

A variation of the social context in the warm-up period influences 18-month-olds' imitation

### Highlights

- 18-month-old infants profit from a model's social behavior compared to a non-social behavior in a prior warm-up period
- When the model acted socially prior to the imitation task, infants showed a higher overall imitation rate in contrast to the condition when the model acted non-socially
- A detailed report about the models' disposition during the warm-up period ought to be included in future studies to enable a better interpretation of the results concerning imitative performance

## Abstract

The present study aimed to investigate how the prior social disposition of a model in a warm-up period influences 18-month-old infants' subsequent imitation. Infants were randomly assigned to an interactive and social warm-up period ( $n = 19$ ) or a non-interactive and non-social warm-up period ( $n = 19$ ) with the model prior to the imitation task. They then participated in an imitation task with different types of actions: novel means actions, arbitrary vs. functional actions and necessary vs. unnecessary actions. An additional social warm-up control group ( $n = 14$ ) and a non-social warm-up control group ( $n = 14$ ) were recruited to assess the spontaneous production of the target actions in the absence of the demonstration. The results showed that infants in the experimental groups performed significantly more target actions than infants in the control groups, showing an imitation effect. Furthermore, the results of the experimental groups showed that the overall imitation performance of the target actions was higher in the social condition than in the non-social condition. This imitation enhancing effect of the social warm-up period held true for the novel means actions and functional vs. arbitrary actions, however not for the necessary vs. unnecessary actions. Implications of the results for theory and future studies are discussed in terms of infants' social motivation and its relation to infants' imitative behavior.

*Keywords:* imitation, warm-up period, social motivation, social context

Running head: SOCIAL VS. NON-SOCIAL WARM-UP PERIOD

A variation of the social context in the warm-up period influences 18-month-olds' imitation

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## 27 **1. Introduction**

28 Imitation refers to social learning in a broad sense, while following a much more strict  
29 terminology it means copying means and goals in a high fidelity manner. Imitation enables  
30 the acquirement of knowledge and skills in a relatively short time by avoiding time  
31 consuming trial-and-error learning (Bekkering, Wohlschlaeger, & Gattis, 2000) and is  
32 therefore an important learning mechanism especially during infancy and childhood.  
33 Accordingly, for the last decades, the study of imitative development during infancy has  
34 received a tremendous amount of attention (Nadel, 2014). Most studies have been conducted  
35 with a standardized imitation paradigm (Meltzoff, 1985). In this experimental procedure, the  
36 infant observes a model performing target actions on one or a series of unfamiliar objects.  
37 After that, the objects are handed to the infant and imitative behavior is observed - either  
38 immediately, assessing action perception and action understanding, or after a delay, assessing  
39 long-term memory processes (Abravanel & Gingold, 1985).

40 As most studies on infants' imitation involve an unfamiliar human model, the vast  
41 majority of studies conduct a warm-up period prior to the demonstration phase to make the  
42 infants familiar with the testing environment and the model. So far, however, the model's  
43 sociability and the type of interaction during a warm-up period have not been systematically  
44 studied; a short warm-up period itself has been considered sufficient to elicit a high level of  
45 imitation and studies have freely chosen the form and content of it (Devouche, 1998).

46 There is some limited evidence in previous work, however, that a variation in the  
47 warm-up period could affect infants' imitation performance. For example, Somogyi and  
48 Esseily (2014) reported that when the experimenter mimicked 16-month-old infants' actions  
49 before a tool-use task, infants imitated the target actions with a higher rate than after a neutral  
50 warm-up period. Also, playing with the infants without mimicking them led to a better

51 performance than when infants played on their own. Zmyj, Schneider and Seehagen (2017)  
52 showed that an extended warm-up phase led to a decrease of infants' cortisol level. The  
53 authors pointed out that an elevated stress level due to a short or non-existing warm-up period  
54 might impair infants' cognitive abilities during the test period. Furthermore, Nielsen (2006)  
55 investigated more specifically the influence of a variation of the model's prior sociability. In  
56 this study, 18-month-old infants were assigned to one of two warm-up conditions. In the  
57 "social" condition, the model was sitting during the warm-up period at a table and engaged in  
58 a social interaction with the child (e.g., smiling, eye contact) while an assistant was playing  
59 with the child and familiarized him/her with the room. In the "aloof" condition, the model was  
60 absent during the warm-up period and met the child for the first time in the test room. In the  
61 demonstration phase, infants watched the model retrieve a toy from a closed box by  
62 disengaging a switch located on the front of the box. Although the box could be easily opened  
63 by hand, the model opened the box by using an object. During demonstration, the model's  
64 actions were either accompanied by social-communicative cues (social condition) or the  
65 model remained focused on the toy and avoided eye contact (aloof condition). The results  
66 showed that 18-month-old infants' imitative behavior was influenced by the social disposition  
67 of the model. Infants imitated more exactly the specific object-use when the model acted  
68 socially, but imitated selectively only the end-state of the action when the model acted aloof.

