effect of the four blocks in the cup-grasping task (P=0.24).

As we can see, the results of the non-parametric tests for the three tasks across the four blocks by considering age levels in the analyses, confirmed the ANOVA-results in which the interaction of task* age-group and also, the interaction of block*age-group was found significant.

The non-parametric test results for the four conditions in the three tasks showed significant effects of the zero-right (χ^2 (2) = 33.70, p < .001) and zero-left (χ^2 (2) = 16.58, p < .001) conditions in the three tasks. However, 90° and 180° conditions did not show any significant effect in the three tasks, (*P*=.276) and (P=.246) respectively. These results confirm the mixed-ANOVA results in which the two zero conditions had yielded not significant differences between each other but with 90 and 180 degrees conditions and vice versa.

In general, the results of the non-parametric tests were in line with the ANOVA-results.

Table 18 non-parametric test statistics for OE task, age-wise analyses across the 4 blocks.

kindergarten	**N**	33
	Chi-square	5.281
	df	3
	Asymp. Sig.	.152
six	**N**	32
	Chi-square	5.000
	df	3
	Asymp. Sig.	.172
seven	**N**	32
	Chi-square	9.451
	df	3
	Asymp. Sig.	.024
eight and nine	**N**	36
	Chi-square	5.220
	df	3
	Asymp. Sig.	.156
ten and eleven	**N**	32
	Chi-square	10.971
	df	3
	Asymp. Sig.	.012

Table 19 non-parametric test statistics for NE task, age-wise analyses across the 4 blocks.

kindergarten	**N**	33
	Chi-square	.492
	df	3
	Asymp. Sig.	.921
six	**N**	32
	Chi-square	.363
	df	3
	Asymp. Sig.	.948
seven	**N**	32
	Chi-square	10.761
	df	3
	Asymp. Sig.	.013
eight and nine	**N**	36
	Chi-square	5.297
	df	3
	Asymp. Sig.	.151
ten and eleven	**N**	32
	Chi-square	5.301
	df	3
	Asymp. Sig.	.151

5.2 Adult control group:

The Iranian adult control group was the reference group for the analysis of the child sample. As mentioned in part 3.1, the control group consisted of 22 adults (12 female and 10 male) with an age range between 17.47 and 34.00 years. The mean percentages and standard deviations of the adults' imitations with respect to matching, mirroring, effector and the other movements as our measures in all conditions and with considering the average of the four blocks in on-hand-to-ear, near-hand-to-ear and cup-grasping tasks are shown in Table 20, Table 21 and Table 22, respectively.

Table 20 The M percentages and SDs of matching /mirroring/effector/other across all conditions and blocks in the On-Hand-To-Ear task (Adults).

condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
zero-left	N	5	5	5	5
	Mean	.9125	.0875	.0000	.0000
	Std. Deviation	.19566	.19566	.00000	.00000
zero-right	N	5	5	5	5
	Mean	.9625	.0125	.0000	.0250
	Std. Deviation	.05590	.02795	.00000	.05590
90	N	6	6	6	6
	Mean	.0833	.8958	.0208	.0000
	Std. Deviation	.10206	.09410	.05103	.00000

Table 20 (Cont.)

condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
180	N	6	6	6	6
	Mean	.3542	.6354	.0104	.0000
	Std. Deviation	.44135	.43376	.02552	.00000
Total	N	22	22	22	22
	Mean	.5455	.4403	.0085	.0057
	Std. Deviation	.44912	.44466	.02922	.02665

Table 21 The M percentages and SDs of matching /mirroring/effector/other across all conditions and blocks in the Near-Hand-To-Ear task (Adults).

condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
zero-left	N	5	5	5	5
	Mean	.9000	.1000	.0000	.0000
	Std. Deviation	.22361	.22361	.00000	.00000
zero-right	N	5	5	5	5
	Mean	.9875	.0125	.0000	.0000
	Std. Deviation	.02795	.02795	.00000	.00000
90	N	6	6	6	6
	Mean	.2604	.7396	.0000	.0000
	Std. Deviation	.24500	.24500	.00000	.00000
180	N	6	6	6	6
	Mean	.3438	.6563	.0000	.0000
	Std. Deviation	.46225	.46225	.00000	.00000
Total	N	22	22	22	22
	Mean	.5938	.4063	.0000	.0000
	Std. Deviation	.42859	.42859	.00000	.00000

Table 22 The M percentages and SDs of matching /mirroring/effector/other across all conditions and blocks in the cup-grasping task (Adults).

condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
zero-left	N	5	5	5	5
	Mean	.8500	.1375	.0000	.0125
	Std. Deviation	.30169	.27386	.00000	.02795
zero-right	N	5	5	5	5
	Mean	.9750	.0000	.0000	.0250
	Std. Deviation	.05590	.00000	.00000	.05590
90	N	6	6	6	6
	Mean	.4479	.4271	.0521	.0729
	Std. Deviation	.27787	.22156	.10013	.10013
180	N	6	6	6	6
	Mean	.2917	.6250	.0521	.0313
	Std. Deviation	.37011	.36228	.07307	.03423
Total	N	22	22	22	22
	Mean	.6165	.3182	.0284	.0369
	Std. Deviation	.38830	.34552	.06605	.06297

In order to show how adults imitate the movements based on different situations that we had designed in our experiment such as different tasks, conditions and blocks, we first provide bar charts which show the amount of matching, mirroring, imitation of the effector and other imitated movements which are

calculated based on these independent variables. For instance, Figure 25 shows the adults' responses to the experimenter's movements in the on-hand-to-ear, near-hand-to-ear and cup-grasping tasks. Moreover, Figure 26 and Figure 27 show the different kinds of adults' responses in the four perspective conditions (i.e. 180°, 90°, zero-left, zero-right) and the four blocks, respectively.

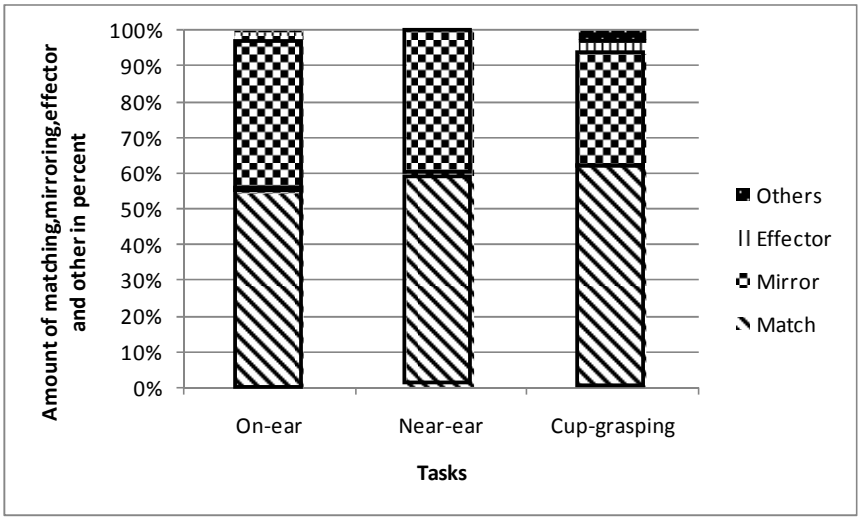

Figure 25 Matching, mirroring, effector and other movements' imitation over different tasks (Adults).

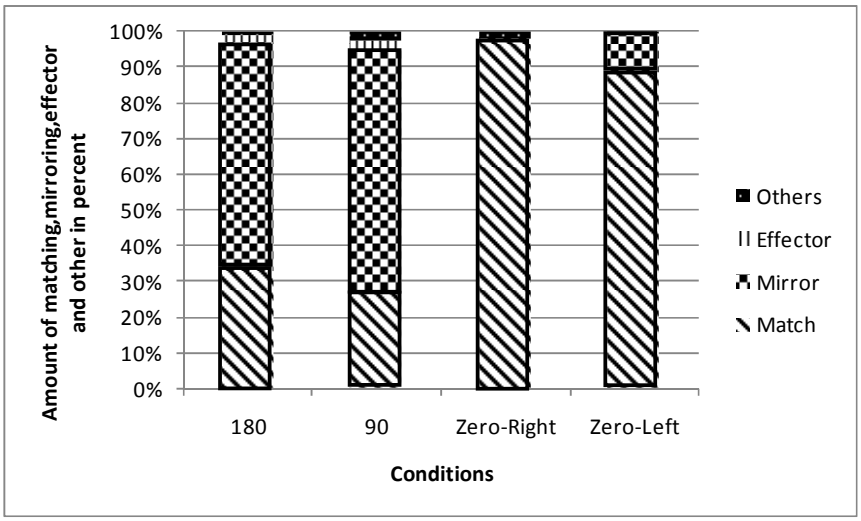

Figure 26 Matching, mirroring, effector and other movements' imitation over different conditions (Adults).

