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DOI: https://doi.org/10.1016/j.jecp.2023.105797

Originally published at:
Wermelinger, Stephanie; Moersdorf, Lea; Daum, Moritz M (2024). Automatic imitation in school-aged children. Journal of Experimental Child Psychology, 238:105797.
DOI: https://doi.org/10.1016/j.jecp.2023.105797

Journal of Experimental Child Psychology 238 (2024) 105797

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Automatic imitation in school-aged children

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ARTICLE INFO

Article history:
Received 6 April 2023
Revised 16 August 2023
Available online 3 November 2023

Keywords:
Imitation
Imitation-inhibition task
Interference effect
Inverse efficiency
Reachtion times
Error rates

ABSTRACT

Children imitate others for different reasons: To learn from others and to reach social goals such as affiliation or prosociality. So far, imitative acts have been measured using diverging methods in children and adults. Here, we investigated whether school-aged children's imitation can be measured via their automatic imitation with a classical imitation-inhibition task (Brass et al., 2000) as has been used in adults. To this end, we measured automatic imitation in $N = 94$ 7–8-year-olds and $N = 10$ adults. The results were similar in children and adults: Observing actions that are incongruent with participants' actions interferes with their responses resulting in increased reaction times and error rates. This shows that assessing automatic imitation via the imitation-inhibition task is feasible in children, and creates the basis for future studies to compare the behaviour of different age groups with the same imitation task.

Introduction

Imitation describes the faithful (deliberate or automatic) copying of an observed action in such that an observer achieves the action goal by using the same method and the same or similar topographical body movements as the model (e.g., Heyes, 2021; Heyes, 2001). By imitating others, people benefit from what others have already learnt (Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). Furthermore, cultural practices and inventions are passed on through instruction, interaction with, and imitation of other people (Harris, 2012; Heyes, 2021; Nielsen, 2012). People also imitate to affiliate with (Lakin

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https://doi.org/10.1016/j.jecp.2023.105797
0022-0965/

& Chartrand, 2003; Meltzoff, 2005), being liked by (Catmur & Heyes, 2013; Chartrand & Bargh, 1999; Dignath, Lotze-Hermes, Farmer, & Pfister, 2018) or feel close to others (AshtonJames, van Baaren, Chartrand, Decety, & Karremans, 2007), and promote prosocial behaviour (Catmur & Heyes, 2013; van Baaren, Holland, Kawakami, & van Knippenberg, 2004). These imitative acts are indicative of a strong interdependence: Humans highly depend on others for survival and security (Brewer, 2007; Baumeister & Leary, 1995). Furthermore, the human need to belong is already present in childhood (Over & Carpenter, 2013). Children use imitation to adhere to norms (Clay, Over, & Tennie, 2018), show group membership (Buttelmann, Zmyj, Daum, & Carpenter, 2013), and affiliate with other people (Nielsen & Blank, 2011; Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2012).

Differences in conceptualisation and methods to assess imitation make it difficult to compare findings across the lifespan (Over, 2020; Moersdorf, Freund, & Daum, 2022). In the current paper, we test the suitability of a tool to measure imitation that allows us to investigate imitative acts from childhood to late adulthood (Wermelinger, Gampe, & Daum, 2017). More specifically, we explore a classical automatic imitation task from adult research (imitation-inhibition task; Brass, Bekkering, Wohlschläger, & Prinz, 2000; Brass, Bekkering, & Prinz, 2001) in school-aged children. Automatic imitation refers to the phenomenon that people's execution of actions is automatically influenced by actions they observe (Cracco et al., 2018). It has been used to assess imitation in adults and is sensitive to social influences (e.g., pro-social cues, Leighton, Bird, Orsini, & Heyes, 2010; affiliation, Farwaha & Obhi, 2020; Hogeveen & Obhi, 2013), hinting at underlying social processes (Cracco et al., 2018). Thus, investigating automatic imitation helps understand how the observation and execution of actions are interrelated in social settings (Cracco et al., 2018; Heyes, 2011). Here, we investigate children's responses in an automatic imitation task and compare their result pattern to adult data to bridge the methodological gap present in the literature.