69 One theory that was suggested to explain these differences is the social affiliation  
70 account which explains that infants' exact versus selective imitation varies to the extent to  
71 which they are motivated primarily by cognitive or social motivation (Carpenter, 2006; Over  
72 & Carpenter, 2012; see also Užgiris, 1981). That is, in situations in which cognitive  
73 motivation predominates, infants focus much of their attention on the functions of the objects  
74 in order to learn a new skill and are accordingly mainly interested in attaining a particular  
75 result. Consequently, they selectively imitate the elements of the demonstrated target actions

76 that are relevant for achieving that result. In contrast, in situations in which social motivation  
77 predominates, infants seek to affiliate with the model and are interested in sustaining the  
78 interaction. As a function of this social motivation to imitate, infants are more likely to match  
79 their own behavior with the models' behavior. Accordingly, the modeled target actions are  
80 imitated more exactly by the infants, even if the actions are irrelevant to achieve a certain  
81 outcome or to manipulate an object. Hence, it has been suggested that infants' exact imitation  
82 can be used as an indicator of social motivation (e.g., Carpenter, 2006; Van Etten & Carver,  
83 2015). In contrast, alternative theories explain infants' variation in imitative behavior  
84 according to what infants interpret as the models' intentions or goals to be: infants imitate the  
85 modeled actions more exactly when no other end-state of an action could be perceived as a  
86 goal. However, when a clear final end-state is present, infants selectively imitate only the  
87 relevant actions in order to achieve the goal (Bekkering et al., 2000; Carpenter, Call, &  
88 Tomasello, 2005). Since this account cannot explain why infants in the social condition  
89 imitated also the unnecessary actions although the end-state was clear to distinguish (Yu,  
90 2015), support for the social affiliation account seems to be more plausible.

91         There are, however, some important limitations in previous studies that preclude a  
92 precise understanding of how the prior social disposition of the model in a warm-up period  
93 influences infants' subsequent imitation. First, in Nielsen's (2006) study, the assistant and not  
94 the model had a warm-up period with the infant in the social condition. Hence, no active  
95 interaction between the model and the infant took place. Furthermore, in the aloof condition,  
96 the model did not meet the infant before the demonstration phase and was, accordingly, an  
97 unfamiliar person for the infants. Second, as the use of social-communicative cues was varied  
98 between the social vs. aloof condition in the demonstration phase as well, it is not clear  
99 whether the disposition of the model in the warm-up period was the only factor that could  
100 have had an impact on infants' imitation.

101 Third, infants' exact imitation was investigated with only one action type, whereas in  
102 other previous studies, exact imitation was also measured with different action types. For  
103 example, the first type of imitation task measures the acquisition of novel means actions,  
104 which are unusual novel actions to produce an interesting effect on novel objects even though  
105 the same effect could be easily achieved by more familiar means (e.g., using one's forehead  
106 instead of one's hand to turn on a light, see Meltzoff, 1988; Herold & Akhtar, 2008). A list of  
107 studies showed that the social-communicative context had an effect on infants' exact imitation  
108 of novel means actions (e.g. Király, Csibra, & Gergely, 2013; Shimpi, Akhtar, & Moore,  
109 2013).

110 The second type of imitation task varies the functionality of target actions (see Óturai,  
111 Kolling, Rubio Hall, & Knopf, 2012). Functional actions are those that require specific object  
112 properties and are thus strongly connected to the objects, whereas arbitrary actions do not  
113 require specific object properties and thus could be performed on a wide range of objects.  
114 Óturai et al. (2012) showed that 12-month-old infants only imitated the functional actions,  
115 whereas 18-month-olds imitated both kinds of actions. The authors pointed out that the  
116 imitation of arbitrary actions observed in older infants may serve social functions.

