DOI: 10.1111/cdev.14061

CHILD DEVELOPMENT

EMPIRICAL ARTICLE

Children's distinct drive to reproduce costly rituals

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Funding information
Australian Research Council Discovery Project Grant, Grant/Award Number: DP140101410

Abstract

Costly rituals are ubiquitous and adaptive. Yet, little is known about how children develop to acquire them. The current study examined children's imitation of costly rituals. Ninety-three 4–6 year olds (47 girls, 45% Oceanians, tested in 2022) were shown how to place tokens into a tube to earn stickers, using either a ritualistic or non-ritualistic costly action sequence. Children shown the ritualistic actions imitated faithfully at the expense of gaining stickers; conversely, those shown the non-ritualistic actions ignored them and obtained maximum reward. This highlights how preschool children are adept at and motivated to learn rituals, despite significant material cost. This study provides insights into the early development of cultural learning and the adaptive value of rituals in group cognition.

Across cultures, humans engage in a wide variety of rituals, ranging from ordinary gestures of greeting or dining to highly elaborated ceremonies like weddings and funerals. Rituals are argued to serve adaptive functions, facilitating group coordination and cooperation, laying the foundations for complex societies (Henrich, 2009; Wen et al., 2016; Whitehouse & Lanman, 2014). Given its ubiquity and adaptiveness in human group living, ritual is considered a trademark of our species (Legare & Nielsen, 2020; Whitehouse, 2021).

Defined as cultural conventions determined by shared social norms and values, rituals comprise actions that appear to be repetitive, rigid, formal, and redundant (Hobson et al., 2018; Legare & Souza, 2014; Watson-Jones & Legare, 2016). Ritualistic actions typically display *causal opacity*, meaning the functional value of these actions is uninterpretable due to a lack of any obvious connection between the performed actions and their intended outcome (Kapitány & Nielsen, 2015; Legare & Souza, 2012; Nielsen, 2018; Whitehouse, 2021). Another key feature of such actions is *goal demotion*, where the immediate goal of an actor's behavior is clear enough (e.g., using a cloth to wipe a surface will lead to the surface being cleaned), but the ultimate goal or the intended outcome for performing those actions in certain ways is indeterminate (e.g., why is the cloth being moved systematically left to right then up and down while a low humming noise is offered?; Boyer & Liénard, 2006; Kapitány & Nielsen, 2017). These characteristics allow us to discriminate ritualistic actions from ordinary ones. The study of rituals has drawn ample attention from anthropologists (Fischer, 2021); however, less research has examined the social-cognitive aspects of ritual, much less the developmental trajectory of ritual learning. The current research, therefore, aimed to investigate how children interpret ritualistic actions and respond to them when doing so is costly.

Children are active ritual learners

Children are proficient imitators, soaking up complex knowledge and skills like sponges by observing and copying the actions of people around them (Legare &

Nielsen, 2015; Whiten et al., 2009). They display an early developing propensity to learn via imitation, even to the striking extent of copying actions that have no perceivable causal value, a phenomenon termed "over-imitation" (Horner & Whiten, 2005; Lyons et al., 2007; Nielsen et al., 2012). Through such faithful replication, children progressively acquire the wealth of human skill repertories necessary for them to become competent adults.

Imitation allows children to learn hard-won technological knowledge, which often involves processes that are not easily understandable from a physical-causal perspective. However, there is much more to imitation than just a way of acquiring instrumental skills. Imitation provides a means for forming and maintaining relationships with others (Nielsen et al., 2008; Nielsen & Blank, 2011; Over, 2020; Watson-Jones et al., 2014), learning social norms (Kenward et al., 2011), and sharing intentions (Carpenter, 2006; Tomasello et al., 2005). Imitation can be driven by fear of ostracism (Over & Carpenter, 2009), group membership (Buttelmann et al., 2013; Schleihauf et al., 2019), and consensus or synchrony among individuals (DiYanni et al., 2015), suggesting an underlying motive to affiliate with social in-groups. These social concerns are fundamental for learning cultural conventions (Herrmann et al., 2013; Legare et al., 2015; Legare & Nielsen, 2015).

Rituals, being a crucial subset of conventions (Legare & Nielsen, 2015), are motivated by social affiliative goals and function to increase in-group preferences (Wen et al., 2016), promote coordinated and cooperative group actions (Watson-Jones et al., 2014), and signal group trust and loyalty (Hobson et al., 2018). Recognition of rituals' social significance begins in our infancy, with 16 month olds expecting adults who were enacting the same ritualistic actions to share social affiliation (Liberman et al., 2018). Driven by a similar social motive, imitation plays an indispensable role in understanding and inheriting ritualistic actions (Heyes, 2021). Indeed, high-fidelity imitation is seen as the basis of ritual learning, demonstrating children's social and cognitive preparedness to participate in ritualistic behavior (Nielsen et al., 2020; Whitehouse, 2021).

Actions characterized by ritualistic features are suggested to prompt the ritual stance of imitation (Herrmann et al., 2013; Legare et al., 2015; Legare & Herrmann, 2013). When this interpretive mode is activated, children seek rationale behind the observed actions based on social convention instead of physical causation, paying closer attention to the specifics of whatever has been demonstrated to them (Clegg & Legare, 2016b; Moraru et al., 2016). Both children and adults thus tend to perceive ritualistic actions as informative and normative, meaning all action steps should be faithfully reproduced (Kapitány & Nielsen, 2015; Nielsen et al., 2015; Watson-Jones & Legare, 2016). Children, typically between the ages of 4–6 years, are especially sensitive to ritualistic features, imitating with increased fidelity when cued by causal opacity (Clegg & Legare, 2016b; Legare et al., 2015; Schleihauf et al., 2018) and goal demotion (Nielsen et al., 2018; Watson-Jones et al., 2014).

Costly ritual learning

Another common feature of ritualistic behaviors is their costliness. Rituals often include actions that incur a deficit in terms of time and energy expenditure, in some instances extending to wasteful, dangerous, and even fateful acts (Watson-Jones & Legare, 2016). The substantial effort and resources required in ritual participation are thus suggested to be highly valuable: by incurring personal costs, one can signal honest commitment to the social group (Henrich, 2009; Hobson et al., 2018; Legare & Nielsen, 2020; Rossano, 2015). In doing so, participants produce hard-to-fake costly rituals that could deter free-riders from reliable group membership, diminishing the risk of cooperation (Soler, 2012). Consequently, costly ritualistic actions are linked to liking for one's group (Whitehouse, 2021), trust among group members (Hobson et al., 2017), prosociality (Xygalatas et al., 2013), and longevity of the group (Sosis & Alcorta, 2003).

