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Clay, Zanna, Over, Harriet orcid.org/0000-0001-9461-043X and Tennie, Claudio (2018) What drives young children to over-imitate? Investigating the effects of age, context, action type and transitivity. *Journal of Experimental Child Psychology*. pp. 520-534. ISSN 0022-0965

<https://doi.org/10.1016/j.jecp.2017.09.008>

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**What drives young children to over-imitate? Investigating the effects of age,
context, action type and transitivity**

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Abstract

Imitation underlies many traits thought to characterise our species, which includes the transmission and acquisition of language, material culture, norms, rituals and conventions. From early childhood, humans show an intriguing willingness to imitate behaviours, even those that have no obvious function. This phenomenon, known as ‘over-imitation’, is thought to explain some of the key differences between human cultures as compared to those of non-human animals. Here, we used a single integrative paradigm to simultaneously investigate several key factors proposed to shape children’s over-imitation: age, context, transitivity and action type. We compared typically-developing children aged 4-6 years in a task involving actions

verbally-framed as being instrumental, normative or communicative in function.

Within these contexts, we explored whether children were more likely to over-imitate transitive versus intransitive actions; and manual actions or body-part actions. Results showed an interaction between age and context; as children got older, they were more likely to imitate within a normative context, whereas younger children were more likely to imitate in instrumental contexts. Younger children were more likely to imitate transitive actions (actions on objects) than intransitive actions compared to older children. Our results show that children are highly sensitive to even minimal cues to perceived context, and flexibly adapt their imitation accordingly. As they get older, children's imitation appears to become less object-bound and less focused on instrumental outcomes, and more sensitive to normative cues. This shift is consistent with the proposal that over-imitation becomes increasingly social in its function as children move through childhood and beyond.

Keywords: copying; transitivity; ritual; instrumental, communicative, normative

Imitation is a hallmark of the human cultural capacity and underlies many of the core aspects of what it means to be human; it plays a key role in the acquisition and transmission of both material culture and language, as well as for social norms, rituals and conventions (Legare & Nielsen, 2015; Meltzoff & Prinz, 2002; Tomasello, 1999; Whiten, 2012, 2017). From early on in development, children spontaneously imitate the complex actions of others (Tomasello, 1999), a capacity that increases steadily with age (McGuigan *et al.*, 2007; 2011; 2012; Whiten *et al.*, 2016). Given the importance of imitation to both human cultural and social life, one obvious question concerns how imitation emerges across development, and in particular which factors shape what and why children imitate.

Developmental research consistently shows that children are strongly motivated to copy others and often do so with a high degree of fidelity (Hopper *et al.*, 2008; McGuigan *et al.*, 2011; 2012; Whiten *et al.*, 1996; Whiten & Flynn, 2010). Children prefer to learn socially than asocially (Flynn *et al.*, 2016) and their tendency to imitate increases with age (McGuigan *et al.*, 2007; 2011; 2012; Whiten *et al.*, 2016). In some cases, children copy so faithfully that they are even willing to copy actions that are

visibly causally-irrelevant, a phenomenon known as ‘over-imitation’ (Horner & Whiten, 2005; Lyons *et al.*, 2007; Over & Carpenter, 2012). While other animals may show some competence towards imitation (Bugnyar & Huber, 1997; Huber *et al.*, 2009), over-imitation itself appears to be a uniquely human phenomenon and as such, is sometimes discussed as a hallmark of human culture (Clay & Tennie, 2017; Horner & Whiten, 2005; Nielsen *et al.*, 2010; Tennie *et al.*, 2012;).

Multiple explanations have been offered for over-imitation, which broadly fall into two categories – *instrumental* and *social*. The best-known variant of an *instrumental* account has been offered by Lyons and colleagues (2007); they argue that children’s over-imitation is primarily due to their perception of the action as being causally-opaque, that is to say, they mistakenly perceive actions that are seemingly unfamiliar as being causally-relevant and thus copy them in order to acquire instrumental skills (Lyons *et al.*, 2007; 2011; Whiten *et al.*, 2009).

Although the instrumental account may explain children’s over-imitation in some situations, recent research has shown that over-imitation is also notably influenced by social factors (Over & Carpenter, 2012). *Social* explanations for over-imitation have focused mainly on affiliation and norm-following. The ‘*normative*’ or ‘*conventional*’ account proposes that children over-imitate as a result of perceived social pressures, namely in regards to perceived norms, conventions or rituals (Clegg & Legare, 2016; Kenward, 2012; Legare & Nielsen, 2015; Legare & Watson-Jones, 2015; Moraru *et al.*, 2016). This account, which we will henceforth refer to as ‘normative’ is supported by evidence that children will actively protest against a puppet who omits a causally-irrelevant action, after having seen it being performed by a demonstrator (Kenward,

2012; Keupp *et al.*, 2013). The second social account, complementary to this, proposes that children over-imitate in order to *be like* or *affiliate with* others (Over & Carpenter, 2012; Uzgiris *et al.*, 1981). Both accounts are consistent with evidence showing that children are more likely to copy in-group than out-group members (Kinzler *et al.*, 2011), are more likely to copy after being primed with third-party ostracism (Over & Carpenter, 2009) and show greater trust for individuals that have imitated them (Over *et al.*, 2013).