117 The third type of imitation task is a two-action sequence on an object in two different  
118 causal contexts. In the necessary condition, the first action is causally necessary in order to  
119 execute the second action that yields the effect (e.g., producing a sound by pressing a button  
120 on the object). In the unnecessary condition, the first action is causally unnecessary in order to  
121 execute the second action. Hence, in former studies, exact imitation as evidenced by imitation  
122 of first action in the unnecessary condition was used as an indicator for the social motivation  
123 to imitate (e.g., Hilbrink, Sakkalou, Ellis-Davies, Fowler, & Gattis, 2013).

124 In the present study, then, we investigated whether 18-month-old infants' imitative  
125 behavior differs upon a social warm-up period versus a non-social warm-up period with the



126 model prior to the imitation task. Importantly, to ensure that any differences found in  
127 imitation across conditions were due to the different prior social conditions, the model used  
128 social-communicative cues during the demonstration phase in both conditions. Furthermore,  
129 in order to assess if infants' imitation rate in the experimental groups is above the rate of  
130 spontaneous propensity to produce the target actions in absence of a demonstration, two  
131 control groups were used. They were treated the same as the experimental groups - one  
132 control group had a social warm-up period and the other control group had a non-social  
133 warm-up period - with the difference that no target actions were modeled. Additionally, to  
134 consider if a variation of the models' sociability in the warm-up period has an effect on  
135 infants' exact imitation across different action types, the above-mentioned three different  
136 action types were chosen.

137         The present study tested the following predictions: First, we expected that infants in  
138 both conditions (social warm-up vs. non-social warm-up) of the experimental groups would  
139 perform above the rate of spontaneous production of target actions by infants in the control  
140 groups. Second, to the extent that infants' affiliation with the model is hypothesized to  
141 facilitate imitative learning (e.g., Brugger, Lariviere, Mumme, & Bushnell, 2007) we  
142 expected that a social condition would lead infants to imitate the model's actions more  
143 frequently than infants in a non-social condition. Finally, based on previous findings which  
144 suggested a correspondence between infants' social motivation to imitate and exact imitation  
145 (e.g., Carpenter, 2006; Hilbrink et al., 2013; Yu & Kushnir, 2014), we anticipated that infants  
146 in the social condition would imitate irrelevant actions (actions having no clearly visible  
147 outcome or causal function) more frequently than infants in the non-social condition due to  
148 their higher social motivation to sustain interaction and affiliate with the model and that this  
149 difference would hold true across the three different action types.

## 150 **2. Method**

151 *2.1. Participants*

152 A total of sixty-six healthy, 18-month-old infants ( $M = 18$  months 22 days;  $SD = 33$   
153 days, 29 girls) participated in the study. Three additional infants were tested but not included  
154 in the final sample due to technical problems ( $n = 1$ ) or lack of cooperation ( $n = 2$ ). All  
155 participating infants were typically developing, with a mean birth weight of  $M = 3285$  g  
156 (minimum 2600g, maximum 4300g,  $SD = 526.5$ ).

157 *2.2. Materials and target actions*

158 *Novel means actions.* Two target objects adapted from former studies (e.g., Herold &  
159 Akhtar, 2008; Shimpi et al., 2013) were used. The first one was a white push-on circular light  
160 which was activated by applying pressure to it. The second one was a round table bell which  
161 produces a ringing sound when pressing the top of it. The model demonstrated one target  
162 action on each of the objects: to activate the lamp, the model leaned forward and touched its  
163 top with her forehead ('headtouch' task; see also Meltzoff, 1988). To activate the table bell,  
164 the model used one elbow to press the top. The hands were unoccupied and clearly visible on  
165 the tabletop during both target action demonstrations.

166 *Functional vs. arbitrary actions.* Six target objects of the Frankfurt Imitation Test for  
167 18 Month Old Children were used (FIT 18, see Goertz, Kolling, Frahsek, & Knopf, 2008).  
168 The model demonstrated two target actions with each of the six objects: a *functional* and an  
169 *arbitrary* one adapted from Óturai et al. (2012). For example, clicking a metal box onto a  
170 magnetic toy cow's belly is defined as a functional action as the child can discover the  
171 function of the magnet. In contrast, lifting the toy cow with the metal box on the belly and  
172 placing it back on the table is defined as an arbitrary action.