Yet, little research has charted the ontogeny of costly rituals and how children respond to or acquire such actions. Past studies with benign tasks reviewed above reveal how children readily reproduce ritualistic actions with high fidelity. However, in these studies, children were typically provided little reason to not imitate faithfully, as there was either no material reward involved at all (see Clegg & Legare, 2016b; Legare et al., 2015), or no difference in the reward available between choosing to imitate or not (see Moraru et al., 2016; Nielsen et al., 2018; Schleihauf et al., 2018). Imitating faithfully in these studies did require reproducing extra actions that had no causal affordance, which cost children time and energy. However, such costs are minimal and the motive to save such expenditure may be restricted, as being brought to experimental contexts may serve as a special event for children that triggers expectations to follow the "rules" and "do well" (Hoehl et al., 2019).

One study, conducted by Wilks et al. (2016), utilized more costly ritualistic behaviors. In this study, imitating the model's actions led to failure in retrieving a toy from a puzzle box. Children copied the ritualistic but unsuccessful actions at high rates. Nevertheless, the ritualistic actions were demonstrated by a group member with ingroup members standing behind her, whereas the successful instrumental actions were performed by a single individual. This means we cannot separate the impact of group membership or majority bias from costly rituals. Besides, not being able to retrieve a toy was not a direct material cost to the child, as the toy was only part of the experimental setting and did not belong to the child (it was not a reward they got to keep).

Current study

The aim of the current study was thus to examine children's imitative responses to ritualistic actions that were costly in terms of material rewards. To incorporate an inescapable cost, we created a novel task where imitative fidelity

was pitted against material rewards. Children were introduced to a task where they could win stickers by inserting tokens into a tube. The more tokens children put into the tube within one minute, the bigger the reward. However, the modeled actions were so inefficient that by the end of the minute, the model was only able to win one sticker. Precise reproduction of the observed actions meant forsaking three more stickers (combined across three trials this meant a difference of three vs. 12 stickers). Stickers are selected as rewards in this study given their established use in previous research as both participation rewards and key experimental manipulations (e.g., Flynn et al., 2018), and their wide acceptance as a motivating tool that children enjoy.

Rituality of the actions was demonstrated by repetition and rigidity (producing the exact pattern three times), as well as redundancy and ambiguity (these actions were apparently redundant in gaining the rewards and did not involve the tube at all). This is a unique approach to contextualize rituality, as previous studies on children's imitation of ritualistic actions predominantly focused on causal opacity and goal demotion (e.g., see Kapitány & Nielsen, 2015, 2017; Nielsen et al., 2018). Avoiding these two features allows us to gain a deeper and more comprehensive understanding of different forms of ritual learning. Moreover, past studies frequently employed conventional language cues (Clegg & Legare, 2016a, 2016b; Legare et al., 2015; Moraru et al., 2016) and group-related settings (Herrmann et al., 2013; Watson-Jones et al., 2014; Wen et al., 2016; Wilks et al., 2016). Kapitány et al. (2018) suggested that these two contextual factors are more salient cues to rituality than actions alone. The current study, therefore, deliberately avoided these contextual cues, so as to examine children's responses to the costly ritualistic actions themselves.

Given the adaptive value of costly rituals and children's proclivity to imitate actions with ritualistic features, we predicted that children would imitate the ritualistic actions with high fidelity, despite their costliness. Additionally, we investigated the extent to which children would treat ritualistic actions and non-ritualistic actions differently. We incorporated a second set of demonstrations where the model performed equally costly actions, but in a non-ritualistic manner. Research has found that when not cued by conventionality, children focus on the instrumental aspects of imitation, prioritizing functional values of the observed actions rather than replicating the specifics (DiYanni et al., 2011, 2022; Fong, Imuta, et al., 2021; Legare et al., 2015). Therefore, we predicted that children would imitate the non-ritualistic actions less faithfully compared to the ritualistic actions. We also examined the difference between ritualistic and non-ritualistic actions in terms of their perseverance. Children were allowed three attempts at the same task. Rituals, as conventions that need to be adopted and passed on to others, are suggested to suppress innovation and change (Whitehouse, 2021, p. 601). Thus, we predicted that when the actions were ritualistic, children would imitate faithfully across all three trials, but decrease their fidelity when the actions were non-ritualistic. Confirmatory analyses were conducted to test these hypotheses.

METHOD

Participants

Ninety-three 4- to 6-year-old children (M = 5.53 years, SD = 0.82, 47 girls) were included in the final sample. This age group was selected as children within this range have been found both to display sensitivity to ritualistic features (Clegg & Legare, 2016b; Nielsen et al., 2018) and to exhibit high fidelity imitation (Lyons et al., 2007), while also possessing the necessary manual dexterity to complete the tasks. The present sample size allowed us to detect a large effect size in a post hoc power analysis (calculated with G*Power, f = .40, power over 90%, α = .05). An additional 7 children were excluded due to experimenter error (n = 2) or failure to complete the task (n = 5). Participants were tested while visiting a museum located in the center of a large urban city from February 2022 to June 2022. Consent was obtained from children's caregivers before their participation. Most caregivers reported education background (67%) and ethnicity (71%); of those who reported, 92% of the families had at least one parent with a university degree or higher (63% of whom had a higher university degree). Participants were mostly Oceanians (from Australia or New Zealand, 45%), 15% were from mixed ethnic backgrounds, 18% Asian, and 14% European. Children received stickers and a wristband as rewards for their participation. This study was approved following the ethical review processes of the University's Health and Behavioral Sciences Review Committee. The current study was pre-registered and can be accessed here: https://osf.io/bkrxj/?view_only=ae4ec01ac89a493b85395fb287c6c58f. Preregistration was done after piloting the methods.

Materials

A box of black and white tokens (6 mm high, 3.2 cm diameter each; a total of 48 tokens, half were black) and a transparent tube (25.5 cm high, 4.5 cm diameter, can be filled with 36 tokens) were used. The upright tube was affixed to a base (9.3 cm × 8.7 cm). Four black lines marked the tube at four levels of equal inter-level heights (7, 12, 18.5, and 25 cm). A digital countdown timer with a 10.9-inch screen was used to time the experimental task (see Figure 1).

Procedure

All testing was undertaken with the child sitting opposite the experimenter on the floor. A camera was focused toward the child to allow for later independent coding.

The testing session started with the experimenter presenting the tokens and the tube to the child. The experimenter then detailed the rules of the task by pointing to each line on the tube and explaining how many stickers the child could win if they reached each respective line (see Appendix for the full script). After that, the experimenter took out the digital countdown timer and explained that children had only 1 min to perform the task. Children were then asked how many stickers they could win if they could reach a certain line on the tube to make sure they understood the rules (each line reached equated to one sticker gain). The experimenter repeated the rules if a child answered incorrectly. Children were then randomly assigned to one of the three between-subject conditions: Ritual, Non-Ritual, and Control. All children participated consecutively in three trials; each trial ended when 1 min passed. Non-directive verbal encouragement was given if a child was reluctant or shy.