Development of imitation

Imitation and the alignment of behaviour and expressions with others is an important building block for higher social cognition (e.g., empathy; Rauchbauer & Grosbras, 2020). The complexity of cognitive processes involved in imitation is still debated (Heyes, 2021), with some findings suggesting that imitation is based on basic learning mechanisms that connect observed and executed actions if they are experienced simultaneously (Catmur, Walsh, & Heyes, 2009; Catmur, Walsh, & Heyes, 2007; Heyes & Catmur, 2021). In line with this notion, already children imitate others' actions and their ability to imitate improves steadily with age (Tomasello, 2009; McGuigan, Whiten, Flynn, & Horner, 2007; McGuigan, Makinson, & Whiten, 2011). Starting already in infancy, children imitate selectively: They differ in the extent of their imitation depending on situational constraints (Gergely, Bekkering, & Király, 2002; Schwier, van Maanen, Carpenter, & Tomasello, 2006; Zmyj, Daum, & Aschersleben, 2009; Seehagen, Schneider, Miebach, Frigge, & Zmyj, 2017), the age (Zmyj, Aschersleben, Prinz, & Daum, 2012; Zmyj et al., 2012) and the competence of a model (Zmyj, Buttelmann, Carpenter, & Daum, 2010). Similar to adults, children use imitation to learn instrumental skills (Meltzoff et al., 2009), take the context into account for more efficient learning (Langeloh, Buttelmann, Pauen, & Hoehl, 2020), and follow social goals when imitating (Jaswal & Kondrad, 2016; Over & Carpenter, 2013). Children's imitative acts are often investigated via overimitation (Gruber, Deschenaux, Frick, & Clément, 2019; McGuigan & Robertson, 2015), or nonconscious mimicry (van Schaik & Hunnius, 2016), that is the unconscious copying of someone's behaviour in social settings (Chartrand & Bargh, 1999). In adults, imitation is often measured via automatic imitation (Genschow, Cracco, Verbeke, Westfal, & Crusius, 2021; Leighton et al., 2010), which refers to the phenomenon that movement execution is facilitated when observing similar movements and hindered when observing dissimilar movements (Cracco et al., 2018).

Automatic imitation in adults

Stimulus–response compatibility tasks such as the *imitation-inhibition task* (Brass et al., 2000; Brass et al., 2001) are typical paradigms to investigate automatic imitation that have primarily been used in adults. In these tasks, participants execute finger movements in response to observed congruent or incongruent finger and object movements or symbolic cues. Participants typically respond faster and with fewer errors when presented with congruent than incongruent movements, an indication of automatic imitation (Brass et al., 2000; Cracco et al., 2018; Genschow et al., 2021). According to ideomotor theory, not only the execution but also the observation of an action leads to the activation of the associated motor representations (*perception–action-link*; Brass & Heyes, 2005; Greenwald, 1970; Prinz, 1990; Prinz, 1997). By activating the corresponding motor plan, the observation of a certain action (e.g., index finger movement) makes it easier to respond with the same action. In contrast, the response with a different action (e.g., middle finger movement) needs inhibition of the prevalent action and is, therefore, more difficult to perform (Cross, Stadler, Parkinson, Schütz-Bosbach, & Prinz, 2013). In automatic-imitation tasks, this results in faster reaction times and lower error rates in congruent trials, where the observed movement matches the required response movement (facilitation effect) and the opposite pattern in incongruent trials (interference effect; Brass et al., 2000; Brass et al., 2001; Cracco et al., 2018).

In adults and in line with the ideomotor theory, facilitation and interference effects can occur without attention (Catmur, 2016), are influenced by participants' experience with actions (Vogt et al., 2007), can be altered by sensorimotor training (Catmur et al., 2008) and a modulation of participants' self-other focus (Genschow, Schuler, Cracco, Brass, & Wänke, 2019), and are absent when observing non-biological movements (Kilner, Paulignan, & Blakemore, 2003). Furthermore, automatic imitation can be delineated from effects of spatial compatibility (Bertenthal, Longo, & Kosobud, 2006; Catmur & Heyes, 2011; Heyes, Bird, Johnson, & Haggard, 2005) [1] and executive functions - in particular inhibition processes. While participants' executive functions certainly play a role in their performance in automatic-imitation tasks, the perception–action-link uniquely contributes to the observed differences in reaction times and error rates (Bart, Koch, & Rieger, 2021; Brass, Derrfuss, & von Cramon, 2005).