173 *Necessary vs. unnecessary actions.* Two target objects adapted from a former study  
174 (Hilbrink et al., 2013) were used. The first one was a wooden box and the second one was a  
175 toy train. Each object was used once in the *necessary condition* and once in the *unnecessary*

176 *condition*, with modifications for each condition so that there were four different toys in total.  
177 In the *necessary condition*, the first action was necessary in order to perform the second  
178 action which always led to an effect. In the *unnecessary condition*, the first action was  
179 irrelevant to the second action which leads to an effect. The first object was a wooden box  
180 which had a lid that could be pulled open with a knob to reveal a hidden ball. In the *necessary*  
181 *condition*, a Velcro latch was attached to the lid of the box that needed to be removed before  
182 the lid could be opened. The model's first action was to remove the Velcro latch, which was a  
183 necessary action, and the second action was to open the lid. In the *unnecessary condition*, the  
184 Velcro latch was positioned on the other half of the box which did not hold the lid shut. The  
185 model's first action was to remove the Velcro latch on the other half of the box, which was  
186 unnecessary to perform, and the second action was to open the lid. The second object was a  
187 toy train which contained two puppets, one in the front seat and one in the back seat. Pushing  
188 the puppet in the front seat of the train caused music to play. In the *necessary condition*, a  
189 blue plastic cover in a form of a pyramid was placed over the puppet in the front seat of the  
190 train. The model's first action was to remove the cover from the puppet in the front seat and  
191 the second action was to push the puppet in order to make a noise. In the *unnecessary*  
192 *condition*, the cover was placed over the animal in the back of the train. In this condition, the  
193 model's first action was to remove the cover from the puppet in the back seat, which was  
194 unnecessary to perform, and the second action was to push the puppet in the front seat in  
195 order to make a noise.

### 196 2.3. Design and procedure

197 Infants were randomly assigned to either the social warm-up experimental group ( $n =$   
198 19) or the non-social warm-up experimental group ( $n = 19$ ). A social warm-up control group  
199 ( $n = 14$ ) and a non-social warm-up control group ( $n = 14$ ) were recruited to assess the  
200 spontaneous production of the target actions in the absence of the demonstration. Upon arrival

201 at the university, the infant and parent(s) were escorted to a quiet lab room. The warm-up  
 202 period began after the purpose and procedure of the study were explained to the parent(s) and  
 203 written informed consent was obtained<sup>1</sup>. The warm-up period lasted for 8 minutes in each  
 204 condition. This time period was chosen as a previous study (Bretherton, 1978) showed that  
 205 after 8 minutes of play infants were able to establish a rapport with an unfamiliar adult.

206 To control for effects based on temporal order of action presentation, the infants in the  
 207 experimental groups were randomly assigned to different presentation orders. In the case of  
 208 functional vs. arbitrary actions, the order of target actions was varied in an incomplete  
 209 counterbalanced design. In the condition “presenting order 1” ( $n = 19$ ) the functional actions  
 210 were presented firstly for the second, the third and the sixth item and the arbitrary actions  
 211 were presented thereafter. In the condition “presenting order 2” ( $n = 19$ ) the arbitrary and  
 212 functional actions were presented in the reversed order. In the case of necessary vs.  
 213 unnecessary actions, infants were shown both types of target objects in both conditions in one  
 214 of four possible orders counterbalanced across infants: (1) wooden box necessary, toy train  
 215 unnecessary, wooden box unnecessary, toy train necessary ( $n = 10$ ), (2) wooden box  
 216 unnecessary, toy train necessary, wooden box necessary, toy train unnecessary ( $n = 10$ ), (3)  
 217 toy train necessary, wooden box unnecessary, toy train unnecessary, wooden box necessary ( $n$   
 218  $= 9$ ), (4) toy train unnecessary, wooden box necessary, toy train necessary, wooden box  
 219 unnecessary ( $n = 9$ ).

### 220 2.3.1. Social warm-up period

221 The model started the warm-up period by picking up a ball and saying ‘Look [Infant’s  
 222 Name], let’s play with the ball’. The model actively initiated reciprocal games such as ball-  
 223 games (rolling the ball back and forth) as well as give-and-take games (giving the ball and  
 224 requesting it) that establish a social rapport. All infants accepted the model’s offer of a toy at

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<sup>1</sup> The study has been conducted in full accordance with the ethical guidelines of the German Psychological Society and is also in line with the Ethical Principles of Psychologists and Code of Conduct of the American Psychological Association.

225 least once, directly from the model's hand or indirectly (e.g., by catching the ball) and also  
226 initiated a social interaction at least once, by giving the model a toy. The model maintained  
227 and initiated eye contact, smiled at the infant and vocalized the infant's behavior during this  
228 condition.

