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Variation in pedagogy affects overimitation in children and adolescents

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ABSTRACT

Children are strong imitators, which sometimes leads to overimitation of causally unnecessary actions. Here, we tested whether learning from a peer decreases this tendency. First, 65 7- to 10-year-old children performed the Hook task (i.e., retrieve a reward from a jar with tools) with child or adult demonstrators. The overimitation rate was lower after watching a peer versus an adult. Second, we tested whether experiencing peer-to-peer learning versus adult-driven learning (i.e., Montessori or traditional pedagogy) affected overimitation. Here, 66 4- to 18-year-old children and adolescents performed the Hook task with adult demonstrators only. Montessori-schooled children had a lower propensity to overimitate. These findings emphasize the importance of the teaching model across the school years. Whereas peer models favor selective imitation, adult models encourage overimitation.

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Introduction

Learning from others is an integral part of life, and children display imitative abilities from an early age (Want & Harris, 2002). Imitation can be of two forms; selective imitation and exact imitation (Hilbrink et al., 2013; McGuigan & Whiten, 2009; Over & Carpenter, 2013). Selective imitation refers to a careful consideration of what to replicate or not. Conversely, exact imitation relates to the reproduction of both the process (i.e., all the actions demonstrated) and the end state (i.e., the outcome). Children's exact imitation leads to replicating unnecessary actions for a pursued goal (Horner & Whiten, 2005), termed *overimitation* (Lyons et al., 2007; for a review, see Hoehl et al., 2019). Here, we examined how variations in the pedagogy experienced daily by children might modulate how overimitation behaviors occur. To this aim, we first attempted to replicate a previous finding that traditionally schooled children tend to overimitate an adult demonstrator more than a child demonstrator. Based on this result, we further examined to what extent children experiencing a pedagogy based more on peer-to-peer learning would overimitate an adult demonstrator compared with children experiencing a more traditional pedagogy essentially involving a learning process coming from an adult.

Both children and adults use different types of imitation, including overimitation, according to the context, their perception of the situation, and their personal goals (Hoehl et al., 2019; Keupp et al., 2015, 2018). Early debates to explain the occurrence of overimitative behavior have opposed a rather cognitive account to a rather social and normative account. The cognitive account argues that overimitation results from a belief based on causal distortions that all actions demonstrated by an individual, necessary or unnecessary, are essential to accomplish the task (Lyons et al., 2007, 2011). On the other hand, the social account claims that overimitation is driven by social motivations to affiliate with the individual who performs the sequence of actions (Nielsen & Blank, 2011; Nielsen et al., 2012; Watson-Jones et al., 2014). From the normative point of view, whereas overimitation is perceived as irrational in a strictly instrumental aspect, inefficient and efficient actions are combined to achieve a conventional goal (Keupp et al., 2013). However, these three hypotheses are not mutually exclusive given that the occurrence of overimitation may depend on the context, which emphasizes either cognitive or social goals and norms (Schleihauf & Hoehl, 2020).

According to the social account, a central aspect of overimitation relies on the nature of the social agent children observe and imitate. Children want to be part of a social group and identify themselves with the demonstrator (Over & Carpenter, 2012). Therefore, they have inherent social biases (Over & Carpenter, 2013). Consequently, when the adult demonstrator is not present, children show a lower propensity for overimitation (Nielsen & Blank, 2011; Schleihauf & Hoehl, 2020; Stengelin et al., 2019). Overimitation may result from the fact that, from an early age, most Western children are primarily taught by adults and respond to their ostensive cues (Csibra and Gergely, 2009). Adults are perceived as making fewer mistakes and irrelevant actions (Wood et al., 2012). Overimitation may then happen because children see all adult actions as causally significant, including unnecessary ones, as stated by the cognitive account (Lyons et al., 2007, 2011). Whereas the emphasis is given to how children overimitate adults, there are very few investigations on peer-to-peer overimitation. Concerning imitation, whereas children imitate more peers for familiar or rational actions (Ryalls et al., 2000; Taylor et al., 1991; Zmyj, Aschersleben, et al., 2012), they preferentially imitate adults for novel and irrational actions (Mak, 2005; Zmyj, Daum, et al., 2012). Indeed, when the task is perceived to require knowledge and expertise such as in the case of puzzle boxes (but see also VanderBorght & Jaswal, 2009), children seem to overimitate an adult more than another child (McGuigan et al., 2011; McGuigan & Robertson, 2015; Nielsen & Blank, 2011; Wood et al., 2012). Conversely, when the apparatus is presented as a toy, children tend to follow the child demonstrations more than the adult ones, potentially because adults might be perceived as less familiar with this type of apparatus (e.g., Wood et al., 2016).

