Over-imitating preschoolers believe unnecessary actions are normative and enforce their performance by a third party

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Acknowledgements

Abstract

Over-imitation, which is common in children, is the imitation of elements of an action sequence which are clearly unnecessary for reaching the final goal. A variety of cognitive mechanisms have been proposed to explain this phenomenon. Here, 48 three- and five-year-olds together with a puppet observed an adult demonstrate instrumental tasks including unnecessary actions. Failure of the puppet to perform the unnecessary action resulted in spontaneous protest by the majority of the children, with some using normative language. Children also protested in comparison tasks in which the puppet violated convention or instrumental rationality. Protest in response to the puppet's omission of unnecessary actions occurred even after the puppet's successful achievement of the goal. This observation is not compatible with the hypothesis that the primary cause of over-imitation is that children believe the unnecessary action causes the goal. There are multiple domains which children may believe determines the unnecessary action's normativity, two being social convention and instrumental rationality. As the demonstration provides no information about which domains are relevant, children are capable of encoding apparently unnecessary actions as normative without information as to which domain determines the unnecessary actions' normativity. This study demonstrates an early link between two processes of fundamental importance for human culture: faithful imitation; and the adherence to and enforcement of norms.

Keywords: over-imitation, norms, enforcement, conformity, preschoolers

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In contrast to other primate species, humans have a remarkable tendency to faithfully copy all elements of an action sequence they observe, including actions which do not appear to contribute to causing the final goal state of the action sequence (Call, Carpenter, & Tomasello, 2005; Horner & Whiten, 2005; Nagell, Olguin, & Tomasello, 1993; Whiten, 2011; Whiten, Custance, Gomez, Teixidor, & Bard, 1996). This peculiarly human tendency has been argued to enable the development of unique aspects of human culture such as cumulative cultural evolution and artifacts whose functions are causally opaque (Boyd & Richerson, 1996; Lyons, 2009; Shea, 2009; Tennie, Call, & Tomasello, 2009). The tendency is not usually seen in infants (Brugger, Lariviere, Mumme, & Bushnell, 2007; Gergely, Bekkering, & Kiraly, 2002; Hamlin, Hallinan, & Woodward, 2008; Zmyj, Daum, & Ascherslebenb, 2009), begins in early childhood (Buchsbaum, Gopnik, Griffiths, & Shafto, in press; Lyons, Young, & Keil, 2007; McGuigan, Whiten, Flynn, & Horner, 2007; Nielsen, 2006; Nielsen & Tomaselli, 2010), increases through the childhood years (McGuigan & Whiten, 2009; McGuigan, et al., 2007; Nielsen & Tomaselli, 2010), and is even present in adults (McGuigan, Makinson, & Whiten, 2011). When this tendency leads individuals to act in ways which appear inefficient, it is dubbed over-imitation (Lyons, et al., 2007; although see Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009).

A diverse array of hypotheses have been advocated to explain the mechanisms behind over-imitation, and there is little consensus as to their relative merits. The majority of hypotheses emphasize either social or causal cognition. Two social hypotheses are closely related: over-imitation occurs because of children's desire to be like adults and to share experiences with other individuals (the shared experience hypothesis); and over-imitation occurs because of children's desire to communicate an affiliation with and be liked by the demonstrator (the social affiliation hypothesis) (Hilbrink, Sakkalou, Ellis-Davies, Fowler, & Gattis, 2011; Meltzoff, 2007; Nielsen, 2006; Nielsen & Blank, in press; Nielsen, Simcock, & Jenkins, 2008; Tomasello, Carpenter, Call, Behne, & Moll, 2005; Uzgiris, 1981; reviewed in Over & Carpenter, in press). Demonstration of the unnecessary action in studies of over-imitation is generally carried out in an ostentatious pedagogical context. This observation lends plausibility to two further social hypotheses. Children may believe that they are expected by the demonstrator to carry out the unnecessary action (the demonstrator's expectation hypothesis; Lyons, Damrosch, Lin, Macris, & Keil, 2011). Alternatively, the natural pedagogy hypothesis states that children are naturally predisposed to learn actions (and other things) which are ostentatiously communicated to them (Csibra & Gergely, 2009; 2011; see also Buchsbaum, et al., in press).

Causal hypotheses, unlike social hypotheses, emphasize the impact of the demonstration on the child's causal understanding and therefore on the child's subsequent goal-directed instrumental behavior. One possibility is that children, because they perceive the unnecessary action as intentional, assume that it is performed for a good reason, and therefore presumably causes something, although they are unsure as to what that might be (the unspecified purpose hypothesis; Horner & Whiten, 2005; Kenward, Karlsson, & Persson, 2011; Whiten, Horner, & Marshall-Pescini, 2005; Whiten, et al., 2009; Williamson & Markman, 2006). Alternatively, Lyons and colleagues (2011; 2007) have argued that the demonstration leads the child to automatically encode the action as causally necessary for reaching the final goal state, even though without the demonstration they would have understood the mechanical causal relations of the apparatus. Lyons et al. (2011) refer to their

hypothesis as the automatic causal encoding hypothesis but as it is specified to involve a "distortion in children's causal beliefs" (Lyons, et al., 2007) I refer to it as the distorted causal belief hypothesis, to distinguish it from the unspecified purpose hypothesis which also invokes a form of causal encoding.