### 229 *2.3.2. Non-social warm-up period*

230 The model started the warm-up period by saying 'Look, you can play with the toys  
231 over there'. The parent(s) were asked to engage in play with the child. The model was sitting  
232 beside at a desk on a chair and there was no active interaction between the model and the  
233 infant. The model did not talk to the infant and avoided eye-contact during this condition.

### 234 *2.3.3. Demonstration of target actions*

235 After the warm-up period the demonstration phase began. The infant and the parents  
236 were escorted to a table that was behind a partition wall in the same room. The infant was  
237 seated on the caregiver's lap opposite to the model. The model retrieved the first object from a  
238 hidden container below the table and placed it on the table in front of the infant. Then, the  
239 model started to demonstrate the target action, saying: "Look, [Name], I will show you  
240 something!" The model demonstrated the target action two times within roughly 30 seconds.  
241 Then, the object was handed over to the infant while the model said: "Now it's your turn".  
242 The infant was given 30 s to play with the object starting from the moment when the model  
243 removed her hands from the object. The same procedure was repeated for all target objects.  
244 The infant and the model were videotaped by two cameras.

### 245 *2.3.4. Control conditions*

246 After the warm-up period, the infant and the parents were escorted to a table that was  
247 behind a partition wall in the same room. The experimenter placed the first object in front of  
248 the infant and directed the infant's attention to it, saying: "Look, [Name], you can play with  
249 this." After 30 seconds, the experimenter removed the object and put the next object on the

250 table, saying: “Look, [Name], now you can play with this one”. The same procedure was  
251 repeated for all target objects.

#### 252 2.4. Coding procedure

253 A naïve rater scored the performance of target actions in the videotaped sessions. One  
254 third of the videotapes was also scored by a second rater and a good inter-rater reliability was  
255 obtained,  $k = .83$  ( $p < .001$ ). For each task infants received a score of 1 when they produced  
256 the target action and otherwise a score of 0. Therefore, infants could receive an imitation  
257 score from 0 to 2 for the novel means actions (head touch task, elbow task), a score from 0 to  
258 2 for overall goal attainment by any means (put the light on, ring the bell by either using the  
259 hand or using the novel means), a score from 0 to 6 for the functional actions, a score from 0  
260 to 6 for the arbitrary actions. In the case of the necessary vs. unnecessary actions, the focus  
261 was on the first action as the second actions remained constant between the social vs. non-  
262 social conditions (see also Brugger et al., 2007; Hilbrink et al., 2013). Accordingly, infants  
263 could receive an imitation score from 0 to 2 for the first actions in the unnecessary condition  
264 and a score from 0 to 2 for the first actions in the necessary condition (toy train task, box  
265 task). Target objects, actions and possible imitation scores are shown in Table 1.

Table 1

*Test objects and target actions*

Action type	Object	Relevant action	Max.	Irrelevant action	Max.
Novel means actions	Lamp	<b>Goal attainment</b> Turn on the light <i>Will be coded as yes, if the child press the lamp with one or both hands even if the child's press was too weak to actually turn on the light</i>	2	<b>Novel means actions</b> Using the forehead to turn on the light <i>Will be coded as yes, if the child use any part of the face or head</i>	2
	Bell	Activate the bell <i>Will be coded as yes, if the child press the bell with one or both hands even if the child's press was too weak to actually ring the bell</i>		Using the elbow to press the bell <i>Will be coded as yes, if the child twists the arm and touches the bell with the back of the wrist, fist or forearm</i>	
Functional vs. Arbitrary actions	Ship	<b>Functional action</b> Putting a hand into the ship and waving <i>Will be coded as yes, if the child puts a hand into the ship</i>	6	<b>Arbitrary action</b> Taking the ship from one hand to another and back <i>Will be coded as yes, if the child take the ship from one hand to the other</i>	6
	Cow and metal box	Clicking the box on the cow's belly <i>Will be coded as yes, if the child clicks the box on the cow's belly, even if the magnets do not hold</i>		Lifting the cow from the table and placing it back <i>Will be coded as yes, if the child lifts the cow and places it back on the table, regardless if the metal box is in the belly</i>	
	Mouse	Shutting the mouse <i>Will be coded as yes, if the child clicks the mouse, even if she/he is too weak to produce a noise</i>		Moving the mouse on a curvy path <i>Will be coded as yes, if the child pushes the mouse forwards on the table, regardless if the path is curvy</i>	
	Frog and ring	Putting a finger into the frog and holding it upright <i>Will be coded as yes, if the child puts a finger into the frog</i>		Sitting the frog into the ring and sliding it to and fro <i>Will be coded as yes, if the child slides the frog to and fro on the table, regardless if the frog is sitting in the ring</i>	
	Drum	Pressing the red button <i>Will be coded as yes, if the child presses the red button on the drum</i>		Sliding the drumstick around the drum <i>Will be coded as yes, if the child slides the drumstick around or next to the drum</i>	
	Duck and octopus	Sitting the duck in the octopus <i>Will be coded as yes, if the child places the duck onto the octopus</i>		Turning the duck <i>Will be coded as yes, if the child turns the duck, regardless if it is sitting on the octopus</i>	
Necessary vs. Unnecessary actions	Box	<b>Necessary first action</b> Removing the Velcro latch attached to the lid of the box which is opened <i>Will be coded as yes, if the child grabs the latch and tries to remove it even if she/he is too weak to remove it</i>	2	<b>Unnecessary first action</b> Removing the Velcro latch attached to the other half of the box which did not hold the lid shut <i>Will be coded as yes, if the child grabs the latch and tries to remove it even if she/he is too weak to remove it</i>	2
	Toy train	Removing the cover from the puppet in the front seat <i>Will be coded as yes, if the child lifts the cover up from the puppet</i>		Removing the cover from the puppet in the back seat <i>Will be coded as yes, if the child lifts the cover up from the puppet</i>	

