Rational over-imitation: Preschoolers consider material costs and copy causally irrelevant actions selectively

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ABSTRACT

Children's strong tendency to over-imitate – i.e., to reproduce causally irrelevant actions – presents a well-documented, yet puzzling, phenomenon. On first sight this instrumentally inefficient behavior seems maladaptive and different accounts have been put forward to explain it. Causal accounts claim that children are misled by an adult's demonstration, mistake the superfluous actions as causally necessary, and therefore imitate them. Other accounts emphasize cognitive-motivational aspects underlying over-imitation, e.g. social motivations to affiliate with the model, or to adhere to normative conventions. Since all accounts predict the occurrence of over-imitation under typical conditions, different parameters and circumstances have to be considered to distinguish between them. Thus, we investigated children's over-imitation and their spontaneous verbal reactions to a puppet's behavior, in contexts in which a causally irrelevant action either led to the destruction of a valuable object belonging to the experimenter, or not. In addition, children saw the full action sequence being demonstrated either with an instrumental or a conventional focus. Causal accounts predict no flexibility across these contexts, because over-imitation is said to occur automatically. Normative accounts claim that different normative considerations affect children's behavior and action parsing, and therefore predict different response patterns across conditions. We found that over-imitation was less frequent in costly and instrumental conditions. Children criticized the puppet for omitting irrelevant actions more often in the non-costly condition, but criticized her more often for performing irrelevant actions in the costly condition, often expressing their moral concern. The results support the rational normative action interpretation account of over-imitation.

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1. Introduction

Humans, as a species, are particularly good at imitating others around them. Imitation helps us to deal with new social situations, acquire new instrumental skills, and transmit our cultural knowledge to others (Nielsen, 2012; Tomasello, 1999; Whiten, Hinde, Laland, & Stringer, 2011). Due to its flexibility, imitation constitutes a powerful learning strategy, which is present since early in childhood. From a very early age, children are not just blind imitators but adjust their copying behavior to situational circumstances in impressive ways, for example with regard to inferring intended goals from failed attempts (Meltzoff, 1995), complementing only partially observed actions (Carpenter, Akhtar, & Tomasello, 1998), or taking into account characteristics of the model (Zmyj, Buttelmann, Carpenter, & Daum, 2010), as well as physical

constraints of a model during performance of goal-directed actions (Gergely, Bekkering, & Kiraly, 2002). In light of these findings of selective and rational imitation, it comes as a surprise that more and more studies have accumulated, which report a phenomenon that has been termed "over-imitation". Over-imitation refers to the faithful reproduction of causally irrelevant elements in goal-directed action sequences. For example, children will reproduce a superfluous action, such as tapping on the surface of a transparent box with a stick, at high rates, after having observed an adult perform this action before she opened the box to retrieve a reward from inside (Horner & Whiten, 2005). Over-imitation occurs robustly in humans across different cultures (Nielsen, Mushin, Tomaselli, & Whiten, 2014; Nielsen & Tomaselli, 2010; but see Berl & Hewlett, 2015, for an interesting recent finding on cultural differences), increases with age (e.g., McGuigan, Makinson, & Whiten, 2011), and is absent in nonhuman primates (Horner & Whiten, 2005; Nielsen & Susianto, 2010). Because such behavior renders the actions of the copier less efficient than necessary, from a purely instrumental point of view, the behavior seems maladaptive on first sight and in need of explanation.

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One class of explanatory approaches claims that over-imitation rests on children's lack of causal understanding. Lyons and colleagues argue that children are causally confused as a consequence of an adult's intentional demonstration of such actions, and mistake them for causally relevant (automatic causal encoding hypothesis, ACE) (Lyons, Damrosch, Lin, Macris, & Keil, 2011; Lyons & Keil, 2013; Lyons, Young, & Keil, 2007). Children thus over-imitate because "the normally adaptive ACE process blinds them to the irrelevance of the adult's unnecessary actions", i.e. "they have to" (Lyons et al., 2011, p. 1159).

Another class of approaches emphasizes cognitive-motivational aspects. Some of these accounts put special emphasis on imitators' motives to affiliate with the model by reproducing his or her actions very precisely (Nielsen & Blank, 2011; Over & Carpenter, 2012). For example, Nielsen and Blank (2011) found that children, in the presence of a model, adapted their method to retrieve a toy from an apparatus to the method previously used by the model. Crucially, they did so flexibly depending on the presence of one of two models, who had either demonstrated the efficient or inefficient method.

