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Acquiring sub-efficient and efficient variants of novel means by integrating information from multiple social models in preschoolers

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ABSTRACT

Sub-efficient action routines often represent culture-specific conventional forms of actions that belong to the repertoire of cultural knowledge shared by a social group. Children readily acquire such sub-efficient routines from social demonstrations and often preserve them in their action repertoire despite encountering more efficient alternatives. This suggests that they can treat sub-efficient conventional forms and their efficient alternatives in a context-sensitive selective manner. We hypothesized that children may rely on their sensitivity to differentiate speakers of their own language versus a foreign language as an informative cue indicating whether the model belongs to their own cultural community and the action modeled represents shared cultural knowledge. We assessed preschoolers' imitation following two different demonstrations. The first model demonstrated a *sub-efficient action* sequence, whereas the second model presented a *more efficient alternative* to obtain the same goal. We varied whether the children had heard the models speak their own language or a foreign language before their nonverbal action demonstrations. We found that 4-year-olds adopted the second model's efficient alternative, but only when she spoke their own language. However, they disregarded the efficient alternative if it was presented by a foreign-language speaker and continued to perform the sub-efficient routine they initially acquired. Therefore, 4-year-olds employed the cue of shared language to optimize acquiring and maintaining culturally shared sub-efficient action routines by

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selectively updating their action repertoire relying on their language-based evaluation of the demonstrator's culture-specific competence. In contrast, 5- and 6-year-olds adopted the efficient alternative independently of the demonstrator's language. Possible reasons for this developmental trend are discussed.

Introduction

Agents tend to pursue their goals through efficient means, but in certain social contexts they often preserve customary, conventionalized, and normative means actions of their cultural groups,[1] which tend to deviate from efficiency (Gergely & Csibra, 2006; Legare & Nielsen, 2015). Such sub-efficient action routines are socially transmitted and form part of the repertoire of cultural knowledge shared by members of a child's community. Acquiring such sub-efficient yet culturally shared routines is, therefore, an important developmental task that significantly contributes to children's socialization to become competent members of their cultural group. Indeed, preschool-aged children readily learn novel sub-efficient means from social models as documented by so-called "over-imitation"[2] studies (e.g., Horner & Whiten, 2005; Lyons, Damrosch, Lin, Macris, & Keil, 2011; Lyons, Young, & Keil, 2007; for a review, see Hoehl et al., 2019). It is less clear, however, what enables learners to preserve such actions in their repertoire despite the high likelihood of encountering more efficient alternative means of achieving the same goal.

Exposure to efficient alternatives can happen through contact with agents who either do not possess the shared knowledge of the child's cultural group (Oláh, Elekes, Bródy, & Király, 2014) or do so but on particular occasions pursue the goal more efficiently (Burdett, McGuigan, Harrison, & Whiten, 2018; Evans, Laland, Carpenter, & Kendal, 2018; Hoehl, Zettersten, Schleihauf, Grätz, & Pauen, 2014). After all, the sub-efficient culture-specific means action often coexists in a cultural community with more efficient variants that are also considered acceptable in everyday situations. For example, when you are invited to a formal dinner, you may be expected to wear a tuxedo and follow rules of etiquette prescribing that you *ought to* consume your dinner in a culturally standardized *proper* manner performing sub-efficient, often opaque and arbitrary, normative action routines. However, when you are having lunch "on the go" it may be quite acceptable to adopt a more relaxed everyday style of eating that is not constrained by conventionalized cultural prescriptions, allowing you to achieve your goal through more efficient action alternatives.

Given the frequent coexistence of sub-efficient forms of actions along with more efficient alternative means, how do naïve learners integrate such conventional action routines and their efficient alternatives? This is not a trivial learning problem for a young cultural learner to solve. It has been argued that cultural means actions—that is, ways of doing things in various cultural groups—are often inherently *cognitively opaque* to the naive observer such as a child learner (Csibra & Gergely, 2011; Gergely & Csibra, 2006; Hernik & Gergely, 2015; Hoehl et al., 2019). In other words, the ultimate goal of the action sequence, or the factors assumed in the cultural group to constrain and influence the action steps, might not be readily apparent to the child. Thus, even though young infants already expect goal-directed actions to be efficient (Csibra, Gergely, Bíró, Koos, & Brockbank, 1999; Gergely & Csibra, 2003; Gergely, Nádasdy, Csibra, & Bíró, 1995), the primary mechanisms supporting acquisition of the means actions customary in the child's cultural group should not rely on efficiency

[1] Throughout this article, by "cultural group" we mean first and foremost a community characterized by arbitrary and opaque cultural knowledge that is communicatively transmitted and commonly shared by its members.

[2] We find the term "over-imitation" misleading because it suggests that children imitate what they should not imitate. We would argue that children's tendency to "over-imitate" cognitively opaque actions demonstrated by knowledgeable adults is, in fact, a "smart" cultural learning strategy based on the assumption that such sub-efficient means should be imitated precisely because they are evaluated as culturally relevant (despite their opacity to the learner).

considerations given that the teleological and casual structure behind such actions often will not be accessible to the child. Indeed, children tend to imitate the casually irrelevant action steps even if they know them to be unnecessary or if they are unsure of their causal role (Kenward, Karlsson, & Persson, 2011; Keupp, Behne, & Rakoczy, 2013). So, what kind of information can young children rely on to acquire cognitively opaque cultural means and to either maintain them or not after learning about more efficient and acceptable action alternatives?

Several findings suggest that certain social signals may help children to adopt the efficient alternative to the demonstrated sub-efficient action routine, indicating how flexible children's imitation in fact is (for a review, see Over & Carpenter, 2012). For example, if demonstration was accompanied by outcome-oriented language cues (e.g., "I am going to make a necklace"), as opposed to convention-oriented language cues (e.g., "Everyone always does it this way"), preschoolers were more likely to prioritize efficient attainment of the goal despite the demonstrated sub-efficient means (Clegg & Legare, 2016; Herrmann, Legare, Harris, & Whitehouse, 2013; Legare, Wen, Herrmann, & Whitehouse, 2015). Moreover, when the demonstration of a sub-efficient action routine was verbally framed so as to emphasize the particular way in which the outcome should be attained (i.e., "daxing" as opposed to "ringing the bells"), children were more likely to protest if a third party (i.e., a puppet) omitted the sub-efficient mean action (Keupp et al., 2013; Keupp, Behne, Zachow, Kasbohm, & Rakoczy, 2015). Altogether these studies document that children can flexibly engage in conventional reading of the task and reproduce the process faithfully (and also expect third parties to reproduce the process faithfully), or engage in instrumental reading of the same task and prioritize the goal outcome in their imitation, based on the different social contextual cues.