Condition 1: Ritual

After the rules were explained, children were given two identical demonstrations before their trials. The experimenter started the session by informing the child that the experimenter would first demonstrate how to play the game, before it was the child's turn. Then the experimenter started the timer and began to take out the tokens from the box and put them down on the floor one by one into three identical diamond-shaped patterns (see Figure 2). Tokens were taken in an alternating black-and-white sequence. The placement of the tokens was the same for each pattern. The three patterns were lined up with the experimenter naming the color of each token when putting them down (to emphasize the ritualistic feature of altering the color of the tokens). After completing the three patterns, the experimenter started to put the tokens into the tube one by one while again naming the colors. After that, the experimenter tried to repeat the whole process but failed due to insufficient time. This was to inform children that the three patterns were a set and that they could take more than 12 tokens. Notably, there was no environmental constraint for the experimenter to act in this way and they could have simply taken the tokens and put them directly into the tube, which would obviously be an easier and more effective method. After the time was up, the experimenter reached only the bottom line and hence "won" one sticker. The same demonstration was repeated before children began their trials.

FIGURE 1 Test apparatus and setup.

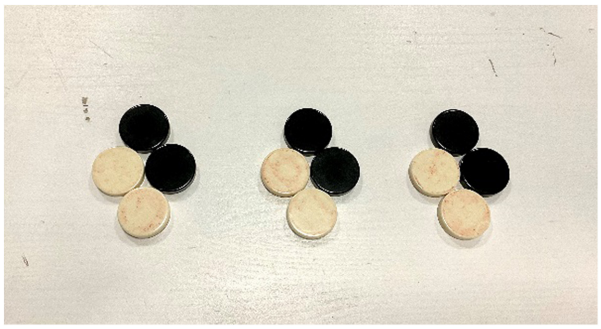

FIGURE 2 Pattern of tokens in the Ritual condition.

Condition 2: Non-ritual

The Procedure in this condition was identical to the Ritual condition but with different demonstrated actions. In this condition, the experimenter started by taking out the tokens from the box, counting as she did so (matching the verbal component of the Ritual condition). The tokens were put into the tube directly one by one but very slowly so that after 1 min the experimenter was able only to reach the bottom line and "win" one sticker. The same demonstration was repeated before children began their trials.

Condition 3: Control

In this condition, children began their trials after having heard the rules without any demonstration. The trials began with the experimenter saying, "now you can have your turn, are you ready?"

Coding and reliability

Children were scored for two measures on each test trial: (1) the number of stickers won (children could score from 0 to 4 in each trial and hence 0 to 12 in a total of three trials); and (2) the percentage of actions replicated. Breakdown of the replicated actions measure in the Ritual condition included naming the color, placing the tokens on the floor, putting the tokens into the pattern, putting the tokens into the tube one by one, and in black-and-white sequence. Replication of each action type gained a score of 1, so children could score from 0 to 5 in each trial in the Ritual condition (0–15 across three trials). In the Non-Ritual condition, children could score from 0 to 3 in

each trial (0–9 across three trials), including counting the number of tokens, putting the tokens into the tube one by one, and moving deliberately slowly (children would score 1 if they placed fewer than 10 tokens into the tube within the time limit, which is equivalent to one sticker) while doing so. The percentage of actions replicated was used as standardization for direct comparison between the two demonstration conditions. The Control group was scored based on the number of spontaneous creations of the same actions as demonstrated in the two experimental conditions. Given there were a total of seven different actions in both conditions, children could score from 0 to 21 across three trials. Children were granted scores for performing the actions rather than successful completion. Processed data can be accessed here: https://osf.io/52b7g/?view_only=83b19583bb7942af82453ad274758a26.

A second coder who was blind to the hypotheses of the present study and the conditions to which children were assigned coded 15% of the videotapes independently. Intraclass correlation coefficients (Shrout & Fleiss, 1979) indicated very good agreement between the two coders on the total number of actions imitated ($r = .99$) and the total number of stickers won ($r = .99$).

RESULTS

Preliminary analyses showed no effect of sex, so it was not considered further. Overall, there was a significant negative correlation between the total number of rewards won and the total percentage of actions replicated ($r = -.75$, $p < .001$) in both experimental conditions, suggesting that the core experimental rationale had worked.

A detailed breakdown of children's scores on each action type in the three conditions is shown in Table 1. A mixed factorial ANOVA examined how action feature (ritual vs. non-ritual) and trials affected the total percentage of actions replicated by children (see Figure 3). Age had no effect ($F[2, 56] = 0.18$, $p = .839$) and was excluded from further analysis. There was a significant main effect of action feature, $F(1, 60) = 10.69$, $p = .002$, $\eta_p^2 = .15$, indicating that children in the Ritual condition replicated more actions proportionally than those in the Non-Ritual condition across all trials (see Table 2). Additionally, there was a significant main effect of trials, with Huynh–Feldt corrected $F(1.62, 97.29) = 36.65$, $p < .001$, $\eta_p^2 = .38$. Tukey's post hoc tests indicated significant differences between the first and the second ($p_{1-2} < .001$, 95% CI [9, 21]) as

TABLE 1 Mean and standard deviation of children's score on each action type across all trials in three conditions.

	Demonstrated action type						
Condition|M(SD)	Naming	Placing on floor	Pattern	Black and white	One by one	Counting	Slowly
Ritual	0.97 (1.35)	1.73 (1.36)	1.47 (1.41)	2.07 (1.26)	2.23 (1.04)	N/A	N/A
Non-Ritual	N/A	N/A	N/A	N/A	1.69 (1.26)	0.84 (1.27)	0.28 (0.63)
Control	0	0	0	0.1 (0.40)	0.94 (1.12)	0	0

Note: Children could score from 0 to 3 on each action type. No child performed actions that were not demonstrated in the Ritual and Non-Ritual conditions.