More generally, the fact that children overimitate more an adult demonstrator than a child demonstrator might be confounded by the type of pedagogy experienced by the children participating to the task. Indeed, most studies on children's overimitation have been conducted in Western societies. The child participants attend formal (hereafter *traditional*) schools where they depend on adult teachers, reinforcing children's perception of adults as experts. Interestingly, depending on the culture and

the communities, cross-cultural investigations have yielded mixed results with non-Western children. For instance, some have similar rates of overimitative behaviors after an adult demonstration in South African hunter–gatherer, Indigenous Australian, and Westernized children (Nielsen et al., 2014, 2016; Nielsen & Tomaselli, 2010). However, contrariwise, Berl and Hewlett (2015), who compared overimitation variations in Western children with two groups of non-Western children (i.e., Aka and Ngandu), reported that whereas the Ngandu and Western children did not differ, the Aka children showed less overimitation than the other two groups. This was explained by the fact that the Ngandu receive a Western-line education akin to most Western traditional schools, whereas the Aka receive an education where self-guidance and horizontal and peer interactions are privileged (Hewlett et al., 2011). Indeed, recent work has shown that non-Western children attending nonformal education show less persistence of overimitation across different tasks than Western children attending formal education (Stengelin et al., 2019, 2020).

As such, the type of education (i.e., pedagogy) seems to be a key factor in predicting overimitation in children. Crucially, and complementary to cross-cultural studies, intracultural research could provide important insights into this question by excluding the confound of culture and focus on the variation in pedagogy. More specifically, there are alternative pedagogies in Western society where self-direction and peer-to-peer learning are encouraged as in Montessori education. Indeed, in these settings, children develop cooperative learning with peers of different ages (Lillard & Else-Quest, 2006; Montessori, 1949/1967). Moreover, the learning materials more closely resemble the challenges of everyday life, which promotes children's independence (Lillard, 2011, 2019). The didactic materials support them in exploring and understanding concepts through trial-and-error strategies rather than using rote learning (Denervaud, Knebel, et al., 2020). Children self-direct their activities and benefit from uninterrupted working hours individually or in small groups (Marshall, 2017). As such, given the similarities between the Montessori pedagogy and the nontraditional pedagogy observed in some hunter–gatherer communities, it is plausible that overimitation in Montessori-schooled children would differ from that in traditionally schooled children. Indeed, the context in which Montessori-schooled children spend their schooling experience is much less driven by an adult giving formal grades but instead is more driven by increased independence and self-learning than in more traditional school contexts. As such, although Montessori-schooled children still perceive adults as authoritative figures, particularly their teachers, they might not consider these figures as behavioral models as much as traditionally schooled children might. If we consider the social motivation account, Montessori-schooled children might be less inclined to conform to an adult model than traditionally schooled children in the context of overimitation. Similarly, if we consider the normative account, the authority-free schooling of the Montessori pedagogy might lead to differences in perception of what is considered relevant information provided by the authority figures. Indeed, there is evidence that situational parameters can influence how different actions are parsed and interpreted in overimitation contexts. Indeed, Keupp et al. (2013) observed that emphasizing the method rather than the goal leads to more overimitation, potentially because distinct elements (which include relevant and irrelevant actions) of the sequence in that condition are seen as parts of a bigger normative action. Therefore, it is possible that Montessori-schooled children would not automatically perceive the demonstrative actions as containing normative elements such as social–normative constructions (i.e., parsing the action sequence as two separate actions rather than as one action with two normative elements), leading to lower rates of overimitation given that the irrelevant action is not interpreted as part of a whole. Conversely, traditionally schooled children would automatically perceive the adult's behavior as normative (i.e., parsing the action sequence as one action with two normative elements), leading to higher rates of overimitation. In line with this rationale, there is evidence that if irrelevant actions are performed on the same tool rather than on two distinct tools, the former case leads to higher overimitation rates (Frick et al., 2021; but see Schleihauf & Hoehl, 2020).