Critically, even though children can acquire new cultural knowledge from third-person observations of others' actions (Phillips, Seston, & Kelemen, 2012), cultural knowledge transmission often takes place in a second-person ostensive communicative context, where an adult social partner uses ostensive signals to address and demonstrate to the child the new and relevant cultural skill or knowledge to be acquired (Csibra & Gergely, 2006, 2009, 2011; Egyed, Király, & Gergely, 2013; Gergely & Jacob, 2012; Király, Csibra, & Gergely, 2013). It has been shown that young children are sensitive to ostensive-communicative demonstration contexts, which lead them to establish stable cultural representations of novel means actions. Furthermore, the acquired functions of novel tools ostensively demonstrated appear to be relatively resistant to change through counterexamples and tend to "survive" competition coming from later evidence (Butler & Markman, 2012; Hernik & Csibra, 2015).

Thus, whether a sub-efficient action routine already acquired is going to be maintained or rather modified as a result of encountering more efficient action alternatives may depend on whether the efficient alternatives were communicatively or noncommunicatively presented to the child. Hoehl et al. (2014) addressed this question by investigating the influence of ostensive communicative signaling on cultural learning in 5-year-old preschoolers. Consistent with the burgeoning literature (Horner & Whiten, 2005; Lyons et al., 2007, 2011; Nielsen & Blank, 2011), 5-year-olds faithfully imitated the causally irrelevant action steps that the model performed on the box before retrieving the token inside with the last causally efficacious action. Yet, when this sub-efficient routine was followed by a second model's demonstration of a more efficient alternative (the last action step only), children flexibly adopted this efficient action. However, they did so only in the condition where the efficient alternative was presented within an ostensive communicative context. In another condition where—in Hoehl et al.'s interpretation[3]—no ostensive signals were provided by the "completely noncommunicative model," who presented the more efficient alternative, children did not modify their already acquired sub-efficient action routine.

However, apart from the communicative versus noncommunicative source of novel information, the cultural learning process may also be influenced and guided by another relevant informative factor

[3] Note, however, that the "nonostensive" demonstrator in Hoehl et al. (2014) study preceded her action presentation by first verbally announcing her intention to retrieve a marble from the apparatus. Given the demonstrator's informative verbal behavior, characterizing this condition as nonostensive and noncommunicative may in fact be misleading. Rather, the verbally expressed instrumental intention not accompanied by any clear cues specifying the addressee is a highly unusual, if not ill-formed, ostensive communicative act that may have simply confused children. Consequently, they might have avoided considering the presented actions as relevant evidence and failed to rely on it to modify their already acquired sub-efficient action routine.

that is the focus of our current study: Children may preferentially rely on information coming from agents who they can identify as expert sources of the cultural knowledge repertoire shared in children's cultural group (Oláh et al., 2014). One informative signal that children can use to identify reliable sources of cultural knowledge is shared language. Even very young infants prefer speakers of their native language (Kinzler, Dupoux, & Spelke, 2007; Shutts, Kinzler, McKee, & Spelke, 2009). A recent EEG study indicated that such preferences are driven by infants' expectation that they are likely to receive relevant information from agents speaking their own language (Begus, Gliga, & Southgate, 2016). Yet, direct empirical evidence on young children's propensity to selectively evaluate and learn from the speakers of their own language is rather limited (Buttelmann, Zmyj, Daum, & Carpenter, 2013; but see also Howard, Henderson, Carrazza, & Woodward, 2015). One possible reason is that young children may interpret shared language not as a categorical cue, which renders them either willing or unwilling to learn from a model dependent on whether she speaks the child's own language or not, but rather as a nuanced signal, which informs the likelihood that the model possesses the knowledge of the child's cultural group.

In this study, we test the hypothesis that in preschool children maintaining the already acquired sub-efficient means action is facilitated by a selective evaluation of the model presenting the more efficient alternative. Based on recognizing that the model is speaking the shared language (the one used in the child's cultural group), the child may be able to infer that the model is likely to possess the knowledge repertoire shared in the child's own cultural group. If so, this will influence whether the child adopts and integrates the alternative efficient means or disregards them as culturally nonrelevant.

Experiment 1

In Experiment 1, we employed a between-participant design in which the child received two ostensive demonstrations performed by two different models, each showing the child a different way of operating a novel apparatus to retrieve a sticker from it. Our procedure closely resembled that in Hoehl et al. (2014) study, and we targeted the same age group in our sample. However, the models in Hoehl et al.'s experiment displayed verbal ostensive signals before demonstrating their novel means actions to the child. In contrast, in our procedure, neither model addressed the child verbally before or during the demonstrations. Furthermore, both models used only *nonverbal* ostensive signals and referential gestures before demonstrating either the sub-efficient action routine or the more efficient action alternative to retrieve the sticker from the same apparatus (e.g., establishing eye contact and smiling at the child, referentially pointing to the apparatus, looking back and forth between the child and the apparatus). This way, both action demonstrations were equally communicative and involved ostensively addressing the child in a second-person manner before the demonstrations of the novel action sequence. On the other hand, information about whether the model was speaking in the child's own language or in a foreign language unfamiliar to the child was manifested only in an implicit manner in an "overheard" phone conversation that the slowly approaching model was engaged in and that was clearly not addressed to the child (in fact, it was accessible to the child only through third-person observation). This initial period of implicit observational access to the language cue ended prior to the demonstrations when the model put her phone down and turned to the child for the first time, addressing the child with second-person ostensive communicative (but nonverbal) signals to introduce the demonstration phase.

