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Age-related Changes in Imitating Transitive and Intransitive Actions: Changes Going from Low to High Fidelity

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Abstract

Imitation is an interpretative process mostly influenced by the hierarchy process. To examine the imitative hierarchy, eighty-five children aged between 3.5 to 7.5 years were asked to observe and then imitate a human adult model performing intransitive (locomotion) and transitive (with objects) action in: (1) immediate imitation, (2) short term deferred imitation and (3) long term deferred imitation. Whereas some of action sequences were necessary for achieving goals, some others were unnecessary to pursue these goals. Children's responses were recorded, scored in dichotomous data (1-0), and then transformed in performance percentages. Results showed that: (1) for intransitive actions, all children imitated the goals in all imitation conditions. (2) For transitive actions (implying both necessary and unnecessary action sequences), there was a significant effect of age in long term deferred imitation. The 3.5 age group obtained lower scores than the other age groups for necessary sequences. For unnecessary sequences, the 3.5 and 4.5 age groups obtained lower scores than the older age groups, both in short term and long term deferred imitation conditions. The current results mostly sustain the children's fidelity to extract the goal-critical elements and ignoring useless ones.

Keywords: Imitation; Age groups; Hierarchy; Necessary and unnecessary sequences; Encoding and memory process

Introduction

Imitation is the ability to translate observed movements into our own movements and reproduce them as our own action. The translate ability presents an apparent paradox in children's imitation. They sometimes copy selectively [1-4] and sometimes they copy exactly [5-10]. Selective imitation has typically been explained in terms of understanding process and age factor [11], where as that exact imitation has been made of children's tendency to over imitate by reproducing even the irrelevant actions [5,8].

One of the basic principles of education for children in preschool and lower school age is imitation. From this point of view, the current study examined which information children extract to imitate a human adult model demonstrating transitive and intransitive actions comprising necessary and unnecessary sequences. Investigating necessary and unnecessary action sequences imitated by different age groups in different conditions is quite interesting and creates possibility to explore a hierarchical process adopted by children while imitating.

Imitating demonstrated behaviors would depend on imitation condition and recalling mechanism [4,12-15]. For example, in immediate imitation, the ability to recall is easy and presumably involves a perceptive memory [4]. In short term deferred imitation, the interval between demonstration and reproduction is short and recalling is limited and requests a short term memory [16]. In long term deferred imitation, the demonstration and reproduction interval is long and recalling requests a long term memory [17].

Imitating would also depend on critical factors. The first one concerns goals and sub-goals hierarchy. Wohlschläger et al. [4] showed that the model's goals were immediately and correctly imitated by 3- to- 6-year-old children but the sub-goals (e.g. how to touch the ear) were usually neglected and considered as unnecessary for goals. They demonstrated the importance of a goal extracted from the movements and imitation-specific process of goal selection. The second factor concerns the nature of behaviors. Rumiati and Bekkering [18] showed

that healthy individuals imitated better meaningful actions than meaningless ones, because they had a relevant goal. The third factor concerns the encoding type and memory system [19]. For example, in certain condition, imitator is not informed of what he/she will have to reproduce later. In such a case, incidental encoding is susceptible to intervene in short term memory because he/she does not expect a further imitation test. In other imitation condition, imitator is informed about later reproduction. In such a case, intentional encoding is susceptible to intervene in long term memory because he/she is warned to a further imitation test.

It is well known that recalling for imitating increases in ontogenesis period [20-23]. Agostini et al. [24] showed that the reproducing performance increased from 2 items in 3-year-olds to 5 items in 6-year-olds and to 6 items in 8-year-olds. Travis [25] demonstrated that 2-year-old children already started interleaved pairs of three-step action sequences (six actions: three actions for each pair) by chunking together, performing them in a temporally continuous sequence. In this case, recalling ability is governed by a chunk process [26,27]. The chunk is used in decomposing actions or events on behavioral sequences [28,29].

Therefore, the current work addresses a potential interest about the hierarchical process that children of different age groups adopt to imitate modeled behaviors. Most research in this area investigates manual actions with tools, whereas we study in addition locomotion

movements. The actions to imitate were chosen because they were already existed in the children's motor repertoire and represent a fundamental change in their gross motor skills. Testing children of successive years of life is also appropriate to the objective of our study, because the different ages corresponded to different developmental degree of many abilities. We firstly hypothesized that all age groups would perform the goals of both transitive and intransitive actions by selecting only the necessary sequences, whereas the unnecessary ones would be neglected or forgotten. Second, we hypothesized that imitation condition and age factors would determine the encoding and memory systems to accurately imitate the modeled behaviors.