A third important function of imitation, which is less often discussed in the over-imitation literature, is for communication. It is known from previous research that imitation is closely involved in language learning (Toth *et al.*, 2006) and reliably predicts language ability in both typically-developing (Bates *et al.*, 1979; Bates, 2014) and non-typically developing children (Charman *et al.*, 2000, 2003; Stone & Yoder, 2001). Learning a new system for communication requires faithful reproduction of communicative signals (Tennie *et al.* 2012). However, although there has been some more recent related studies on vocal over-imitation (Bannard, Klinger & Tomasello, 2013; Klinger, Mayor & Bannard, 2016; Subiaul *et al.*, 2016), there is surprisingly little research exploring children's over-imitation of communicative behaviours as compared to instrumental or normative ones. In this context, it is important to consider imitation of communicative gestures in relation to the imitation of other types of actions.

To date, only a small number of studies with infants have compared imitation of gestures and object-directed actions (Abravanel, Levan-Goldschmidt, & Stevenson, 1976; Christie & Slaughter, 2009; Kim *et al.*, 2015; Rodgon & Kurdek, 1977; Zmyj *et*

al., 2012). We use the term gesture to refer to “discrete, mechanically ineffective physical movements of the body produced during period of intentional communication” (Hobaiter & Byrne, 2011). Overall, these studies have shown that infants appear to be less likely to imitate gestural actions as compared to motorically-similar actions that are object-directed. However, these studies confound the communicative function of the action with whether or not it is performed on an object. Thus it is not clear which factor is driving the observed difference in imitation. A systematic comparison of young children’s tendency to over-imitate non-object direct actions, that are communicative versus non-communicative, remains outstanding.

Given these gaps in the literature, the goal of the current study was to compare imitation of instrumental, normative and communicative behaviours. We sought to explore which type of contextual cue is the most powerful predictor of over-imitation – instrumental, normative or communicative, and moreover, how context might relate to other aspects of the task, as we explain below. These three different types of cue, and the interactions between them, have not been compared within the same paradigm and thus their relative influence on over-imitation is not yet understood. We used verbal cueing to manipulate the context of imitation, a method that has been shown to be effective in other studies (Clegg & Legare, 2016; Herrmann *et al.*, 2013; Hoehl *et al.*, 2014; McGuigan *et al.*, 2007; 2011; 2012; Moraru *et al.*, 2016).

We were particularly interested in how the communicative context relates to these two contexts. If children perceive imitation of communicative actions (i.e. gestures or actions whose primary function is for communication) as being an opportunity to

acquire instrumental information, then we should expect to see no difference in patterns of imitation between the communicative and instrumental contexts.

Alternatively, if children perceive communicative actions to be normative in their function, then we should expect children to treat the normative and communicative contexts similarly, thus resulting in more overlap between imitation patterns in these two conditions.

We were also interested in how these three different types of cue might interact with other factors. For example, whether the relative influence of context would change with age. As a result, we explored over-imitation behaviour in children from 4 to 6 years. Children at this age show strong tendencies towards imitation and have been widely used in other studies, allowing for direct comparison (e.g. Clay & Tennie, 2017; Clegg & Legare, 2016; Horner & Whiten, 2005; Kenward, 2012; Lyons *et al.*, 2007; Legare & Nielsen, 2015; Legare & Watson-Jones, 2015; McGuigan *et al.*, 2007; 2011; 2012; Moraru *et al.*, 2016; Nielsen *et al.*, 2010; Over & Carpenter, 2012; Whiten *et al.*, 2016). We predicted there would be a significant interaction between age and context. Some previous research has suggested that instrumental cues might be particularly important for younger children (Nielsen, 2006), who may be less certain of the causal relations between objects and as a result, may depend more on social learning (Williamson *et al.*, 2008). Accordingly, if young children are more likely to depend on instrumental cues that they perceive to be causally-relevant, we should expect young children to be more likely to imitate actions placed in the instrumental context as compared to older children, who may be more confident in their own assessment of causal-relevance.

Although children from the age of three are sensitive to normative cues (Rakockzy & Schmidt, 2013), research has shown that the effect of normativity on children's imitation becomes significantly stronger with age, as children become increasingly attuned to social norms (Clegg & Legare, 2016; Keupp *et al* 2013; Moraru *et al* 2016). As a result, we expected older children to show higher rates of imitation within the normative context, as compared to in either the instrumental or communicative contexts.

A subsidiary prediction related to the imitation of transitive and intransitive actions. Generally speaking, most manual gestures are naturally produced "in the air", that is to say they are *intransitive*. In contrast, instrumental actions more often involve physical contact with an object i.e. they are *transitive*. Previous research suggests that infants are more likely to imitate transitive actions as compared to intransitive ones (Kim *et al.*, 2015), perhaps because infants perceive transitive actions to be more causally-relevant for achieving instrumental goals. Nevertheless, the apparent overlap between context and action transitivity, has not been directly investigated before. Therefore, in order to tease apart these two inter-connected influences, we additionally examined the interaction between context (normative, communicative, instrumental) and action transitivity (whether the agent is in contact with the object) on children's over-imitation. Based on previous research (Kim *et al.*, 2015), we expected children to show a stronger tendency to imitate transitive actions as compared to intransitive ones. Moreover, if transitivity does interact with context ,then we should expect more imitation of intransitive actions within a communicative context and more imitation of transitive actions within the instrumental context.