The first model always demonstrated a *sub-efficient* action routine in retrieving a sticker (by performing a series of superfluous actions on the apparatus before presenting the only causally relevant action that was necessary to obtain the sticker), and the second model always presented a more *efficient* action alternative (by performing only the causally relevant action). Children were given the apparatus after each demonstration to operate it themselves. Before these action demonstrations, children witnessed the model speak either children's own language (Hungarian) or a foreign language (Turkish).

In the *same + foreign* condition, the first model entered the room speaking on her cellphone to someone in children's own language. Similarly, when the second model entered, she was also speaking on her cellphone to someone but in a foreign language. We expected children in this condition to

reproduce the novel sub-efficient action routine ostensively demonstrated to them by the first model. We also expected that children would continue to reproduce the initially demonstrated sub-efficient action sequence even after having observed the second model's presentation of the more efficient alternative means action.

To rule out the possibility that this predicted pattern of imitation in the *same + foreign* condition was merely due to children's reluctance to learn from a foreign-language speaker (Buttelmann et al., 2013; Howard et al., 2015), we also tested another group of children in a *foreign + same* condition where the first model spoke the foreign language on the phone and the second model spoke children's own language. Here we predicted that even if during the first imitation period children reproduced the sub-efficient action routine of the first model, during the second imitation period they would later adopt the more efficient alternative of the second model.

Method

Participants

There were 16 5-year-olds in the *foreign + same* condition (5 girls; M_{age} = 65.43 months, *SD* = 3.86, range = 60.68–71.88) and 16 5-year-olds in the *same + foreign* condition (10 girls; M_{age} = 66.03 months, *SD* = 4.14, range = 60.71–71.81). There were 16 6-year-olds tested in the *foreign + same* condition (6 girls; M_{age} = 76.82 months, *SD* = 2.78, range = 73.13–81.83) and 16 6-year-olds tested in the *same + foreign* condition (10 girls; M_{age} = 78.24 months, *SD* = 3.39, range = 72.87–84.82).

A further 11 5-year-olds were tested but excluded from all analyses due to not acting on the sticker dispenser in the first imitation round (n = 1) or in either imitation round (n = 2), not watching the demonstration (n = 2), seeing the resetting of the sticker dispenser (n = 1), or experimenter error (n = 5). An additional two 6-year-olds were also tested but excluded from all analyses due to seeing the resetting of the sticker dispenser. All participants in the final sample were monolingual (as established based on parental reports during consent), speaking only Hungarian as their native language, and were recruited from local kindergartens in the Budapest inner-city area. Parents were contacted by the head teacher in the participating kindergartens to give written consent. The study was approved by the United Ethical Review Committee for Research in Psychology, Hungary, at the Central European University and conducted in accordance with the Declaration of Helsinki.

Materials

A mini-bowling game used for the warm-up phase involved two cups placed on top of each other with two stickers inside and a tennis ball. There were three identical 10 × 10-cm sticker sheets for the stickers collected, one for the child and one for each model. The sticker dispenser (Fig. 1) was a transparent Plexiglas box with a wooden platform inside that could be pulled out by using a tool provided. On the platform, there was a small container with four stickers. Another small Plexiglas box with an opening on its top and a button inside was attached to the right side of the container. There was also a wooden lever glued on the top of the main box.

Procedure

All participants were tested in a quiet room of their own kindergarten.

Warm-up phase. First, the experimenter played a mini-bowling game with the child. This game was played to ensure that children were introduced to obtaining stickers themselves and were able to place the stickers on their own sticker sheets (see online supplementary material for details).

After the warm-up phase, the experimenter said that she was going to keep the child's sticker sheet and that other people would be coming to the room to get a sticker by using the box. The experimenter instructed the child to sit on a mat next to the box and to watch closely. She then sat in the corner of the testing room close to the door, facing away from the child and the apparatus, pretending to read.

First demonstration phase

The first model came into the room speaking to someone on her cellphone for about 15 s on a topic unrelated to the procedure (see supplementary material). As she was sitting down in front of the

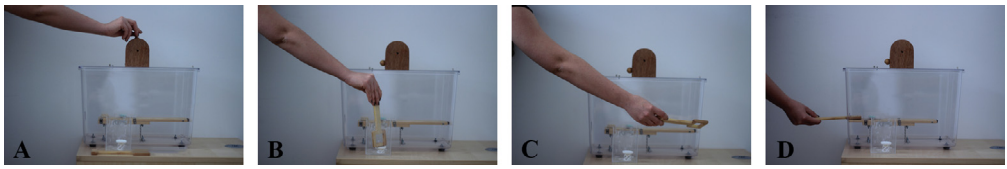

Fig. 1. Sticker dispenser and three irrelevant actions (manipulating the lever [A], pushing the button inside the small box with the tool [B], and tapping the tool on the side of the apparatus [C]) and one relevant action (pulling the platform out with the tool [D]), in attaining the sticker.

sticker dispenser, the model hung up the phone, looked and smiled at the child, showed her own sticker sheet, and pointed at the stickers in the dispenser to indicate her intention to get a sticker. The model performed three irrelevant actions on the apparatus (manipulating the lever [Fig. 1A], pushing the button inside the small box with the tool [Fig. 1B], and tapping the tool on the side of the apparatus [Fig. 1C]) and one relevant action (pulling the platform out with the tool [Fig. 1D]) that was necessary to obtain the sticker. Sub-efficient action demonstration consisted of all four actions in the order depicted in Fig. 1A–D.

Once the model successfully retrieved the sticker from the dispenser, she again looked and smiled at the child, put her sticker sheet on the floor, and placed the retrieved sticker on her sheet. This conspicuously signaled the end of the demonstration to the experimenter.

The experimenter then approached the child and oriented the child toward herself and away from the apparatus, allowing the model to reset the sticker dispenser without the child watching. As soon as the model left the room, the experimenter pointed at the dispenser and said, "It is your turn now." Then she went back to the corner and sat down on her chair, facing toward the door and away from the child. This was the beginning of the first imitation round. If the child did not act on the sticker dispenser for about 30 s, the experimenter turned around and asked, "Do you want to get a sticker?" as a further prompt for the child to act on the dispenser. If the child did not act on the dispenser for approximately 90 s, the imitation round was terminated.