*Note. Infants received one point for each action.*

### 266 3. Results

#### 267 3.1. Preliminary analysis

268 ANOVAs were used to test whether the imitation rate differed between the  
269 presentation order conditions. The presentation order of functional vs. arbitrary actions had no  
270 significant effect on the imitation rate,  $F(1, 36) = 2.10, p = .156$ . Also, the presentation order  
271 of necessary vs. unnecessary action had no significant effect on the imitation rate,  $F(3, 34) =$   
272  $1.24, p = .310$ . This factor was therefore not included in any of the following analyses.

#### 273 3.2. Overall analysis of imitation

274 The results showed that infants in the experimental groups performed  $M = 10.47$  ( $SD =$   
275  $2.96$ ) target actions while infants in the control groups performed  $M = 3.50$  ( $SD = 1.20$ ) target  
276 actions. A 2 (group: experimental vs. control groups) x 2 (condition: social vs. non-social)  
277 ANOVA was used for an overall analysis of imitation. A significant main effect of group was  
278 found,  $F(1, 62) = 173.72, p < .001, r = .86$ , indicating that infants in the experimental groups  
279 performed significantly more target actions than infants in the control groups. Hence, an  
280 imitation effect was shown. Also, a significant main effect of condition was found,  $F(1, 62) =$   
281  $7.02, p = .010, r = .32$ , indicating that infants in the social condition performed significantly  
282 more target actions than infants in the non-social condition. The interaction between group  
283 and condition was also significant,  $F(1, 62) = 8.53, p = .005, r = .35$ . This interaction shows  
284 that the experimental groups and the control groups were affected differently by condition.  
285 Planned comparisons revealed that the imitation rate in the social ( $M = 3.43, SD = 1.09$ ) and  
286 non-social condition ( $M = 3.57, SD = 1.34$ ) did not differ in the control groups,  $t(26) = .31, p$   
287  $= .760, r = .06$ ; however, the imitation rate was significantly higher in the social condition ( $M$   
288  $= 11.95, SD = 2.59$ ) than in the non-social condition ( $M = 9.00, SD = 2.58$ ) in the  
289 experimental groups,  $t(36) = -3.51, p = .001, r = .72$ .

#### 290 3.3. Imitation performance for different action types



291 *3.3.1. Imitation of novel means as a function of condition*

292 An independent *t*-test revealed that infants in the social condition ( $M = 1.42$ ,  $SD =$   
293  $0.77$ ) showed a significantly higher imitation rate of the novel means actions (put the light on  
294 by using the head, use the elbow to ring the bell) than infants in the non-social condition ( $M =$   
295  $0.68$ ,  $SD = 0.82$ ),  $t(36) = -2.858$ ,  $p = .007$ ,  $r = .54$ . Additionally, to examine if infants in the  
296 social vs. non-social condition showed differences in achieving the end-state of the action, the  
297 overall goal attainment by any means (put the light on, ring the bell by either using the hand  
298 or using the novel means) in the two conditions was investigated. The results showed no  
299 significant difference between infants in the social ( $M = 1.89$ ,  $SD = 0.46$ ) and non-social  
300 condition ( $M = 1.58$ ,  $SD = 0.61$ ),  $t(36) = -.651$ ,  $p = .519$ ,  $r = .11$ , showing that infants in the  
301 non-social condition and social condition achieved the end result of the action at a similar  
302 rate.