5   Finally, the sensorimotor hypothesis makes reference to the fact that imitation is not always consciously goal-directed (Chartrand & Bargh, 1999), and can be enabled by non-conceptual sensorimotor processes (Heyes & Bird, 2007; Leighton, Bird, & Heyes, 2010). This leads to the suggestion that over-imitation might similarly be explained by a non-conceptual process by which perception of an action automatically leads to its performance

10   (Simpson & Riggs, 2011). In summary, while there is no consensus on the psychological mechanisms causing over-imitation, enough evidence has accumulated for a range of different accounts to support the contention that over-imitation is not caused by a unitary psychological mechanism.

          The purpose of the current study is to test a relatively new hypothesis concerning

15   what has been learnt by over-imitating children. The norm acquisition hypothesis states that they have acquired an understanding that it is prescriptively normative to perform the unnecessary action (Kenward, et al., 2011). Because of the different ways that the term *normative* is used, it is important to be clear about what this hypothesis entails. Firstly note the difference between descriptive and prescriptive norms – the former are factual statements

20   concerning what *is* ("in Sweden lunch is eaten around noon"), whereas the latter state what *ought to be* ("lunch should be eaten around noon"). We are concerned here only with prescriptive norms. Although sociologists and some psychologists use the term norm to refer only to social conventions and moral rules (Chudek & Henrich, 2011; Sripada & Stich, 2007), a philosopher's definition of normativity holds that any statement or belief about a

25   state of affairs that ought to be is normative (Wedgwood, 2007). Prescriptive norms, therefore, are rules determining appropriate behavior. While this definition (which is adopted here) is broad, it is nevertheless a psychologically useful one, not least because normative understanding so defined is the source of a specific and important type of behavior, namely the use of normative language. Such language is characterized by the use of terms such as

30   *must*, *should*, *right*, and *wrong*, which express what agents ought or ought not to do. Similarly to the phenomenon of over-imitation, conforming to and enforcing norms has also been identified as a particularly human phenomenon which has had profound impact on our evolution and culture (Chudek & Henrich, 2011; Sripada & Stich, 2007).

          The norm acquisition hypothesis therefore states that over-imitating children

35   believe the unnecessary action ought to be performed. Note, however, that the norm acquisition hypothesis does not state *why* the norm is acquired. This account is therefore compatible with many other hypotheses, some of which can be seen as more specified cases of the norm acquisition hypothesis, and some of which complement the norm acquisition hypothesis by stating more precisely why the norm is acquired (see discussion). The most

40   obvious more specified case is the hypothesis that children believe there is a social convention stating that the unnecessary action ought to be performed. The unspecified purpose hypothesis and the distorted causal belief hypothesis are also more specified cases of the norm acquisition hypothesis, because they state that children believe the unnecessary action is normative because it achieves a desired goal. In this case, the relevant normative

45   domain is that of instrumental rationality, according to which, all else being equal, an agent should perform an action which leads to the agent's goal. As will be discussed, however, it is possible that children may be capable of holding beliefs about what actions are normative without an understanding of what determines the actions' normativity, even to the extent of not knowing within what domain (instrumental or conventional) the normative status is

determined. Note also that it is common for actions to be normative according to both social convention and instrumental rationality (Rakoczy, Warneken, & Tomasello, 2008): since forks became available it is both against convention and less practical to carry food to the mouth with a knife.

5   Kenward et al. (2011) did not directly test the norm acquisition account of over-imitation, but argued that it closely fit available data. This argument built on parallels between young preschoolers' behavior in over-imitation studies and in studies demonstrating their prolific ability to rapidly acquire arbitrary norms (Rakoczy, et al., 2008; Schmidt, Rakoczy, & Tomasello, 2011a) and reason using normative language (Beller, 2010; Cummins, 1996; Harris & Nunez, 1996). In a typical such study, three-year-olds were taught the arbitrary conventions of a game and were then observed to protest using normative language when a puppet broke these rules (Rakoczy, et al., 2008). Three-year-olds understand that such normative conventions are context relative (Rakoczy, Brosche, Warneken, & Tomasello, 2009; Wyman, Rakoczy, & Tomasello, 2009), and they can acquire them even outside of a pedagogical context (Schmidt, et al., 2011a). Young preschoolers also rapidly acquire arbitrary norms about appropriate uses for novel artifacts (Wohlgelernter, Diesendruck, & Markson, 2010), protesting when these norms are violated (Casler, Terziyan, & Greene, 2009).