If the child successfully retrieved a sticker in the first imitation round, the experimenter returned the sticker sheet while orienting the child away from the apparatus so that the experimenter could reset the dispenser without being seen by the participant. She then said that there were more people coming to get a sticker from the box and that the child should watch closely, and she again sat back in her chair in the corner pretending to read.

Second demonstration phase. The second model came in, again talking on her cell phone (see supplementary material). Everything was the same as it was in the first demonstration except that this time the model attained the sticker efficiently. The efficient action demonstration consisted only of pulling the platform out with a tool (Fig. 1D).

After the model left the room, the child was again prompted to get a sticker by the experimenter with the instruction "It is your turn now." This was the beginning of the second imitation round.

If the child was unable to retrieve a sticker during one or both imitation rounds despite acting on the sticker dispenser, the child was excluded from all analyses. This exclusion criterion ensured that all children were equally successful in obtaining the sticker in both imitation rounds. At the end of the testing session, each child received four stickers in total (two from the mini-bowling game and two from the sticker dispenser) regardless of their performance. The two models were White female postgraduate students of two different nationalities with similar physical features (white skin tone, dark hair, and brown eyes), and they were native speakers of the respective languages. All the testing sessions were videotaped for later coding.

Coding

The number of irrelevant actions children imitated was coded for each imitation round (range = 0–3) as an imitation score. Approximately 30% of the data (10 children) were coded by a second coder naïve to the condition and hypotheses of the study. Intercoder reliability was high for 5-year-olds

(Cohen's kappa = .94, $p < .001$) and was perfect for 6-year-olds (Cohen's kappa = 1, $p < .001$). See supplementary material for coding of the causally relevant action.

For all participants, we also coded the amount of time they looked at the demonstration to check whether the familiarity or novelty of the model's language might have affected children's overt attention to the demonstrations.

Results

Data were collapsed across participant gender because preliminary analyses showed no significant main effects or interactions of gender with condition and imitation round.

A 2 × 2 × 2 (Condition × Imitation Round × Age Group) repeated-measures analysis of variance (ANOVA) on children's imitation score revealed no statistically significant three-way interaction but did reveal a main effect of imitation round, $F(1, 60) = 94$, $p < .001$, partial $\eta^2 = .61$. There was also a statistically significant interaction between imitation round and age group, $F(1, 60) = 3.78$, $p = .03$, partial $\eta^2 = .08$. There was no main effect of condition for either imitation round ($ps > .05$) (see Fig. 2).

Planned comparisons revealed that children's imitation scores decreased significantly from the first to second imitation rounds both in the *foreign + same* condition ($M_{foreign} = 1.97$, $SD = 0.97$; $M_{same} = 0.50$, $SD = 0.92$), $t(31) = 6.98$, $p < .001$, Cohen's $d = 1.23$; Wilcoxon signed ranks test, $z = -4.17$, $p < .001$, and in the *same + foreign* condition ($M_{same} = 2.16$, $SD = 0.85$; $M_{foreign} = 0.69$, $SD = 1.06$), $t(31) = 6.42$, $p < .001$, Cohen's $d = 1.13$; Wilcoxon signed ranks test, $z = -4.03$, $p < .001$. There were no differences between 5- and 6-year-olds' imitation scores in the first round, $t(62) = 0.41$, $p = .26$, Cohen's $d = 0.21$; Mann–Whitney $U = 495$, $p = .77$. However, in the second imitation round, the imitation score of 5-year-olds was higher ($M = 0.84$, $SD = 1.11$) than that of 6-year-olds ($M = 0.34$, $SD = 0.79$). This difference was statistically significant with a parametric test, $t(62) = 2.08$, $p = .042$, Cohen's $d = 0.52$, but not with its nonparametric equivalent, Mann–Whitney $U = 392.5$, $p = .05$. See supplementary material for generalized linear mixed-model (GLMM) analyses on binary data (i.e., each action was coded as imitated or not), where age group and imitation round interaction indicated a statistically significant effect ($p = .006$), mirroring the result with the parametric test.

Demonstrations from the same- and foreign-language speakers were attended to equally well (all medians = 100% of the demonstration duration for the two age groups).

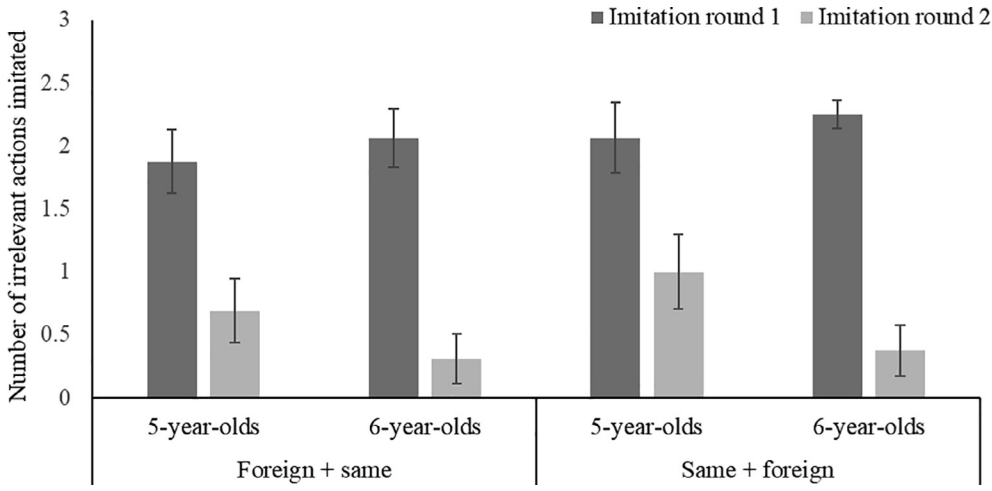

Fig. 2. Mean number of irrelevant actions imitated by 5- and 6-year olds in each imitation round in two conditions. Error bars show ± 1 standard error.