Method

Participants

Eighty-five pre schoolers and schoolers children coming from socio-economic middle class anddivided into five age groups: 3.5, 4.5, 5.5, 6.5 and 7.5 years respectively were asked by a human adult model to reproduce a series of actions. Each age-group comprised 17 children. All participants belonged to the same state school but there was no communication between them during the entire duration of experiment. Parents signed an informed consent form to participation of their children.

Materials and procedure

Children were tested in their school sports room. Videotape equipment (JVC SR-VS10 VHS/DV) digital video camera operated by a cameraman was set up to film their executions.

The adult model individually asked each child of each age-group 'to observe and do alone the same thing he had just done'. Child had to start with both feet in circle N°1 (30 cm in diameter) for walking on the first two obstacles (30 cm long x 15 cm wide x 10 cm high). Upon arriving on the second obstacles, he/she jumped into circle N°2 situated between two symmetrically placed boxes (50 cm long x 25 cm wide x 20 cm high). Each box contained one umbrella (25 cm). A container (30 cm long x 20 cm wide x 10 cm high) was placed behind each box with four tennis balls in it. From circle N°2, he/she turned the body to the right-hand side,took two tennis balls in the right container, carried them to the left side, and put them in the left-hand side container. With both feet still in circle N°2, he/she opened the right hand-side box, picked up the umbrella and carried it to the left side. With the umbrella, he/she pointed to three holes drilled in the box and afterwards he/she

put the umbrella inside the left box. From circle N°2, he/she walked and jumped between the last two obstacles and landed on both feet into circle N°3. Each child individually reproduced in three different imitation conditions over two separate experimental series.

The first series was realized in the same day and reserved for (Figure 1)

1. Immediate and simultaneous imitation (ISI): the adult model and child were positioned side-by-side. The adult model asked each child of each age-group to observe and reproduce at the same time and in the same direction, but each in his/her own course. The model performed slowly for allowing the child to keep up. Each child had one trial. This imitation likelihood did not require a recalling mechanism.

2. Short term deferred imitation (STDI) was realized in a short delay (5-s delay) just after finishing the previous imitation (ISI). The adult model separately invited each child of each age-group to reproduce alone the same course without accompanying him/her. Each child had one trial. This imitation would require a short term memory using an incidental encoding because he/she did not expect a further test.

3. The second series was reserved for the long term deferred imitation (LTDI): (Figure 2)

After one week to the two previous imitation conditions, each child of each age-group was individually and separately asked to reproduce alone after the model's demonstration. During six following weeks, he/she reproduced the course demonstrated by the model at the beginning of each session after a three-minute delay. Children reproduced in randomly thus, in a different order each week. This imitation would require a long term memory using an intentional encoding because they were warned to reproduce later.

Data collection and statistical analysis

Children's imitative responses were recorded and subsequently coded in dichotomous data (1–0) by an independent person. Each action's sequence was independently scored as "1" if he/she imitated it and as "0" if he/she absolutely did not imitate it. For example, if the child imitated walking, reaching, or any other action, his/her response was coded as "1" (recalling), and when he/she did not, his/her response was coded as "0" (forgetting).

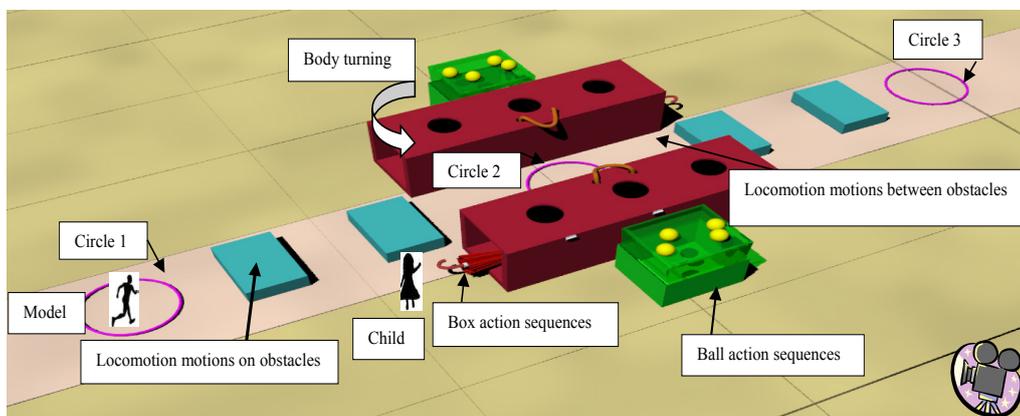The statistical process of dichotomous data mobilized specific