Other accounts stress a more broadly social and normative motivation to do what is best in a given situation, including considering normative demands. Specifically, the rational normative action account suggests that the imitator may conceive the causally irrelevant action to be an essential part of an overarching conventional activity (Keupp, Behne, & Rakoczy, 2013; Keupp, Behne, Zachow, Kasbohm, & Rakoczy, 2015). That is, when confronted with a typical over-imitation action sequence (demonstration of causally superfluous action A, effect-relevant action B, and effect E) children can engage in flexible and hierarchical action parsing and individuation. They see each action element, and they see the causal connection between B and E. Depending on additional contextual information, they may see the whole sequence as constituting a bigger, conventional action comprising A, B and E. In such conditions –for example, when the action sequence has been introduced with a focus on the specific conventional means of behavior, with a specific label, or with a "ritual" rather than instrumental stance (Herrmann, Legare, Harris, & Whitehouse, 2013) – children will assume that the task is to reproduce this bigger action sequence, will thus over-imitate and will normatively expect third parties to reproduce the whole sequence. In other contexts, in contrast, for example when the action is introduced with a focus on efficiency, or an instrumental stance, children will segment the action accordingly, interpreting it primarily as "bringing about E", and will omit causally superfluous elements and expect others to do so.

In line with this account, Kenward, Karlsson, and Persson (2011) documented that even though children claim to be unsure as to why a causally unnecessary action has to be performed, they insist that it has to be done. In addition, they segment and interpret such actions in normative ways and criticize others for failing to imitate the causally unnecessary action. (Kenward, 2012; Keupp et al., 2013).

At first sight these three accounts are not easy to test against each other, since all three predict the occurrence of over-imitation under normal circumstances. However, there are two ways to distinguish between them. One is to use additional measures, such as protest that sheds light on children's action interpretation (Rakoczy & Schmidt, 2013). The second is to study over-imitation under special circumstances, in particular those that tap into the flexibility – or rigidity – of children's over-imitation. Here, the most informative cases are those in which over-imitation evokes some costs. Depending on how the imitator interprets the causally-unnecessary action she will either omit or include it under costly circumstances (for details see below).

Two recent studies have started to explore this issue– with mixed results. Lyons et al. (2011) found that children over-imitated even in costly scenarios. In their study, children first saw an adult retrieve a reward from a box, by performing both causally irrelevant and relevant actions. The reward could be accessed from two sides of the box, and the children then took part in a competitive race game against an orangutan puppet, to see who could retrieve the reward first. Despite losing the game repeatedly, children continued to re-enact the model's causally irrelevant actions. In addition, children performed a noisy causally irrelevant action when retrieving their participation gift from a box, despite risking waking up the orangutan puppet who would potentially steal it from them. Thus, in both situations over-imitation occurred despite the potential costs involved. In contrast to this, in a study with adults, Flynn and Smith (2012) observed that the rate of over-imitation decreased significantly when the adult participants faced time pressure (i.e., when told they could win a monetary reward for the quickest object retrieval from a puzzle box). Whether these divergent findings are a consequence of developmental change (with adults being more flexible than preschoolers), or whether they have to do with methodological differences between the two studies, is not clear at this point. The possible confound between participant's age and study procedure makes it difficult to draw conclusions about the early flexibility in children's over-imitation.

In the present study we examined the flexibility of early over-imitation with a new refined method (cf. Lyons et al., 2011) and with a much more comprehensive approach, including not only over-imitation itself, but third-party sanctioning. And we tested the three accounts against each other in a systematic manner, examining in particular the specific predictions generated by the rational normative action account (Keupp et al., 2013). According to this account, varying contexts engender different kinds of normative considerations, including conventional, instrumental-rational and moral ones, which results in flexible action interpretation in accordance with the situation-specific "rational" demands.[1] For example, when observing a model perform an action sequence comprising two action elements, A (tapping on a box) and B (flipping a switch), and an effect E (box opens), children do understand that only action B is causally necessary to bring about E. However, they might still consider action A relevant for conventional-normative reasons (this is the way boxes are opened, here), or for affiliative reasons (this is how the model likes boxes to be opened), and therefore reproduce it. Based on their flexible rational action interpretation, children may also chose to omit action A, if there are good reasons for this, for example, if A invokes negative moral consequences or unjustifiable costs.

To test the predictions of the rational normative action account, we investigated children's over-imitation, and their third-party intervention, in contexts in which a causally irrelevant element of a bigger action sequence did or did not go along with costs. The costliness was realized in the form of morally bad consequences resulting from material loss of certain items: the causally irrelevant action element led to the destruction of a valuable object belonging to the experimenter. This implementation of 'costly' actions was chosen in order to overcome some methodological problems of the Lyons et al. (2011) study, where children's robustly high rate of over-imitation in the competitive situation might be a consequence of the (false) assumption that both the participant, and the competitor, are supposed to produce the effect in the

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[1] It is important to note, that what we mean by "rational action interpretation" refers more broadly and generally to "having good reasons for actions" and not only to instrumental rationality and efficiency. Children, in this view, interpret the actions as being guided by various forms of reasons (e.g., practical, but also conventional or social reasons), and act accordingly in their own imitative responses.

demonstrated inefficient way; and not because they automatically assume that causally irrelevant actions are, in fact, relevant. It is not clear, for example, whether children assumed that one disqualifies from the game when one uses a more efficient means and omits the causally irrelevant actions, because they never actually saw the competitor's actions.