Discussion

Consistent with the literature (Hoehl et al., 2014; Schleihauf, Graetz, Pauen, & Hoehl, 2018), the 5- and 6-year-olds readily imitated the clearly sub-efficient action sequence that was ostensively demonstrated to them by the first model who showed them how to retrieve a sticker from the novel apparatus. Notably, children in both age groups tended to reproduce most steps of the sub-efficient action routine that was ostensively demonstrated to them by an unfamiliar adult regardless of whether she was a speaker of their own language or a foreign language. This indicates that the overheard foreign language did not result in a categorical interpretation of the speaker as a model not to be imitated.

Critically, and contrary to our hypothesis, once the efficient alternative was demonstrated in the second round, children adopted the efficient means action *both* when it was presented by the speaker of their own language and when it was presented by a foreign-language speaker. Below, we consider some possible reasons for this.

First of all, the age groups (5- and 6-year-olds) we chose may have been too *old* for testing our hypothesis. Older preschoolers' experience with multilingual speakers in their social environment may have made it acceptable for them that an overheard conversation with an unseen interlocutor in a foreign language does not rule out the possibility that the person is *also* a speaker of children's own language.

Moreover, by this age children might have already learned to put relatively less weight on others' language when deciding whether to acquire cultural information from them. Previous research indeed documented that incidental exposure to linguistic diversity was a factor influencing children's propensity to learn from a model speaking a foreign language (Howard, Carrazza, & Woodward, 2014). In addition, as recent research shows, older preschoolers do not always choose to imitate the sub-efficient means when these are pitted against the efficient ones simultaneously (Burdett et al., 2018; Evans et al., 2018). Considering the trend in our data, which indicated that 6-year-olds more readily adopted the efficient alternative in their second imitation round—in contrast to 5-year-olds—independent of the model's language, it is possible that older children might be more likely to employ the efficient alternative to complete the task.

Yet, the above results do not rule out that children—especially those with less relevant social experience—can be sensitive to the language of a model as an informative cue to her cultural competence. To explore this possibility, in Experiments 2 and 3 we tested 4-year-olds. Children at this age can already reliably imitate complex target behaviors (Kenward et al., 2011) and can rely on contrastive information that can be diagnostic of social groups (Chalik, Rivera, & Rhodes, 2014).

Experiment 2

Since our procedure did not involve any direct verbal communication between the models and the participant during the demonstration phase (as was the case in Hoehl et al., 2014 paradigm with 5-year-olds), we first wanted to ensure that in 4-year-olds the nonverbal ostensive demonstrations also elicit high imitation of sub-efficient actions followed by reduction upon encountering the nonverbal efficient alternative. Thus, Experiment 2 had a procedure exactly like Experiment 1 except that both models were speakers of the child's own language (cf. *pedagogical-then-pedagogical* condition in Hoehl et al., 2014).

Method

Participants

Participants were 16 4-year-olds (7 girls; M_{age} = 53.51 months, *SD* = 3.00, range = 49.18–57.7). A further three 4-year-olds (2 girls) were tested but excluded from all analyses due to not acting on the apparatus in the first imitation round. All participants were monolingual, speaking only Hungarian as their native language, and were recruited from local kindergartens in the Budapest inner-city area.

Design and procedure

The procedure was the same as in Experiment 1 except that both models were speakers of children's own language. Both models were White female postgraduate students of the same nationality with similar physical features (white skin tone, dark hair, and brown eyes) and were locals of the same city speaking with the same accent.

We dubbed this condition as *same + same.* We counterbalanced which model attained the sticker sub-efficiently. Half of the children had seen one model acting sub-efficiently in the first demonstration phase, whereas the other half saw that model acting efficiently in the second demonstration phase.

Coding

The number of irrelevant actions children imitated was coded for each imitation round separately (range = 0–3). Data from five children were also coded by a second coder who was naïve to the condition and hypotheses of the study. Intercoder reliability was perfect (Cohen's kappa = 1, $p < .001$).

Results

Data were collapsed across participant gender and model identity because preliminary analyses showed no significant main effects or interactions of these factors with the imitation round.

The mean number of irrelevant actions imitated was higher in the first imitation round ($M = 1.94$, $SD = 1.29$) than in the second imitation round ($M = 1.13$, $SD = 1.36$), $t(1, 15) = 2.66$, $p = .02$, Cohen's $d = 0.66$; Wilcoxon signed ranks test, $z = -2.23$, $p = .03$ (Fig. 3). Children attended equally well to both demonstrations (both medians = 100% of the demonstration).

Discussion

In Experiment 2, we showed that in the first imitation round 4-year-olds tended to imitate sub-efficient means of achieving the goal demonstrated by a same-language speaker. Crucially, the model's demonstration was ostensive but fully nonverbal, as it was in Experiment 1. Furthermore, in the second imitation round, after observing a demonstration of an efficient action alternative presented again communicatively yet nonverbally by another model speaking the same language, 4-year-olds adopted the efficient alternative and imitated the superfluous causally irrelevant actions of the previously acquired sub-efficient action routine significantly less. These results with 4-year-olds are in line with those reported by Hoehl et al. (2014) with older preschoolers and extend them to a context of nonverbal communicative demonstrations with younger children. After validating the experimental procedure with 4-year-olds, we proceeded to test our main hypothesis in this age group in Experiment 3.

Experiment 3

Experiment 3 had the same structure as Experiment 1 except that participants were a group of 4-year-olds. In line with our earlier predictions, we expected 4-year-olds in the *same + foreign* condition to continue imitating the already acquired sub-efficient routines even after observing an efficient alternative means action demonstrated by a foreign-language speaker. In contrast, we expected children in the *foreign + same* condition to adopt the efficient alternative presented by the speaker of their own language.

Method

Participants

There were 16 4-year-olds in the *foreign + same* condition (8 girls; $M_{age} = 54.31$ months, $SD = 4.02$, range = 48.88–58.9) and 16 4-year-olds in the *same + foreign* condition (6 girls; $M_{age} = 54.5$ months, $SD = 3.7$, range = 48.13–59.13).