Additionally, social aspects influence adults' behaviour in automatic imitation tasks suggesting underlying social processes (Cracco et al., 2018). For example, automatic imitation is stronger for non-goal-directed than goal-directed movements (Cracco et al., 2018), if the participant and the model are the same gender (Butler, Ward, & Ramsey, 2015; Cracco et al., 2018), if participants are primed with a pro-social cue (Leighton et al., 2010), and for greater perceived similarity of the participant with the model (Genschow et al., 2021).

Automatic imitation in children

Already in infancy and childhood, action execution and observation are interrelated (Cannon, Woodward, Gredebäck, von Hofsten, & Turek, 2012; Daum & Gredebäck, 2011; Kochukhova & Gredebäck, 2010; Loucks & Sommerville, 2012). However, the strength of this perception–action-link remains unclear. It is assumed that the link emerges through self-observation and interaction with others across development (Casile, Caggiano, & Ferrari, 2011; Heyes, 2010; Ray & Heyes, 2011) and therefore might not impact children's behaviour as strongly as adults'.

Up until now, only a few studies assessed automatic imitation in children (e.g., Bos, Jap-Tjong, Spencer, & Hofman, 2016; Saby, Marshall, Smythe, Bouquet, & Comalli, 2011; Scott, Emerson, Dixon, Tayler, & Eaves, 2019). Furthermore, the tasks used with children differed from the classical imitation-inhibition tasks used with adults (Brass et al., 2000). In previous work, children were asked to draw vertical or horizontal lines, while an interaction partner drew congruent or incongruent lines simultaneously (Saby et al., 2011; Marshall, Bouquet, Thomas, & Shipley, 2010). These studies indicate that automatic imitation in children is higher for actions thought to be performed in synchrony (e.g., clapping) compared to other actions like pointing (O'Sullivan, Bijvoet-van den Berg, & Caldwell, 2018) and also when children responded to the hand movements of in-group models instead of out-group models (Essa, Sebanz, & Diesendruck, 2019). For instance, interference effects were larger in 4-year-olds' interactions with peers than adults (Marshall et al., 2010). Hence, similar to adults, children's

[1] That is, automatic imitation effects may be confounded with spatial compatibility effects because the response finger not only matches the observed finger in terms of anatomical identity, but in terms of the side on which it was presented (right or left).

behaviour in automatic-imitation tasks is sensitive to social influences. Only two studies employed imitation-inhibition tasks similar to the ones used with adults (3-year-olds, Brezack, Meyer, & Woodward, 2021, 6-year-olds, MacGowan, Mirabelli, Obhi, & Schmidt, 2022). While these studies indicate that children make more errors in incongruent than congruent trials, they failed to replicate the differences in reaction times. For example, in the study by MacGowan et al. (2022), children saw a model's hand lifting either the middle or the index finger. They were asked to hold down buttons with their index and middle fingers and lift one of their fingers in response to a numerical cue appearing. The results indicate lower error rates when children's response finger matched the finger lifted by the model (congruent trials) compared to when the response finger and finger lifted differed (incongruent trials). However, the study found no significant differences in children's reaction times between congruent and incongruent trials.

The present study

There is strong support for the validity of automatic-imitation paradigms in adults, in particular for imitation-inhibition tasks in that they are shown to measure covert imitative response tendencies (Cracco & Brass, 2019). These tasks create more reliable effects than mimicry tasks (Genschow et al., 2017) and have several advantages: Imitation-inhibition tasks can be implemented as within-subject tasks with high experimental controllability (Rauchbauer & Grosbras, 2020), and are suitable for neural measures such as electroencephalography (Deschrijver, Wiersema, & Brass, 2016) or functional magnetic resonance imaging (Brass, Ruby, & Spengler, 2009).

The aim of this study was to assess the feasibility of an imitation-inhibition task in children. The successful application to a young developmental population would allow us to use it in future lifespan research and compare the behaviour of different age groups within the same task (Moersdorf et al., 2022). In the present study, we assessed school-aged children's automatic imitation with a classical imitation-inhibition task (Brass et al., 2000; Brass et al., 2001) and compared the emerging result patterns in child and adult samples within the same task. In contrast to previous studies (Brezack et al., 2021; MacGowan et al., 2022), we used a child hand model in the task and additionally measured the participating children's handedness ensuring that they were dominant in the same hand they observed in the task. The reason for this manipulation was to strengthen the perception–action link and, as a result, enhance possible facilitation and interference effects. That is, by making the observed movement more similar to the child's own movement, we created stimuli that should more easily activate the corresponding motor plan in the child. Furthermore, we included baseline trials in the imitation-inhibition task, in which participants observed no finger movement. This allows for measuring and comparing result patterns in children's and adults' reaction times and error rates in responding to symbolic cues without the interfering or facilitating effect of movement observation. Also, this permits disentangling whether participants show an interfering, or facilitating effect, or both.