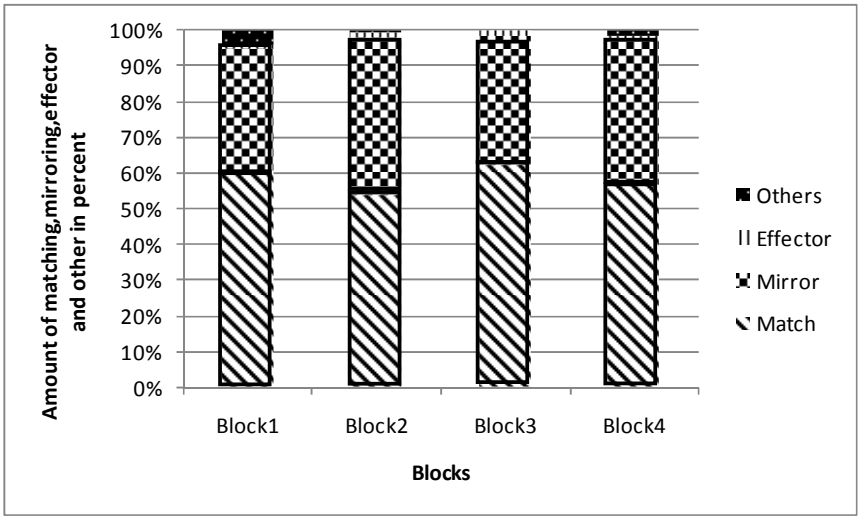

Figure 27 Matching, mirroring, effector and other movements' imitation over the four blocks (Adults).

The results of the mixed ANOVA for the Iranian adult control group showed that there were no main effects of task (F (1.21, 16.88) = 1.20; p = 0.30, ηp2 = 0.08), block (F (1.92, 26.81) = 2.11; p = 0.14, ηp2 = 0.13) or gender (F (1, 14) = 3.50; p= 0.08, ηp2 = 0.20). It should be mentioned that since the Mauchly's test of sphericity was statistically significant for tasks (*P*=.001) and blocks (*P*=007), the Greenhouse-Geisser corrected df's and F-values arereported in the following. Moreover, since gender (as between-subject variable) and task (as within-subject variable) have significant interactions with the four perspective conditions we have maintained them in reporting the results. Thus, the main mixed ANOVA is over task (i.e. within-subject variable), condition and gender (i.e. between-subject variable) as independent variables and matching as dependent variable. Furthermore, the following analyses will collapse over the four blocks because block (as within-subject variable) has no significant effect.

Perspective conditions

The results of the mixed ANOVA showed that perspective condition is the only factor that has a main effect on the adults' imitation in this experiment (F (3, 14) =20.51; p<0.001, η_p^2 =0.82). Adults' mean percentage of matching had the highest amount in the zero-right degree condition (M=.977, SE=.085) as well as in the zero-left degree condition (M=.861, SE=.085). In contrast to the zero degrees conditions, 180° was shown to have a lower mean percentage of matching (M=.330, SE=.076). Moreover, the mean percentage of matching in 90° was the lowest amount in comparison with all other conditions (M=.264, SE=.076) (see Table 23). Figure 28 presents the mean values of matching in adults' imitation in the four conditions, along with error bars representing standard errors.

Table 23 The mean ranks and Standard Errors of matching for four conditions (Adults).

Condition	Mean	Std. Error
zero-left	.861	.085
zero-right	.977	.085
90	.264	.076
180	.330	.076

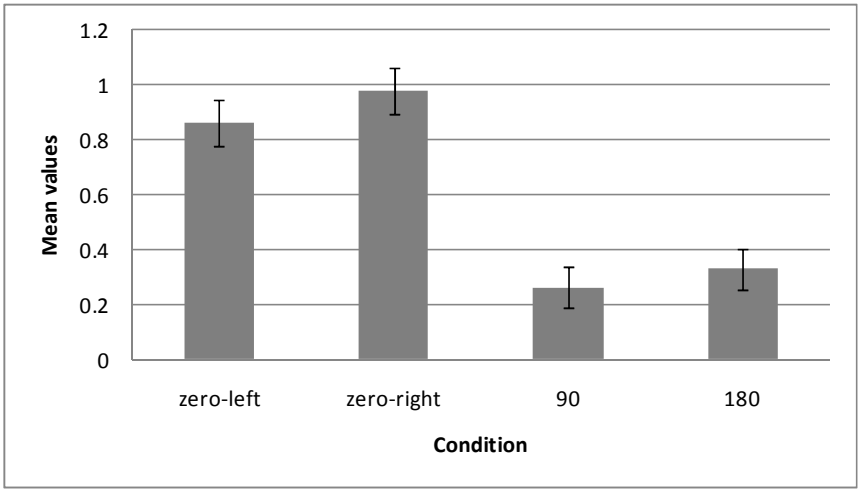

Figure 28 The mean values of adults' matching values (in percentage) in the different perspective conditions (Error bars represent SEs).

Gender*Condition

The 2-way interaction between gender and condition was found significant ($F(3, 14) = 5.40$; $p<0.05$, $\eta_p^2 = 0.54$). Females' mean percentage of matching in zero-right (M=.965, SE=.107) was almost the same as males' mean percentage in this condition (M=.990, SE=.131). This amount of matching in females remained high (M=.993, SE=.107) whereas it dropped somewhat in males

(M=.729, SE=.131). in the zero-left degree condition. The mean percentages of matching for females and males in 90° and 180° conditions were considerably lower in comparison with the zero degree conditions. Females' mean percentage in 90° was (M=.153, SE=.107) which was lower than males' (M=.375, SE=.107). Moreover, female adults' mean percentage of matching (M=.021, SE=.107) in 180° was dramatically lower than that of males (M=.639, SE=.107) (see Table 24). Females hardly matched at all in 180°. Figure 29 represents the mean values of matching in interaction with gender and condition, along with error bars representing standard errors.

Table 24 The mean percentages and Standard Errors of matching for condition*gender (Adults).

Condition	Gender	Mean	Std. Error
zero-left	male	.729	.131
	female	.993	.107
zero-right	male	.990	.131
	female	.965	.107
90	male	.375	.107
	female	.153	.107
180	male	.639	.107
	female	.021	.107

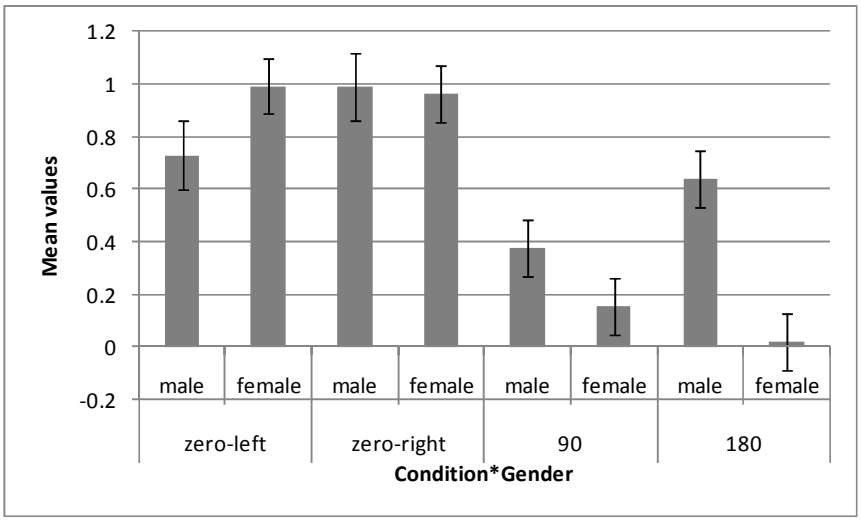

Figure 29 The mean values of adults' matching

in the condition*gender interaction (Error bars represent SEs).

Task*Condition

The interaction of task and condition was also significant (F (3.62, 16.88) = 3.47; $p<0.05$, $\eta_p^2 = 0.43$). The interaction of near-hand-to-ear task and zero-right condition showed the highest (M=.990, SE=.101) and on-hand-to-ear and 90° (M=.083, .074) showed the lowest means of matching (see Table 25). The mean values of adults' matching along with error bars which representing standard errors are shown in Figure 30.

Furthermore, in the analyses of the adult control group, other interactions were all insignificant.

Table 25 The mean percentagess and Standard Errors of matching for condition*task (Adults).

Condition	Task	Mean	Std. Error
	OE	.891	.082
zero-left	**NE**	.875	.101
	CUP	.818	.109
	OE	.964	.082
zero-right	**NE**	.990	.101
	CUP	.979	.109
	OE	.083	.074
90	**NE**	.260	.090
	CUP	.448	.098
	OE	.354	.074
180	**NE**	.344	.090
	CUP	.292	.098

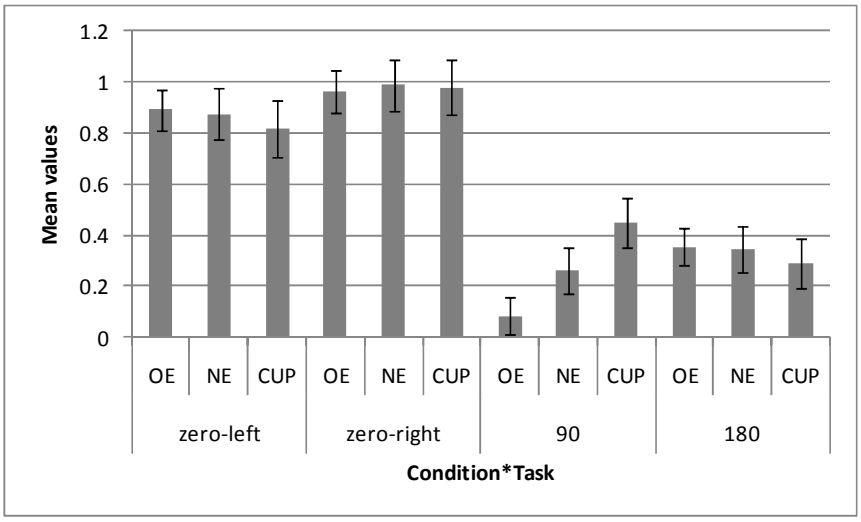

Figure 30 The mean values of adults' matching in the condition*task interaction (Error bars represent SEs).