Finally, we were interested in whether the type of action itself might also influence children's imitation (Gergely & Csibra, 2006; Kim *et al.*, 2015). Although previous studies have examined imitation of unusual body-part actions, such as the forehead (e.g. Gergely *et al.*, 2002; Gellen & Buttelmann, 2016), these types of action have not been directly compared to the copying of manual actions, despite there being reason to expect that children may perceive them differently. Therefore, to extend the current literature, we also included an action type component to our paradigm by comparing imitation of manual actions to that of non-manual body-part actions (*henceforth* body-part actions). We focussed on actions involving unusual body-parts such as the forehead and elbow. Unlike manual actions, which can have a multitude of functions, the performance of unusual body-part actions, such as using a forehead instead of an unrestrained hand, may be perceived as irrational, causally-opaque and therefore more normative in its function. Therefore, we examined evidence for an interaction between action type and context, expecting greater imitation of body part actions in the normative context than either as instrumental or communicative contexts.

Method

Participants

Participants were 167 children aged 4 to 6 years (N = 62 4-year olds, mean age = 4.4 years; N = 54 5-year olds, mean age = 5.4 years; N = 52 6-year olds, mean age = 6.5 years). Eighty-three participants were female and eighty-four were male. Two additional 5-year-olds were excluded from analyses due to their refusal to participate in the task. We excluded the data from one 4-year old after it was discovered post-

testing that this child was not typically-developing.

Children were opportunistically recruited from ThinkTank Science Museum in Birmingham, UK. Using parental questionnaires, we determined that all children were typically-developing, had normal/corrected to normal vision and spoke English: 150 children were monolingual, 16 were bi-lingual (English + Urdu/Punjabi/Bangla/French/German/Polish) and one was tri-lingual (English + Spanish + Italian). The sample comes from an area of high ethnic diversity consisting of approximately 58% Caucasian, 27% Asian/British Asian, 9% Black/African/Caribbean, and 6% Mixed-Race children, coming from Working-to-Middle Class backgrounds (estimated from census data, Office of National Statistics, 2011). The parents of all participating children gave prior consent for their participation.

Design

Children were informed that they were going to learn some things about “*a land far away*” called ‘*Blicketland*’. The creation of this imaginary land was inspired by a well-established set of developmental studies by Gopnik and colleagues, which show that the term ‘blicket’ reliably evokes a novel property or feature in an object or event (Gopnik & Sobel, 2000; Sobel *et al.*, 2007). Children were given a spoken introduction, which contained subtle verbal cues that were either communicative, instrumental or normative in nature. Next, the experimenter performed two arbitrary actions onto or above one of two boxes, before it was opened to reveal an object. The child was then provided with a duplicate box and their spontaneous imitation behaviour was recorded. In all conditions, the other experimenter opened the box; the

reason for this was to ensure contextual validity across contexts i.e. in the communicative condition, the actions were verbally framed to imply they were being used by one experimenter to ‘ask’ the other experimenter to open the box.

Performance of the demonstrated actions was not necessary in order to open either box, see Fig. 1.

Children were randomly assigned to one of the six conditions within a 2 x 3 x 2 design, which included the between-subjects factors of context (communicative/instrumental/normative) and transitivity (intransitive/transitive) as well as the within-subjects factor of action type (manual action/ (henceforth termed body-part action), see Table 1 for a summary. Each participant received two trials involving the performance of one manual action and one body-part action. The order of presentation of the action types and the boxes used were counterbalanced across participants.

Table 1. Table summarising the mixed research design used to examine children’s imitation behaviour.

Between-subjects variables	
1.Context	2. Transitivity
Normative	Transitive
	Intransitive
Communicative	Transitive
	Intransitive
Instrumental	Transitive
	Intransitive
Within-subjects variable	

3. Action type

Manual action + Body part action

Data was analysed from a total of $N = 60$ children in the communicative context; $N = 58$ in the instrumental context and $N = 49$ in the normative context, with transitivity type balanced across conditions. Although participant exclusions resulted in slight imbalances between context conditions, the data was analysed using linear mixed models, which can account for such imbalances.

Materials

The study took place in a quiet classroom, where each child was tested individually. The child and experimenter sat next to one another on chairs at a table at waist-height of an adult; another experimenter sat opposite them on the other side of the table. Actions were demonstrated on two different boxes placed sequentially on the table. Each box used in the demonstration phase was paired with an identical ‘duplicate’ box, which was provided to the child during the test phase. One box was a medium-sized, leather-bound hinged ‘treasure chest’ (lattice-style leather design) (27 x 16 x 19 cm) with a flip clasp mechanism, see Figure 1a. The other was a plain wood flat-topped hinged box (24 x 15 x 7cm) with a lock-and-key mechanism, see Figure 1b. A small key was placed inside the lock, which needed to be turned once to the right to unlock it. A small toy/object (golden leaf brooch; string of coloured-blocks; bottle of seeds; plastic whale) was placed inside each box see Figure 1. All trials were videotaped on a Sony Handy-cam HDR CX330 mounted on a tripod.