        This study also adopts the method of revealing children's normative beliefs by eliciting protest against an individual who violates norms. Children and a puppet together observe an adult demonstrate methods of removing and replacing objects in boxes, with each method including an unnecessary action. Following the demonstration, the child and puppet take turns. As children are known to protest against norm-violating puppets, the norm acquisition hypothesis is tested here by examining its prediction that over-imitating children will protest using normative language if the puppet does not perform the unnecessary action. Also measured are other protest types such as imperative commands that are not explicitly normative but that can be seen as weaker evidence for normative understanding (Rakoczy, et al., 2008).

        The over-imitation tasks here involve removing and replacing jewels in jewel boxes, and these tasks are placed in a clear context of an overarching instrumental goal, which is to clean the jewel collection. This establishes that the point of the exercise (from the child's point of view) is not to learn arbitrary conventional sequences of actions, as it generally has been in previous experimental studies of normative protest. It also provides a context for interspersing over-imitation tasks with conventional tasks (sorting the jewels by color) and instrumental tasks (cleaning the jewels) in which the puppet also deviates from the demonstration by violating conventional and instrumental normativity. This allows the comparison of preschoolers' tendencies to protest against deviations in the three different types of task, conventional, instrumental, and over-imitation.

        For all three types of task, control tasks are included in which the puppet does not deviate from the demonstration, in order to control for protest made for reasons other than the puppet's deviation. A further prediction of the norm acquisition account of over-imitation is also tested, that a child's tendency to protest against failure to over-imitate on a particular task will correlate with the child's own tendency to over-imitate on that task. If children have a distorted causal belief that the unnecessary action is necessary for jewel retrieval or replacement, then protest should cease after successful retrieval or replacement of the jewel, as the belief will have been directly proved false. This prediction is tested. Three- and five-year-olds are examined, because although normative protest is first clearly observed in three-year-olds (Rakoczy, 2008; Rakoczy, et al., 2009; Rakoczy, et al., 2008) older children might

be expected to make clearer statements, but no strong predictions are made regarding age effects.

Method

Participants

5   Participants were a self-selected sample who responded to an invitation letter sent to all families with children of appropriate age living in a medium-size Swedish city; therefore, participants were mostly ethnically Swedish and had mixed socioeconomic backgrounds. Included in all analyses were 24 3-year-olds (mean age = 37.7 months, SD = .7, 8 girls) and 24 5-year-olds (mean age = 62.0 months, SD = 1.5, 10 girls).[1] A further five
10   children were tested but never over-imitated. As this study is an investigation of the beliefs of children who over-imitate, these children were replaced and excluded from all analyses except for descriptions of over-imitation frequency. Four further children were replaced and excluded from all analyses because of refusal to participate (two), experimenter error (one), and parental interference (one).

15   ### Materials

         Two transparent plastic jewel boxes, the push box and the hook box, each contained 12 jewels (Figure 1). Each jewel box had special ways to retrieve and replace jewels, which included an unnecessary action. Jewels were pushed out of a hole in the bottom of the push box by inserting a stick in a hole in the front, but first a dial connected to a paddle
20   on top of the box was unnecessarily turned. Before jewels were replaced into the push box through the front hole, they were unnecessarily knocked on the side of the box. Jewels were hooked out of the hook box with a special hook (the jewels had metal loops attached), but first the hook was unnecessarily shaken in a plastic loop on the side of the box. When jewels were to be replaced in the hook box, a small piece of white cardboard was first used to
25   unnecessarily transfer them to the box's upper surface before they were pushed into the box opening.

Figure 1. The push box (left) and the hook box (right), with pushing stick and hook.

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[1]The gender imbalance is due to the random self-selected nature of the sample, and does not comprise a problem firstly because there is no prior reason to suspect gender effects in this design and secondly because of the primarily within-subject design.

For each box's jewels, there was also one conventional task and one instrumental task. The conventional task for jewels from both boxes was sorting them by color on a mat with circles of the appropriate colors (ostensibly to ensure all jewels were present). The puppet's mistake was to incorrectly color sort them. The instrumental task for jewels from the hook box was to wash them in a bowel of water. The puppet's instrumental mistake was to attempt to wash them in an empty bowl. The instrumental task for jewels from the push box was to polish them with a tool with a cloth end. The puppet's mistake was to use the wrong end of the polishing tool, which resulted instead in them being marked black.

Design

Each participant was engaged with both boxes in turn, giving a total of four over-imitation tasks, two conventional tasks, and two instrumental tasks (Table 1). For each of these eight tasks, the demonstration was first (using four of the 12 jewels), followed by the participant's turn (also intended to use four jewels), then the puppet's turn (using the remaining jewels, usually four). Demonstration of the over-imitation task always included the unnecessary action. For every participant the puppet omitted the unnecessary action in three over-imitation tasks but performed it in one over-imitation task (within-subjects design). For each participant, the puppet either made mistakes in both instrumental tasks and not in the conventional tasks, or vice versa (between-subjects design). Which box was first and in which tasks the puppet deviated from the demonstration were counterbalanced by Latin square.