303 *3.3.2. Imitation of arbitrary vs. functional actions as a function of condition*

304 The data of arbitrary vs. functional actions were analyzed using a 2 (condition: social  
305 versus non-social) x 2 (action type: arbitrary versus functional) mixed model ANOVA.  
306 Condition was a between-subject factor and action type was a within-subject factor. A  
307 significant main effect of condition was found,  $F(1, 36) = 8.56$ ,  $p = .006$ ,  $r = .44$ , indicating  
308 that, overall, infants in the social condition ( $M = 7.63$ ,  $SD = 2.00$ ) performed significantly  
309 more actions than infants in the non-social condition ( $M = 5.79$ ,  $SD = 1.93$ ). Also, a  
310 significant main effect of action type was found,  $F(1, 36) = 105.78$ ,  $p < .001$ ,  $r = .86$ ,  
311 indicating that, overall, infants imitated significantly more functional actions ( $M = 4.50$ ,  $SD =$   
312  $1.33$ ) than arbitrary actions ( $M = 2.21$ ,  $SD = 1.18$ ). The interaction between action type and  
313 condition was not significant,  $F(1, 36) = .014$ ,  $p = .907$ ,  $r = .01$ .

314 *3.3.3. Imitation of necessary vs. unnecessary actions as a function of condition*

315 The data of necessary vs. unnecessary actions were analyzed using a 2 (action type:  
316 necessary vs. unnecessary) x 2 (condition: social vs. non-social) mixed model ANOVA.  
317 Condition was a between-subject factor and action type was a within-subject factor. A  
318 significant main effect of action type was found,  $F(1, 36) = 31.85, p < .001, r = .47$ , indicating  
319 that, overall, infants imitated significantly more necessary actions ( $M = 1.71, SD = 0.46$ ) than  
320 unnecessary actions ( $M = 1.00, SD = 0.74$ ). However, no significant main effect of condition  
321 was found,  $F(1, 36) = 1.52, p = .226, r = .04$ , indicating that infants in the social condition ( $M$   
322  $= 2.89, SD = 0.86$ ) did not perform significantly more actions than infants in the non-social  
323 condition ( $M = 2.53, SD = 0.96$ ). Also, the interaction between action type and condition  
324 failed to meet significance,  $F(1, 36) = 3.54, p = .68, r = .09$ .

#### 325 **4. Discussion**

326 Most imitation studies conduct a warm-up period, but the form and content has not  
327 been systematically controlled so far. The present study investigated whether 18-month-old  
328 infants' imitative behavior differed upon a social warm-up period versus a non-social warm-  
329 up period with the model prior to the imitation task. First, as predicted, the present findings  
330 show a broad effect of infant learning regardless of warm-up condition. Infants imitated  
331 significantly more actions in the experimental condition than in the control condition.  
332 Furthermore, the results showed that infants imitated significantly more functional than  
333 arbitrary actions and were also more likely to imitate the first action if it was necessary than if  
334 it was unnecessary to perform. These results demonstrate that 18-month-old infants are tuned  
335 to imitate and learn important, relevant actions and show an understanding of the causal  
336 relations embedded in the task, replicating previous findings (Brugger et al., 2007; Hilbrink et  
337 al., 2013; Óturai et al., 2012).

338 Second, the present findings confirmed our expectations that 18-month-olds' imitative  
339 behavior is guided by the model's social nature during a warm-up period. The results show

340 that 18-month-old infants profit from a model's social behavior compared to a non-social  
341 behavior. When the model acted socially prior to the imitation task, infants showed a higher  
342 overall imitation rate than when the model acted non-socially. Importantly, this was shown  
343 even though the model was social during the demonstration phase in both conditions. Hence,  
344 the present result is consistent with the proposal that what impacts on infants' imitation  
345 behavior is not simply the familiarity with the model but the nature of the relation that is built  
346 between the model and the infant (Devouche, 1998; see also Nielsen, Simcock, & Jenkins,  
347 2008).