Here, we tested this reasoning by examining how peer-to-peer learning experience (Montessori-schooled children) and adult-to-child learning experience (traditionally schooled children) might result in different overimitation rates. To do so, we conducted two studies with different aims but where the first study allowed us to best conceptualize the second study. Such a strategy was motivated by the fact that children experiencing a peer-to-peer learning pedagogy are from a rarer population than children being schooled in a more traditional adult-to-child learning environment.

In Study 1, we sought to replicate that traditionally schooled children tend to overimitate an adult demonstrator more than a peer demonstrator (McGuigan et al., 2011; Wood et al., 2012). But we also aimed to extend such replication to a simpler everyday task, although one requiring adult-like knowledge and expertise. Indeed, most previous overimitation studies used either a glass-ceiling box (i.e., a transparent box containing a reward that must be retrieved using a tool with a magnet on the tip; Horner & Whiten, 2005) or a wooden puzzle box (i.e., an opaque box that must be opened to retrieve a reward; Nielsen & Blank, 2011), which are tasks that are not frequently encountered by the children. It is important to report the occurrence of overimitation in different tasks, and perhaps with tasks that tap into situations that are more likely to happen in children's daily lives, to make sure that such behavior is not an experimental artifact (for discussions, see Collins, 1984; Franklin, 1981). As such, we used the Hook task (Beck et al., 2011), which is a tool-based problem where children must shape a pipe cleaner into a hook to retrieve a reward. This innovation paradigm has revealed itself as ideal to study overimitation by embedding the latter as part of the demonstration following a failure to innovate the hook (Frick et al., 2017, 2021). But perhaps more important, Study 1 served as a means to select the adult demonstrator rather than the child demonstrator for Study 2, which aimed to show that traditionally schooled children would overimitate more than Montessori-schooled children in that context.

Study 1

The main aim of Study 1 was to replicate previous findings showing that traditionally schooled children overimitate an adult demonstrator more than a child demonstrator and extend these findings to a simpler task that replicates everyday actions. In addition, previous studies of overimitation with the ceiling box have tested children aged 3 to 6 years; thus, it would be interesting to investigate whether this effect persists at an older age. To this end, we tested 7- to 10-year-old traditionally schooled children using the Hook task (Beck et al., 2011), adapting the procedure by Frick et al. (2021) (see the Method section for more details). Half of the children saw a video of an adult demonstrating unnecessary and necessary actions, whereas the other half saw a video of another child doing so. Thus, we predicted that children would overimitate the adult demonstrator to a greater extent than the child demonstrator.

Method

Participants

A total of 65 traditionally schooled children (M_{age} = 8.7 years, *SD* = 0.9, range = 7.1–10.3; 32 girls) were recruited in three collaborating private and public schools. We targeted children around late childhood to ensure that the number of successful and unsuccessful children at the pre-demonstration would be roughly equivalent based on previous studies (Beck et al., 2011; Frick et al., 2017). The protocol was approved by the university's ethical committees. All parents signed informed consent for their children. Children received an oral explanation of the study and gave their consent verbally.

Procedure

All children were tested individually in a quiet room in their school. Children performed the Hook task (Beck et al., 2011), consisting of a bucket containing a reward placed inside a jar and two different tools: a pipe cleaner and a string. Because previous success or failure appears to influence overimitation, children started with a self-exploration trial (Frick et al., 2021). Children were presented with the experimental material—a glass jar (height = 23 cm, width of opening = 4 cm) attached to a wooden board (length = 35 cm, width = 21 cm) and containing a small plastic bucket (height = 7.5 cm, width = 3 cm) with a reward alongside a black pipe cleaner and a white string placed next to the jar—and their attention was raised about the reward within the bucket inside the jar as well as the two tools on the side. They were then given the following instructions: "The goal is to catch the reward. You can use whatever tools you'd like. You have 1 minute to try." Children were told that