Figure 1. Images of the two test boxes used in the imitation experiment

Procedure

The child was invited to sit down at a table next to the experimenter, with the other experimenter facing them on the other side of the table. The box for the first trial was already present on the table. Turning to the child, the experimenter introduced the activity using one of three introductory scripts according to the three contexts. Each script started off in the same way, the experimenter first said to the child “*There is a land far away from here called Blicketland. Today, you’re going to learn some things about Blicketland*”. Next, the experimenter said one of three different phrases, before pointing to the box. In the communicative context, the experimenter said: “*In Blicketland, they have a different language – instead of their voices, they use their hands and bodies to talk to each other.*” The experimenter then pointed at the box and said: “*This is a box from Blicketland. Let’s watch how I ask ‘name of other experimenter’, using the Blicket language, to open the lid to see what’s inside this box.*” In the instrumental context, the experimenter instead said: “*In Blicketland, the things are different. People make the things work differently in Blicketland.*” The experimenter then pointed at the box and said: “*This is a box from Blicketland. Let’s*

watch what I do - I would like to open the lid to see what's inside this box." In the normative context, the experimenter said: *"In Blicketland, they have ways to do things. They do things in these ways in Blicketland."* The experimenter then pointed at the box and said: *"This is a box from Blicketland. They have a way to open the lid to see what's inside this box. Let's watch how it's done in Blicketland."*

After the verbal introduction, the experimenter then performed two actions, one after the other. Each action was either performed in contact with the box (transitive condition) or above the box (i.e. no contact with box; intransitive condition), with transitivity kept constant for a given participant. For each trial, there was one manual action and one body-part action, with the order counterbalanced across participants. The first action combination was composed of an elbow-present (body-part action) and a manual 'sawing' action (manual action). The body-part action consisted of presenting the right elbow on or above the box (according to transitivity condition). The manual action consisted of a 'sawing' action, whereby the right hand was positioned in a vertical position with closed stacked fingers, with the thumb on top/little finger on the bottom, see Figure 2. For this action, the upright hand was placed onto/above the left side the box and the experimenter proceeded to make a saw-like/ 'zig-zag' motion across the top of the box using four strokes, finishing on the right side of the box. The second action combination was composed of a circle-trace action (manual action) and a forehead present (body-part action). The manual action was composed of fingers closed in a fist (right hand), except the index finger, which extended into a pointing gesture. Starting on the right side of the box, the index finger traced a rolling circle shape across the top of the box (touching in the transitive condition / not-touching in the intransitive condition) for three circles, finishing on the

right side. For the body-part action, the experimenter leant forward to present her forehead on/over the box (according to transitivity condition), see Figure 2. Each action component lasted approximately three seconds.

Once the actions were completed, the experimenters looked at one another, and the experimenter said “*The box is now open!*” and, showing an expression of mutual understanding, the other experimenter then opened the box. In all conditions, the other experimenter opened the box. The child and both experimenters then could look, for a few seconds, at the object inside the box. The experimenter then removed the opened demonstration box and replaced it with a closed identical ‘duplicate’ box. The duplication of the boxes ensured that the child did not see closing and re-presentation of the same box without first observing the demonstration. The experimenter looked at the child and said, “*Now your turn*”. If the child opened the box, the child/experimenters looked inside and then removed it from the table and replaced with the next box type. If the child performed an action on the box and looked to the other experimenter (which would be the expected response in the communicative condition, this experimenter opened the box and everyone looked inside. If the child did not open the box, it was removed from the table and replaced with the next box. For the next box, the script was repeated, excluding the first introduction sentences. i.e. starting with “*This is another box from Blicketland.*” The rest of each of the three scripts remained as above. After completing both trials, the child was rewarded with a sticker and a certificate for their participation



a.



b.



c.

d.

Figure 2. Video stills showing the demonstrated actions (manual actions and body part actions) within the *intransitive* condition (no contact with box). a. elbow present; b. manual sawing; c. index finger circle; d. forehead present. These actions were also presented in the transitive condition (i.e. contact with box)

Coding and analysis

We video-coded children's imitation behaviour during the test phase, using a points system for each action within a given trial. A child could score a maximum of two points per action, with a maximum of four points per trial, that is to say eight points overall (across both trials). Imitation behaviour was scored irrespective of whether the child attempted to open the box. For each action, one point was awarded for correctly matching the action type and an additional point was awarded for correctly copying the transitive part of the demonstration (i.e. if the child performs correct action but does it transitively after observing it intransitively they score 1 point rather than 2).