The results of the contrasts for the adult control group with considering simple contrast for the tasks (within subj. var.), conditions (between subj. var.) and gender (between subj. var.) and repeated contrast for blocks (within subj. var.) are presented in the following:

- The contrasts between all the three tasks were found insignificant.

- The two-way interaction of task and condition was found significant with respect to the on-hand-to-ear and cup-grasping tasks ($F (3, 14) = 6.13$; $p<0.01$, $\eta_p^2 = .57$).

- No significant repeated contrast for the four blocks was found.

- The three-way interaction of task, block and condition between near-hand-to-ear and cup-grasping task and over block 2 and block 3 was found significant ($F (3, 14) = 4.24$; $p<0.05$, $\eta_p^2 = .48$).

- The three-way interaction of task, block and gender between on-hand-to-ear and cup-grasping tasks and over block 3 and block 4 was found significant ($F (1, 14) = 8.07$; $p<0.05$, $\eta_p^2 = .37$).

- The four-way interaction of task, block, condition and gender was significant in the contrast between on-hand-to-ear and cup-grasping over block 3 and block 4 ($F (3, 14) = 10.55$; $p<0.01$, $\eta_p^2 = .69$). Besides, this interaction was significant between near-hand-to-ear and cup-grasping over block 2 and block 3 ($F (3, 14) = 6.06$; $p<0.01$, $\eta_p^2 =.57$) and also, block3 and block 4 ($F (3, 14) = 4.83$; $p<0.05$, $\eta_p^2 =.51$).

In the following, the results of the Bonferroni-corrected post-hoc tests for tasks, blocks, conditions and gender in adults' imitation with considering matching as dependent variable are reported:

Tasks

- All the comparisons between the three tasks were found insignificant. In detail, adults' matching in the on-hand-to-ear task was not significantly different from the near-hand-to-ear task (*P*=.136). This insignificancy was also found for the on-hand-to-ear and cup-grasping tasks (*P*=.540), near-hand-to-ear and cup-grasping tasks (*P*=1).

Blocks

- Adults' matching in imitation was not significantly different over the four blocks, i.e. block 1 and block 2 (*P*=.872), block1 and block 3 (*P*=1), block 1 and block 4 (*P*=1), block 2 and block 3 (*P*=.535), block 2 and block 4 (*P*=1), block 3 and block 4 (*P*=1).

Conditions

- There was a significant difference in the amount of matching in adults' imitation between the zero-right degree condition and 90 (*P*=.000) and also between zero-right and 180 degrees (*P*=.000). However, the difference between the zero-right and zero-left degree condition was insignificant (*P*=1).

- There was a significant difference between zero-left and 90° (*P*=.001) and also, between zero-left and 180° (*P*=.002).

- Adults' imitation was not significantly different in 90 and 180 degrees (*P*=1).

Gender

- There was no significant effect of gender in adults' imitation overall (*P*=.082).

In the following, we will not discuss the results of the adults by themselves but in comparison with the results of the children.

5.3 Comparison of children and adults:

In order to compare adults and children, we do not think it makes sense to formally test adults and all children by creating a dummy variable "adults" vs. "children". To us, it makes more sense to compare them qualitatively in a developmental perspective. As the results demonstrated, all the within- and between-subject variables (e.g. task, block, age and condition) except gender had main effects on the imitation of the children. Of these independent variables only condition had a significant effect on the adults' imitation performance. Moreover, in the case of adults, the two-way interactions of gender*condition and task*condition significantly affected their imitation.

Firstly, in order to compare children' and adults' imitation, we qualitatively compared their mean values in different conditions which had been proved to have main effects on the imitation of both groups (i.e., children and adults). As Figure 31 shows, adults do more matching in the four different conditions in comparison with children. In addition, without consideration of the difference between their matching rates, it can be seen from this figure that the pattern of imitation is similar for children and adults in the different conditions. This means that matching had its highest rate in the two zero degree conditions and its lowest rate in the 90° and 180° conditions.

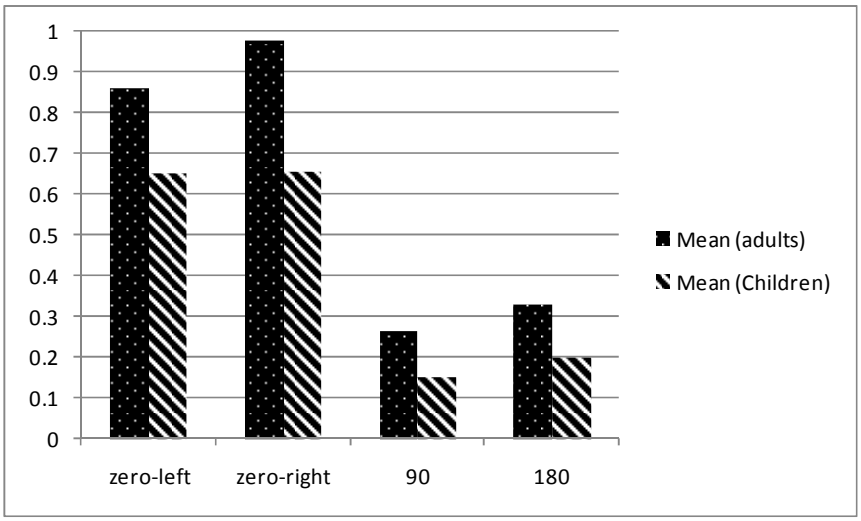

Figure 31 Comparison of the mean values (i.e. matching) of adults vs. children in different perspective conditions.

This result for the adults is surprising since we had expected equally high matching rates in all conditions. However, as pointed out above, it seems that adults, like children, distinguish roughly between the two "parallel" conditions (right and left 0°) and the two "opposite" conditions (90° and 180°).

Since the two-way interaction of task*condition was found as a significant effect for both children and the adult control group, we consider this effect also as a comparison factor between these two groups. In general, adults do much more matching in all the tasks and conditions than children do, except in the 90° condition of the on-ear task. For the zero-degree conditions, specifically zero-right, the matching rate is almost near 1 which is much higher than the children's rate of matching in the three tasks. Moreover, the 90° and 180° conditions had lower matching rates in comparison with the zero-degree conditions in both children and adults. Adults' performance in the cup-grasping task in 90° condition showed the highest rate in comparison with matching rates of children and adults in the other tasks in this condition (See Figure 32).

Furthermore, as the results showed there was no gender effect found for the children; in the adults however, the interaction of gender*condition had a significant effect in their imitations.

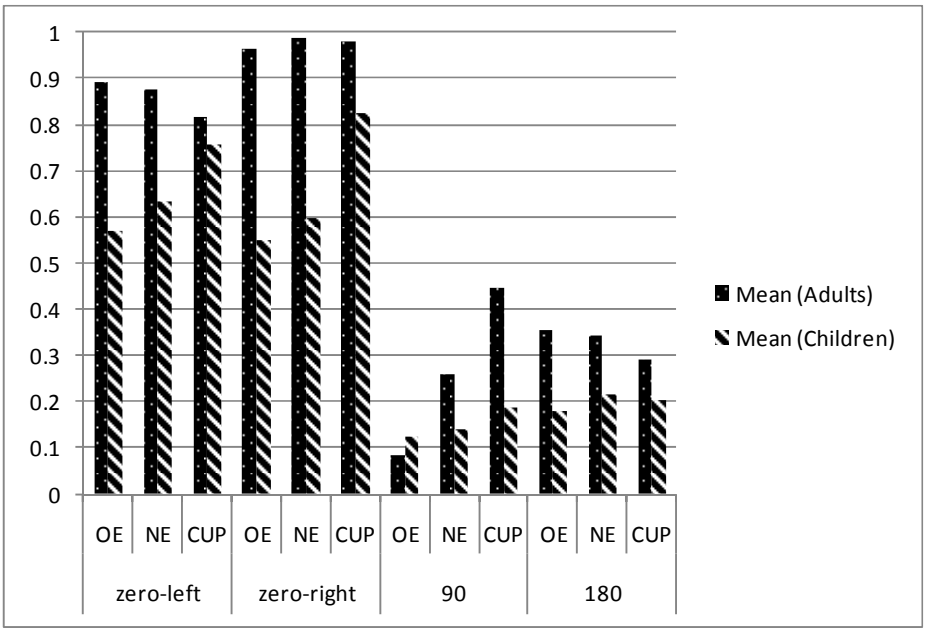

Figure 32 Comparison of the mean values (matching) of the adults vs. children for the task*condition interaction.