they could not turn the jar upside down to retrieve the reward from the bucket. Following the procedure of Frick et al. (2017, 2021), children had 1 min (timed with a sand timer) to retrieve the reward. Afterward, they were told that they would see a video without any additional explanation. They were randomly assigned to either the adult demonstration condition (n = 32, M_{age} = 8.70 years, SD = 1.03; range = 7.17–10.30; 13 girls) or the 7- to 9-year-old child demonstration condition (n = 33, M_{age} = 8.77 years, SD = 0.83, range = 7.08–10.10; 19 girls). The distribution of the demonstrator's sex was randomly assigned independent of the child's sex. In both video demonstrations, a demonstrator (either a woman/girl or a man/boy) wearing a gray T-shirt first made a loop at the top extremity (unnecessary action) and then made a hook without retrieving the reward from the jar (necessary action; see Fig. 1). The demonstrator's face remained neutral during the demonstration of these two actions. After the demonstration, children received the instruction to try again to retrieve the reward within 1 min. If children asked whether they needed to copy the demonstrator, the former instruction was similarly repeated. Children were offered the reward after the experiment regardless of performance. All the sessions were video-recorded for later analyses, and the experimenter remained next to the children during the session.

Data analyses

Coding. For the pre- and post-demonstration phases, children who successfully retrieved the reward by making a hook with the pipe cleaner were given a score of pre/post success = 1, whereas unsuccessful children were given a score of pre/post success = 0. In the post-demonstration phase, children who made a loop with the pipe cleaner *before* and *after* making a hook *with* or *without* further use of it were given a score of overimitation = 1, whereas children who did not make any sort of loop were given a score of overimitation = 0. Other actions that included the use of the tools were not considered as overimitation. The last author coded all video-recordings, and a rater blind to the experiment double-coded 30% of the experiment to ensure proper scoring, with 100% agreement.

Statistical analyses. Data were analyzed using R Version 4.3.1 (R Core Team, 2023). Age and sex were statistically tested to be comparable between groups using an independent t test and a chi-square test, respectively.

Then, we performed a binary logistic regression analysis to predict the probability that a child would overimitate the unnecessary action (i.e., the loop). The main predictor variable was the condition of interest: type of demonstrator (adult or child). Based on previous research, we further added the sex of the participants (girl or boy; Frick et al., 2017) and success in the pre-demonstration phase (successful or unsuccessful; Frick et al., 2021) as fixed factors. Finally, we included the interaction between the type of demonstrator and success in the pre-demonstration phase to explore whether being successful or unsuccessful before the demonstration did influence the likelihood of overimitating a child demonstrator and an adult demonstrator.

To reduce the likelihood of obtaining Type I error, we compared the full model with the interaction (Overimitation $\sim$ DemonstratorType + PreSuccess + Sex + DemonstratorType:PreSuccess) with a null model lacking the predictors of interest (Overimitation $\sim$ 1). We then compared the full model with the interaction with the full model with the main effects only (Overimitation $\sim$ DemonstratorType + PreSuccess + Sex) to check whether a simpler model could be used for the analyses. These tests of significance were performed using the function *anova()* with the argument test set to "Chisq". For the selected model, we checked whether there was any collinearity issues with the function *vif()* from the "car" package (Fox & Weisberg, 2019) with values that should be below 3. Results were obtained using the *drop1()* function from the "stats" package (R Core Team, 2023) to avoid any Type I errors. Plots were generated on Python using the module "seaborn" (Waskom, 2021).

Results

Groups (i.e., adult demonstrator and child demonstrator) did not differ on age, $t(63) = -0.30$, p = .768, Cohen's $d = -.074$, or on sex ratio, $\chi^2 = 2.60$, p = .107.