Each trial was composed of two action types: one body-part action (elbow or head) and one manual action. For the body-part action, the child received one point for presenting the correct body part (i.e. only when this body part was used, not any other body-part). For the manual action, one point was scored if the child performed the same manual action observed in the demonstration phase. Admissible variation included use of finger instead of hand (or vice versa) to perform the action and/or demonstration of the manner component of the action rather than its manner combined with path (i.e. some children performed the circle or sawing motion in one position on the box instead of moving it across the box). In order to reduce ambiguity, only actions that clearly matched the demonstrated actions were scored; alternative or ambiguous actions were excluded (i.e. no points were scored). Children received a score of zero if they directly opened the box without showing any imitation behaviour.

A rater, blind to the conditions and the hypotheses, independently coded a randomly chosen 25% of the data, using the same criteria for identifying occurrence of imitation. A Cohen's Kappa of 0.981 was achieved, demonstrating excellent reliability.

We used a negative binomial regression to model the influence of context, transitivity and the co-variate of age on total imitation score. We selected this model instead of the standard Poisson model due to the fact that the latter was over-dispersed (dispersion parameter = 2.58), whereas the negative binomial model was not (dispersion parameter = 0.73). Prior to fitting the model, we Z-transformed age to achieve a more symmetrical distribution and to enable investigation of interactions.

We included interaction terms into our model to investigate interactions between context and transitivity as well as between both of these variables and age.

We fitted the model in R (version 3.2.3; R Core Team 2015) using the function `glmer.nb` of the package `lme4`. We determined dispersion parameters using the function `overdisp.test` from a set of functions written by R. Mundry (`'diagnostic_fcns'`). After running diagnostic tests for model stability, we tested the overall effect of the three test predictors by comparing the full model's deviance with that of a null model comprising only the intercept using a likelihood ratio test. The sample for this model comprised of a total of 167 subjects.

Ethical statement

We received ethical clearance from the University of Birmingham Ethical Review Committee (ERN_13-1412) and the Marie Curie European Commission Ethical Screening Program (n° 628763). This study conformed to University of Birmingham's Code of Practice for Research. We received full approval and ethical clearance from ThinkTank Museum and full informed consent from parents.

Results

Overall, the full model was significantly better at predicting imitation score than the null model (full-null model comparison: $\chi^2 = 30.22$, $df = 9$, $p < .001$, see Figure 3). As indicated in Figure 3, there was a significant interaction between age and context; specifically, while imitation increased with age within the normative context; younger

children were more likely to over-imitate in the instrumental context as compared to older children (estimate + $SE = - 2.90 1.41$, $z = -2.06$, $p = .04$). There was no significant interaction between age and context for the communicative condition (estimate + $SE = - 1.90 1.32$, $z = 1.44$, $p = 0.14$). Model results are shown in Table 2.

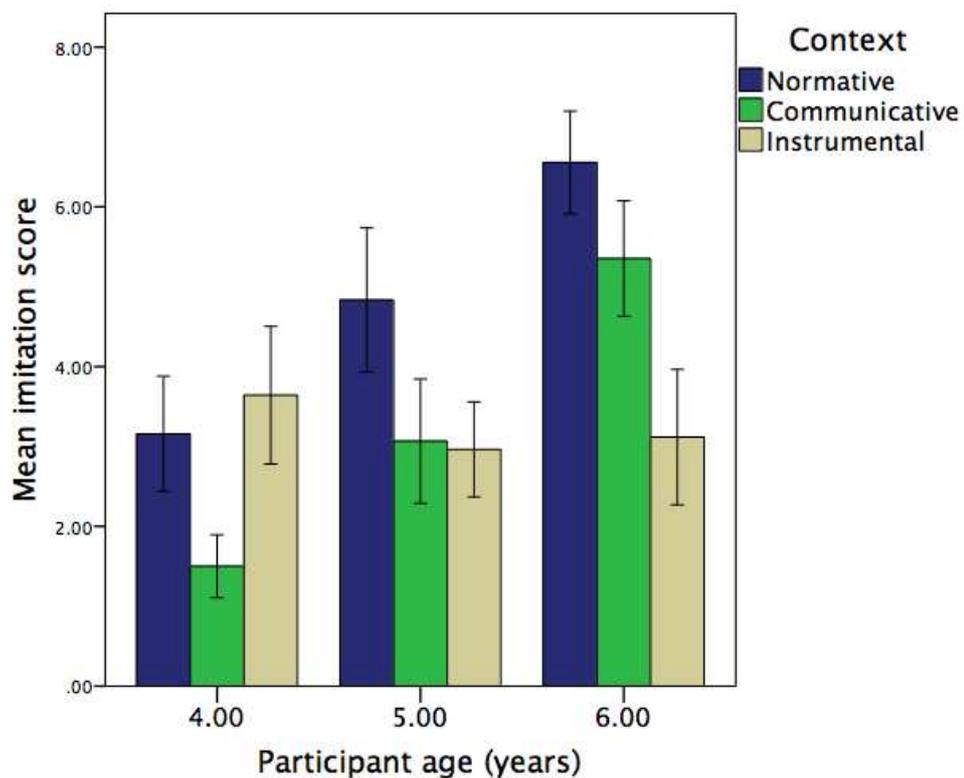


Figure 3. Mean imitation score as a function of age and demonstration context.