Overall, contrary to what we had hypothesized, adults' imitations were found to be much more continuous with those of the children, only at higher levels of matching in general. This means that there may not be a single order parameter, i.e., matching, as the target of imitative development but rather two main order parameters, i.e., matching and mirroring. The appearance of these order parameters depends on other than only internal, i.e., cognitive conceptual factors, namely external factors such as spatial perspective. For instance, in the 0 degree conditions the difference between matching and mirroring is actually blurred because this condition is easier, as mentioned in the specific discussion on "condition". Thus, it shows that considering condition is really important in order to compare the imitation performance of children and adults. Secondly, this point is important in dynamic systems since it shows external variables (i.e.

perceptual perspective) can facilitate a more mature cognitive response like matching over mirroring. It means that the 0 degree conditions are important since, as the results showed, even the younger children can first achieve this transition in their imitation before they can achieve it in more challenging situations (i.e. 90° or 180°), where the support from the same perspective is missing. As the results of the children showed, the shift between mirroring and matching for zero degree conditions occurs earlier, at the age between six and seven years, as compared with the shift in 90° and 180° where it occurred later, at the age between seven and eight and nine years, which is fully consistent with a dynamic systems perspective.

Moreover, gender seems to modulate imitative behavior in the adults but not in the children. Female adults match less in the "opposite" conditions than male adults. This means that beyond the age of 12 years, which is where our child sample stopped, other factors become important for females to a certain extent in certain spatial settings. These factors will be discussed in more details in the following general discussion.

CHAPTER 6

GENERAL DISCUSSION

In this chapter we generally compare the most significant results of our study with the he literatures that we reviewed in Chapter 2. Then, we discuss our findings from a dynamic point of view.

First of all, the results of our study confirmed the theory of goal-directed imitation (GOADI) (Wohlschläger et al. 2003). As pointed out in the literature review part, one of the most important claims of this theory is about imitation of goals. Based on the GOADI theory, the goals are mostly imitated and this is because of the fact that the imitator decomposes the observed model's movements in a hierarchical order in which goals are located higher in the hierarchy than other features. Thus, they claim that movements without end goals or with clear goals are imitated better than movements with less clear, ambiguous goals. In our study, as explained in detail in the previous parts, the effects of goals on children's imitation performance were investigated in two separate tasks, i.e. a hand-to-ear task (on-ear and near-ear) and a cup-grasping task. We considered the amount of matching in order to estimate to what extent the goals and the movements will be imitated by children. As the results showed, the three tasks were significantly different and the amount of matching in the on-ear task was the least, then near-ear and finally, the cup-grasping task had the highest matching rate. With considering theses results and the assumptions of the GOADI theory together, we can conclude that the cup-

grasping task, in which the goals were non-ambiguous and decidedly clear, had the highest rate of matching. On the other hand, the on-ear task showed the lowest amount of matching. This finding confirms the point that when the movements are less clear (e.g., the own ear is not visible) this leads to more errors (less matching) in imitation of the movements. The near-ear task is a task without a true end goal. It showed a higher amount of matching as compared to the on-ear task. Thus, from this comparison between the on-ear and near-ear tasks, it can be clearly seen that the movements without goals are definitely imitated better as compared to similar movements with final goals. In the near-ear task where there is no final goal, the movement(s) of the hand(s) become the" goal" instead and so is imitated better as compared to the on-ear task in which the ears as the main goal claim less attention compared to the movements of the hands as the sub-goal. In addition, these results also confirm the assumption about the ideomotor principle. Across different tasks and different perspective conditions, the hierarchically highest goal, the main goal, and following it, the sub-goals elicit the corresponding motor programme of the children.

Furthermore, we can also confirm Wohlschläger et al.'s (2003) findings about bimanual movements (i-e., both-ipsi, both-contra). They reported that bimanual contra-lateral movements were imitated precisely correct in contrast with unimanual contra-lateral movements. The results of our study also showed that almost all the children performed the bimanual contra-lateral movements correctly even in difficult condition perspectives like 90 and 180 degrees. Wohlschläger et al. (2003) and we as well found that although bimanual cross-lateral movements seems difficult since the movements needs double crossing of the arms, most of the children imitate this kind of movement correctly. Thus, like Wohlschläger et al. (2003) we refute Kephart's (1971) claim it is an immature motor system that leads to the avoidance of unimanual cross-lateral movements. Additional evidence should be mentioned here as a strong confirmation of the GOADI theory in the form of an unexpected result related with both-contra movement that the present experimenter observed during

running the on-ear task. This was the reaction of a few children when they imitated the both-contra movement. These few children, who all were in kindergarten and in the six-year-old age groups, first touched their ears with an ipsi-lateral movement (i.e. right hand to the right ear and at the same time left hand to the left ear) and then tried to close their elbows together in order to make the same crossing movement as both-contra-lateral movements of the experimenter. This unexpected result is very important for the confirmation of the GOADI theory since it clearly represents the point that children, even in the youngest age group in our study (e.g., kindergarten children), first select the goals, i.e., the spatial end points, in their imitation and then pay attention to the movements or the means as sub-goals. Thus, this clearly shows the decomposition of the movements, goal selection and hierarchical order in children's imitation und thus further confirms the GOADI theory. The other observation related to the both-contra movements was same as the one that was reported in Wohlschläger et al. (2003). We also observed that some of the children that all were from the kindergarten and the six-year-old age groups for the both-contra movement in the cup-grasping task firstly grasped the cups by ipsi-lateral movements and then crossed their hand in different ways in order to attain the observed both-contra movement of the experimenter. For instance, some children crossed their hand after grasping while lifting the cups, some took the cups ipsi-lateraly but turned their wrists, and some grasped the cups from their top or in general, they responded with similar movements to these that we noted here. This result was exactly the same as what Wohlschläger et al. (2003) had reported in their study. Again, this is another strong confirmation of the GOADI theory with the same explanation as noted above for the on-ear task. Yet another point that can be added here is our observation of unimanual contra-lateral movements mostly in kindergarten and six-year-old children. Some of these children responded to unimanual contra lateral movements of the experimenter (e.g., right-contra, left-contra) with ipsi lateral movement (e.g., right-ipsi, left-ipsi) while their hand or their forearm made some vicarious crossing or tilting movements that, however, did not cross the body contra-laterally. For example, one child, in response to a right-contra-lateral movement

raised her left hand ipsi-laterally and then turned her fist somewhat as proximal realization of the distal crossing movement. Another child raised her hand ipsi-laterally and then tilted her hand from her elbow towards the right side of her body. As in the GOADI theory, it seems that when the goals (e.g., ears, cups) are absent then the means (e.g., hands) which were sub-goals in the on-ear and cup-grasping tasks are considered as main-goals and children pay more attention to imitate them correctly. Moreover, in these specific examples of unimanual contra-lateral movements, it seems that the absence of the goal causes that the child chooses the wrong direction of her/his crossing movements; however she/he at least attempts the crossing movement somehow.

The last point about both-contra movements in our study is about how some of the adults responded to this movement. It was observed that when the experimenter showed the both-contra movements, some of the adults consumed a little bit more time in order to recognize exactly which hand is crossed first and which hand is crossed second to reach the goals. It can be concluded that of course the adult selects the goals but the hand movements as the means to reach the goals are also important for him/her, so, this observation illustrates that adults (1) also parse a complex movement into its constituent properties, (2) choose the highest goal, i.e., the spatial end-point, and (3) have enough resources to represent sub-goals like the effectors and their order and direction of movement with respect to each other.

In general, the results of our study were in the same line with the results of Wohlschläger et al. (2003). Moreover, we decidedly confirmed their claims about the functional nature of the GOADI theory because our findings showed that its assumptions underly children's imitation performance even in the different perspective conditions. In addition, the results of the adult control group showed the accuracy of the general validity assumption since imitation in adults had a similar pattern to that seen in (older) children, namely more matching responses and less mirroring, effector imitation and other movements responses. Still, in adults both conceptually-based matching and also

perceptually-based mirroring are equally valid options, depending on the concrete task set-up.

Furthermore, like Wohlschläger et al.'s (2003) study, our findings were similar to those in Gleissner et al. (2000). They had reported that the number of the errors in the near-body tasks (e.g., near-ear and near-knee) was lower than the number of the errors in the on-body tasks (e.g., on-ear and on-knee). As explained above, our study also found similar results for near-ear with a higher rate of matching and on-ear with a lower rate of matching. In addition, they could not find any sex and handedness difference in their results just as we did. Moreover, as noted above about the AIM theory and likewise Perra et al. (2008) who claim that imitation is not a mere mapping – in the sense of an unmediated correspondence between observed action and motor response – we also believe that imitation is not direct mapping of the observed movements to the motor programme but is mediated by the cognitive system as well as other internal and external factors, as we will argue in the following dynamical view discussion.

In the following, after comparing the results of this study with the related findings on goal-directed imitation in the literature, we try to evaluate our findings in terms of a dynamic system framework and discuss how our findings support dynamical views on imitation.

First of all, it should be mentioned that the adaptive power of imitation can be considered as a main factor when we are evaluating imitation from a dynamical view. We think imitation is an ideal test-case for dynamic systems theory since imitation allows a very easy assimilation of information from outside-in which is actually related to the notion of an "exo"- and "endo-system". Imitation as a mechanism and learning device is present from birth onwards, that is, it shapes the entire development. Moreover, it is a way of "ingesting" the environment into the own endo-system (perceptual outside-in), processing it in the cognitive system (inside, at the interface of perception-action, in accordance with the

ideomotor principle and also AIM) and then releasing the result again into the environment (inside-out) by means of the imitative action.