Of the 65 children tested, 37 (60%) successfully retrieved the reward during the pre-demonstration. In the child demonstrator condition, 15 of the 32 children (46%) randomly assigned were successful in

Fig. 1. Four demonstration videos showing the four demonstrators presenting the unnecessary action (i.e., the loop at the top of the hook).

the pre-demonstration phase, and 22 of the 33 children (67%) were successful in the adult demonstration. This difference was not significant, $\chi^2 = 1.04$, $p = .309$. After the demonstration, 53 children (81%) were successful overall, that is, 24 of the 32 children (75%) in the child demonstrator condition and 29 of the 33 children (87%) in the adult demonstrator condition. The comparison of these two proportions of successful children in the two conditions revealed that they were not statistically different, $\chi^2 = 1.04$, $p = .309$.

The deviance of the model with the interaction provided a better fit than the null model, $\chi^2 = 17.22$, $df = 4$, $p = .002$. However, this full model with interaction did not provide a better fit than the full model with main effects only, $\chi^2 = 0.32$, $df = 1$, $p = .568$. For the sake of parsimony, we selected the full model with main effects only. This model had no signs of collinearity (variance inflation factors [VIFs] < 1.45). Results from this model indicated that children overimitated the adult demonstrator more than the child demonstrator, $\beta = 2.17$, $SE = 0.68$, $df = 1$, $p < .001$, confidence interval (CI) [0.93, 3.64], and more when they were previously unsuccessful than successful at the Hook task, $\beta = -1.85$, $SE = 0.67$, $df = 1$, $p = .003$, CI [−3.31, −0.61]. Sex did not have a significant effect on the likelihood to overimitate, $\beta = 0.98$, $SE = 0.61$, $df = 1$, $p = .097$, CI [−0.17, 2.23]. See Fig. 2.

Discussion

Corroborating previous work, children overimitated an adult demonstrator more than a peer demonstrator (McGuigan et al., 2011; McGuigan & Robertson, 2015; Nielsen & Blank, 2011; Wood et al., 2012), even with the causally irrelevant action being embedded within a paradigm that

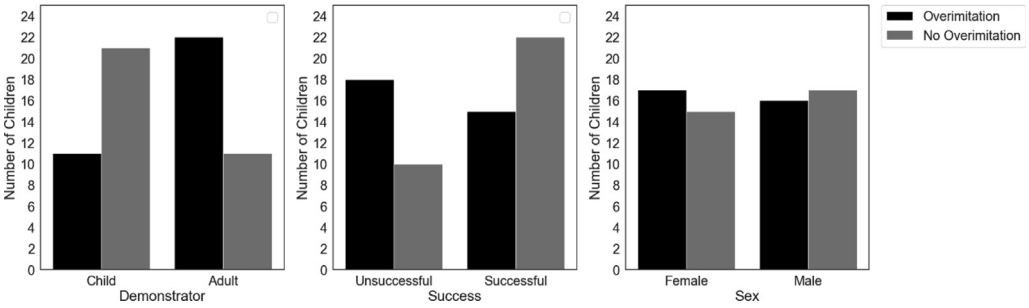

Fig. 2. Numbers of children who overimitated or not based on the demonstrator (child or adult), previous success (unsuccessful or successful), and sex (female or male).

represents more everyday actions, and this effect persists later in childhood. Moreover, in line with previous work (Frick et al., 2021), children overimitated more when they were unsuccessful at first, confirming a potential carryover effect of previous unsuccessfulness.

Study 2

Traditionally schooled children showed a lower propensity for overimitation when observing a child demonstrator versus an adult demonstrator. We then hypothesized that school experiences that mostly rely on peer learning rather than adult-driven teaching would train selective imitation daily. Accordingly, we specifically investigated the overimitation rate in traditionally schooled versus Montessori-schooled children in the specific context of adult models. In comparison with traditionally schooled children, do children experiencing daily peer-to-peer learning instead of adult-driven learning show a lower tendency to overimitate as expected by both the social motivation and normative accounts (Keupp et al., 2013; Nielsen & Blank, 2011; Nielsen et al., 2012; Watson-Jones et al., 2014)? To answer this question, Study 2 investigated the potential effects of schooling experience on the overimitation rate of adult demonstrators. Moreover, as in Study 1, we replicated the overimitation pattern at an older age and, given the mixed results of age on overimitation (Freier et al., 2015; Marsh et al., 2014; McGuigan et al., 2011), we believed it would be interesting to investigate the impact of education across ages. For this purpose, we tested 4- to 18-year-old Montessori-schooled and traditionally schooled children and adolescents using the same adapted version of the Hook task as in Study 1 (see the Method section for more details) with the sole exception of the use of adult demonstrators only. We predicted that children with a track record of Montessori schooling would overimitate the adult less often than traditionally schooled children.