Imitation score was calculated on the basis of faithful reproduction of the *action* and its *transitivity* for each action within a trial (2 trials of 2 actions each). Error bars represent SEM. The statistical model included age as a co-variate.

There was a main effect of transitivity suggesting that children were more likely to copy transitive actions as compared to intransitive actions (estimate + $SE = 4.11 + 1.93$, $z = -1.93$, $p = .03$). There was also a significant interaction between age and transitivity: younger children preferably copied transitive over intransitive actions compared to the older children who preferably copied intransitive over transitive actions (estimate + $SE = -2.23 + 1.12$, $z = -1.99$, $p = .04$). There was no significant interaction between context and transitivity. See Figure 4 and Table 2.

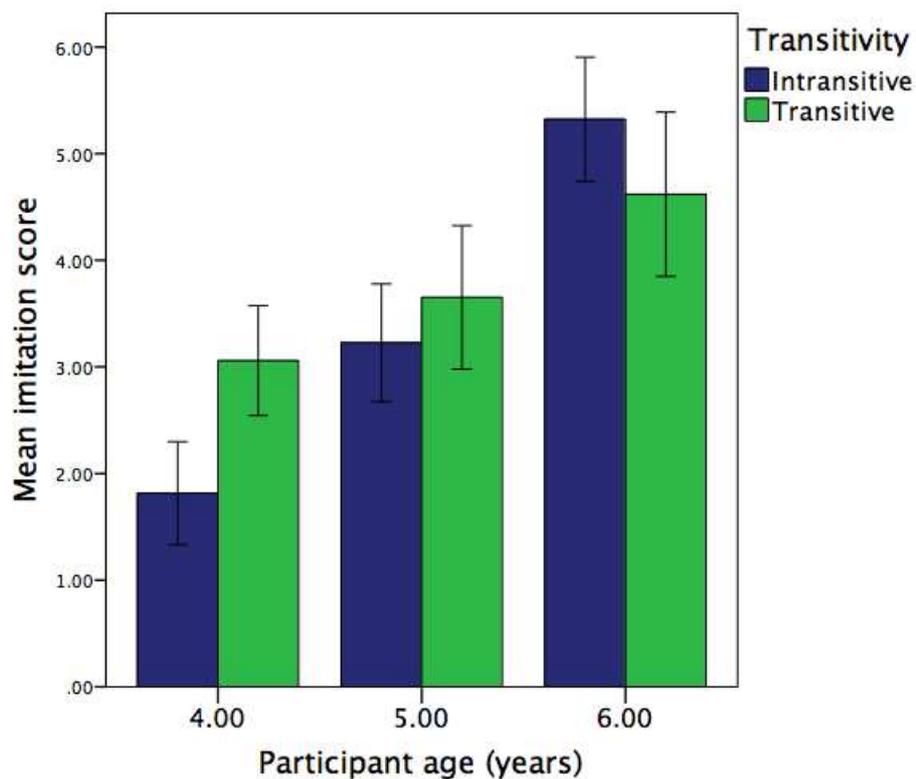


Figure 4. Mean imitation score as a function of age and action transitivity. Error bars represent SEM. The statistical model included age as a co-variate.

Table 2. Output for the negative binomial model investigating effect context,

transitivity and age on child imitation score. The model included age as a z-transformed covariate. The reference category for Context was Normative and for Transitivity it was Transitive.

	estimate	SE	z	p
Context (Communicative)	-3.84	2.31	-1.66	0.09
(Instrumental)	4.85	2.41	2.01	0.04
Transitivity (Intransitive)	4.11	1.93	1.93	0.03
Age (<i>Covariate</i>)	3.33	1.12	2.98	0.002
Context (Communicative) * Age	1.91	1.32	1.44	0.15
Context (Instrumental) * Age	-2.90	1.41	-2.06	0.04
Transitivity (Intransitive) * Age	-2.23	1.12	-1.99	0.04
Context (Communicative) * Transitivity	0.25	0.45	0.54	0.58
Context (Instrumental) * Transitivity	-0.63	0.43	-1.44	0.15

Action type

Next, we investigated whether action type influenced children's over-imitation across contexts. A mixed ANOVA showed a significant interaction between context and action type ($f(2, 160) = 3.46, p = 0.034$): children were significantly more likely to copy manual actions as compared to body-part action; however, rates of body-part imitation were higher in the normative context as compared to the communicative and

instrumental contexts, see Figure 5 and Table 3.