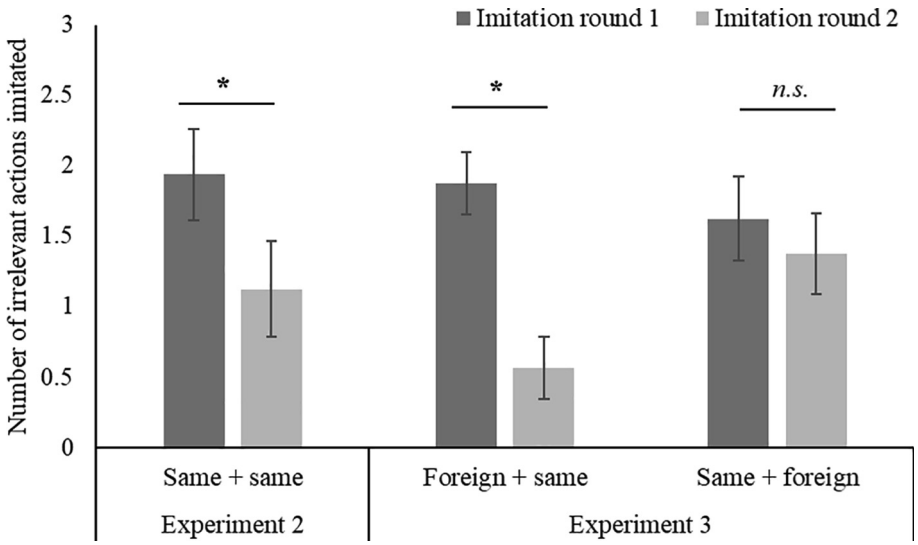

Fig. 3. Mean number of irrelevant actions imitated by 4-year-olds in each imitation round in Experiment 2 (same + same) and in two conditions of Experiment 3 (foreign + same vs. same + foreign). An asterisk (*) marks a statistically significant difference; *n.s.* marks a nonsignificant difference. Error bars show ± 1 standard error.

A further 25 4-year-olds (15 girls) were tested but excluded from all analyses because they did not act on the sticker dispenser at all in either one imitation round (n = 1) or both imitation rounds (n = 4), did not retrieve the sticker from the sticker dispenser in one imitation round (n = 10; $n_{same+foreign}$ = 4, $n_{foreign+same}$ = 6) or both imitation rounds (n = 4; $n_{same+foreign}$ = 2, $n_{foreign+same}$ = 2), did not watch the demonstration (n = 2), or saw the resetting of the sticker dispenser (n = 1) or due to camera failure (n = 1), or experimenter error (n = 2).

All participants in the final sample were monolingual, speaking only Hungarian as their native language, and were recruited from local kindergartens in the Budapest inner-city area.

Design and procedure

The design and procedure were the same as in Experiment 1. The models were the same models who performed the demonstrations in Experiment 1.

Coding

The number of irrelevant actions children imitated was coded for each imitation round separately (range = 0–3) as an imitation score. Approximately 30% of the data (10 children) were coded by a second coder who was naïve to the condition and hypotheses of the study. Intercoder reliability was perfect (Cohen's kappa = 1, p < .001). If the camera angle allowed ($n_{same+foreign}$ = 14, $n_{foreign+same}$ = 15), we also coded the amount of time participants looked at the demonstrations to check whether the familiarity or novelty of the model's language might have affected children's overt attention to the demonstration.

Results

Data were collapsed across participant gender because preliminary analyses showed no significant main effects or interactions of this factor with condition and imitation round.

A 2 × 2 (Condition × Imitation Round) repeated-measures ANOVA on imitation scores revealed a statistically significant interaction, $F(1, 30)$ = 8.90, p = .006, partial η^2 = .23. Planned comparisons revealed that imitation scores in the *foreign + same* condition decreased significantly from the first

imitation round (M = 1.88, SD = 0.88) to the second imitation round (M = 0.56, SD = 0.89), $t(15) = 4.61$, $p < .001$, Cohen's $d = 1.15$; Wilcoxon signed ranks test, $z = -2.91$, $p = .002$. However, imitation scores in the *same + foreign* condition did not change significantly from the first imitation round (M = 1.63, SD = 1.20) to the second imitation round (M = 1.38, SD = 1.15), $t(15) = 1.17$, $p = .26$, Cohen's $d = 0.29$; Wilcoxon signed ranks test, $z = -1.13$, $p = .50$.

Demonstrations from the same- and foreign-language speakers were attended to equally well (both medians = 100% of the demonstration duration).

We further carried out a 2 × 2 × 3 (Condition × Imitation Round × Age Group) repeated-measures ANOVA on imitation scores with the participants of Experiments 1 and 3. This indicated no statistically significant three-way interaction among these factors, $F(2, 90) = 2.38$, $p = .098$, partial $\eta^2 = .05$, but did indicate a statistically significant interaction between the imitation round and age group, $F(2, 90) = 6.70$, $p = .002$, partial $\eta^2 = .13$. There were no differences among the three age groups in their imitation scores during the first imitation round, $F(2, 93) = 1.44$, $p = .24$, partial $\eta^2 = .03$; $\chi^2(2) = 2.15$, $p = .35$. Yet both parametric and nonparametric tests revealed a statistically significant difference between the age groups in their imitation scores during the second imitation round, $F(2, 93) = 3.45$, $p = .04$, partial $\eta^2 = .07$; $\chi^2(2) = 6.99$, $p = .03$. Post hoc Bonferroni comparisons showed that 4-year-olds' imitation scores were higher in the second round, in contrast to those of 6-year-olds ($p = .04$) but not in contrast to those of 5-year-olds ($p > .05$). There were no differences between the imitation scores of 5- and 6-year-olds in the second imitation round ($p = .15$).

Discussion

Similar to Experiment 2, in Experiment 3 4-year-olds readily imitated the sub-efficient action routines that they had acquired from the ostensive demonstration of the first model. Notably, this tendency to faithfully imitate the sub-efficient routine was present irrespective of whether it was initially demonstrated to them by a speaker of their own language or a speaker of a foreign language. Furthermore, just like in Experiment 2, the 4-year-olds in this experiment reduced their imitation of the superfluous steps of the sub-efficient action sequence after a more efficient alternative was presented to them by a speaker of their own language.