Table 1. Summary of Task Types and Task Order

| Box | Task | | |
	Order	Description	Type
Push box	1	Pushing jewels out	Over-imitation
	2	Polishing jewels	Instrumental
	3	Color-sorting jewels	Conventional
	4	Replacing jewels	Over-imitation
Hook box	5	Hooking jewels out	Over-imitation
	6	Color-sorting jewels	Conventional
	7	Washing jewels	Instrumental
	8	Replacing jewels	Over-imitation

Note: Tasks occurred in the order above or the same order but with the hook box first. The puppet always over-imitated on three over-imitation tasks but not on the fourth (within-subjects design). The puppet made errors on either the conventional or instrumental tasks (between-subjects design).

Procedure

Two experimenters conducted the procedure, one who demonstrated tasks and one whose sole role was to operate the puppet. Parents were present but seated away from the table at which tasks were performed, and instructed not to intervene. After an initial informal warm-up play session with both experimenters, children participated in a formal warm-up

phase, copied exactly from Schmidt et al. (2011a), in which the demonstrator introduced three instrumental tasks, which the child and puppet were also encouraged to perform. The puppet made basic instrumental mistakes on the first and third tasks, and the demonstrator encouraged the child to help the puppet. This phase was intended to overcome inhibitions children might have against intervening in the puppet's actions.

The demonstrator then engaged the child and puppet in the eight tasks of cleaning the jewels from the two boxes. She explained that in contrast to the previous play session, it was a serious task which she needed help with. For each task, the demonstrator first instructed the child and puppet to watch while she dealt with four jewels, one at a time, reminding the puppet and child to watch before each jewel. She then asked the child to deal with four jewels, during which time she turned her back and busied herself with other materials. After the child had dealt with four jewels, she asked the puppet to deal with the remaining four, while she again turned her back and busied herself. Occasionally a child would deal with more than four jewels, but there were always at least two left for the puppet, who also dealt with each jewel one at a time.

Coding

Children's verbal responses during the puppet's turn were segmented into separate utterances using the communication unit method (Loban, 1976; SALT Software, 2011). Utterances were usually segmented by intervening silence as clearly as by grammar, as the mean interval between protest utterances was 3.9 s, $SD = 1.8$. Each utterance was coded for the presence of protest using normative or non-normative language. Normative protest was most commonly scored due to use of the words *should* (Swedish: *ska*), e.g. "You should do this"; *must* (*måste*); or *wrong* (*fel*). Non-normative protest was scored due to either non-normative imperative language (e.g. "Use this thing") or descriptive language that was clearly disapproving (e.g. "But you have not done this"). Each participant was coded twice, once by an individual blind to the study's purpose and hypotheses. Inter-observer reliability was excellent for frequency per second of both normative protest, $r = .99$, and non-normative protest, $r = .96$. The blind coding was used in all analyses.

Analysis

For compatibility with previous studies we primarily report the proportion of tasks containing normative protest. This measure does not however capture differences in vociferousness of protest. The frequency per second of normative protest does capture this, and is therefore more powerful, so it is also reported for the most important test concerning over-imitation tasks. It is calculated separately for each task for each participant by counting protest utterances during the puppet's turn and dividing by the puppet's turn length (from the moment it began dealing with its first jewel to the moment it was finished with its last).

To investigate the effects of age, task type, and puppet behavior, the proportion of tasks containing normative protest was modeled with a general linear mixed model (GLMM) using adjusted sums of squares, entering as fixed factors age (three or five), task type (conventional, instrumental, or over-imitation), puppet behavior (conforming to or deviating from the demonstration), all possible fixed factor interactions, and as a random factor participant nested in age (inclusion of this term allows valid analysis of repeated measures on individuals, Kutner, Nachtsheim, Neter, & Li, 2004). The correlation between children's over-imitation and their protest at the puppet's failure to over-imitate was investigated as follows. For all over-imitation tasks in which the puppet did not over-imitate, normative protest frequency was modeled with a GLMM using adjusted sums of squares, entering the

proportion of jewel replacement/retrievals in which the child used the unnecessary action as a covariate and participant as a random factor.

As normative protest frequency was left-skewed it was square-root transformed prior to parametric modeling. Proportion variables were arcsine square-root transformed. Visual inspection of residual plots confirmed model fits (Grafen & Hails, 2002). To be conservative, however, planned comparisons were conducted using non-parametric tests, with effect sizes presented as the non-parametric Cliff's δ converted to Cohen's d (Rogmann, 2011). As conditions with between-subject controls (conventional and instrumental) are presented side by side with a condition with a within-subject control (over-imitation), the within-subject standard errors have been adjusted using Morey's (2008) method to allow appropriate comparison. All tests were two-tailed.