Methods

Here, we report the findings of the first part of a study which explored the effect of perceived similarity on children's automatic imitation. In this study, automatic imitation was assessed twice: Once at the beginning of the study and once after the manipulation of perceived similarity. Children were randomly assigned to one of two between-subject conditions (i.e., Similar and Dissimilar Condition). The two groups of children differed in their automatic imitation before the manipulation of perceived similarity. This made conducting the pre-registered analyses challenging. We, therefore, decided to describe the findings of this study elsewhere (PsyArXiv, https://psyarxiv.com/6k5hy) and limited the analysis reported here to the first measurement of children's automatic imitation. We preregistered the study (https://osf.io/bneau) and made the collected data and analysis codes available on the Open Science Framework (OSF, https://osf.io/q75xs/).

Participants

We recruited a sample of $N = 101$ children ($n = 52$ girls, $n = 49$ boys) at the age of 7.25 to 8.55 years ($M_{age} = 92.57, SD_{age} = 3.28$ months) from a medium-sized city in Switzerland.[2] All children were right-handed, had normal or corrected-to-normal vision, and had no diagnosed developmental disorders as reported by the caregivers. From the overall sample, $n = 94$ children were included in the automatic-imitation analyses (see Table 1). For these analyses, we excluded $n = 7$ children due to ambidexterity ($n = 4$) or because they met the exclusion criteria in the adapted imitation-inhibition task ($n = 3$; see section Imitation-Inhibition Task). In addition, $N = 10$ adults (6 females and 4 males, $M_{age} = 38.82, SD_{age} = 14.62$ years) participated in the imitation-inhibition task. All adults were right-handed and had normal or corrected-to-normal vision.

The children were recruited from the database of the research unit Developmental Psychology: Infancy and Childhood of the University of Zurich. The database contains contact data of children whose caregivers signed up to participate in developmental studies. Adult participants were recruited among the research unit staff. The participating children received a small gift (approximately 5$ in value) and a personalised certificate for participating in the study. The children's caregivers and the adult participants, respectively, gave informed written consent. The study was approved by the ethics committee of the UZH Faculty of Arts and Social Sciences. All procedures were performed in accordance with the ethical standards of the 1964 Helsinki Declaration and its later amendments.

The sample size was determined based on an a priori power analysis for the effect of perceived similarity on children's automatic imitation (see https://psyarxiv.com/6k5hy). Because we are focusing on children's automatic imitation in this paper, we ran an additional sensitivity analysis for a repeated-measures ANOVA. With our final sample size of $N = 94$ children, an alpha level of 0.05, and an assumed power of 0.80, we could have detected an effect of $d = 0.15$. This is even smaller than the effect size for automatic imitation tasks with adults reported in a recent meta-analysis ($d = 0.95$; Cracco et al., 2018).

Procedure

All children were tested individually with at least one caregiver present. One test session lasted up to 45 min. The experimenter welcomed the children and their caregivers in the research unit's playroom, where the caregiver read and signed the informed consent form while the experimenter played with the child. The experimenter then asked the child and the caregiver to move to the laboratory. The laboratory was unfurnished except for the test equipment. The child sat at a table across from the experimenter. The caregivers were seated on a chair behind the child and filled out a questionnaire. This questionnaire contained demographic questions about the participants, including their age, gender, socioeconomic status (approximated through the caregivers' highest level of education, current occupation and income), nationality, fine and gross motor skills (Daum et al., 2021), and social understanding (CSUS; Tahiroglu et al., 2014). This data is not analysed in this study.