Method

Participants

A total of 66 children and adolescents were recruited through an existing cohort tracking the effect of schooling experience on neurodevelopment. Two children were excluded because of a mixed schooling background (shifted from one schooling system to the other over the past 2 years). Among the remaining 64 participants, 27 had a track record of Montessori schooling (M_{age} = 10.6 years, *SD* = 3.45, range = 4.6–18.0; 14 girls) and 37 had a track record of traditional schooling (M_{age} = 10.0 years, *SD* = 2.96, range = 4.1–15.7; 23 girls). In Switzerland, school is standardized and starts at 4 years of age; therefore, all participants had started to attend school.

Procedure

All children were tested individually in a quiet room in the lab, and the procedure was like that in Study 1 with the exception that only the adult demonstrator videos were used.

Data analyses

Coding. For the Hook task, recordings of the pre- and post-demonstration phases were manually coded identically to Study 1.

Statistical analyses. Data were analyzed similarly to Study 1 with the exception that one of the main predictor variables of the binary logistic regression analysis was pedagogy experienced (Montessori or traditional) and given that the age range was large and previous studies have reported that overimitation rates can drastically vary across age during childhood (e.g., Freier et al., 2015; Marsh et al., 2014), this variable was set as another predictor in the model. Finally, a two-way interaction was again included in the full model with interaction, this time between pedagogy experience and success at the pre-demonstration phase.

Results

Groups did not differ on age, $t(62) = 0.72$, $p = .476$, Cohen's $d = .181$, or on sex ratio, $\chi^2 = 0.680$, $p = .409$.

The deviance of the model with the interaction provided did not fit better than the null model, $\chi^2 = 10.40$, $df = 4$, $p = .065$. However, the full model without the interaction did fit better than the null model, providing better fit than the null model, $\chi^2 = 10.33$, $df = 4$, $p = .035$, but not than the full model with the interaction, $\chi^2 = 0.07$, $df = 1$, $p = .789$. For the sake of parsimony, we selected the full model with main effects only. This model had no signs of collinearity (VIFs < 2.02). Results from this model indicated that traditionally schooled children overimitated more than Montessori-schooled children, $\beta = 1.15$, $SE = 0.58$, $df = 1$, $p < .041$, CI [0.05, 2.33], and that the older the children were, the less they overimitated, $\beta = -0.25$, $SE = 0.13$, $df = 1$, $p < .045$, CI [−0.53, −0.006]. However, the model suggested no significant effects of previous success, $\beta = 0.60$, $SE = 0.79$, $df = 1$, $p < .445$, CI [−0.93, 2.22], or of sex, $\beta = 0.19$, $SE = 0.57$, $df = 1$, $p < .737$, CI [−0.93, 1.32]. See Fig. 3.

Discussion

Corroborating our hypothesis, the pedagogy experienced by our participants influenced the probability of them overimitating an adult. Montessori-schooled children and adolescents, who are used to learning from other children, showed a lower propensity for overimitation compared with