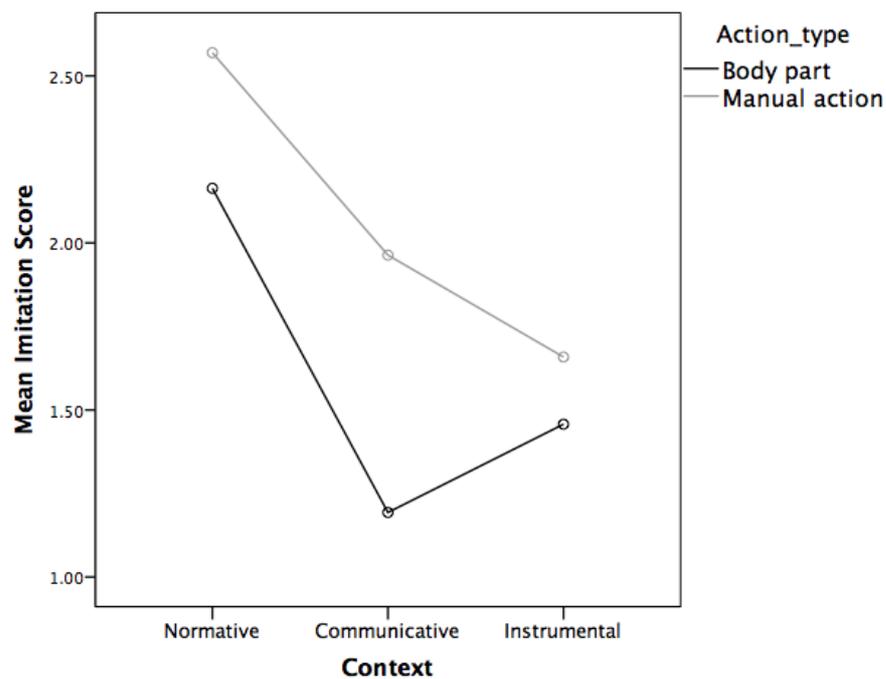


Figure 5. The interaction between action type and demonstration context on children's mean imitation score. Covariates appearing in the model are evaluated at the mean age of 5.39.

Table 3. Mean (+ SD) imitation score as a function of Age, Context and Action Transitivity broken down for each Action Type. In the main analyses, imitation score

included manual and body-part imitation scores together, thus these data broken down for action type are only provided for illustrative purposes.

Context	Transitivity	Action type	Age		
			4	5	6
Normative	Intransitive	Manual	1.25 (1.48)	2.57 (1.90)	3.20 (1.68)
		Body part	1.64 (1.06)	2.40 (1.38)	3.50 (1.69)
	Transitive	Manual	2.18(1.88)	3.20 (1.09)	3.50 (0.92)
		Body part	1.63 (1.96)	2.40 (2.19)	3.50 (0.92)
Communicative	Intransitive	Manual	0.46 (1.19)	1.78 (1.85)	3.16 (1.58)
		Body part	0.15 (0.55)	1.11 (1.45)	2.17 (1.80)
	Transitive	Manual	1.73 (1.66)	2.00 (1.78)	2.80 (1.78)
		Body part	0.53 (0.91)	1.33 (1.63)	2.60 (1.34)
Instrumental	Intransitive	Manual	1.83 (1.60)	1.67 (1.75)	2.44 (1.94)
		Body part	2.00 (1.98)	1.27 (1.73)	1.89 (1.48)
	Transitive	Manual	1.75 (1.98)	1.50 (1.50)	1.00 (1.94)
		Body part	1.75 (1.98)	1.5 (1.73)	0.75 (1.48)

Discussion

In the current study, we used a single integrative paradigm to simultaneously investigate several factors proposed to shape young children's over-imitation behavior: age, context, transitivity and action type. Adding a new dimension to the literature, which has generally only compared normative and instrumental contexts (Clegg & Legare, 2016; Legare & Nielsen, 2015; Moraru *et al.*, 2016); we examined how over-imitation is shaped when placed in a communicative context. Despite only minimal manipulation via verbal cues, children were highly sensitive to context, which interacted with age: as they got older, children became increasingly likely to over-imitate actions that were framed as being normative as compared to those framed as instrumental or communicative. By comparison, younger children were more likely to imitate within an instrumental context. The interaction between age and context is consistent with the idea that children's imitation is relatively influenced by different motivations at different ages. Although infants will imitate when it is rational to do so (e.g. Gergley *et al.*, 2002; Gergley & Csibra, 2006; Zmyj & Buttelman, 2014), children's imitation becomes increasingly complex and selective with time, and also more strongly influenced by social factors (Nielsen, 2008), such as to follow perceived social rules (Kenward *et al.*, 2011; Kenward, 2012; Moraru *et al.*, 2016). In line with other work, our results show that children's imitation from around aged 5 years can be increasingly explained within a social-normative framework (Kenward *et al.*, 2011, Kenward, 2012; Keupp *et al.* 2013; Legare & Nielsen, 2015; Moraru *et al.*, 2016; Over & Carpenter, 2012).

There are numerous possible reasons why the youngest children in our study showed higher imitation fidelity in the instrumental context as compared to the other contexts.