Figure 1: Obstacle course in short term (STDI) and long term (LTDI) deferred imitation.
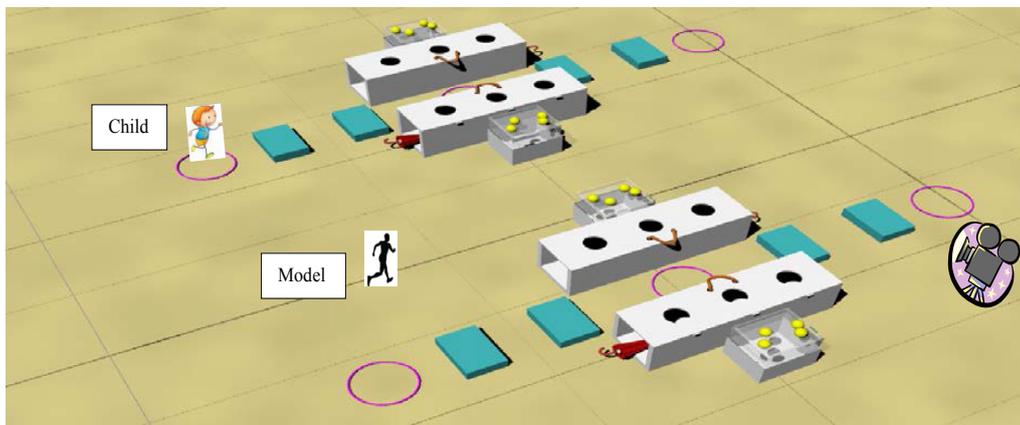
Figure 2: Obstacle course in immediate and simultaneous imitation (ISI).

	Short term deferred imitation				Long term deferred imitation			
	W-J on obstacles	Ball actions	Box actions	W-J between obstacles	W-J on obstacles	Ball actions	Box actions	W-J between obstacles
3.5 years	100%	33%	33%	100%	100%	82%	83%	100%
4.5 years	100%	36%	50%	100%	100%	97%	97%	100%
5.5 years	100%	65%	74%	100%	100%	90%	98%	100%
6.5 years	100%	83%	77%	100%	100%	95%	98%	100%
7.5 years	100%	98%	97%	100%	100%	94%	96%	100%

Table 1: Children's performance (%) in the reproduction of walking and jumping (W/J) on the obstacles; ball: catching-carrying-putting; box: opening-catching-pointing-putting away actions, and walking and jumping (W/J) between the obstacles in short and long term deferred imitations. The immediate and simultaneous imitation (ISI) did not included because the recalling performance was 100%.

methods. They did not share out according to a normality law, and thus did not allow the normality test. Therefore, it was necessary to use a log-transformation of performances to apply an adequate ANOVA. The most frequently used transformation was "angular transformation in percentage" [30]. The software used for data analysis was Statistica 6.1 (Statsoft, Inc.). The statistical significance was set at $p \leq 0.05$. A post hoc Reduced distance test was carried out for measuring the significant effect of variables with more than two levels to determine what this effect should be ascribed to.

The dependent variable was the recalling scores (%) of each age group and the independent variable was the three imitation conditions.

For the first series of imitation, the analysis was a two-factor ANOVA. The independent factors were: -age group (five: 3.5 to 7.5-year-olds), imitation condition (two: immediate and simultaneous imitation, short term deferred imitation).

For the second series of imitation, the analysis was a two-factor ANOVA, the independent factors were –age group (five: 3.5 from 7.5 years) and trial (six levels of averaged repetitions).

Results

Necessary sequences for goals

Intransitive movements- walking and jumping: All age groups imitated the intransitive locomotion movements in all imitation conditions (ISI, STDI, LTDI) with 100% recalling score.

Transitive actions: balls and umbrellas: In immediate and simultaneous imitation, all age groups imitated the sequences of balls and umbrellas with 100% recalling score (Table 1).

In short term deferred imitation, ANOVA showed a significant effect of age in the sequences of balls: $F(4, +\infty) = 18.43$, $p < 0.0001$. The Reduced distance test attributed the difference to the 3.5 and 4.5 age groups, who recalled worse (33%, 36%) than the older ones (5.5: 65%, 6.5: 83% and 7.5-year-olds: 98%). ANOVA also showed a significant effect of age in the umbrella sequences: $F(4,+\infty) = 12.22$, $p < 0.0001$. The Reduced distance test revealed that the recalling scores of younger age groups (3.5: 33%, 4.5-year-olds: 50%) were inferior to those of older ones (5.5: 74%, 6.5: 77% and 7.5-year-olds: 97%).