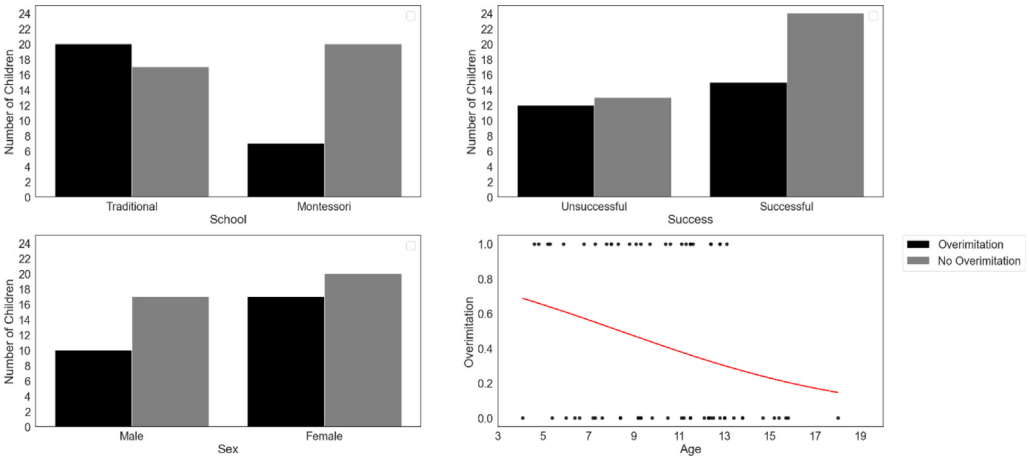

Fig. 3. Numbers of children who overimitated or not based on the school attended (traditional or Montessori), previous success (unsuccessful or successful), sex (female or male), and age (continuous).

their traditionally schooled peers. This finding provides the first evidence of intracultural differences in the field of overimitation and suggests that, depending on the type of pedagogy experienced, selective imitation can be favored over exact imitation (i.e., overimitation).

General discussion

In this work, we first aimed to investigate the effect of the type of demonstrator (adult or child) before examining the effect of the type of schooling experienced (traditional or Montessori) on overimitation in children and adolescents. Based on previous studies, we hypothesized that children observing peers would not overimitate as often as when observing adults. We further hypothesized that children and adolescents experiencing daily peer-to-peer learning, such as in a Montessori learning environment, would be less inclined to overimitate adults than traditionally schooled children. Results from Study 1 showed that (traditionally schooled) children are more prone to overimitate an adult demonstrator than a child demonstrator, and results from Study 2 revealed that Montessori-schooled children are less likely to overimitate an adult demonstrator than children exposed to adult-driven learning (i.e., traditional pedagogy).

In Study 1, we conceptually replicated a finding resulting from several previous studies showing that children overimitate an irrelevant action made by an adult more often than one made by a peer (McGuigan et al., 2011; Wood et al., 2012). But this replication also indicates that well-established results in the overimitation literature obtained with a more classical paradigm such as the puzzle box (e.g., Horner & Whiten, 2005) can easily transfer to other experimental tasks. Although the exact reason for this effect is still unknown, it could be hypothesized that children perceive adults as more expert than their peers, especially in the context of the Hook task, which is challenging for children until late childhood (Beck et al., 2011). Indeed, as Wood et al. (2012) suggested, children consider their peers as less knowledgeable than adults. There is evidence that children as young as 3 or 4 years prefer to learn from more knowledgeable agents over less knowledgeable ones (Einav & Robinson, 2011). Moreover, even before schooling starts, children preferentially use adults' pointing as compared with peers' pointing (Kachel et al., 2018) and prefer learning the rules of a game from an adult than from a peer, even protesting if a third party deviates from the adult demonstration, indicating a normative stance to rely on adults in children (Rakoczy et al., 2010). Although children do not blindly rely on adults to learn information, as evidenced by the fact that they opt to learn from a more reliable peer if the adult has been shown to be unreliable (Jaswal & Neely, 2006), children may put more weight on the information they receive from an adult versus from a peer, leading to more overimitation when the actions are performed by the former versus the latter.

However, in Study 2, and consistent with our expectations, children and adolescents enrolled in a Montessori pedagogy engaged in less overimitation than traditionally schooled children. As mentioned in the Introduction, such a result could be explained by the motivational account or the normative account or both given that these hypotheses are not mutually exclusive (Hoehl et al., 2019; see also Schleihauf & Hoehl, 2020) and can fall under the umbrella of social motivation (Frick et al., 2021). One way to potentially test for these social and motivational explanations would be to examine whether Montessori-schooled children would overimitate a child demonstrator more than an adult demonstrator, which was not feasible here given that it is difficult to test large samples of Montessori children. Indeed, although there are no existent studies on child–teacher relationships in Montessori-schooled children (Lillard et al., 2021), there is evidence that peer relationships are stronger in Montessori classrooms (Castellanos, 2002; Flynn, 1991; Rathunde & Csikszentmihalyi, 2005), which could increase children's willingness to (over)imitate their peers (Zmyj & Seehagen, 2013) that they take as behavioral models. However, we acknowledge that it can also go the other way given that Montessori schooling encourages independence and self-directed learning (Lillard, 2011, 2019; Marshall, 2017), which might leave these children without strict behavioral models, and therefore no particular will to affiliate themselves with a model, as compared with traditionally schooled children. In addition, authority-free schooling and a less normalized perception of children's environment would favor a parsing approach rather than a standardized whole. All in all, these considerations offer