The third-party intervention measure consisted in assessing children's spontaneous protest in response to a puppet's behavior (e.g., the puppet sometimes omitted causally irrelevant actions in her performance). Such protest has been used successfully in a number of studies as a measure of children's normative understanding of events (see Rakoczy & Schmidt, 2013, for a recent review).

Thus, our first prediction derived from the normative rational action account is that children's rate of over-imitation will decrease, if performing the causally irrelevant action invokes costs.

A second prediction derived from this account is that children's over-imitation is sensitive to the context of action performance. Specifically, if the context stresses the conventional nature of the action, then children's tendency to reproduce the causally irrelevant action will be higher than if the focus is on achieving an instrumental goal (see Herrmann et al., 2013; Keupp et al., 2013, 2015, for empirical support). This effect of the context of action performance may interact with the cost factor. Specifically, we predicted that the over-imitation rate will be more affected by the costs involved when the context stresses the instrumental rather than the conventional nature of the action, because in addition to the consideration of costs, the instrumental focus of the task weakens the obligation to perform causally irrelevant actions.

Regarding the first two hypotheses, neither causal nor affiliation account predict such flexibility in children's over-imitation. As the causally unnecessary action is automatically encoded as causally necessary, according to the causal account, if the child wants to reproduce the instrumental effect, she needs to over-imitate whatever the costs or context of action performance (or else decide not to act at all). The affiliation account in its pure form claims that over-imitation occurs out of the motivation to affiliate with and "be like" the model. In this reading, the affiliation account similarly predicts no differences in over-imitation between conditions: in order to affiliate with the model, the demonstrated action sequence should be reproduced regardless of context of action production (there are several amendments one can make regarding the affiliation account and its predictions, which will be elaborated on in the general discussion).

Our third set of predictions concerns how children's protest against the omission of the causally irrelevant action by a third party is modulated by these two factors, the context of action performance and the costs involved. As with their own imitative responses, we predicted that children will criticize a third party for omitting the irrelevant actions less frequently when the costs of performing them are high – and they will do so even less when the context of action performance has an instrumental rather than a conventional focus – because children will consider the necessity to perform the causally irrelevant actions much more carefully and will not necessarily consider them as a binding part of the overall activity.

And finally, we expect a new form of protest to occur: we predict that children will protest when a third party performs irrelevant actions if this invokes high costs, because children are sensitive not only to conventional rules, but also to other normative transgressions, such as causing harm or destroying other persons' property (Turiel, 1983; Vaish, Carpenter, & Tomasello, 2010).

Regarding the protest measure, the causal account would not predict any differences between conditions. Specifically children's protest against the omission of the causally irrelevant action should be independent of the context or costs involved: Given that

the action is mistakenly encoded as causally irrelevant, if an actor wants to reproduce the instrumental effect, she needs to over-imitate (or else decide not to act at all) regardless of the circumstances. Furthermore, no protest at all would be predicted against the performance of the causally irrelevant action. And as the affiliative motive concerns the relation between model and child, the affiliation account predicts no third-party critique at all, i.e. neither form of protest should occur.

2. Methods

2.1. Participants

Participants were recruited from a local database of families, who had volunteered to participate in developmental studies. Socio-economic status was not formally recorded, but children came from different day-care institutions in a middle-sized city that typically span diverse socio-economic backgrounds. Data of 57 children, 4–5 years of age, were included in the final sample (age range: 48–71 months; mean = 59 months; 24 girls). Five additional children were tested but excluded due to technical/experimenter error ($n = 3$) or uncooperativeness ($n = 2$). This age group was chosen because over-imitation is known to occur frequently at this age and a reasonable base-rate of over-imitation is necessary to test children's flexibility under different conditions.

2.2. Design

In a mixed design with four conditions, children played four games in total: they saw a block of two games in the "high cost" condition and a block of two games in the "low cost" condition. Half of the children were randomly assigned to the means-oriented conventional "method" condition and the other half to the ends-oriented instrumental "goal" condition (between-subject condition: context). The order of within-subject conditions (i.e. high or low cost) and the assignment of games to conditions were counterbalanced across children. Each game consisted of a main apparatus on which goal-relevant actions were performed, and included target objects that were broken or lost when the causally irrelevant action was performed. All games were designed to be equally intuitive and causally transparent (see Fig. 1 for details).

2.3. Procedure and materials

2.3.1. Warm-up phase

In the warm-up phase, children and main experimenter (E1) engaged in some conversation and a puppet ("*Lola*"), operated by E2, was introduced. This phase was designed for two specific purposes: first, to familiarize children with the situation and encourage them to interact with Lola and to intervene when necessary (e.g. when she made a mistake or needed help). Second, it ensured children's understanding that things cannot be retrieved from boxes with locks such as the one they just saw. They played a picture-matching game together and during this phase, two aspects were crucial: (a) Lola made some mistakes (e.g. combining the wrong pictures or putting a picture upside-down), and (b) Lola discovered a box, threw in a piece of paper, and then she requested to know how the box can be opened. E1 acted alarmed and explained that the box cannot be opened at present because one needs a tool to unlock it (E1 points out the locking mechanism), and she doesn't have the tool with her.