It could be that younger children are more willing to accept the experimenter's claims that these actions are causally-relevant. Indeed, it has been suggested that young children perceive intentional actions performed by an adult as being causally-meaningful and thus causally-relevant (Lyons *et al.*, 2007; 2011; Whiten *et al.*, 2009). For instance, although children are sensitive to model reliability during social learning contexts (Turner *et al.*, 2017; Wood *et al.*, 2013), children will copy actions performed by an adult, even when the adult explicitly denotes them as being 'silly' or inefficient (Lyons *et al.*, 2007; Nielsen & Tomaselli, 2010). Relatedly, younger children may feel that they need to rely more on social learning to achieve the same result because they are less confident in their own abilities or perceive greater causal opacity than do older children (Whiten *et al.*, 1996; Call *et al.*, 2005; Tennie *et al.*, 2009; Tomasello *et al.*, 2005; Whiten *et al.* 2009). For instance, Williamson and colleagues (2008) showed that young children flexibly combine their own prior experiences and the perceived causal efficacy of the model in order to determine whether and what to imitate. In this regard, older children may have been more confident about their ability (or experience) to open the box without additional assistance from a demonstration.

We also found that transitivity also interacted with age: specifically, younger children were more likely to imitate transitive actions as opposed to intransitive actions as compared to older children. Related to the above points, about young children's tendencies to depend on instrumental learning (Williamson *et al.*, 2008); this effect may be due to the fact that young children may perceive transitive actions to have more causal-relevance than intransitive actions (Kim *et al.*, 2015; Labiadh *et al.*, 2015; Patrick & Richman, 1985). This perceptual bias appears to part of an

evolutionary continuum as captive non-human animals trained to imitate actions in ‘Do-as-I-do’ tasks are also more likely to copy transitive actions than intransitive ones (Huber *et al.*, 2009; Tennie *et al.*, 2009).

In this study, the action contexts that we compared – normative, communicative and instrumental- differ in their primary goals: to conform, to communicate and to act on the physical world. However, it is worth emphasising that these goals are not mutually exclusive. In real world contexts, actions often have multiple motivations/components. For instance, communicative actions often contain a normative component, such as the cultural conventions of gestures used in social greetings. Consistent with this, we did not find major differences in imitation between the normative and communicative contexts, which suggests that children may perceive normative and communicative contexts as broadly similar. Further research that compares both children’s implicit and explicit perception of these two contexts can provide further insights to address this question.

Nevertheless, we found an interaction between action type (manual or body-part) and context suggesting that children may have different expectations for actions that are unusual or more obviously causally-opaque than those that have an obvious communicative or instrumental function. In the communicative condition, children were less likely to copy body-part actions than manual actions whereas they were comparatively more likely to copy body-part actions in the normative condition. This contextual shift in the imitation of body-part actions, i.e. the forehead and elbow, may be due to natural plausibility of the action, given the context. In real world settings, communicative gestures are frequently manual, especially those used in linguistic

communication, as was verbally-implied to the children here. In contrast, it is comparatively less easy to infer the causal-relevance of an irrational action, especially involving an unusual body-part. In the normative context, however, such actions may have gained a greater social function as, even from this age, children are already sensitive to the fact that even unusual and causally-opaque actions can have social or normative significance (Clegg & Legare, 2016). Further research is needed to address to extent to which children are willing to ascribe social significance to unusual actions as opposed to typical ones, and to what extent this influences their imitation behaviour.

Although our study was unable to determine how children perceive body-part actions as compared to manual actions, higher rates of copying of body-part actions within the normative context could indicate that children perceived these actions as being ritualistic (Clegg & Legare, 2016; Legare & Watson-Jones, 2015). According to Clegg & Legare (2016), rituals are an extension of normative actions, and involve actions/behaviours that combine normative behavior with a socially affiliative function. In the current study, spontaneously presenting body parts is both causally-implausible and unusual; thus their function can only be inferred by taking into account social cues and contextual information. In this regard, the ingredients for a child to perceive an action ritualistically appear to be in place.

Overall, this study highlights the key role that context plays in shaping and explaining children's imitation behavior and how its impact varies across the age span. Younger children appear to be more sensitive to instrumental cues compared to older children, who are increasingly attuned to perceived normative and, to some extent,

communicative cues. Importantly, we found that context interacts with other factors in shaping imitation, including action transitivity and action type. Given the evident complexity and subtlety that underlies children's imitation, our study highlights the value of examining multiple factors simultaneously across more than one age group. Previous research has sometimes sought to explain over-imitation by resorting to a single factor, for example, Lyons and colleagues (Lyons et al., 2007) propose that it results from causal misunderstanding. Our study shows that multiple factors are involved and moreover, that these factors can interact. Our findings therefore suggest that a multi-dimensional approach should be taken in future research in order to understand what factors explain the development of imitation. Moreover, while over-imitation has been sometimes referred to as 'unavoidable' (Lyons et al., 2007), our results support a growing literature which highlights the flexibility of over imitation. Far from being fixed, children adapt their imitation behavior according to the kinds of inferences available to them (Clegg & Legare, 2016; Herrmann *et al.*, 2013; Moraru *et al.*, 2016). While more research into children's copying behavior during communication contexts is required, it is likely that the flexibility and sensitivity of children's imitation is also critical in shaping their learning about language and communicative conventions, and is thus essential for understanding the complexity of how human communication and human culture develop (Tomasello, 1999; 2008). In future work, expanding the study of over-imitation to the domain of language and communication may provide important insights into the role imitation plays in explaining human unique forms of culture and communication.

Declaration of Interest

The authors confirm no conflict of interests

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