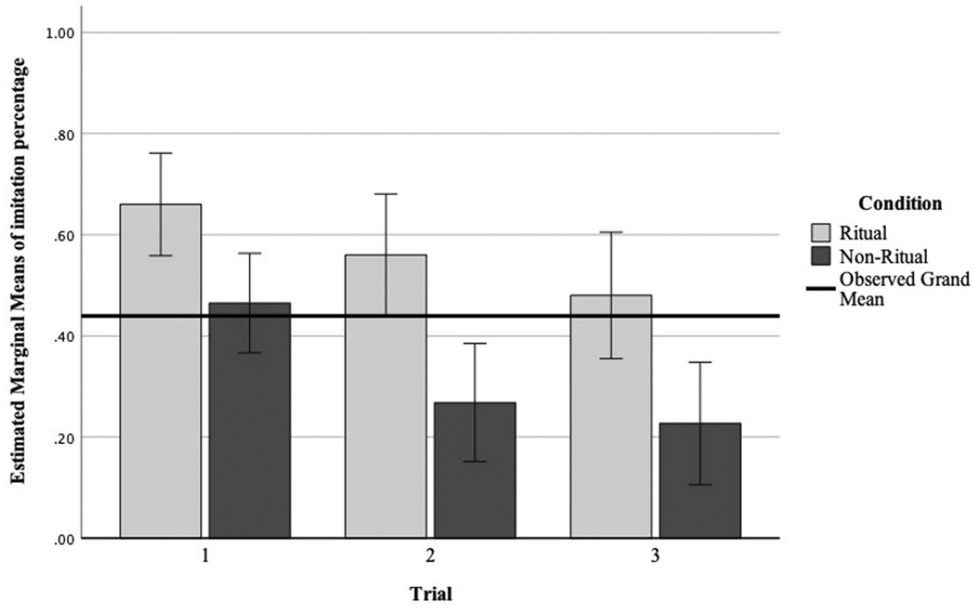

FIGURE 3 Mean percentage of actions imitated in each trial in both experimental conditions. Error bars represent a 95% confidence interval of the mean.

well as the third ($p_{1-3} < .001$, 95% CI [13, 28]) trials, which suggests that children replicated fewer actions in the follow-up trials. There was no significant interaction effect of trials on action feature, $F(1.62, 97.29) = 1.87$, $p = .166$; suggesting this decrease is not affected by the type of action demonstrated. On average, children in the Control condition produced only one out of the 21 demonstrated actions (as shown in Table 2), indicating that the demonstrated actions are unlikely to be produced by children spontaneously.

A mixed factorial ANCOVA examined how conditions and trials affected the total number of stickers won by children, with age as a covariate (see Figure 4). There was a significant main effect of condition, $F(2, 89) = 29.81$, $p < .001$, $\eta_p^2 = .40$. Tukey's post hoc tests indicated that children in the Ritual condition won significantly fewer stickers than children in the Non-Ritual ($p_{R\text{-}NR} < .001$, 95% CI [−1.94, −0.89]) and the Control ($p_{R\text{-}C} < .001$, 95% CI [−2.01, −0.96]) conditions (see Table 2 for means and SDs). There was no significant difference between the Non-Ritual and the Control conditions. There was also a significant main effect of trials, with Huynh–Feldt corrected $F(1.79, 159.41) = 18.82$, $p < .001$, $\eta_p^2 = .23$. Tukey's post hoc tests indicated significant differences among stickers won in the first, the second, and the third trials: $p_{T1-2} < .001$, 95% CI [−0.65, −0.32]; $p_{T1-3} < .001$, 95% CI [−0.82, −0.45]; $p_{T2-3} = .014$, 95% CI [−0.28, −0.02]. This suggests that children won an increasing number of stickers throughout the three trials. Furthermore, age was a significant covariate with older children winning more stickers, $F(1, 89) = 12.02$, $p < .001$, $\eta_p^2 = .12$. A significant interaction effect of age on trials was also found ($F[1.79, 159.41] = 11.10$, $p < 0.001$, $\eta_p^2 = .15$), indicating that older children who have participated in more trials won more stickers. There was no significant interaction effect of trials on condition, $F(3.58, 159.41) = 0.60$, $p = .647$, which suggests the effect of trials was not modulated by condition.

Overall, the results indicated that children in the Ritual condition imitated more faithfully and won the least stickers. Older children were able to win more stickers than younger children across all conditions, despite imitating to a similar extent. Additionally, with each progressive trial children imitated less and hence won more stickers.

TABLE 2 Children's imitation score in percentage and cumulative frequency as well as the number of rewards gained across different conditions and trials.

	Imitation percentage	Imitation frequency	Rewards gained
	M (SD)	*M* (SD)	*M* (SD)
Across all trials			
Control	N/A	1.03 (1.20)	10.35 (2.07)
Ritual	57% (0.34)	8.50 (5.13)	5.87 (3.68)
Non-ritual	32% (0.25)	2.91 (2.25)	10.13 (2.03)
Ritual			
Trial 1	66% (0.28)	3.30 (1.39)	1.63 (1.07)
Trial 2	56% (0.38)	2.80 (1.92)	2.00 (1.46)
Trial 3	48% (0.41)	2.40 (2.03)	2.23 (1.38)
Non-ritual			
Trial 1	46% (0.28)	1.41 (0.84)	3.00 (0.80)
Trial 2	27% (0.27)	0.81 (0.82)	3.53 (0.72)
Trial 3	23% (0.27)	0.69 (0.82)	3.59 (0.67)
Control			
Trial 1	N/A	0.58 (0.56)	3.03 (1.02)
Trial 2		0.29 (0.46)	3.58 (0.72)
Trial 3		0.16 (0.37)	3.74 (0.58)

Note: On the imitation cumulative frequency scale, children could score from 0 to 21 in the Control condition, from 0 to 15 in the Ritual condition, and from 0 to 9 in the Non-Ritual condition. Percentage of replicated actions was used as standardization for comparison between the experimental conditions. On the number of rewards gained scale, children could score from 0 to 4 in each trial and 0–12 across all trials.

Abbreviation: SD, standard deviation.

DISCUSSION

Being a pervasive and significant aspect of human life, rituals are actively learned by children (e.g., engaging in decorating a Christmas tree from a young age, or pretending to prepare and serve tea in a traditional way with toy tea sets; Whitehouse, 2021). Yet, it is not clear how young children interpret and respond to ritualistic actions, especially in occasions that incur a material cost. We thus employed a novel task where material rewards were pitted against faithful replication of ritualistic actions. Our findings demonstrate for the first time that preschool children have a strong tendency to imitate ritualistic actions even at a significant material cost, something that is less likely to happen for ordinary actions.