2.3.2. Test phase

Children then participated in the four test games (see Fig. 1 for details). Depending on condition, the games differed slightly with

Game A

Joint activity before the test game:
E1, puppet and child make bracelets from animal beads; unfortunately, there is no elastic left for E1 and she announces that she will make her bracelet later at home, where she has more elastics. E1's beads, therefore, remain in the middle.
Material:
Object category: Beads
- High value items: animal beads
- Low value items: normal beads
Irrelevant actions:
Throw a bead into the green rubbish bin (from which it cannot be retrieved)
Relevant actions:
Hook the red block to ropeway and let it slide down
Effect:
The bells (attached to the rope) ring when the block slides by.

Game B

Joint activity before the test game:
E1 provides stickers and landscape pictures. E1, puppet, and child put stickers on the pictures. There are no pictures left for E1 to put her stickers on, which therefore remain in the middle.
Material:
Object category: Stickers
- High value items: Theme sticker (e.g. animals, pirates, Fairy)
- Low value items: Monochrome adhesive labels
Irrelevant actions:
Rip a sticker in two and put each part onto one field of the yellow board
Relevant actions:
Use the magnetic end of a stick to lift two barriers which block a marble from running down an inclined plane.
Effect:
Ringing Xylophone bars at the end of the marble run.

Game C

Joint activity before the test game:
E1, puppet, and child color various artwork pictures. E1's pictures remain in the middle.
Material:
Object category: Sheet of paper
- High value items: Self-made pictures
- Low value items: Empty sheets
Irrelevant actions:
Rip a sheet of paper and put each part into the purple box.
Relevant actions:
Release a marble to run through the pipes.
Effect:
Collect marble along an "animal-picture scale" at the end of the pipe.

Game D

Joint activity before the test game:
Hang baubles on hooks/sort them by color; they are taken from a box provided by E1, who emphasizes that she wants to use the glittering red balls later as a window decoration; after the sorting/hanging activity the yellow blocks with the hooks are taken aside but there are still balls of various colors left in the box, which remains in the middle.
Material:
Object category: Baubles
- High value items: glittering balls (red)
- Low value items: Non-glittering balls (green, yellow, blue
Irrelevant actions:
"junkpress" a ball with the red-blue tool.
Relevant actions:
Navigate marble through the labyrinth by moving it accordingly.
Effect:
Marble ends up in a collector's bag attached to the labyrinth.

Fig. 1. Test games including main apparatus, and supplementary material to perform effect-irrelevant actions.

regard to available objects: In the low-cost condition, the availability of target items was manipulated so that the causally irrelevant action could be performed with valueless items belonging to no one. In contrast, in the high cost condition, the only remaining suitable items to perform the irrelevant action with were high value items belonging to E1. Furthermore regarding the context manipulation, the introduction of the games in the Demonstration phase differed for method and goal condition (see Fig. 1).

The *prior phase* of each game served to introduce the target objects (see Fig. 2 for an overview of the procedure). For each game, E1 provided items belonging to the same object category, e.g. *beads*. These items included nine high-value ones (e.g. different beads depicting animals) and some boring, low-value ones (e.g. different colored plain beads two or more depending on condition).

E1, puppet and child each chose three for themselves, so that only low-value items were left (since everyone chose high-value
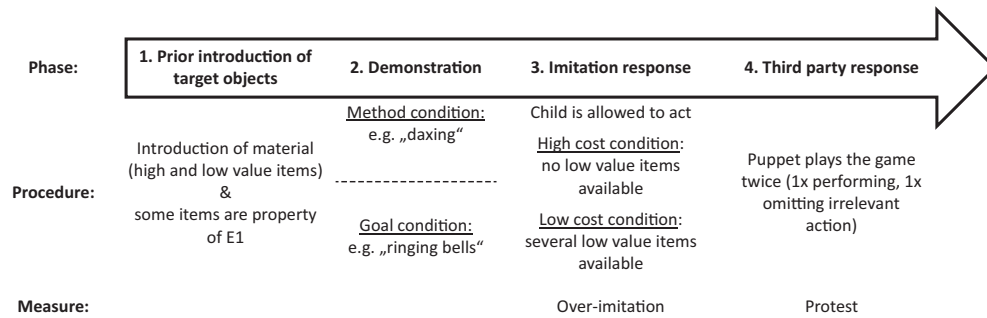
Phase:	1. Prior introduction of target objects	2. Demonstration	3. Imitation response	4. Third party response
Procedure:	Introduction of material (high and low value items) & some items are property of E1	Method condition: e.g. „daxing" -------------------- Goal condition: e.g. „ringing bells"	Child is allowed to act High cost condition: no low value items available Low cost condition: several low value items available	Puppet plays the game twice (1x performing, 1x omitting irrelevant action)
Measure:			Over-imitation	Protest