Second, the strong relation of perception and action in the imitation on the one side and the importance of the actions in a dynamical system on another side link these two issues. In this regard, a human being is an active participant, , who lives in an environment together with other cognitive agents and in this regard s/he should have intentions, purposes, a theory of mind, etc. In general, the system and the interaction between the active participant and the environment help her/him to survive and thrive. Thus, imitation as one of the most important gates to the social and physical environment with its valuable cognitive and physical inputs and resources should be investigated as a dynamic system.

After mentioning these general points that makes imitation an important area for dynamic systems research, it is reasonable to express some specific points in terms of the dynamical view which are also based on the results of this study:

First of all, as mentioned in section 2.2.4 we had considered four kinds of imitation responses in our study, i.e. matching, mirroring, effector imitation and the other movements by which the children responded. In fact, these four responses are considered as our order parameters in a dynamical system. As the results showed, from these four responses matching and mirroring were the main two reactions of the children. They can be considered as two options alongside each other that are related to the perceptual and conceptual system. Without any doubt, both forms of imitation are valid forms since they both make sense. For instance, Wohlschläger et al. (2003) in their study have not even requested matching as a response and just have taken mirroring as the "correct" form of imitation, as long as the children show goal-directed imitation. However, in our study these two responses (e.g. matching and mirroring) and the distinction between them are nevertheless important since the shift from mirroring to matching can be considered as a bifurcation and therefore, such a qualitative, jumpwise change in children's imitation is an

important point that can be evaluated in terms of dynamical points of view. In the traditional view, based on Piaget's stage theory of development, human development during life span is defined based on some specific stages. In a dynamical system, when we consider development as a process which occurs in stages, this entails the fact that all of the system's components should work coherently. In other words, the system should have the property of self-organizing, which is a property of a complex system as well. In this view, we can consider the stages during the human life span but it is doubtful whether these stages contain continuous transitions or discontinuous transitions. Van Geert (2009, p.258) argues that "rapid, jumpwise development takes place in a variety of domains". It seems to be that imitation confirms the rapid, jumpwise transitions with respect to this argument.

As explained above, considering the human being as an active participant who develops over the life span and interacts with the environment, during this period "self"-development is a very basic and important issue. Now, with regard to imitation in children, the question arises how the development of the "self" may be related to the shift between mirroring and matching and from perception to conception. Moreover, it should explain that although "self"-development is a vast field, here it is meant quite specifically. Perceptual mirroring holds in the situation in which the effectors and the goals of the model and the imitator are opposite of each other (leading to RI imitation of a LI model's hand movement in the 180° condition) while conceptual matching holds when the effectors and the goals of the model and the imitator correspond to each other in the way that the imitator's right hand is equated with the child's right hand (leading to RI imitation of RI model in the 180° condition). In addition, we argued that there is a qualitative nonlinear developmental shift between mirroring and matching which is also qualified by the conditions. According to our findings, for the zero-degree conditions, matching strongly increases between 6 and 7 years of age; for 90° and 180° between 7 and 8-9 years of age. The older child appreciates that the "model's right hand" corresponds to "her/his right hand". This pattern in the older children shows

that this similarity on the conceptual level is more successful than the similarity on the perceptual level by mirroring the effector and the goal. Hence, from this "self"- development it follows that matching presupposes a "self" that is not perceptually- but conceptually-based.

In this regard, one might argue that we should consider rather the difference between "sensation" and "inference' than the difference between "perception" and "conception", which we considered so far. The problem space, in our case imitation of hand gestures, is continuous, it is always the same computational problem that the subject wants to resolve but may give different responses at different times (e.g., mirroring at a younger age or matching at an older age). As the subject gains experience (through sensation) with the problem, s/he also gains inferential abilities. That's why an older child may argue: "Your right arm corresponds to my right arm" which is clearly an inference. The reason why someone may find "perception" vs. "conception" not a convincing dichotomy is that they are always mixed somehow, i.e., there is no "pure perception" or "pure conception", but it is always a mix of both. However, speaking of "perception" and "conception" does make sense if we invoke the notion of "self" as a conceptual framework here. This means that the subject does not choose her/his imitation responses only based on whether they are similar to the ones of the model or for instance, the point(s) that the model's movements terminate but rather the subject's imitative responses also depend on her analysis of his/her own bodywith respect to the model and his/her developing notion of "self". Understanding of such indexical expressions like "you" and "me" in children as well as the issue of theory of mind may have directly affected children's imitation performance [personal communication, Annette Hohenberger and Cem Bozsahin, September 2011].

Interestingly, this point is clearly seen during the experiment in a rare number of children who rotated their body somehow in order to map their movements exactly with the ones of the experimenter (especially in the 180° condition). When they were later asked in the exploration phase why they did this kind of

movement they said “I wanted to imagine myself in your stead and exactly be in your place” or “I put myself in your place”. Although the subject matter of the developing notion of the “self” deserves an in-depth discussion, this is beyond the scope of this study.

As a second point in evaluating this study in a dynamic view, the role of different perspectives in the sense of a control parameter should be mentioned. The novelty in our task was to vary the perspectives and to see whether this manipulation makes a difference for mirroring or matching. Ideally, perspective as a control parameter would have many small and continuous variations, like 0, 30, 60, 90, 120, 150, 180 degrees. However, that is very hard to achieve, practically. In this study we had 3 variations, the most interesting one being the 90 degrees condition. We particularly added the 90° condition because it was in between 0 and 180 degrees. Therefore, this is a particularly challenging condition form a dynamic point of view.

In a dynamic system, if a control parameter varies continuously, there will be a critical value beyond which the system shows a radically different behavior (bifurcation). As mentioned above, there was a quite clear qualitative shift from mirroring to matching which takes place at two different ages for the zero conditions (e.g. between 6 and 7 years of age) and for the 90° and 180° conditions (e.g. between 7 and 8-9 years of age). Thus, we can see this shift happens earlier for the zero-degree conditions. As mentioned in the specific discussion part of “condition” in section 5.2.1, in the zero-degree conditions the children just have to carry out a “parallel shift” and not a “diagonal shift” as in the 90° and 180° conditions. Thus, it can be concluded that the spatial arrangement makes it easy for them to show mapping to some extent. One may even argue that what we call matching in the zero condition is not really matching but luckily coincides with perceptual-based mirroring. So, the kids get it “for free” in this case which also can be considered as the effect of the environment on this dynamical system which we will discuss later in this chapter. Besides this, the fact that 90 degrees were similar to 180 degrees shows

already that the perspective might be more a categorical factor and not a continuous one. If the system behaved continuously then the results of 90º conditions should be in between the results of 0 and 180 degrees. But, as explained, the results of the 90º condition were similar to 180º which shows that the system is working discretely. At around 90 degrees and beyond, children take the opposite and not the identical perspective towards the model which shows that as soon as the nice parallelism of zero degree is destroyed, matching becomes difficult.

Thirdly, the results showed that different tasks which in this study consisted of the object- and body-related grasping tasks have significant effects on the children's imitation performance. In addition, we found a non-linear polynomial effect across the blocks which we discussed in depth in section 5.2.1, in the specific discussion of the tasks and blocks, respectively. The only point that should be added to what was discussed in section 5.2.1 is the possible effect of "semantics". In the specific discussion related to the tasks, we mentioned one of the observations of the experimenter during the near-ear task in which the boys reacted to the movements as if it was a personal defense or an attack game. In that part we mentioned that this can be considered as a sample for a pre-programmed motor routine that causes better performance in this specific task. Moreover, in the method part it was mentioned that a final question was asked from all the children in order to better understand why they reacted as they did to one of the movements. Some of the children responded that "because we were talking on the phone", especially for the movements in the near-ear task. Another response from children was: "we are playing Rock-paper-scissors game", which is a traditional hand game played by two or more people. From all of these observations we can conclude that although the six gestures in our study were free of any meaning (they were not "meant" to "mean" anything), the children tended to load them with meaning. This is a very general observation, indeed. As Kaya (2010) states there are meanings which can be called "memes" (in analogy to "genes") which consist in culturally acquired meanings that are transmitted and changed through

imitation. The observations during our study confirm that even when all the gestures were devoid of any meaning, the meaning that the children inferred from them (i.e, the memes) can affect the results of their imitation performance.

Another point that should be mentioned here is the role of working memory as an unspecific control parameter that may yet modulate the imitative response. According to Gathercole et al. (2004) who investigated the structure of working memory across different age groups, the age in which working memory capacity increases considerably is six years of age and there is a linear developmental function related with working memory capacity until early adolescence. Furthermore, "at this age, children become able to keep track of three information units in working memory, instead of just two" (Johnson, Fabian, & Pascual-Leone, 1989; MorraCarla & Scopesi, 1988; as cited in Perra and Gattis, 2008, p. 136). Based on these facts, the pattern of imitation in children in this age range should be different from that of younger children, in terms of mapping between perception and action since working memory influences perspective-taking. It is obvious that more memory resources are needed in order to represent the model's and the own action if they do not look perceptually similar, as in matching which is less similar and as opposed to mirroring which is more similar. In addition, keeping these two representations separate (model, self) probably requires some inhibition, which is typically an executive component. Furthermore, representing sub-goal and not just the main goal, the spatial end-point of the action, requires more working memory capacity. The role of working memory is also acknowledged in the goal-directed theory of imitation (Wohlschläger et al., 2003) in that they consider working memory capacity as a variable that causes differences in the imitation of adults from children and animals.