Results

Across task types, the proportion of tasks with normative protest was greater when the puppet deviated from the demonstration than when it conformed (Table 2, Figure 2). Task type and its interaction with puppet conformity/deviation were also significant predictors (Table 2, Figure 2). In planned comparisons it was therefore confirmed that for each task type individually, normative protest occurred in a greater proportion of tasks in which the puppet deviated from the demonstration: conventional, rank-sum Wilcoxon's $W = 709.0$, $p = .002$, $d = .68$, 95% CI [.22, 1.21]; instrumental, rank-sum Wilcoxon's $W = 750.0$, $p < .001$, $d = 1.02$, 95% CI [.43, 1.68]; and over-imitation, signed-rank Wilcoxon's $W = 99.5$, $p = .027$, $d = .26$, 95% CI [.04, .51]. The effect on normative protest of the puppet's deviation from the demonstration in over-imitation tasks is clearer when considering the frequency per second of normative protest, which takes into account protest vociferousness: deviation, $M = .013$, $SD = .023$; conformity, $M = .003$, $SD = .013$; signed-rank Wilcoxon's $W = 123.0$, $p = .005$, $d = .43$, 95% CI [.19, 70]. Although normative protest against the puppet's omission of the unnecessary action occurred in a relatively low proportion of tasks (Figure 2), the majority of children made at least one protest against omission of the unnecessary action in the more liberal protest category also including non-normative protest (Table 3).

Table 2. GLMM of Proportion of Tasks with Normative Protest, by Puppet Deviation or Conformity, Task Type, and Age

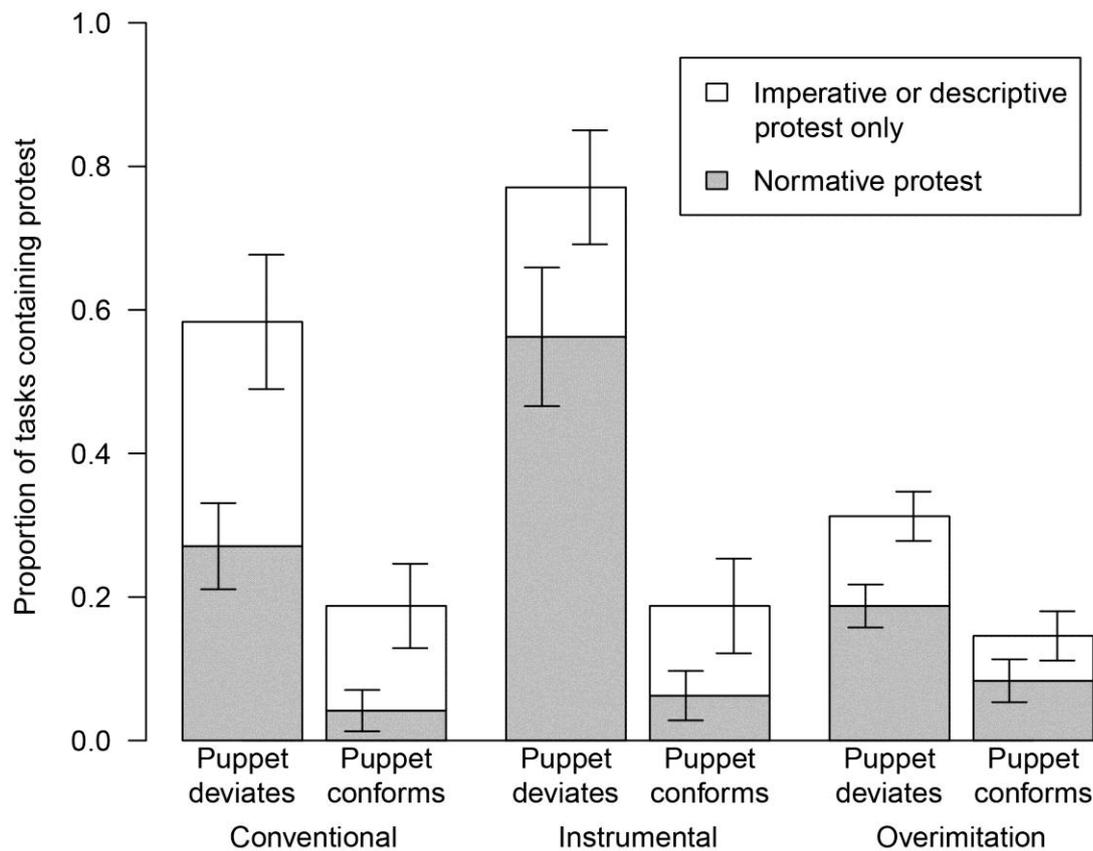| Factor	d.f.	F	p	η^2
Deviates or Conforms	1, 326	61.39	<.001	.07
Task Type	2, 326	9.71	<.001	.05
Age	1, 326	0.33	.568	.00
Deviates or Conforms * Task Type	2, 326	8.69	<.001	.04
Deviates or Conforms * Age	1, 326	2.06	.152	.00
Task Type * Age	2, 326	1.81	.165	.01
Deviates or Conforms * Task Type * Age	2, 326	2.95	.054	.01
Participant (Random Factor)	46, 326	3.67	<.001	.28

Figure 2. Normative and imperative or descriptive protest in response to the puppet's deviation from or conformity to the demonstration in the different task types. Three-year-olds ($n = 24$) and five-year-olds ($n = 24$) are not separated as no age effects were detected. The lower error bars show standard error for normative protest and the upper error bars show standard error for the stack (both protest categories combined).