Fig. 2. Schematic procedure and measures.

ones). The puppet and child used their items immediately (e.g., to make a bracelet), but E1 could not (e.g., there was no elastic left). She emphasized how much she liked her items and would need them later (e.g., to make her bracelet). Thus, at the end of this phase three high-value items, belonging to and valued by E1, were accessible, together with some low-value items (*high cost condition*: two items, *low cost condition*: at least five items). The puppet then remembered something and excused herself.

At this point, the *main test phase* began. The introduction of the test game varied between the two context conditions. In both conditions, children saw a brief video clip of the apparatus and its effect. (In the video, only a human hand was visible but not the full person who operated the apparatus, i.e., the children did not see E1 acting as the model in the video – in fact, it was not even E1's hand but another person performed the videotaped actions). E1 made sure that the child paid attention and pointed out the relevant aspects. Then, E1 brought a real version of the game apparatus and performed a live demonstration. During this phase the context manipulation was introduced:

(a) *Method condition:* E1 checked that the child recognized the apparatus ("See, it's just like the one in the video. Do you recognize it?"). She reminded the child of the effect it produced and contrasted it with the activity she was going to perform ("Remember, there was a bell ringing in the video. But there is something else one can do with it: *daxing* (for example). And I am going to *dax* now. This is how *daxing* goes").

(b) *Goal condition:* As in the method condition, E1 ensured that the child remembered and recognized apparatus and effect. But instead of introducing a new activity, she announced that she was "also going to *ring the bells* (for example)".

For both conditions, E1 then performed the same action sequence including the irrelevant and relevant actions and the effect. Specifically, she announced what she was going to do (e.g., *dax* or ring the *bells*, depending on condition), then searched through the items left over from the *prior phase*, pretending to take any one randomly, but in fact always choosing a low-value one (saying, e.g., "OK, to dax/ring the bells I need a bead. Hmmm, . . . OK, I'll just take this one. Now I will dax/ring the bells"), and used it for the irrelevant action. Note that we chose this procedure to emphasize that both high and low value items belong to the same category. During a pilot phase we tried different items and combinations, and the ones we report here worked best for both being of the desired high/low value while at the same time being perceived by children as similar enough to be considered the same category. This is important because we are aiming to assess protest against performance of irrelevant actions for reasons of instrumental rationality and moral transgressions. Hence it is important to not confound different reasons for such protest (i.e. "don't throw this into the box because it's not necessary (and morally wrong)" vs.

"don't throw this into the box because it's the wrong kind of object"). Following the irrelevant action, E1 performed the relevant action that produced the effect, displayed her delight and marked the end of the activity: "Done with daxing/ringing bells". Hence, start and end of each activity were clearly marked verbally to avoid confusion about whether *daxing* might refer to the effect-irrelevant action part only. E1 performed this demonstration twice. This resulted in the following scenarios: in the high-cost condition, E1 has used up the last two low-value items and hence there are only three high-value items left in the middle. In the low-cost condition, there are three high-value items as well as several low-value items left in the middle. Then E1 invited the child to have a go, (saying e.g., "now you can have a go and dax/ring bells"). During this *imitation phase* E1 turned away and pretended to be busy writing, thereby not attending to the child's behavior. When the child had finished, Lola returned and took two turns playing the game, once omitting the irrelevant action and once performing it (order counterbalanced across games and conditions). In this *third party observation phase*, E1 was also turned away and not paying attention.

2.4. Coding

2.4.1. Over-imitation

Coding was binary, looking at whether or not a child performed the irrelevant action. In a few individual cases, a child would perform approximations of the demonstrated irrelevant actions, e.g. putting a sticker onto the designated board without tearing it beforehand. But usually, an item could be considered "gone" despite the incomplete action.

2.4.2. Protest

Episodes of protest were coded separately for both types of the puppet's turns. Turns, in which Lola performed irrelevant actions, resulted in possible episodes of "protest against *performance* of irrelevant actions". Here we distinguished 3 hierarchically organized coding categories:

(1) *Moral protest:* explicit verbal protest which included reference to E1 (e.g. "But if you take the lion she will be very sad").

(2) *Other explicit protest:* explicit verbal protest with imperative or normative character, regarding the performance of irrelevant actions (e.g. "Stop, don't throw something into the box!"), the use of a specific item (e.g. "No, not this. Oh no, now the animal is gone!"), or both the puppet's actions and her choice of item (e.g. "No, that's not how daxing goes. Actually, you must not use this bead!").

(3) *Hints of protest* (weak forms of verbal protest, e.g. "No. But . . ."; purely physical reactions, e.g. head shaking, insistently offering material).