Crucially, consistent with our prediction, these younger children continued to preserve and use the initially acquired sub-efficient action routine even after the more efficient alternative was subsequently demonstrated to them by the foreign-language speaker. Children's persistence in imitating the sub-efficient means after being exposed to the efficient alternative from a foreign-language speaker could not have stemmed from mere reluctance to imitate the speaker of a foreign language, as illustrated by the high level of imitation in the first round in the *foreign + same* condition. Neither could it be due to an inability to modify their imitation of the means acquired from a same-language speaker given that children in Experiment 2 were clearly able to do just that. We conclude that 4-year-olds selectively either adopted or disregarded the efficient alternative in Experiment 3 as a function of whether it was demonstrated to them by the speaker of their own language or by the speaker of a foreign language. This result is in line with our proposal that in young children the retention of sub-efficient customary ways of doing things may be aided by their selective evaluation of the cultural competence of the source of the efficient alternative. This selectivity depends on whether models can be recognized as members of the cultural community sharing a common body of cultural knowledge in which children are growing up.

General discussion

The current study investigated how children optimize their acquisition of common cultural practices that are shared by the members of their community. We focused on the learning and retention of sub-efficient action routines because—although they may appear arbitrary and remain cognitively opaque to naïve learners—they are likely candidates for customary and normative culture-specific practices that are part of the common cultural knowledge repertoire shared by members of a community (Legare & Nielsen, 2015). As such, they should be prime targets of cultural transmission, and

young naïve cultural learners should be able to acquire and maintain them in their repertoire despite the availability of efficient alternatives (Gergely & Csibra, 2006; Király et al., 2013).

We proposed that from early childhood this process is aided by the tendency to embrace later encountered, more efficient alternative means only selectively depending on whether the efficient alternative comes from an agent who is considered to possess the cultural knowledge of the child's community, as evidenced by the language the agent speaks. We hypothesized that having learned a sub-efficient way of achieving a goal, preschoolers should adopt the more efficient alternative if it was demonstrated by a same-language speaker but should be more likely to disregard it (and retain the sub-efficient action routine already acquired) if its source is a foreign-language speaker.

To sum up our three experiments, contrary to our hypothesis, after having acquired the sub-efficient action routine demonstrated to them, 5- and 6-year-olds (Experiment 1) flexibly adopted the novel but more efficient alternative means action presented by the second model regardless of whether the model was a speaker of the shared or nonshared language. On the other hand, whether 4-year-olds (Experiments 2 and 3) adopted the efficient alternative indeed depended on the language spoken by the person modeling it.

The difference between 4-year-olds and the older age groups was not predicted, and further studies are needed to clarify it. For now, we suggest that 5- and 6-year-olds may have already come to possess a broader scope of contextually relevant knowledge that they could more flexibly integrate into their evaluation of an informer's likely cultural competence. For example, by 5 or 6 years of age preschoolers may have encountered in their social environment a sufficient number of relatives, familiar adults, and/or kindergarten teachers who could speak more than one language but nevertheless proved to be reliable sources of shared cultural knowledge. Given their growing experience with people speaking multiple languages in their cultural environment, these older children may have come to rely less on spoken language as a strong indicator of cultural competence. In particular, they might not consider evidence of speaking a foreign language as sufficient to evaluate the source agent as lacking relevant culture-specific knowledge shared by the children's social community. It should be noted, however, that in this study we did not assess children's exposure to languages in their social environment and, thus, were not able to test this post hoc account of the observed differences between age groups.

We also recognize that our procedure itself might have played a role in the developmental trend we found. First of all, we carried out this paradigm at the kindergartens of the children. This alone might have led them to perceive all three female adults (the experimenter and two models) as belonging to the same cultural group independent of the language the models spoke. More crucially, after an ostensive and detailed explanation of the game structure to the children during the warm-up phase, the experimenter explicitly instructed that they should attentively watch the models who would be coming soon to obtain stickers from the sticker box. This ostensive introduction by itself might have led children to construe the models as knowledgeable about the goal of the game and about how to work the novel apparatus—indicating that they are reliable informants.

Previous research documented similar age differences in the way in which verbal cues influence children's imitative flexibility, suggesting that as children get older they might be more attuned to the content of the verbal framing of the task (Clegg & Legare, 2016). In our study, the outcome-oriented language used during the introduction might have led especially the older children to take a more dominantly instrumental stance in interpreting the task and to prioritize the efficient attainment of the sticker over the sub-efficient action routine. For 4-year-olds, on the other hand, the verbal content of the communicative instruction about the task context and the implication of the verbal instruction concerning the likely knowledgeability of the upcoming demonstrators about the task structure might have played a lesser role and did not yet interfere with their language-based evaluation of the model as a likely source of cultural knowledge.

The current results are in line with the view that from early on in their development human children are proficient learners of culturally shared knowledge. Young children form different expectations about the generalizability of the newly acquired information depending on whether it was ostensively communicated to them or not (Bonawitz et al., 2011; Butler, Schmidt, Bürgel, & Tomasello, 2015; Csibra & Gergely, 2006, 2009, 2011; Király et al., 2013). They readily acquire novel means actions regardless of their apparent sub-efficiency (Hoehl et al., 2014; Horner & Whiten, 2005; Lyons et al., 2007, 2011; Schleihauf et al., 2018), show selectivity in reproducing sub-efficient

action routines depending on their audience (Nielsen & Blank, 2011), and transmit such sub-efficient means actions to third parties (2015; Kenward, 2012; Keupp et al., 2013). Young children also monitor opportunities for learning culturally shared information by attending to the language spoken by informants (Begus et al., 2016; Buttelmann et al., 2013; Howard et al., 2015; Oláh et al., 2014; Shutts et al., 2009). As our study shows, at around 4 years of age children are also sensitive to the speaker's language as a cue to shared cultural knowledge and rely on it when deciding whether to incorporate the demonstrated efficient action alternatives into their own cultural knowledge repertoire.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2020.104847.