348 Third, as expected, the results of the present study also demonstrate that 18-month-old  
349 infants were more likely to imitate the specific target actions when the model acted socially,  
350 even if those actions were irrelevant to achieve a certain end-state. Interpreted in the  
351 framework suggested by Nielsen (2006) and Over and Carpenter (2012), these results indicate  
352 that as a part of their desire to affiliate and sustain social interaction, infants in the social  
353 condition were more motivated to exactly match their behavior to a model's clearly  
354 suboptimal and inefficient actions to reach a goal. As exact imitation can be used as an  
355 indicator for social motivation, these results shows that as a part of their desire to affiliate, a  
356 variation of the models' sociability in a warm-up period prior to the imitation task has a  
357 powerful influence on infants' social motivation, and thus on what they imitate. These  
358 findings are also relevant to previous empirical work suggesting that children may imitate  
359 irrelevant actions as a way of learning about social or cultural norms (e.g., Nielsen & Blank,  
360 2011). The imitation of all modeled actions that are demonstrated in a purposeful way could  
361 be potentially useful in learning the rules and conventions of society (see Kenward, Karlsson,  
362 & Persson, 2011). Hence, the present results suggest that closer rapport with the model could  
363 lead to infants becoming more open to the model's "norms" of using a tool.

364           However, the extent to which infants' imitation behavior was influenced differed  
365 depending on the type of action that was demonstrated. For the novel means actions, the  
366 results confirmed our expectation that infants in a social warm-up period would engage in  
367 more imitation: they imitated the observed (unusual and clearly suboptimal) head-, and  
368 elbow- action to achieve the goal significantly more often than infants in the non-social  
369 warm-up period who achieved the same final goal, but used rather the more efficient hand  
370 action. These findings are in line with the results of Shimpi et al. (2013) showing that infants  
371 were more likely to imitate novel means actions if they had prior social experience with the  
372 model (familiarization phase) than if they had not met the model before. Our findings  
373 furthermore extend these results by showing that not only the presence or absence of a  
374 familiarization phase but also the sociability of a model in the warm-up period prior to  
375 demonstration has influence on infants' subsequent imitation of novel means actions.  
376 Furthermore, for the arbitrary actions, the results also confirmed our hypothesis that infants in  
377 a social warm-up period would engage in more imitation. However, for the unnecessary  
378 actions, contrary to our expectations the infants in a social warm-up period did not engage in  
379 more imitation.

380           Why did infants imitate differently with respect to the type of actions? A possible  
381 explanation could be that at 18 months of age, the influence of the social context during a  
382 warm-up period interacts with infants' cognitive motivation to learn. In case of novel means  
383 actions, there was nothing 'new' to learn regarding the manipulation of the objects. Infants  
384 had a choice between achieving a goal by imitating novel means or just easily use their hands  
385 and the present results demonstrate that a social interaction with the model in the warm-up  
386 period led infants to engage more frequently in exact means-directed imitation. However, in  
387 case of the functional vs. arbitrary and necessary vs. unnecessary actions, the modeled actions  
388 included new learning aspects of attaining a particular result or state by manipulation of the

389 objects. This could have led to a priority of achieving end-results as a goal, which made it to  
390 be selected over other, social, goals. Hence, infants were not sufficiently motivated by the  
391 social warm-up period to imitate actions that are irrelevant and disregarded their prior  
392 interaction with the model in favor of their own judgement about whether the elements of the  
393 demonstrated target actions are relevant to achieve an overarching end-state in a two- (or  
394 more) action sequence.

395         One critical aspect of the present study that has to be acknowledged is that the warm-  
396 up periods were not video recorded and therefore information about the exact numbers and  
397 durations of eye-contact, give-and-take games etc. could not be reported precisely. Hence, a  
398 more detailed report and analysis of manipulations in the warm-up period based on video  
399 coding remains an important topic for future studies. Moreover, further research is needed to  
400 explore whether the present results hold for different age groups as well.

## 401 **5. Conclusions**

402         Overall, the current study is an important step into exploring the influence of the social  
403 context during a warm-up period on infants' subsequent imitation, which has rarely been  
404 addressed in empirical work so far. In the light of the present findings, two main points should  
405 be considered in future research. First, researchers need to be cautious when interpreting  
406 results only as an account for capacity, thereby disregarding the influence of motivation  
407 (Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2012). Second, a detailed report about the  
408 form, content and the models' disposition during the warm-up period ought to be included in  
409 future studies to enable a better interpretation of the results concerning imitative performance.

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412

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414 **References**

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