In long term deferred imitation, ANOVA showed a significant effect of age in the sequences of balls: $F(4,+\infty) = 10.69$, $p < 0.0001$. The Reduced distance test attributed the difference to the 3.5 age group by recalling fewer score (82%) than the other age groups (4.5: 97%, 5.5: 90%, 6.5: 95% and 7.5-year-olds: 94%). ANOVA also showed a significant effect of age in the umbrella sequences: $F(4,+\infty) = 3.18$, $p < 0.05$. The Reduced distance test also attributed the difference to the 3.5 age group by recalling fewer score (83%) than the other age groups (4.5: 97%, 5.5: 98%, 6.5: 98% and 7.5-year-olds: 96%).

Unnecessary sequences for goals

Body turning and umbrella carrying: In immediate and simultaneous imitation, (Table 2) ANOVA did not show a significant effect of age in the body turning sequence: $F(4,+\infty) = 1.42$, $p > 0.05$. However, the same analyses showed a significant effect of age in the umbrella carrying sequence: $F(4,+\infty) = 3.50$, $p < 0.001$. The Reduced distance test revealed that the 3.5, (35%), 4.5 (44%) and 5.5 (38%) age groups recalled less these sequences than the 6.5 (73%) and 7.5 (53%) age groups.

In short term deferred imitation, ANOVA showed a significant effect of age in the body turning sequence: $F(4, +\infty) = 8.98$, $p < 0.0001$.

	Body turning			Umbrella carrying		
	ISI	**STDI**	**LTDI**	**ISI**	**STDI**	**LTDI**
3.5 years	56%	9%	45%	35%	26%	35%
4.5 years	71%	21%	63%	44%	21%	46%
5.5 years	59%	44%	69%	38%	32%	81%
6.5 years	79%	38%	74%	73%	38%	82%
7.5 years	70%	68%	77%	53%	56%	84%

Table 2: Children recalling performance (%) in the reproduction of unnecessary sequences: body turning and umbrella carrying in immediate and simultaneous (ISI), short term (STDI) and long term deferred (LTDI) imitations.

The recalling scores of 3.5 (9%) and 4.5 (21%) age groups were inferior to those of other age groups (5.5: 41%, 6.5: 38% and 7.5-year-olds: 68%). The same analyses also showed a significant effect of age in the umbrella carrying sequence: $F(4, +\infty) = 2.81$, $p < 0.05$. The Reduced distance test revealed that the 3.5 (26%) and 4.5 (21%) age groups recalled less than the other age groups (5.5: 32%, 6.5: 38% and 7.5-year-olds: 56%).

In long term deferred imitation, ANOVA showed a significant effect of age in the body turning sequence: $F(4, +\infty) = 17.61$, $p < 0.0001$. The Reduced distance test attributed the difference to the 3.5 age group by recalling less (45%) than the other age groups (4.5: 63%, 5.5: 69%, 6.5: 74% and 7.5-year-olds: 77%). ANOVA also showed a significant effect of age in the umbrella carrying sequence: $F(4, +\infty) = 60.40$, $p < 0.0001$. The Reduced distance test attributed the difference to the 3.5 and 4.5 age groups. They recalled less (35%, 46%) than the other age groups (5.5: 81%, 6.5: 82% and 7.5-years: 84%).

Discussion

Typical imitation literature evokes that observed actions are broken down and then reconstructed in terms of their goals. Goals are represented in a hierarchy, such that goals at the top of the hierarchy are imitated accurately and the sub-goals further down the hierarchy are neglected. Our results were consistent with this point of view in imitating transitive and intransitive actions with necessary and unnecessary sequences.

Necessary sequences for goals

All age groups reproduced with higher accuracy the demonstrated goal-actions in locomotion. This result is consistent with the typical literature showing that both animals and humans segment the flow of action sequences on goals [12-15,19,31-35]. This enhances the idea that in early stage of life, children are able to perform the goal-directed actions [1,36-38]. It is agreed that, at least by the middle of the first year of life, infants already construct the actions seen on other persons in goals [39-41].