On average, children who observed a ritualistic demonstration replicated over half of the demonstrated actions, even when doing so meant only earning five stickers out of the maximum possibility of 12. In contrast, children who observed an alternative non-ritualistic method acted the same as those who completed the task without any demonstrations, resulting in a more efficient approach that earned them twice the rewards. This suggests that preschool children are sensitive to ritualistic cues embedded in actions and are highly motivated to learn such actions precisely. This finding is not only consistent with previous studies where children were found to imitate ritualistic actions with high fidelity (Nielsen et al., 2018; Schleihauf et al., 2018; Watson-Jones et al., 2014; Wilks et al., 2016) but also provides evidence that children continue to imitate faithfully even when such actions entail a significant cost (earning less desirable rewards). These dispositions are particularly striking in the context of the present study, as the demonstrated ritualistic actions were minimal

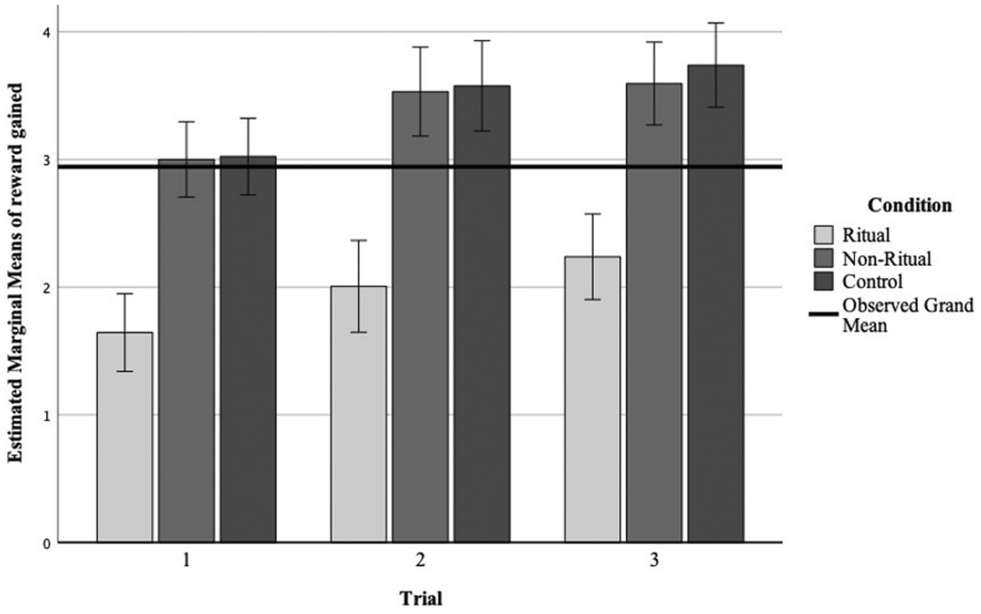

FIGURE 4 Mean number of rewards gained in each trial by condition. Error bars represent a 95% confidence interval of the mean.

(simplistic repetition of laying tokens on the floor) and deprived of any tangible meaning or value. The present task also had a clear instrumental goal of earning stickers and was not embedded within conventional group practices, two factors suggested to decrease children's imitative fidelity (Clegg & Legare, 2016b; Herrmann et al., 2013; Legare et al., 2015).

The fact that children imitated significantly fewer actions in the Non-Ritual condition suggests that their faithful replication of ritualistic actions was not due to a distorted or immature understanding of the task's causal linkages. On the contrary, when the actions were non-ritualistic, children responded rationally and maximized their rewards. This finding is consistent with previous studies where young children prioritized instrumental efficacy over normality when the demonstrated actions were causally relevant (DiYanni et al., 2011; Fong, Imuta, et al., 2021). This supports a view that children can actively interpret the context and parse the observed actions when learning from others (Keupp et al., 2018; Schulz et al., 2008), and will behave appropriately and adaptively in their imitation (Evans et al., 2018; Gergely & Csibra, 2006). The findings reported here suggest that children as young as 4 years old imitate selectively to achieve optimal outcomes when observing costly demonstrations in an instrumental task.

The striking contrast in children's responses between the Ritual and Non-Ritual conditions supports the notion that rituals are highly adaptive in the context of human group living. Rituals are argued to be of paramount importance in signaling group identity, facilitating cooperation, and exhibiting commitment (Legare & Watson-Jones, 2015; Nielsen et al., 2018; Wen et al., 2016). These functions are essential to the formation and prolongation of cohesive groups, which in turn benefit individual fitness (Thompson, 2019), facilitate innovation (Krause et al., 2010), and contribute to the evolution of sophisticated human cognition (Reader & Laland, 2002). Our findings emphasize the potential importance of costly rituals in particular, which is consistent with theories arguing that these foster strong cooperation and illustrate genuine in-group commitment (Rossano, 2015; Ruffle & Sosis, 2007).

We failed to detect an effect of age on imitative responses. This may be a function of even 4-year-old children being well prepared to learn, and follow, rituals at the expense of desirable rewards. This has important implications for our understanding of the ontogeny of cultural learning and is in line with the perspective that humans have an early developing capacity to adopt conventional practices. This finding also aligns with past research indicating that 3- to 4-year-old children create assumptions of conventionality based on a systematic analysis of who and what is conventional (Diesendruck & Markson, 2011). Children at 3 years of age have been found to engage in explicit normative protest, indicating their understanding of the conventional structure (Rakoczy et al., 2008). Together, these findings suggest that the ability to identify and engage in socially bound acts is a vital developmental achievement, offering new insight into the development of human sociality.

Contradictory to our hypothesis that ritualistic actions would be replicated with similarly high fidelity across three trials, children imitated fewer actions and earned more rewards gradually. Rituals are argued to resist modification and innovation as they are normative information uninterpretable in terms of causality (Legare & Souza, 2012; Legare & Watson-Jones, 2015). However, the current finding suggests that even though the perseverance of conventional information is integral to human social life, children

may still opt to omit ritualistic actions they observe, to better serve themselves. An alternative explanation would be that children adopted a "copy-all, refine later" strategy of imitative learning (Whiten et al., 2009). We argue that this is unlikely as children imitated with low fidelity when observing non-ritualistic actions, suggesting a "copy all" at first reaction was not triggered when the inefficiency of demonstrated actions can be easily discovered. Another possibility could be that children believed ritualistic actions needed to be performed only once to fulfill the social requirement of the task. Further research is therefore needed to examine the reproduction and perseverance of ritualistic actions to better understand the motivations behind faithful ritual learning. Specifically, it would be informative to include subsequent teaching trials (Corriveau et al., 2017; Fong, Sommer, et al., 2021), where children are given the opportunity to teach others how to perform the task. Additionally, varying the group identity of the person being taught (in-group vs. out-group) would allow us to investigate the potential impact of group dynamics on children's ritual transmission.