Turns, in which Lola omitted irrelevant actions, resulted in possible episodes of "protest against *omission* of irrelevant actions". The coding here followed the same scheme, except that the first category – moral protest – did not apply (because no items of the experimenter were used).

All sessions were videotaped and coded by two observers. An independent reliability coder who was blind to the hypotheses of the study coded 25% of the data. Inter-rater agreement was very good for both variables, imitation: *kappa*, $\kappa = .96$, protest: *kappa*, $\kappa = .91$.

Given the binominal structure of our data, we analyzed our 2 (costs) × 2 (context) mixed-factor design using generalized linear mixed model analysis (GLMM) with binomial error structure and logit link function to assess the effect of the experimental treatments cost and context on the dependent variables imitation, protest against omission and protest against performance of irrelevant actions. These statistical analyses were conducted in the R statistical computing environment (R Development Core Team, 2008) using the glmer function from the lme4 package (Bates, Maechler, Bolker, & Walker, 2015). Before testing, we assured that assumptions were met by checking for influential cases (by excluding subjects one at a time from the data) and collinearity (using the function vif from the package car, Fox & Weisberg, 2011). We included 'context' (method or goal) and 'cost' (high or low) as fixed factors, as well as their interaction. We included 'trial', 'game' and 'subject ID' as random factors, to control for order effects, unexpected influential effects of specific games, and multiple testing. We compared the full model including interaction and random factors (model formulation: response ~ context × cost + (1|trial) + (1|game) + (1|ID)) to a reduced model without interaction (model formulation: response ~ context + cost + (1|trial) + (1|game) + (1|ID)), and to the null model only including intercept and random factors (model formulation: response ~ 1 + (1|trial) + (1|game) + (1|ID)), using likelihood ratio tests of the function anova.

3. Results

3.1. Over-imitation

Children reproduced the causally irrelevant actions in roughly half of the trials (overall rate of over-imitation: 57%), with 54 of 57 children over-imitating in at least one game. The GLMM analysis revealed significant effects for the two fixed factors cost and context, but no significant interaction. The full model (see Table 1) was significantly different from the null model ($\chi^2 = 94.12$, $df = 3$, $p < .001$), but not from the reduced model ($\chi^2 = 1.08$, $df = 1$, $p = .3$). Over-imitation was significantly more likely to occur in the method ($M = .66$, $SD = .46$) compared to the goal condition ($M = .45$, $SD = .5$) ($z = 2.97$, $p < .001$), and in the low cost ($M = .8$, $SD = .29$) compared to the high cost condition ($M = .33$, $SD = .48$) ($z = -5.52$, $p < .001$) (see Fig. 3).

3.2. Protest

For statistical analysis, only clear forms of protest were considered (i.e., moral and/or other explicit protest). The majority of children (35 out of 57) criticized the puppet for omitting irrelevant actions at least once (protest rate: 28%), and 17 of 57 children protested at least once against the puppet's performance of irrelevant actions (protest rate: 12%).

The GLMM analysis on the variable protest against omission of irrelevant actions only revealed a significant effect for cost. The full model (see Table 2) was significantly different from the null model ($\chi^2 = 20.97$, $df = 3$, $p < .001$), but not significantly different from the reduced model ($\chi^2 = 3.74$, $df = 1$, $p = .05$). Children were more likely

Table 1
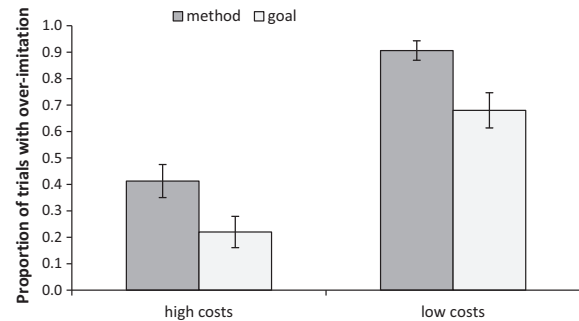Effects of the predictor variables on over-imitation.

Coefficients	Estimate	Std. error	z value	Pr(>|z|)
(Intercept)	1.2430	1.0550	1.178	0.2387
Context "method"	2.4337	0.8142	2.989	0.0028**
Cost "high"	−3.6745	0.8557	−4.294	1.75e−05***
Context "method" × Cost "high"	−0.9246	0.8895	−1.039	0.2986

* $p < .05$.
** $p < .01$.
*** $p < .001$.

Fig. 3. Proportion of trials (±*SE*) in which children over-imitated in the different conditions.