The originality of our work is that the selection of goals varied according to the nature of action. For example, the walking and jumping movements were easily recognized, retained and then reproduced by all age groups in all imitation conditions (100% recalling) [14]. The intransitive locomotion movements probably require fewer cognitive resources than the ones involved in a stable body. This is in agreement with Berthenthal's [42] assumption that recognition of action changes whether children produce stable or dynamic body movements. The locomotion movements additionally might merely reflect a primacy/recency effect [25] as known from words list learning [43]. In other words, what was better recalled here concerned mostly the first and last movements, namely walking and jumping, probably requesting heavy memory demands.

Contrary to intransitive movements, transitive actions were encoded differently according to the age factor and imitation condition. Indeed, actions with objects were significantly less recalled in the 3.5 and 4.5 age groups in short term deferred imitation, while they were already encoded in immediate and simultaneous imitations (0% forgetting) because the adult model accompanied the children's reproduction. In this imitation condition, the cognitive resources such as planning or recalling did not have an impact on their performance. Child performed step by step favored by the adult model's guidance and the physical presence of objects (e.g. container, balls, box or umbrellas). The restoration of these actions with objects in chunks was governed by a short term memory in short term deferred imitation and by a long term memory in long term deferred imitation [14]. Recently, Carmo and Rumiati [44] found that imitation among healthy adults engaged in a speed imitation task was significantly poorer when meaningful gestures involved object (e.g., hammering with an imaginary hammer), rather than no objects (e.g., waving good-bye). Transitive actions more likely pose greater processing demands on the cognitive system because they intrinsically more complex due to their association with the object representation [45].

Unnecessary sequences for goals

Generally, children do not integrate all details of demonstrated behaviors. They forget the unnecessary sequences and thereby had a detriment effect on their imitation quality [14]. As hypothesized, the unnecessary sequences to pursue the goals were deliberately ignored. In fact, all age groups considered the sequences of body turning and umbrella carrying as not useful for goals. For example, he/she reached the balls or opened the box for grasping the umbrella without changing of sides. Consequently, those sequences were less goal-directed both in short and long term deferred imitation conditions. If those two unnecessary sequences are neglected in short delay retention, this signifies that information do not encoded and is also forgotten in long delay retention. Because the child can for example, stay in the left side after being put the balls for reaching the umbrella without turning his/her body, or he/she can point in the side where he/she reaches the umbrella without carrying it to the opposite side. The two sequences were therefore unnecessary to accomplish the goals, as was the case for the meaningless *versus* meaningful actions to imitate the final outcome [16]. The number of sequences could also affect the imitation of action goals because the imitation is often affected by a limitation of cognitive resources, such as the working memory [18]. Children have small working memory capacity and hence they disregard other aspects of actions [4]. When the size of the working memory is limited, only the goal is extracted while the sub-goals are neglected.

The second hypothesis predicted that the imitation condition and age would determine the involvement of encoding type and memory system to accurately imitate. Our results also largely confirmed this prediction. For example, in long term deferred imitation, the younger age groups increased their recalling performance compared with

those scored in short term deferred imitation. The ball and umbrella actions were retained by the younger age groups with important success because they were with important perceptual salience. The object carrying sequences were orchestrated according to the actions' sense. For example, it is too silly to reach balls in a container and put them into the same container. There was no child who behaved like this because it did not serve the end goal. While, reaching an umbrella in a box and pointing with it into the same box is quite consistent with the end-state-goal [31]. Interestingly, in long term deferred imitation, children regrouped the actions in structured chunks. They organized three chunks hierarchy: (1) locomotion movements (two sequences); (2) balls (three sequences); (3) umbrellas (five sequences). Chunk is believed to be one of earliest forms of acknowledged representations used in regrouping and categorizing objects, persons, or events. The construction of these chunks was compatible with the results reported by Travis [25]. He demonstrated that, from the age of two, children start interleaved pairs of three-step action sequences by chunking together, performing them in a temporally continuous sequence. Thus, all children walked for jumping, reached balls for putting them away, and reached an umbrella for pointing and then putting it.

Conclusion

The current study provides some conclusions that children imitate in hierarchy process. They selected in priority the necessary sequences while they neglected the unnecessary ones for imitating both transitive (balls and umbrellas) and intransitive actions (walking and jumping). When reproduction was intentional in long term deferred imitation rather than incidental in short term deferred imitation, they increased their likelihood to build a strong and lasting recall level by establishing elaborate encoding type and memory system. These findings expand the point of view that during the preschool and school years, imitation undergoes significant changes going from low to high fidelity.

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