Table 3. Proportion of Children Protesting at Least Once, by Task Type and Puppet Deviation or Conformity

Task	Puppet deviates from demonstration			Puppet conforms to demonstration		
	n	Proportion	95% CI	*n*	Proportion	95% CI
Normative protest						
Conventional	24	.50	[.31, .69]	24	.08	[.01, .25]
Instrumental	24	.62	[.42, .80]	24	.12	[.03, .30]
Over-imitation	48	.33	[.21, .47]	48	.08	[.03, .19]
Any verbal protest (also includes imperative and descriptive protest)						
Conventional	24	.66	[.46, .83]	24	.33	[.17, .54]
Instrumental	24	.83	[.65, .94]	24	.29	[.14, .49]
Over-imitation	48	.60	[.46, .73]	48	.15	[.07, .27]

Planned comparisons showed that the puppet's deviation from the demonstration elicited normative protest in a greater proportion of instrumental than over-imitation tasks, rank-sum Wilcoxon's $W = 1125$, $p = .001$, $d = .71$, 95% CI [.19, 1.31], and in a greater proportion of instrumental than conventional tasks, rank-sum Wilcoxon's $W = 487.5$, $p = .027$, $d = .54$, 95% CI [.02, 1.17]. There was no difference between conventional and over-imitation tasks in this respect, rank-sum Wilcoxon's $W = 968$, $p = .212$, $d = .19$, 95% CI [-.14, .42]. The only age effect approaching significance was the interaction between age, task type, and conformity/deviation (Table 2). If real, this effect represents the observation that the tendency to protest against puppet deviation more in instrumental tasks than in conventional or over-imitation tasks was more pronounced in 5-year-olds (Table 4).

Table 4. Mean Proportion of Tasks with Normative Protest, by Puppet Deviation or Conformity, Task Type, and Age

Age (years)	Task type	Proportion of tasks (SD)	
		Puppet deviates	Puppet conforms
3	Conventional	.25 (.34)	.04 (.14)
	Instrumental	.42 (.51)	.08 (.19)
	Over-imitation	.22 (.31)	.08 (.28)
5	Conventional	.29 (.26)	.04 (.14)
	Instrumental	.71 (.40)	.04 (.14)
	Over-imitation	.15 (.29)	.08 (.28)

Note: $n = 24$ for each age group.

Every child successfully performed every single conventional and instrumental task with at least one jewel, except for one 3-year-old who was unwilling to polish the jewels. Every child successfully retrieved/replaced at least one jewel in every over-imitation task except for three 3-year-olds who refused to perform one over-imitation task each. Children retrieved/replaced most jewels using the unnecessary action: the mean proportion of jewel retrievals/replacements conducted using the unnecessary action was .57, $SD = .33$ (including the five replaced children who never over-imitated), with no age difference, rank-sum Wilcoxon's $W = 712$, $p = .866$, $d = .04$, 95% CI [-.42, .36]. Again including the five replaced children who never over-imitated, 60% of children over-imitated on at least three of four over-imitation tasks.

In over-imitation tasks in which the puppet omitted the unnecessary action, the frequency of normative protests was positively correlated with the proportion of jewel retrievals/replacements the child conducted using the unnecessary action, $F(1,92) = 10.03$, $p = .002$, $\eta^2 = .05$. Despite this correlation, five children protested at the puppet's failure to perform the unnecessary action in at least one task in which they themselves had never performed the unnecessary action.

The mean time point for the onset of each individual's last normative protest in an over-imitation task in which the puppet did not over-imitate was 4.7 s after the puppet's first successful jewel retrieval/replacement was complete, $SD = 8.1$. Of the children who made

such normative protests, 75% made at least one after the puppet's first successful jewel retrieval/replacement, 95% CI [50%, 92%].