Engaging in ritual behavior is a prominent aspect of the uniquely human experience. Understanding the process of ritual learning has important implications for uncovering the origins and consequences of human culture. Here, we conclude for the first time that children are disposed to faithfully imitate ritualistic actions at the expense of a significant material cost. Children opted for material gain and omitted an equally effortful but non-ritualistic method. We propose that preschool children are not only adept at learning rituals, but they are also extremely motivated to do so, even in individual settings with a clear instrumental goal. However, it is important to note that the current sample was limited to mostly Western and well-educated families residing in a metropolitan city, therefore, the generalizability of this finding to other socio-cultural groups may be limited. The present task employed a less explored operationalization of rituality. While causal opacity and goal demotion have been extensively studied as ritualistic features, further research on the role of arbitrariness and repetition in rituals is needed. There is also pressing need to evaluate the impact of different costs (e.g., the value of the reward). Understanding how children interpret various forms of rituality is a critical step to understanding ritual learning and transmission. Overall, the present study offers a unique insight into the early development of cultural learning and the adaptive value of rituals in human group cognition.

FUNDING INFORMATION

This study was supported by an Australian Research Council Discovery Project Grant to MN and AW (DP140101410).

CONFLICT OF INTEREST STATEMENT

There are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

DATA AVAILABILITY STATEMENT

The current study was pre-registered and can be accessed here: https://osf.io/bkrxj/?view_only=ae4ec01ac89a493b85395fb287c6c58f. Processed data can be accessed here: https://osf.io/52b7g/?view_only=83b19583bb7942af82453ad274758a26. Data were analyzed using the built-in tools in SPSS. The analytic code necessary to reproduce the analyses presented in this paper is not publicly accessible. Necessary materials are described in the method section or attached as an Appendix.

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REFERENCES

Boyer, P., & Liénard, P. (2006). Precaution systems and ritualized behavior. *Behavioral and Brain Sciences*, *29*, 635–641. https://doi.org/10.1017/S0140525X06009575

Buttelmann, D., Zmyj, N., Daum, M., & Carpenter, M. (2013). Selective imitation of in-group over out-group members in 14-month-old infants. *Child Development*, *84*, 422–428. https://doi.org/10.1111/j.1467-8624.2012.01860.x

Carpenter, M. (2006). Instrumental, social, and shared goals and intentions in imitation. In *Imitation and the social mind: Autism and typical development* (pp. 48–70). Guilford Press.

Clegg, J. M., & Legare, C. H. (2016a). A cross-cultural comparison of children's imitative flexibility. *Developmental Psychology*, *52*, 1435–1444. https://doi.org/10.1037/dev0000131

Clegg, J. M., & Legare, C. H. (2016b). Instrumental and conventional interpretations of behavior are associated with distinct outcomes in early childhood. *Child Development*, *87*, 527–542. https://doi.org/10.1111/cdev.12472

Corriveau, K. H., DiYanni, C. J., Clegg, J. M., Min, G., Chin, J., & Nasrini, J. (2017). Cultural differences in the imitation and transmission of inefficient actions. *Journal of Experimental Child Psychology*, *161*, 1–18. https://doi.org/10.1016/j.jecp.2017.03.002

Diesendruck, G., & Markson, L. (2011). Children's assumption of the conventionality of culture. *Child Development Perspectives*, *5*, 189–195. https://doi.org/10.1111/j.1750-8606.2010.00156.x

DiYanni, C., Clegg, J. M., & Corriveau, K. H. (2022). If I told you everyone picked that (non-affordant) tool, would you? Children attend to conventional language when imitating and transmitting tool use. *Journal of Experimental Child Psychology*, *214*, 105293. https://doi.org/10.1016/j.jecp.2021.105293

DiYanni, C., Corriveau, K. H., Kurkul, K., Nasrini, J., & Nini, D. (2015). The role of consensus and culture in children's imitation of inefficient actions. *Journal of Experimental Child Psychology*, *137*, 99–110. https://doi.org/10.1016/j.jecp.2015.04.004

DiYanni, C., Nini, D., & Rheel, W. (2011). Looking good versus doing good: Which factors take precedence when children learn about new tools? *Journal of Experimental Child Psychology*, *110*, 575–591. https://doi.org/10.1016/j.jecp.2011.06.002

Evans, C. L., Laland, K. N., Carpenter, M., & Kendal, R. L. (2018). Selective copying of the majority suggests children are broadly "optimal-" rather than "over-" imitators. *Developmental Science*, *21*, e12637. https://doi.org/10.1111/desc.12637

Fischer, R. (2021). Mapping the scientific study of rituals: A bibliometric analysis of research published 2000–2020. *Religion, Brain*

& Behavior, *11*, 382–402. https://doi.org/10.1080/2153599X.2021.1980425

Flynn, E., Turner, C., & Giraldeau, L.-A. (2018). Follow (or don't follow) the crowd: Young children's conformity is influenced by norm domain and age. *Journal of Experimental Child Psychology*, *167*, 222–233. https://doi.org/10.1016/j.jecp.2017.10.014

Fong, F. T. K., Imuta, K., Redshaw, J., & Nielsen, M. (2021). When efficiency attenuates imitation in preschool children. *British Journal of Developmental Psychology*, *39*, 330–337. https://doi.org/10.1111/bjdp.12366

Fong, F. T. K., Sommer, K., Redshaw, J., Kang, J., & Nielsen, M. (2021). The man and the machine: Do children learn from and transmit tool-use knowledge acquired from a robot in ways that are comparable to a human model? *Journal of Experimental Child Psychology*, *208*, 105148. https://doi.org/10.1016/j.jecp.2021.105148

Gergely, G., & Csibra, G. (2006). Sylvia's recipe: The role of imitation and pedagogy in the transmission of human culture. In N. J. Enfield & S. C. Levinson (Eds.), *Roots of human sociality: Culture, cognition, and human interaction* (pp. 229–255). Berg Publishers.

Henrich, J. (2009). The evolution of costly displays, cooperation and religion. *Evolution and Human Behavior*, *30*, 244–260. https://doi.org/10.1016/j.evolhumbehav.2009.03.005

Herrmann, P. A., Legare, C. H., Harris, P. L., & Whitehouse, H. (2013). Stick to the script: The effect of witnessing multiple actors on children's imitation. *Cognition*, *129*, 536–543. https://doi.org/10.1016/j.cognition.2013.08.010

Heyes, C. (2021). Imitation and culture: What gives? *Mind & Language*, *38*, 42–63. https://doi.org/10.1111/mila.12388

Hobson, N. M., Gino, F., Norton, M. I., & Inzlicht, M. (2017). When novel rituals lead to intergroup bias: Evidence from economic games and neurophysiology. *Psychological Science*, *28*, 733–750. https://doi.org/10.1177/0956797617695099

Hobson, N. M., Schroeder, J., Risen, J. L., Xygalatas, D., & Inzlicht, M. (2018). The psychology of rituals: An integrative review and process-based framework. *Personality and Social Psychology Review*, *22*, 260–284. https://doi.org/10.1177/1088868317734944