Table 2
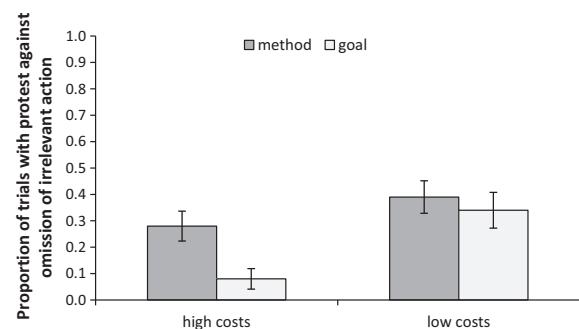Effects of the predictor variables on protest against omission of irrelevant actions.

Coefficients	Estimate	Std. error	z value	Pr(>|z|)
(Intercept)	−1.0978	0.6539	−1.679	0.09316
Context "method"	0.4550	0.6984	0.651	0.51476
Cost "high"	−2.6717	0.8289	−3.223	0.00127**
Context "method" × Cost "high"	1.7135	0.9268	1.849	0.06449

* $p < .05$.
*** $p < .001$.
** $p < .01$.

Fig. 4. Protest against omission of irrelevant actions. Proportion of trials (±*SE*) in which children criticized the puppet for omitting causally irrelevant actions.

to criticize the puppet for failing to perform the irrelevant action in the low cost condition ($M = .37$, $SD = .49$) than in the high cost condition ($M = .19$, $SD = .4$) ($z = -3.22$, $p < .001$) (see Fig. 4).

The GLMM analysis on the variable protest against performance of irrelevant actions only revealed a significant effect for cost. The full model (see Table 3) was significantly different from the null model ($\chi^2 = 24.02$, $df = 3$, $p < .001$), but not from the reduced model ($\chi^2 = .95$, $df = 1$, $p = .33$). Children were more likely to criticize the puppet for performing the irrelevant action in the high cost
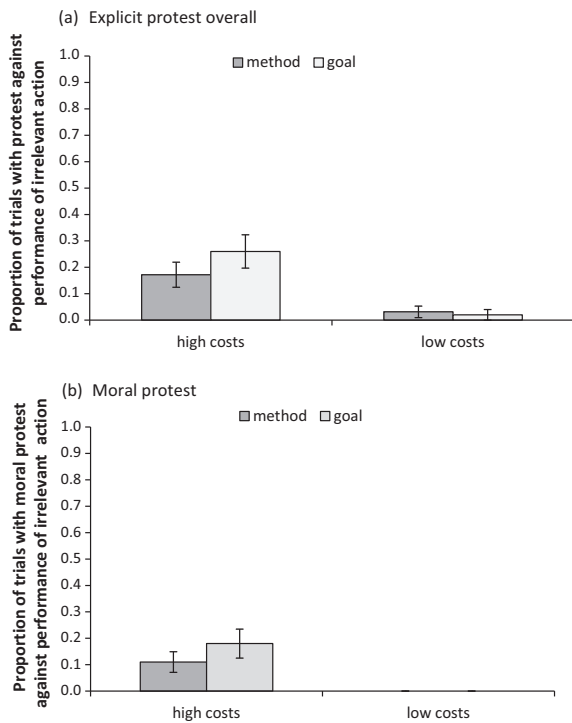
Table 3
Effects of the predictor variables on protest against performance of irrelevant actions.

	Estimate	Std. error	z value	Pr(>|z|)
(Intercept)	−11.8652	4.3371	−2.736	0.00622**
Context "method"	0.8627	2.9180	0.296	0.76749
Cost "high"	5.9164	2.5333	2.336	0.01952*
Context "method" × Cost "high"	−2.4325	2.7248	−0.893	0.37201

*** $p < .001$.
* $p < .05$.
** $p < .01$.

Fig. 5. Protest against the performance of the irrelevant action. (a) Proportions of trials (±SE) with any explicit protest (moral or other), (b) children's moral protest.

($M = .21$, $SD = .38$) than in the low cost condition ($M = .03$, $SD = .16$) ($z = 2.94$, $p < 0.01$) (see Fig. 5a). Moral protest, in particular, only ever occurred when high costs were involved (see Fig. 5b).

4. Discussion

To test different accounts of over-imitation against each other, we examined the effect of two factors, the cost of over-imitation and the context of action performance, looking at both children's own imitative response and their spontaneous response to a third party's action performance. We found that (i) children included the causally irrelevant action less when this would have incurred high costs, and that (ii) they also did this less when the action had been demonstrated with an instrumental rather than a conventional focus. Regarding children's third party interventions, children protested against the puppet's omission of the causally irrelevant action more frequently when the cost incurred by this action was low rather than high. In fact, we observed a new form of protest: children criticized the puppet for performing the irrelevant action, in particular when this action would incur high costs. In this case, children often protested by expressing their concern regarding the moral costs involved.

How does this pattern of results fit with the different accounts put forward to explain over-imitation? According to the causal

confusion account, children should imitate the causally irrelevant action regardless of the costs involved or the focus of action performance. As the causally irrelevant action is automatically encoded as causally relevant, there cannot be any flexibility regarding these factors: To achieve the instrumental goal, children need to perform the action they erroneously believe to be causally necessary. Our findings are thus not compatible with causal confusion accounts.