Discussion

The majority of children over-imitated in the majority of over-imitation tasks, which was to be expected given previous results. Just over one third of children protested using normative language in at least one over-imitation task in which the puppet did not over-imitate. According to the more liberal coding criterion including protests using imperative and descriptive language, which can be seen as less direct evidence for normative beliefs (Rakoczy, et al., 2008), the majority of children protested against omission of the unnecessary action at least once. Furthermore, a child's tendency to protest omission of the unnecessary action in a specific task was positively correlated with the child's tendency to perform the unnecessary action in that task, even though some children protested against the puppet's failure to over-imitate when they had not themselves over-imitated. This demonstrates that a substantial proportion of the children had acquired a normative belief that the unnecessary action should be performed, not only by themselves, but by another individual who has witnessed the same action sequence. The non-conceptual sensorimotor hypothesis (Simpson & Riggs, 2011) can be ruled out at this stage as the primary explanation for over-imitation because verbal protest must be underlain by an explicit concept that the unnecessary action should be performed.

Children protested more in response to violations of instrumental rationality than in response to violations of convention or failure to over-imitate. This is unsurprising, given that deviations from instrumental rationality are most unambiguously wrong. The trend for this effect to become more pronounced with age, which was not entirely clear statistically, may represent 5-year-olds' improved understanding of instrumentally rational behavior, and/or an improved understanding of the difference between instrumental rationality and other forms of normativity. There were no other age effects.

In three quarters of children who made normative protests against omission of the unnecessary action, normative protest continued after it was clear that the puppet had succeeded in retrieving or replacing jewels in the box without performing the unnecessary action. This is further evidence against the distorted causal belief hypothesis (Lyons, et al., 2011; Lyons, et al., 2007) – if protest was motivated by a belief that the unnecessary action was causally necessary to enable retrieval or replacement, it would make sense to protest when it was clear that the puppet was about to attempt retrieval or replacement without the unnecessary action, but not to continue protesting after the goal was successfully achieved. Taken together with the finding that most over-imitating children are uncertain as to the purpose of the unnecessary action (Kenward, et al., 2011), and the finding that children copy an unnecessary action performed after the necessary action has achieved the goal (Simpson & Riggs, 2011), there is now very strong evidence that children do not usually believe that the unnecessary action is causally necessary to achieve the final goal of the action sequence. As will now be discussed, however, this does not rule out the possibility that children may believe the action causes something useful but unknown.

The two types of account which are commonly set up as competing explanations of over-imitation primarily invoke either social factors or causal beliefs. As all beliefs about the appropriate instrumental use of causal relations are normative beliefs, all hypotheses invoking these beliefs can explain the finding of normative protest, given that children are motivated to help others to achieve their goals (Warneken & Tomasello, 2006, 2009). Although the distorted causal belief hypothesis is no longer plausible, over-imitating children may believe that the unnecessary action has an instrumental purpose, without knowing what

it actually is (the unspecified purpose hypothesis; Horner & Whiten, 2005; Kenward, et al., 2011; Whiten, et al., 2005; Whiten, et al., 2009; Williamson & Markman, 2006). Although the evidence proffered by Lyons and colleagues (2011; 2007) falls short of proving the distorted causal belief hypothesis, it does strongly suggest children hold some less specific form of causal belief (Kenward, et al., 2011), so the unspecified purpose hypothesis is very likely to be true for some children.

Although there is good evidence that a variety of social motives are very important for children's imitation (reviewed in Over & Carpenter, in press), social hypotheses cannot in general explain the current findings without incorporating the norm acquisition hypothesis. The hypothesis that children are motivated to act like others in order to be like them and share their experiences (the shared experience hypothesis) is not sufficient to explain why they should protest against a third party's failure to conform. For this hypothesis to explain the current findings, it must be extended to specify that children believe that not only they themselves, but also third parties, should behave in the same way as others. The hypothesis that children feel that they are expected to perform the unnecessary action (the demonstrator's expectation hypothesis) is also insufficient to explain the current findings, unless it is extended to state that children believe the expectation also applies to other individuals. Both of these hypothesis extensions results in hypotheses which have been extended to incorporate the norm acquisition account, because they both specify that children learn a generalizable rule that the unnecessary action should be performed. The protest behavior might be explained by reference to the child's desire to affiliate with and be liked by the demonstrator (the social affiliation hypothesis). But this again requires that children believe that performance of the unnecessary action is held to be normative, because otherwise they would have no reason to assume that the demonstrator would approve of its enforcement in third parties.

The core claim of the natural pedagogy hypothesis, that children are naturally predisposed to learn actions which are ostentatiously communicated to them, also cannot fully explain the current findings, because it does not explain why children should protest against a third party's failure to conform. However, a further claim of the natural pedagogy hypothesis is that children tend to generalize what they learn in pedagogical contexts (Csibra & Gergely, 2009, 2011), and this hypothesis is therefore also amenable to extension to include the norm acquisition hypothesis. The social convention hypothesis, which is a special case of the norm acquisition account, and which states that children believe there is a social convention to perform the unnecessary action, can of course explain the current findings of normative protest – it is well established by the experiments of Rakoczy and colleagues and by other experimental and observational studies (den Bak & Ross, 1996; Ingram & Bering, 2010; Vaish, Missana, & Tomasello, 2011) that preschoolers are motivated to protest against violations of social rules.