Hoehl, S., Keupp, S., Schleihauf, H., McGuigan, N., Buttelmann, D., & Whiten, A. (2019). 'Over-imitation': A review and appraisal of a decade of research. *Developmental Review*, *51*, 90–108. https://doi.org/10.1016/j.dr.2018.12.002

Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal Cognition*, *8*, 164–181. https://doi.org/10.1007/s10071-004-0239-6

Kapitány, R., Davis, J. T., Legare, C., & Nielsen, M. (2018). An experimental examination of object-directed ritualized action in children across two cultures. *PLoS One*, *13*, e0206884. https://doi.org/10.1371/journal.pone.0206884

Kapitány, R., & Nielsen, M. (2015). Adopting the ritual stance: The role of opacity and context in ritual and everyday actions. *Cognition*, *145*, 13–29. https://doi.org/10.1016/j.cognition.2015.08.002

Kapitány, R., & Nielsen, M. (2017). The ritual stance and the precaution system: The role of goal-demotion and opacity in ritual and everyday actions. *Religion, Brain & Behavior*, *7*, 27–42. https://doi.org/10.1080/2153599X.2016.1141792

Kenward, B., Karlsson, M., & Persson, J. (2011). Over-imitation is better explained by norm learning than by distorted causal learning. *Proceedings of the Royal Society B: Biological Sciences*, *278*, 1239–1246. https://doi.org/10.1098/rspb.2010.1399

Keupp, S., Behne, T., & Rakoczy, H. (2018). The rationality of (over) imitation. *Perspectives on Psychological Science*, *13*, 678–687. https://doi.org/10.1177/1745691618794921

Krause, J., Ruxton, G. D., & Krause, S. (2010). Swarm intelligence in animals and humans. *Trends in Ecology & Evolution*, *25*, 28–34. https://doi.org/10.1016/j.tree.2009.06.016

Legare, C. H., & Herrmann, P. A. (2013). Cognitive consequences and constraints on reasoning about ritual. *Religion, Brain & Behavior*, *3*, 63–65. https://doi.org/10.1080/2153599X.2012.736710

Legare, C. H., & Nielsen, M. (2015). Imitation and innovation: The dual engines of cultural learning. *Trends in Cognitive Sciences*, *19*, 688–699. https://doi.org/10.1016/j.tics.2015.08.005

Legare, C. H., & Nielsen, M. (2020). Ritual explained: Interdisciplinary answers to Tinbergen's four questions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*, 20190419. https://doi.org/10.1098/rstb.2019.0419

Legare, C. H., & Souza, A. L. (2012). Evaluating ritual efficacy: Evidence from the supernatural. *Cognition*, *124*, 1–15. https://doi.org/10.1016/j.cognition.2012.03.004

Legare, C. H., & Souza, A. L. (2014). Searching for control: Priming randomness increases the evaluation of ritual efficacy. *Cognitive Science*, *38*, 152–161. https://doi.org/10.1111/cogs.12077

Legare, C. H., & Watson-Jones, R. E. (2015). The evolution and ontogeny of ritual. In *The handbook of evolutionary psychology* (Vol. *2*, 2nd ed., pp. 1–19). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781119125563.evpsych234

Legare, C. H., Wen, N. J., Herrmann, P. A., & Whitehouse, H. (2015). Imitative flexibility and the development of cultural learning. *Cognition*, *142*, 351–361. https://doi.org/10.1016/j.cognition.2015.05.020

Liberman, Z., Kinzler, K. D., & Woodward, A. L. (2018). The early social significance of shared ritual actions. *Cognition*, *171*, 42–51. https://doi.org/10.1016/j.cognition.2017.10.018

Lyons, D. E., Young, A. G., & Keil, F. C. (2007). The hidden structure of overimitation. *Proceedings of the National Academy of Sciences of the United States of America*, *104*, 19751–19756. https://doi.org/10.1073/pnas.0704452104

Moraru, C.-A., Gomez, J.-C., & McGuigan, N. (2016). Developmental changes in the influence of conventional and instrumental cues on over-imitation in 3- to 6-year-old children. *Journal of Experimental Child Psychology*, *145*, 34–47. https://doi.org/10.1016/j.jecp.2015.11.017

Nielsen, M. (2018). The social glue of cumulative culture and ritual behavior. *Child Development Perspectives*, *12*, 264–268. https://doi.org/10.1111/cdep.12297

Nielsen, M., & Blank, C. (2011). Imitation in young children: When who gets copied is more important than what gets copied. *Developmental Psychology*, *47*, 1050–1053. https://doi.org/10.1037/a0023866

Nielsen, M., Kapitány, R., & Elkins, R. (2015). The perpetuation of ritualistic actions as revealed by young children's transmission of normative behavior. *Evolution and Human Behavior*, *36*, 191–198. https://doi.org/10.1016/j.evolhumbehav.2014.11.002

Nielsen, M., Langley, M. C., Shipton, C., & Kapitány, R. (2020). Homo neanderthalensis and the evolutionary origins of ritual in Homo sapiens. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *375*, 20190424. https://doi.org/10.1098/rstb.2019.0424

Nielsen, M., Moore, C., & Mohamedally, J. (2012). Young children overimitate in third-party contexts. *Journal of Experimental Child Psychology*, *112*, 73–83. https://doi.org/10.1016/j.jecp.2012.01.001

Nielsen, M., Simcock, G., & Jenkins, L. (2008). The effect of social engagement on 24-month-olds' imitation from live and televised models. *Developmental Science*, *11*, 722–731. https://doi.org/10.1111/j.1467-7687.2008.00722.x

Nielsen, M., Tomaselli, K., & Kapitány, R. (2018). The influence of goal demotion on children's reproduction of ritual behavior. *Evolution and Human Behavior*, *39*, 343–348. https://doi.org/10.1016/j.evolhumbehav.2018.02.006

Over, H. (2020). The social function of imitation in development. *Annual Review of Developmental Psychology*, *2*, 93–109. https://doi.org/10.1146/annurev-devpsych-033020-024051

Over, H., & Carpenter, M. (2009). Priming third-party ostracism increases affiliative imitation in children. *Developmental Science*, *12*, F1–F8. https://doi.org/10.1111/j.1467-7687.2008.00820.x

Rakoczy, H., Warneken, F., & Tomasello, M. (2008). The sources of normativity: Young children's awareness of the normative

structure of games. *Developmental Psychology*, *44*, 875–881. https://doi.org/10.1037/0012-1649.44.3.875

Reader, S. M., & Laland, K. N. (2002). Social intelligence, innovation, and enhanced brain size in primates. *Proceedings of the National Academy of Sciences of the United States of America*, *99*, 4436–4441. https://doi.org/10.1073/pnas.062041299