exciting venues for future research before trying to explain what the underlying reasons are leading overimitation rates to differ between Montessori-schooled and traditionally schooled children (e.g., trial-and-error learning: Denervaud , Fornari, et al., 2020; Denervaud, Knebel, et al., 2020; social skills training: Denervaud, Mumenthaler, et al., 2020; Lillard & Else Quest, 2006).

Another result of interest is our reporting that there was a negative effect of age on overimitation, meaning that our participants overimitated less with age. As mentioned in Hoehl et al.'s (2019) literature review, determining the direction of the age effects on overimitation is a difficult question to answer given the differences in terms of the tasks used, the nature of actions demonstrated, and the overall context in which the tasks are presented. Still, there is a current consensus that overimitation increases with age, particularly from late infancy to the preschool years, but also up to adulthood (McGuigan et al., 2011; Speidel et al., 2021; Whiten et al., 2016; but see Rawlings et al., 2019). However, this relation does not appear to be that simple given that at least one study has reported a decrease in overimitation with age when the action sequence is familiar to the children (e.g., making a sandwich; Freier et al., 2015). Most studies reporting an age-related increase from childhood to adulthood have used the classical puzzle box from Horner and Whiten (2005). Therefore, it is possible that there are specific characteristics of the task used in the current study such as a pre-demonstration phase when participants can be successful or unsuccessful and the general framework of the task being a tool-solving problem. Again, this point deserves further investigation, and we are very cautious about the replicability of our age result here.

In addition, interestingly, whereas previous success was a predictor of overimitation in Study 1, which conceptually replicated a previous study (Frick et al., 2021), Study 2 failed to replicate these findings. We tentatively explored the interaction between previous success and the type of pedagogy experienced (in the full model with interaction described in our Method section), but this interaction did not reveal a significant effect, suggesting that the type of pedagogy was not responsible for this nonsignificant effect. An alternative explanation would be that children might deal with previous unsuccessfulness differently according to their age, although again a quick check at this interaction does not seem to reveal any effect in that sense. Overall, it appears that the fact that previous unsuccessfulness results in more overimitation should be viewed with caution at the stage given the non-systematic replication of this finding here.

A main limitation of this study relates to the lack of diversity in our sample given that most children enrolled attended private schools and therefore came from a high socioeconomic status, although this information was not collected. Given that socioeconomic status is an important factor leading to variations in overimitation (e.g., Stengelin et al., 2019), future research on the effect of pedagogy styles on overimitation should carefully include children and adolescents enrolled in the public school system as well to make the sample more representative. Nevertheless, our study provides the first evidence that pedagogy seems to influence how children and adolescents learn and imitate other individuals, and it calls for future research to unravel the underlying causes driving this result.

CRediT authorship contribution statement

Marion Décaillet: Data curation, Formal analysis, Investigation, Writing – original draft. **Aurélien Frick:** Conceptualization, Formal analysis, Methodology, Validation, Visualization, Writing – original draft. **Xavier Lince:** Writing – original draft. **Thibaud Gruber:** Conceptualization, Writing – review & editing. **Solange Denervaud:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Project administration, Supervision, Validation, Visualization, Writing – original draft.

Data availability

The raw data (csv and xlsx files for Study 1 and Study 2), the analytic code written in R, and the code for the plots written in Python are publicly available on the Open Science Framework repository (https://osf.io/v2bka/?view_only=09a41bd14254487791e48d3bea28799a).

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