In general, if we consider the age between six and eight years as a bifurcation region in which the imitation in children will switch to a completely different situation, consequently, we can find out some characteristics of the dynamical systems in imitation as well. In fact, imitation is a process which occurs in

stages; however, it seems that there is only one discontinuous switch. This entails the fact that all of the components of this stage-base system should work coherently, or, in other words, imitation as a dynamical system should self-organize. According to van Geert (2009), actions of each individual can be considered as a short-term process in her/his dynamical developmental system. If we apply this property to the imitation process and consider each child as a complex dynamical system, we can find out that differences in working memory capacity, sickness or health, abilities or disabilities of each individual child as unspecific control parameters and spatial perspectives, task demands, and exposure as specific control parameters can be considered as control parameters in the short-term processes which affects the imitative action for each child.

In addition, van Geert (2009) argues that the long-term process is another aspect of a dynamical system, in human development. In order to explain this fact, he mentions the development during life span in terms of considering each individual embedded in a network. The knowledge of the child's parents, how they train the child to improve her/his abilities like training to react or respond to her/his parents in different actions and a lot more small and big factors, can be considered as influencing factors of the environment on child imitation. If this refers to the social environment of children, it is of special importance to imitation, indeed, since social learning is very much based on imitation.

We definitely agree with Maruyama's et al. (2006) claim about the important effects of the task context and the just-previous behavioral history on children's imitation because, as our findings showed, different internal and external factors can significantly change the results. Moreover, as Tschacher et al. (2007) stated, self-organization reduces gradients in the environment which can be physical, chemical, and also cognitive gradients. Gradients can be thought of as pathways between two non-identical states. In imitation, such a gradient is set up by the perceived model gesture that is to be imitated. Immediately and spontaneously (Meltzoff and Moore, 1994; 1997) the infant engages in

imitation, that is, gradient reduction. The reduction of the gradient is achieved by the imitative action of the child. More specifically, the child chooses an action such that motor output and perceptual input are identical (or, as similar as possible), that is, they cancel each other out (in the eye of the child, of course). The child learns to perceive (what the percept is) by acting the percept out. The criteria for effective gradient reduction, however, change during development, namely, from perceptual-based mirroring to conceptual-based matching [personal communication, Annette Hohenberger].

Generally, in the traditional view, the results of imitation studies (e.g., the shift between mirroring and matching at the particular age) have been investigated by a single cause. However, it seems more reasonable to evaluate imitation and each individual child as a complex dynamical system which interacts with the dynamic system of the environment as well. In this view, according to Smith & Thelen (2003), we should consider multi-causality of the system and estimate very many causes which influence imitation in children, since, imitation is not a monolithic response of an observer towards an observee but a multifaceted response to which many factors contribute. In total, the interaction of internal factors (e.g., the setup of the cognitive system in terms of perception or conception, working memory) and external factors (spatial perspective, exposure to the task, number of effectors and many others) lead to some stable outcome, in each point in time. Taken together, they create a developmental trajectory.

Adult control group

The results of the adult control group showed that only condition had a main effect on their imitation performance. Furthermore, there was a two-way interaction of gender*condition and task*condition. Other than that, different tasks, blocks and gender were not significant factors in their imitation. It was found that adults do more matching as compared to the children; however, they nevertheless do mirroring in their responses which was seen more in the 90 and 180 degrees conditions of the three tasks. Although there was no significant

difference between 90° and 180°, the mean percentage of matching in the 90° condition was the least in comparison with the three other conditions. Thus, it can be concluded that the intermediate condition of 90° is the most challenging perspective even in adults' imitation. However, the kind of this similarity between adults and children may have different causes because it seems that mirroring in imitation is like another option for the adults, which does not compromise the fact that they have cognitively mastered matching. It means that they respond by mirroring especially in 180° condition by their own choice.

The other important point that should be discussed about the adult control group is the difference between males and females. As noted in the result part, although there was no general gender difference there were significant interactions of gender*condition and also gender* task nevertheless. Moreover, from the mean values of matching in the two-way interaction of gender*condition it can be observed that Iranian females do less matching as compared to Iranian males, especially in the 90° and 180° conditions. For this reason, only in this special condition we have stated the mean values of mirroring in males and females in the different conditions in order to show to what extent the mirroring rates in females are higher than those of the males (see Table 26 and Table 27). One possibility to explain this unexpected behavior of the females is that in the 90° and 180° conditions they wish to do more parallel rather than opposing movements. . Moreover, this gender difference is specifically sharp in 180° for the males and females where almost all the females do mirroring (females' mirroring mean percentage= .944).

Table 26 The mean percentages and Standard Errors of mirroring in the four conditions (female adult control group)

Condition	Mean	Std. Error
zero-left	.007	.032
zero-right	.007	.032
90	.771	.032
180	.944	.032

Table 27 The mean percentages and Standard Errors of mirroring in the four conditions (male adult control group)

condition	Mean	Std. Error
zero-left	.260	.191
zero-right	.010	.191
90	.604	.156
180	.333	.156

Hence, the question here is that why Iranian females do mirroring to this extent specifically in 180°? Based on the experimenter observation during the tasks, it seems that females do more mirroring because these kinds of movements seem to make more sense for them in terms of obtaining symmetry. For instance, the mirror symmetry that will occur when the experimenter moved her right hand to the right ear and the female subject responded by moving her left hand to the left ear, induces a sense of "correct response" in the females. It appears that female subjects may not want to break this kind of perceptually pleasing symmetry by their movements. In other words, the hands and the reached goals which are both in the same side make more sense for them. Since this situation is also valid for the contra-lateral movements in 180º (e.g., leading to right-

contra imitation of the left-contra model), it can be explained in the way that females adults want to follow the experimenter in the way that maximizes symmetry and consequently seems more beautiful, from an aesthetic point of view. Another explanation of this issue can be come from a social cognition point of view. Imagine a condition in the near-ear task and in 180°, where the experimenter has moved her closed right hand near to her left ear and the female observer should respond to this movement. She has two options: she can move her right fist near to her left ear as the experimenter has done in front of her, or, she can move her left hand to her right ear. If we imagine the whole picture of the first response, we can immediately grasp somehow the sense of "fighting" or the sense of "being in the opposite direction" while the picture of the second response give us the sense of "accordance" or somehow "concurrence". As the results showed, they have chosen the second option in their responses. We are aware that this explanation is a very tentative one that makes reference to social, cultural, and aesthetic frames of mind. However, we think that even simple motor movements are open to such higher-level explanations, as long as they are not too speculative. The other point that can be commented on here is that for both male and female Iranian adults, the experiment does not seem as simple as it is. The observation of the adults' reactions during the experiment brought this idea to our mind that the Iranian adults may have thought and responded in a more complex way as required by the stated simplicity of the tasks at the beginning of the experiment; however, proving this argument needs further investigations.

In sum, the fact that adults keep the developmentally earlier version of mirroring up can be seen as evidence for a dynamical view in which not only earlier solutions do not get lost but may also come up and compete with the developmentally later version of matching if the conditions are favorable. Whatever factors determine these conditions may differ in children – where mapping is not yet developmentally available – and adults – where it is but may not be considered the most optimal form of behavior for other, social, politeness, or aesthetic reasons.

The last but not least point about the results of this study that should be discussed for both children and adults group, are cross-cultural issues, since, most of the imitation studies have been carried out in "Western" countries but this study has been carried out in a country of the "Middle-East". Since imitation is something very basic, one might argue that culture is irrelevant. But, for example, wearing a scarf in this special imitation task which refers to the ears that are hided under the scarf could lead to some differences between the results of this and Western studies. Surprisingly, the results indicated that wearing a scarf did not hinder the girls to imitate as the boys did and we claim that overall we did not find any gender differences for the child sample as well as for the adult control group. Taking all these considerations together, imitation as a powerful and fundamental learning mechanism can be investigated widely in other areas such as anthropology also since humans learn from each other and cultural knowledge is often transferred by imitation, not only in the cognitive development area. Moreover, the results of the specific task related to grasping cups showed that tool use also can be considered as another instance of goal-directed actions that can be investigated in studies related to imitation.

CHAPTER 7

SUMMARY & CONCLUSION

In this study we investigated the developmental changes in the imitative behavior of 165 Iranian children from 4.5 to 11 years of age from traditional and dynamical points of view. Children were supposed to imitate the experimenter's movements in three tasks, i.e., "on-ear", "near-ear" and cup-grasping. In the hand-to-ear tasks, the movements were related to body parts, however, in the "on-ear" task, the hand(s) made contact with the ear(s) but in the "near-ear" task the hand(s) did not. Six movements were shown to the children (RI, RC, LI, LC, BI, and BC) over four blocks for each task. We considered five age groups in our study, i.e., 4.5-5.5, 6, 7, 8-9 and 10-11 years of age. Moreover, in order to investigate the effects of different perspective positions on the children's imitation performance, we designed four perspective conditions between the experimenter and the child, i.e., zero-right, zero-left, 90 and 180 degrees. In the zero-right degree condition, the experimenter sat at the right hand side of the child and in the zero-left degree condition, the experimenter sat at the left hand side of the child. These two zero-degree conditions, above testing the impact of a side-by-side spatial arrangement on imitation, were designed in order to find whether handedness of the children had a significant effect on children's imitation in these two conditions or not. For each child, after running all the three tasks, a short handedness test was carried out in order to determine the hand dominance of the child.