References

Begus, K., Gliga, T., & Southgate, V. (2016). Infants' preferences for native speakers are associated with an expectation of information. *Proceedings of the National Academy of Sciences of the United States of America, 113*, 12397–12402.
Bonawitz, E., Shafto, P., Gweon, H., Goodman, N. D., Spelke, E., & Schulz, L. (2011). The double-edged sword of pedagogy: Instruction limits spontaneous exploration and discovery. *Cognition, 120*, 322–330.
Burdett, E. R., McGuigan, N., Harrison, R., & Whiten, A. (2018). The interaction of social and perceivable causal factors in shaping "over-imitation". *Cognitive Development, 47*, 8–18.
Butler, L. P., & Markman, E. M. (2012). Preschoolers use intentional and pedagogical cues to guide inductive inferences and exploration. *Child Development, 83*, 1416–1428.
Butler, L. P., Schmidt, M. F., Bürgel, J., & Tomasello, M. (2015). Young children use pedagogical cues to modulate the strength of normative inferences. *British Journal of Developmental Psychology, 33*, 476–488.
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.
Chalik, L., Rivera, C., & Rhodes, M. (2014). Children's use of categories and mental states to predict social behavior. *Developmental Psychology, 50*, 2360–2367.
Clegg, J. M., & Legare, C. H. (2016). Instrumental and conventional interpretations of behavior are associated with distinct outcomes in early childhood. *Child Development, 87*, 527–542.
Csibra, G., & Gergely, G. (2006). Social learning and social cognition: The case for pedagogy. *Attention and Performance, 21*, 249–274.
Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences, 13*, 148–153.
Csibra, G., & Gergely, G. (2011). Natural pedagogy as evolutionary adaptation. *Philosophical Transactions of the Royal Society B: Biological Sciences, 366*, 1149–1157.
Csibra, G., Gergely, G., Bíró, S., Koos, O., & Brockbank, M. (1999). Goal attribution without agency cues: The perception of "pure reason" in infancy. *Cognition, 72*, 237–267.
Egyed, K., Király, I., & Gergely, G. (2013). Communicating shared knowledge in infancy. *Psychological Science, 24*, 1348–1353.
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.
Gergely, G., & Csibra, G. (2003). Teleological reasoning in infancy: The naive theory of rational action. *Trends in Cognitive Sciences, 7*, 287–292.
Gergely, G., & Csibra, G. (2006). Sylvia's recipe: The role of imitation and pedagogy in the transmission of cultural knowledge. In N. J. Enfield & S. C. Levenson (Eds.), *Roots of human sociality: Culture, cognition, and human interaction* (pp. 229–255). Oxford, UK: Berg.
Gergely, G., & Jacob, P. (2012). Reasoning about instrumental and communicative agency in human infancy. *Advances in Child Development and Behavior, 43*, 59–94.
Gergely, G., Nádasdy, Z., Csibra, G., & Bíró, S. (1995). Taking the intentional stance at 12 months of age. *Cognition, 56*, 165–193.
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.
Hernik, M., & Csibra, G. (2015). Infants learn enduring functions of novel tools from action demonstrations. *Journal of Experimental Child Psychology, 130*, 176–192.
Hernik, M., & Gergely, G. (2015). To what adaptive problems is human teaching a solution?. *Behavioral and Brain Sciences, 38* e42.

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.
Hoehl, S., Zettersten, M., Schleihauf, H., Grätz, S., & Pauen, S. (2014). The role of social interaction and pedagogical cues for eliciting and reducing overimitation in preschoolers. *Journal of Experimental Child Psychology, 122*, 122–133.
Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal Cognition, 8*, 164–181.
Howard, L. H., Carrazza, C., & Woodward, A. L. (2014). Neighborhood linguistic diversity predicts infants' social learning. *Cognition, 133*, 474–479.
Howard, L. H., Henderson, A. M., Carrazza, C., & Woodward, A. L. (2015). Infants' and young children's imitation of linguistic in-group and out-group informants. *Child Development, 86*, 259–275.
Kenward, B. (2012). Over-imitating preschoolers believe unnecessary actions are normative and enforce their performance by a third party. *Journal of Experimental Child Psychology, 112*, 195–207.
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.
Keupp, S., Behne, T., & Rakoczy, H. (2013). Why do children overimitate? Normativity is crucial. *Journal of Experimental Child Psychology, 116*, 392–406.
Keupp, S., Behne, T., Zachow, J., Kasbohm, A., & Rakoczy, H. (2015). Over-imitation is not automatic: Context sensitivity in children's overimitation and action interpretation of causally irrelevant actions. *Journal of Experimental Child Psychology, 130*, 163–175.
Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences of the United States of America, 104*, 12577–12580.
Király, I., Csibra, G., & Gergely, G. (2013). Beyond rational imitation: Learning arbitrary means actions from communicative demonstrations. *Journal of Experimental Child Psychology, 116*, 471–486.
Legare, C. H., & Nielsen, M. (2015). Imitation and innovation: The dual engines of cultural learning. *Trends in Cognitive Sciences, 19*, 688–699.
Legare, C. H., Wen, N. J., Herrmann, P. A., & Whitehouse, H. (2015). Imitative flexibility and the development of cultural learning. *Cognition, 142*, 351–361.
Lyons, D. E., Damrosch, D. H., Lin, J. K., Macris, D. M., & Keil, F. C. (2011). The scope and limits of overimitation in the transmission of artefact culture. *Philosophical Transactions of the Royal Society of London B: Biological Sciences, 366*, 1158–1167.
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.
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.
Oláh, K., Elekes, F., Bródy, G., & Király, I. (2014). Social category formation is induced by cues of sharing knowledge in young children. *PLoS One, 9*(7) e101680.
Over, H., & Carpenter, M. (2012). Putting the social into social learning: Explaining both selectivity and fidelity in children's copying behavior. *Journal of Comparative Psychology, 126*, 182–192.
Phillips, B. C., Seston, R., & Kelemen, D. (2012). Learning about tool categories via eavesdropping. *Child Development, 83*, 2057–2072.
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.
Shutts, K., Kinzler, K. D., McKee, C. B., & Spelke, E. S. (2009). Social information guides infants' selection of foods. *Journal of Cognition and Development, 10*, 1–17.