In summary, these data demonstrate that some children acquired a belief that the unnecessary action ought to be performed, strong enough to motivate protest against an individual who did not conform to it. This confirms the norm acquisition hypothesis, which states only that children believe the unnecessary action ought to be performed. It remains an open question, however, why children acquire this normative belief. Further summarizing the above discussion, there any many different hypotheses with previous empirical support which can explain why this belief is acquired, and the data presented here cannot distinguish between them. Children may believe the behavior is normative because it serves an instrumental purpose and/or children may believe the behavior is normative because it serves a social purpose. I note that several experiments have tested manipulations or measured factors predicted according to a variety of social or causal hypotheses to reduce over-

imitation (or similar imitation of inefficient actions), and although a reduction was usually observed, a proportion of children continued to imitate faithfully in every case (DiYanni, Nini, & Rheel, 2011; Flynn, 2008; Hilbrink, et al., 2011; Kenward, et al., 2011; Lyons, et al., 2011; Lyons, et al., 2007; McGuigan & Graham, 2010; McGuigan, et al., 2007; Nielsen & Blank, in press; Nielsen & Hudry, 2010; Nielsen, et al., 2008; Simpson & Riggs, 2011). These observations imply that multiple mechanisms lead to norm acquisition and over-imitation, and that conceptions of the unnecessary action are likely to vary between individuals. It should also be noted that as protest was not universal in this study, it may be that not all over-imitating children have a normative conception of the unnecessary action. I advocate that future studies of over-imitation, instead of attempting to prove that one mechanism rather than another is responsible, concentrate on elucidating the complex relations between the multiple mechanisms which underlie this multi-faceted phenomenon.

I end with a further suggestion as to the nature of the normative understanding which has been acquired by over-imitating children. This suggestion is based on two observations: (1) in over-imitation studies there is no clear evidence available to the child as to why the action is performed; (2) in one previous study, using a very simple apparatus, the majority of over-imitating children, when asked why they would perform the unnecessary action, were unable to give any sort of coherent answer, although most could explain that a necessary but otherwise equivalent action was causally necessary (Kenward, et al., 2011). These observations demonstrate that children are capable of encoding observed behavior as prescriptively normative without exposure to clear information as to why it is normative or even as to within which domain the normativity of the behavior is determined, and without having formed an expressible belief about the reasons for the action's normativity.

I therefore suggest that children may sometimes encode an observed action as normative without engaging in any reasoning justifying the action's normativity, and without even believing that the action's normativity is determined within any specific domain such as social convention or instrumental rationality. This suggestion is in line with evidence from adults, who are capable of holding views about the normative status of a behavior without being able to give coherent explanations for why the behavior should be proscribed or prescribed (Haidt, 2001; Hauser, Cushman, Young, Jin, & Mikhail, 2007). The cognitive processes which produce such views are intuitive and not directly available to introspection, and norms can be acquired unconsciously as a result of observing others follow them (Cialdini, 2007; Haidt & Bjorklund, 2008; Sripada & Stich, 2007). Although from the age of two or three years children can often distinguish between what is morally bad and what is bad according to convention (Nucci & Turiel, 1978; Schmidt, Rakoczy, & Tomasello, 2011b; Smetana & Braeges, 1990; Stern & Peterson, 1999), there is also evidence that their early conceptions of rightness and wrongness can be non-domain-specific (Kagan, 1981). This summed evidence lends plausibility to the hypothesis that children may be capable of encoding certain observed actions as normative without encoding reasons for the actions' normativity or even encoding the domain within which the actions' normativity is determined. Furthermore, the fact that adults can unconsciously encode actions as prescriptively normative as a result of observing these actions in others (Cialdini, 2007) opens the possibility that over-imitating children have similarly unconsciously encoded the unnecessary action as normative. This latter possibility comprises a new hypothesis concerning the mechanism of norm acquisition in over-imitation situations. It competes with the social and causal hypotheses outlined above for explaining how norms are acquired, and requires further investigation.

In conclusion, I place the finding of norm acquisition in the context of our understanding of the mechanisms underlying human culture. The peculiarly human tendency

to faithful imitation can be so exaggerated that it leads to what appears to be inefficient behavior, but it has arguably also allowed human culture to become highly advanced in comparison with other species (Boyd & Richerson, 1996; Lyons, 2009; Shea, 2009; Tennie, et al., 2009). The finding of normative protest in response to a third party's failure to faithfully imitate demonstrates that faithful imitation is closely linked to norm adherence and enforcement, which in themselves are also crucial for enabling the advanced form of human culture (Chudek & Henrich, 2011; Sripada & Stich, 2007). Future studies of norm acquisition and enforcement should also take note of the fact that norms can be acquired when their status as conventional or instrumentally rational is ambiguous. The traditional psychologist's stance of treating normativity purely as a moral or conventional phenomenon is limiting.

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