The results showed that, children predominantly imitated the goal in the sense of the end-point of the action. They mainly matched and mirrored the model's actions but very rarely imitated the effectors. Thus, the theory of goal-directed imitation proposed by Wohlschläger et al. (2003) was confirmed in our study. Moreover, we found that there is a qualitative nonlinear developmental shift between mirroring and matching which is qualified by different conditions. This shift occurs between six and seven years of age in the zero-degree conditions, and between seven and 8-9 years of age in the 90° and 180° conditions. Moreover, the amount of matching in the cup-grasping task was significantly higher than in the two hand-to-ear tasks and especially, in the zero-degree conditions. In addition, the results showed higher matching rates in the near-ear than in the on-ear task. The amount of matching and mirroring fluctuated over the four blocks which indicates a dynamic competition between them in the sense of two alternative order parameters. The zero-degree conditions showed higher matching rates than the 90° and 180° conditions. This may be because in the 0°conditions matching can be achieved by a simple parallel shift between imitator and model whereas in 90° and 180° matching requires a more effortful contra-lateral switch. Adults predominantly matched. However, they also showed mirroring to some extent, especially in 180° and 90°, indicating that mirroring remains an option even after the major developmental shift from mirroring to matching has been completed.

In sum, the nonlinear pattern of the shift from mirroring to matching in children indicates that cognitive development can be conceived of as a dynamic system. A shift of order parameters (mirroring and matching) depends not only on age-related changes but also on control parameters such as spatial perspective (0°vs. 90°and 180°), task (cup grasping vs. on-ear vs. near-ear), and repeated exposure (across blocks).

CHAPTER 8

LIMITATIONS OF THE STUDY

As mentioned so far, we basically investigated imitation in preschool and school children. There is a wide range of sciences that are directly related to this issue, beside the cognitive developmental and dynamical view which was our main focus in this study, i.e., philosophy, social cognition, psychology and many others. Although it would have been worthwhile if we could have extended the framework to include all of these aspects, this was really beyond the scope of my thesis. For instance, we considered but did not include the findings of other researchers about the development of working memory during the life span (Gathercole et al., 2004). Other, methodological improvements would have been possible, e.g., determining inter-rater reliability which can be counted as another limitation of our study since we did not code the results by more than one researcher.

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APPENDICES

APPENDIX A THE M PERCENTAGES AND SD TABLES

Table 28 The M percentages and SD tables of matching /mirroring/effector/other across all ages, conditions and blocks in Near-Hand-To-Ear task (Children).

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
kindergarten	zero-left N=8	Mean	.4922	.2656	.1094	.1328
		Std. Deviation	.17177	.12388	.12388	.06194
	zero-right N=8	Mean	.4609	.3750	.1016	.0625
		Std. Deviation	.24076	.12500	.13337	.08839
	90 N=8	Mean	.1484	.7266	.1250	.0000
		Std. Deviation	.08799	.13337	.14562	.00000
	180 N=9	Mean	.0417	.8681	.0694	.0208
		Std. Deviation	.06988	.16957	.11024	.03125
	Total N=33	Mean	.2784	.5682	.1004	.0530
		Std. Deviation	.24858	.28571	.12396	.07349

Table 28 (Cont.)

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
six	zero-left N=8	Mean	.3594	.4297	.1484	.0625
		Std. Deviation	.09882	.08476	.11049	.05786
	zero-right N=8	Mean	.3047	.6484	.0391	.0078
		Std. Deviation	.19318	.17971	.07423	.02210
	90 N=8	Mean	.0313	.9063	.0625	.0000
		Std. Deviation	.06682	.10564	.08839	.00000
	180 N=8	Mean	.0859	.7969	.1016	.0156
		Std. Deviation	.09412	.15934	.13337	.02893
	Total N=32	Mean	.1953	.6953	.0879	.0215
		Std. Deviation	.18360	.22380	.10750	.04081
seven	zero-left N=8	Mean	.6719	.2500	.0547	.0234
		Std. Deviation	.41960	.31693	.07790	.04650
	zero-right N=8	Mean	.6563	.3203	.0078	.0156
		Std. Deviation	.31693	.31594	.02210	.02893
	90 N=8	Mean	.0703	.8828	.0313	.0156
		Std. Deviation	.11782	.14729	.04725	.04419
	180 N=8	Mean	.1016	.8359	.0391	.0234
		Std. Deviation	.16683	.20577	.07423	.06629

Table 28 (Cont.)

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
	Total N=32	Mean	.3750	.5723	.0332	.0195
		Std. Deviation	.39783	.38170	.05937	.04611
eight and nine	zero-left N=10	Mean	.8063	.1875	.0000	.0063
		Std. Deviation	.27394	.27795	.00000	.01976
	zero-right N=10	Mean	.6875	.2563	.0188	.0375
		Std. Deviation	.27951	.26262	.04218	.06038
	90 N=8	Mean	.0391	.9609	.0000	.0000
		Std. Deviation	.04650	.04650	.00000	.00000
	180 N=8	Mean	.2813	.7188	.0000	.0000
		Std. Deviation	.41592	.41592	.00000	.00000
	Total N=36	Mean	.4861	.4965	.0052	.0122
		Std. Deviation	.41299	.42071	.02302	.03604
ten and eleven	zero-left N=8	Mean	.8281	.1719	.0000	.0000
		Std. Deviation	.26464	.26464	.00000	.00000
	zero-right N=8	Mean	.8828	.1094	.0000	.0078
		Std. Deviation	.16849	.15218	.00000	.02210
	90 N=8	Mean	.4219	.5781	.0000	.0000
		Std. Deviation	.42225	.42225	.00000	.00000

Table 28 (Cont.)

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
	180 N=8	Mean	.5625	.4219	.0156	.0000
		Std. Deviation	.44821	.42880	.02893	.00000
	Total N=32	Mean	.6738	.3203	.0039	.0020
		Std. Deviation	.38058	.37391	.01537	.01105
Total	zero-left N=42	Mean	.6399	.2574	.0595	.0432
		Std. Deviation	.31411	.24155	.09658	.06399
	zero-right N=42	Mean	.6027	.3378	.0327	.0268
		Std. Deviation	.30706	.27437	.07591	.05372
	90 N=40	Mean	.1422	.8109	.0438	.0031
		Std. Deviation	.24268	.24819	.08861	.01976
	180 N=41	Mean	.2104	.7317	.0457	.0122
		Std. Deviation	.33241	.32633	.08951	.03485
	Total N=165	Mean	.4030	.5299	.0455	.0216
		Std. Deviation	.37369	.36323	.08768	.04864

Table 29 The M percentages and SDs tables of matching /mirroring/effector/other across all ages, conditions and blocks in Cup-grasping task (Childen).

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
kindergarten	zero-left N=8	Mean	.5156	.1406	.1250	.2188
		Std. Deviation	.17599	.09882	.11573	.12939
	zero-right N=8	Mean	.6094	.1016	.1641	.1250
		Std. Deviation	.24264	.08799	.12912	.12500
	90 N=8	Mean	.0859	.3828	.3281	.2031
		Std. Deviation	.08799	.10263	.19118	.16620
	180 N=9	Mean	.0556	.6528	.2222	.0694
		Std. Deviation	.12672	.29167	.19037	.11458
	Total N=33	Mean	.3087	.3295	.2102	.1515
		Std. Deviation	.29849	.28180	.17175	.14238
six	zero-left N=8	Mean	.5156	.1484	.0547	.2813
		Std. Deviation	.13673	.12912	.06194	.13774
	zero-right N=8	Mean	.7188	.0234	.0234	.2344
		Std. Deviation	.18601	.06629	.03235	.14075
	90 N=8	Mean	.0703	.5469	.3125	.0703
		Std. Deviation	.13126	.19408	.14174	.09111

Table 29 (Cont.)

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
	180 N=8	Mean	.1172	.6406	.1719	.0703
		Std. Deviation	.17815	.31295	.13673	.15103
	Total N=32	Mean	.3555	.3398	.1406	.1641
		Std. Deviation	.31528	.32415	.15227	.15855
seven	zero-left N=8	Mean	.8125	.0469	.0625	.0781
		Std. Deviation	.26726	.08680	.10022	.09882
	zero-right N=8	Mean	.9219	.0313	.0078	.0391
		Std. Deviation	.13258	.05786	.02210	.07423
	90 N=8	Mean	.1406	.6484	.1797	.0313
		Std. Deviation	.14466	.29303	.14345	.05786
	180 N=8	Mean	.0859	.7266	.1250	.0625
		Std. Deviation	.11049	.29112	.13774	.12045
	Total N=32	Mean	.4902	.3633	.0938	.0527
		Std. Deviation	.41975	.38770	.12500	.08854
eight and nine	zero-left N=10	Mean	.9688	.0063	.0125	.0125
		Std. Deviation	.07933	.01976	.02635	.03953

Table 29 (Cont.)