A purely affiliative motive is not likely to explain our pattern of results, either, at least not straightforwardly: if children want to please the model by imitating her way of doing things, why should they perform fewer irrelevant actions in some conditions? And why should they criticize the puppet's behavior? Even if the additional premise was added (in ad hoc ways) that children also want others to affiliate with the model and criticize the puppet for this reason, why should they criticize the puppet's behavior differently in some conditions? With another additional premise that affiliation seeking might be sensitive to what other persons want, one could argue that affiliation with a model is best reached by preventing loss of the model's property, instead of exactly copying her actions in the high-cost condition. However, this does not explain why children perform more irrelevant actions in the conventional, compared to the instrumental condition – especially if the model is not even paying attention. Importantly, though, this does not mean that affiliation seeking should generally be excluded as an underlying motivation for over-imitation. Under some circumstances, for example when contexts differ with regard to affiliation relevant factors such as presence of a certain model, affiliation might well explain differential patterns of over-imitation. Affiliative motives can be considered one specific case of "rational demands" and fit well under the umbrella of the more general account of rational action interpretation.

In summary, the results are most in line with the predictions of the rational normative action interpretation account. Children's response patterns were influenced by the context of action performance, as well as by the costs involved. A higher over-imitation rate in the conventional condition indicates that they conceived of the irrelevant action element as more mandatory than in the instrumental condition, despite having observed the same full action sequence demonstrated by the same experimenter, in both context conditions. Response patterns in the high cost condition indicate that children's behavior was also guided by moral concerns: over-imitation, and protest against omission of irrelevant actions, occurred less frequently, and children criticized the puppet for using the experimenter's valuable items for performing the causally unnecessary actions.

Although the results are generally compatible with the rational normative action interpretation account, not all predictions were borne out. There was no interaction between cost condition, and context of action introduction, and no main effect of context of action introduction regarding protest against omission of irrelevant actions. Our prediction was that making the performance of causally unnecessary actions 'costly' would have a greater impact on children's over-imitation in the instrumental condition, i.e. we expected over-imitation rate to be further reduced in the instrumental than in the conventional condition. We also expected to replicate the result of Keupp et al. (2013) who found that children criticized a puppet for omitting irrelevant actions more often in a conventional compared to an instrumental condition. Keupp and colleagues argue that children conceive of the irrelevant action element in the conventional condition as an essential part of a bigger conventional, generic activity (comprising causally irrelevant and relevant action elements and the resulting effect), whereas it is considered optional, in the instrumental condition. But in contrast to that study, by which the current experiment was inspired, we did not find this effect of context of action introduction for the spontaneous protest measure. A possible explanation might be that

irrelevant actions differed between the studies. In the present study, irrelevant actions consisted of throwing away or destroying something – and even in cases in which these items are not very valuable (i.e., the low cost condition) this might be considered a violation of a general rule which the children know from their daily routines (e.g., "One doesn't destroy objects just for fun"). This might interfere with, or outweigh the difference between conventional, and instrumental context, for the unsolicited spontaneous protest measure. A solution to overcome this possible confound would be to determine the cost condition not by the identity of the respective items (i.e. high vs. low value items), but instead by manipulating the result of irrelevant actions. For example, one could use high value items in both conditions, but the target box is either locked (i.e., items are lost) or unlocked (i.e., items can later be retrieved again).

Results also differ from those of Lyons et al. (2011) who documented that children still over-imitate at high rates in a competitive context when they risk losing a race game and reward. Furthermore, children in this study were even more selective over-imitators than the adults in a study of Flynn and Smith (2012) (with over-imitation ranging from 22% to 90% in the current study depending on condition, compared to the still relatively high rate of overimitation (i.e.,78%) in adults in the competitive game scenario). This indicates that both the context and the costs involved may play a role in eliciting selective over-imitation. A more systematic assessment applying comparable methods is, therefore, needed to be able to draw more general conclusions about developmental differences in over-imitation strategies.

This study reports selective over-imitation of causally irrelevant actions, which is affected by the costs that are involved and the nature of the action that is copied. The results clearly show that children are not blind over-imitators, and indicate that the term over-imitation should be used carefully, at least in imitation studies with humans. Over-imitation usually refers to the reproduction of *causally irrelevant* actions, and implies that something has been imitated unnecessarily. However, a causally irrelevant action might not be irrelevant from a conventional-normative point of view, for example. Hence, calling the reproduction of this action *over*-imitation is, if taken literally, confusing and misleading, since the action element in question is not something over and above the conventional activity, but an inherent part of it. The term may present a useful short-hand to refer to the phenomenon itself, but it can be highly misleading regarding its explanatory force or commitment. Norms are essential elements of human's cultural life, and are the driving force behind many behaviors – including the interpretation and re-enactment of others' actions.

Acknowledgements

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