Rossano, M. J. (2015). The evolutionary emergence of costly rituals. *PaleoAnthropology*, *2015*, 78–100. https://doi.org/10.4207/PA.2015.ART97

Ruffle, B. J., & Sosis, R. (2007). Does it pay to pray? Costly ritual and cooperation. *The B.E. Journal of Economic Analysis & Policy*, *7*, 1 – 35. https://doi.org/10.2202/1935-1682.1629

Schleihauf, H., Graetz, S., Pauen, S., & Hoehl, S. (2018). Contrasting social and cognitive accounts on overimitation: The role of causal transparency and prior experiences. *Child Development*, *89*, 1039–1055. https://doi.org/10.1111/cdev.12780

Schleihauf, H., Pauen, S., & Hoehl, S. (2019). Minimal group formation influences on over-imitation. *Cognitive Development*, *50*, 222–236. https://doi.org/10.1016/j.cogdev.2019.04.004

Schulz, L. E., Hooppell, C., & Jenkins, A. C. (2008). Judicious imitation: Children differentially imitate deterministically and probabilistically effective actions. *Child Development*, *79*, 395–410. https://doi.org/10.1111/j.1467-8624.2007.01132.x

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*, *86*(2), 420–428. https://doi.org/10.1037/0033-2909.86.2.420.

Soler, M. (2012). Costly signaling, ritual and cooperation: Evidence from Candomblé, an Afro-Brazilian religion. *Evolution and Human Behavior*, *33*, 346–356. https://doi.org/10.1016/j.evolhumbehav.2011.11.004

Sosis, R., & Alcorta, C. (2003). Signaling, solidarity, and the sacred: The evolution of religious behavior. *Evolutionary Anthropology: Issues, News, and Reviews*, *12*, 264–274. https://doi.org/10.1002/evan.10120

Thompson, N. A. (2019). Understanding the links between social ties and fitness over the life cycle in primates. *Behaviour*, *156*, 859–908. https://doi.org/10.1163/1568539X-00003552

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, *28*, 675–691. https://doi.org/10.1017/S0140525X05000129

Watson-Jones, R. E., & Legare, C. H. (2016). The social functions of group rituals. *Current Directions in Psychological Science*, *25*, 42–46. https://doi.org/10.1177/0963721415618486

Watson-Jones, R. E., Legare, C. H., Whitehouse, H., & Clegg, J. M. (2014). Task-specific effects of ostracism on imitative fidelity in early childhood. *Evolution and Human Behavior*, *35*, 204–210. https://doi.org/10.1016/j.evolhumbehav.2014.01.004

Wen, N. J., Herrmann, P. A., & Legare, C. H. (2016). Ritual increases children's affiliation with in-group members. *Evolution and Human Behavior*, *37*, 54–60. https://doi.org/10.1016/j.evolhumbehav.2015.08.002

Whitehouse, H. (2021). *The ritual animal: Imitation and cohesion in the evolution of social complexity*. Oxford University Press. https://doi.org/10.1093/oso/9780199646364.001.0001

Whitehouse, H., & Lanman, J. A. (2014). The ties that bind us: Ritual, fusion, and identification. *Current Anthropology*, *55*, 674–695. https://doi.org/10.1086/678698

Whiten, A., McGuigan, N., Marshall-Pescini, S., & Hopper, L. M. (2009). Emulation, imitation, over-imitation and the scope of culture for child and chimpanzee. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *364*, 2417–2428. https://doi.org/10.1098/rstb.2009.0069

Wilks, M., Kapitány, R., & Nielsen, M. (2016). Preschool children's learning proclivities: When the ritual stance trumps the instrumental stance. *British Journal of Developmental Psychology*, *34*, 402–414. https://doi.org/10.1111/bjdp.12139

Xygalatas, D., Mitkidis, P., Fischer, R., Reddish, P., Skewes, J., Geertz, A. W., Roepstorff, A., & Bulbulia, J. (2013). Extreme rituals promote prosociality. *Psychological Science*, *24*, 1602–1605. https://doi.org/10.1177/0956797612472910

How to cite this article: Zhao, M., Fong, F. T. K., Whiten, A., & Nielsen, M. (2023). Children's distinct drive to reproduce costly rituals. *Child Development*, *00*, 1–11. https://doi.org/10.1111/cdev.14061

APPENDIX

Full script of the testing procedure.

Before the experiment begins, the experimenter explains briefly to the guardian(s) that this study is about studying children's social learning behavior and what would they do when there is a cost to learning ritualistic or instrumental behavior.

The experimenter then asks the guardian(s) to not tell the child what to do during the game and hands the guardian(s) the demographics form.

Demonstration phase

The study begins with the child sitting opposite the experimenter on the floor, facing the testing materials.

The experimenter introduces herself and notes down the child's name, age, sex, and condition on the coding sheet. Children are then introduced to the study:

Experimenter: I have a game where you canwin some stickers. Look, I have these tokens and a tube here. The rule is, anyone who can put the tokens into the tube and get to this line (*pointing to the lowest marker line on the tube*), can win one sticker. If we can get the tokens to this line (*pointing to the second to lowest line*), we can win two stickers. If we can get the tokens to this line (*pointing to the next higher line*), we can win three stickers. And if we can get the tokens to the top line here (*pointing to the highest line*), we can win four stickers. Sounds good? But, we have only 1 min to fill the tube (*presenting the timer*). Now, can you tell me how many stickers you can win if you get to this line (*pointing to the second to lowest line*)?

If the child answers wrong, repeat the instructions. If the child answers the question correctly, say the following (skip to the testing phase if it is in the control condition):

Experimenter: That's correct, good job! Now I'm going to show you how I do it first, and then you can have your turns.

The experimenter then starts the timer and performs the actions. After finishing the demonstration once, the experimenter says:

Experimenter: Oh, the time is up. I only got the tokens to reach this line here (*points to the lowest line*), so I can win one sticker (*takes one sticker*). Now I'll try again.

The experimenter resets the tube, starts the timer, and repeats the demonstration.

Experimenter: Oh, the time's up, I only got the tokens to reach this line here as well, so I can win one sticker (*takes one sticker and resets the tube*).

Testing phase

Experimenter: Alright, now you can have a try. Let's see how many stickers you can win! Are you ready? Three, two, one, let's go!

The experimenter starts the timer. If the child does not touch the materials within 15 s, the experimenter gives the prompt to start: "Why don't you try? It's your turn."

After 1 min has passed,

Experimenter: The time's up, you got the tokens to this line here, so you can win XX sticker(s), good job! Now you can have another try. Are you ready? Let's go!

The procedure was repeated until the child had three trials,

Experimenter: Okay we're all done! You get to take your stickers home. You did a great job! Here is an envelope for you to keep the stickers and a wristband for you. Thanks for playing my game today!