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
	zero-right N=10	Mean	.8938	.0000	.0000	.1063
		Std. Deviation	.15604	.00000	.00000	.15604
	90 N=8	Mean	.2813	.4453	.1484	.1250
		Std. Deviation	.26092	.32465	.17971	.15670
	180 N=8	Mean	.2891	.6016	.0859	.0234
		Std. Deviation	.39094	.36126	.14917	.03235
	Total N=36	Mean	.6441	.2344	.0556	.0660
		Std. Deviation	.39861	.34472	.12117	.11947
ten and eleven	zero-left N=8	Mean	.9844	.0000	.0000	.0156
		Std. Deviation	.04419	.00000	.00000	.04419
	zero-right N=8	Mean	.9688	.0000	.0000	.0313
		Std. Deviation	.06682	.00000	.00000	.06682
	90 N=8	Mean	.3672	.4375	.1094	.0859
		Std. Deviation	.37117	.36596	.14466	.07423
	180 N=8	Mean	.4688	.4453	.0625	.0234
		Std. Deviation	.48527	.46344	.06682	.04650
	Total N=32	Mean	.6973	.2207	.0430	.0391
		Std. Deviation	.40941	.35921	.08901	.06300

Table 29 (Cont.)

Age Group	condition		Ave. of matching percentage in 4blocks	Ave. of mirroring percentage in 4blocks	Ave. of effector percentage in 4blocks	Ave. of other movements percentage in 4blocks
Total	zero-left N=42	Mean	.7693	.0655	.0491	.1161
		Std. Deviation	.25806	.10045	.08229	.14383
	zero-right N=42	Mean	.8259	.0298	.0372	.1071
		Std. Deviation	.20822	.06362	.08403	.13545
		N	42	42	42	42
	90 N=40	Mean	.1891	.4922	.2156	.1031
		Std. Deviation	.24288	.27597	.17731	.12624
		N	40	40	40	40
	180 N=41	Mean	.1997	.6143	.1357	.0503
		Std. Deviation	.32181	.34372	.14850	.10099
		N	41	41	41	41
	Total N=165	Mean	.5015	.2962	.1080	.0943
		Std. Deviation	.39834	.34197	.14663	.12924

APPENDIX B TABLES AND PLOTS OF TESTS OF NORMALITY

Table 30 Tests of Normality for the tasks and age groups

Task	Age Group	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
On-hand-to-ear	kindergarten	.230	33	.000	.752	33	.000
	six	.281	32	.000	.779	32	.000
	seven	.211	32	.001	.800	32	.000
	eight and nine	.172	36	.008	.814	36	.000
	ten and eleven	.299	32	.000	.740	32	.000
Near-hand-to-ear	kindergarten	.186	33	.005	.897	33	.004
	six	.172	32	.018	.881	32	.002
	seven	.244	32	.000	.795	32	.000
	eight and nine	.196	36	.001	.824	36	.000
	ten and eleven	.295	32	.000	.782	32	.000
Cup-grasping	kindergarten	.185	33	.005	.888	33	.003
	six	.174	32	.015	.886	32	.003
	seven	.227	32	.000	.810	32	.000
	eight and nine	.241	36	.000	.785	36	.000
	ten and eleven	.293	32	.000	.706	32	.000

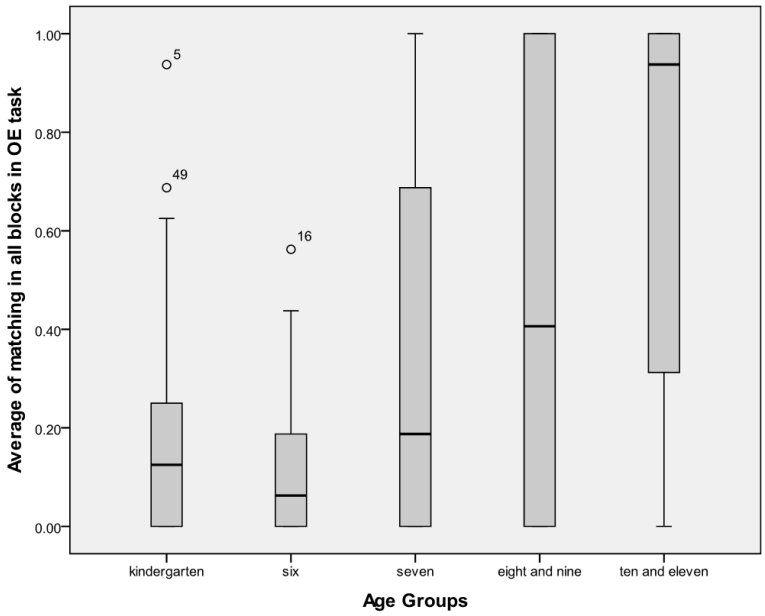

Figure 33 Boxplot of normality for the on-hand-to-ear task in five age levels.

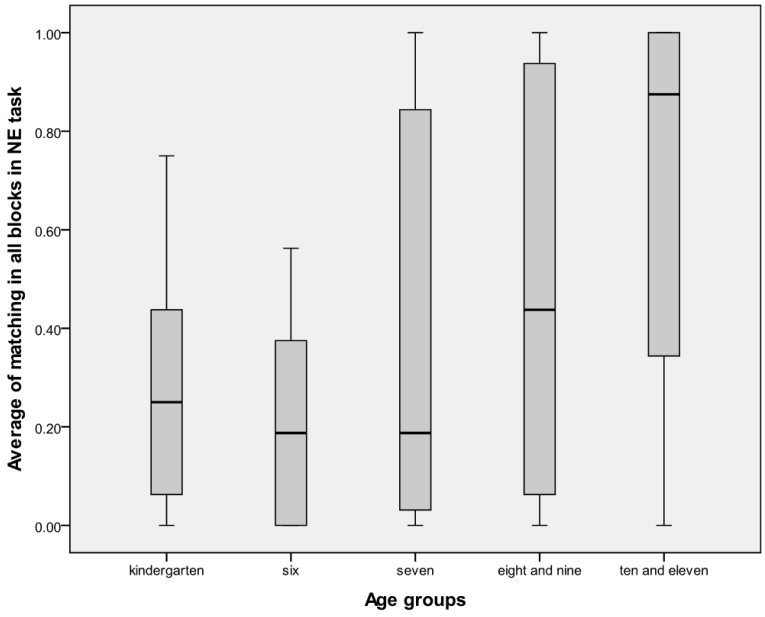

Figure 34 Boxplot of normality for the near-hand-to-ear task in five age levels.

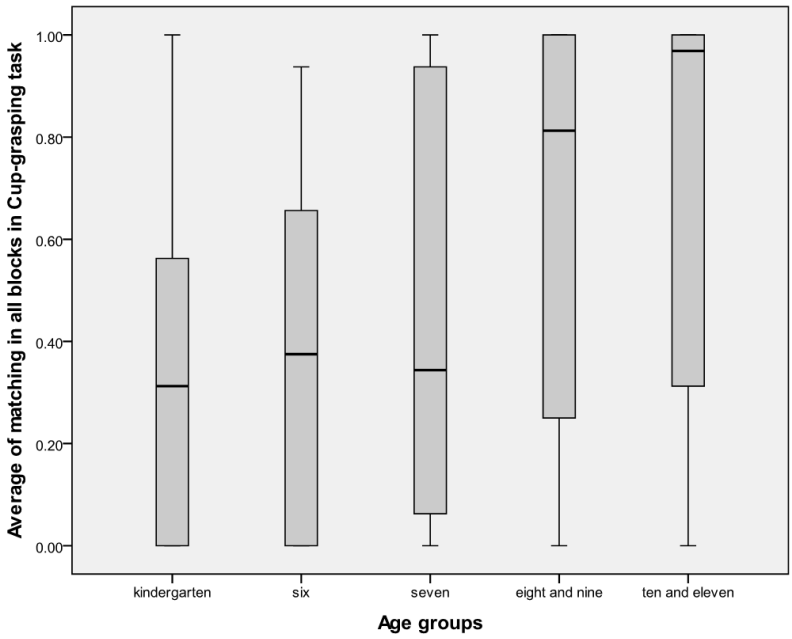

Figure 35 **Boxplot of normality for the cup-grasping task in five age levels.**

APPENDIX C SAMPLE FORM

Table 31 Sample form of the experimenter in order to write responses.

No.	First Name	Last Name	Grade	Gender	Condition	Date of Birth
OE, NE, OC						
ON-hand to ear						
RI	RC	LI	LC	BI	BC	
ON-hand to ear						
BI	LI	RI	LC	RC	BC	
ON-hand to ear						
RC	LC	RI	LI	BC	BI	
ON-hand to ear						
BC	LC	LI	RC	RI	BI	
Near-hand to ear						
RI	RC	LI	LC	BI	BC	
Near-hand to ear						
BI	LI	RI	LC	RC	BC	
Near-hand to ear						
RC	LC	RI	LI	BC	BI	
Near-hand to ear						
BC	LC	LI	RC	RI	BI	
cup grasping						
RI	RC	LI	LC	BI	BC	
cup grasping						
BI	LI	RI	LC	RC	BC	

Table 30 (Cont.)

No.	First Name	Last Name	Grade	Gender	Condition	Date of Birth
cup grasping						
RC	LC	RI	LI	BC	BI	
cup grasping						
BC	LC	LI	RC	RI	BI	