All children completed the tasks in the same order. First, children's automatic imitation was measured with an adapted version of the imitation-inhibition task by Brass et al. (2000) (*neutral phase*). Then, a manipulation of the perceived similarity with the hand model, the measurement of children's handedness (adapted version of Oldfield, 1971), and a second measurement of the imitation-inhibition task (*test phase*) followed. Furthermore, we performed a manipulation check and a Simon Task (adapted from Iani, Stella, & Rubichi, 2014; Mandich, Buckolz, & Polatajko, 2002) with the children. The analyses in this paper only include the first measurement of children's automatic imitation (i.e., neutral phase; for the analyses of the other tasks see https://psyarxiv.com/6k5hy). Adults performed the imitation-inhibition task only. They were tested individually in the same laboratory and with the same task and material as the children.

[2] We pre-registered to test first-graders attending primary school for at least half a year to ensure that their fine motor skills and hand-eye-coordination were already developed enough to perform the imitation-inhibition task. However, data collection was delayed and started right before the summer holidays. For this reason, we also tested second-graders.

Table 1
Sample characteristics of included and excluded children.

Children	n	n_{female}	$M(SD)_{age}$	$M(SD)_{handedness}$	$M(SD)_{education}$	$M(SD)_{income}$
Included	94	50	92.65(3.37)	86.20(15.56)	6.58(1.66)	6.40(1.77)
Excluded	7	2	91.60(1.01)	47.57(39.96)	7.07(2.23)	5.14(2.73)

Note. The levels of caregivers' education were 1 = no school-leaving certificate, 2 = obligatory school, 3 = vocational training, 4 = vocational/technical/business baccalaureate, 5 = baccalaureate degree, 6 = higher technical and vocational education, 7 = bachelor's degree, 8 = master's degree, 9 = PhD. Monthly income levels included 1 = less than CHF 2'000, 2 = 2'000–4'000, 3 = 4'000–6'000, 4 = 6'000–8'000, 5 = 8'000–10'000, 6 = 10'000–12'000, 7 = 12'000–14'000, 8 = 14'000–16'000, 9 = more than 16'000.

Materials and design

Imitation-inhibition task

Automatic imitation was assessed with an adapted version of the imitation-inhibition task by Brass et al. (2000) on a laptop (17" Lenovo Yoga C740-15IML). Stimuli were presented via a PychoPy2 script (Peirce et al., 2019). The participants placed their index and middle finger on the "N" and "M" keys of the keyboard and saw the hand of a similar-aged child on the screen either moving the index or the middle finger down (see Fig. 1). Meanwhile, a cross appeared on the fingernail of either the index or middle finger indicating which finger the participants needed to move down to press a key in response (adapted "spatial finger-cue condition" in Experiment 2, Brass et al., 2000). The task started with 12 training trials with feedback and the possibility to ask questions. This was followed by 90 experimental trials consisting of 30 trials per trial type (i.e., congruent, incongruent, and baseline trials). In congruent trials, the cross appeared on the fingernail of the moving finger. In incongruent trials, the cross and the moving finger differed. In baseline trials, the cross appeared, but no finger moved. The order of trial type (congruent vs. incongruent vs. baseline) and relevant finger (index finger vs. middle finger) were randomised for every participant, with a maximum of three stimulus-event repetitions (according to Brass et al., 2000). To engage children in the task, we showed them a short animated video of a marble being tossed into a jar every 18 trials.

We compared mean reaction times and error rates in baseline, congruent, and incongruent trials to assess whether participants showed automatic imitation. Furthermore, in line with MacGowan et al. (2022), we calculated the inverse efficiency by dividing reaction times by the proportion of correct responses (see also Bruyer & Brysbaert, 2011). We included participants in the analyses if they performed at least 7 of the 12 training trials correctly. We excluded training trials and any trial in which the participants responded very fast (< 100 ms) or very slow (> 1000 ms) (Epstein et al., 2011; Kiselev, Espy, & Sheffield, 2009; Mandich et al., 2002). Furthermore, any trial in which the participants pressed the wrong key was excluded from the analyses of the reaction times (Brass et al., 2000; Genschow et al., 2021). Finally, we excluded participants if they contributed less than 9 trials per trial type and finger (Genschow et al., 2021; Wermelinger et al., 2017). On average, children included in the data analysis provided $M = 81.86$ valid trials ($SD = 4.96, min = 59, max = 90$).

Assessment of handedness

Children's handedness was assessed with the Oldfield Handedness Inventory (1971) and calculated according to the manual (Oldfield, 1971). The experimenter read the questions and asked the child to perform the according actions (e.g., "With which hand do you hold the toothbrush when brushing your teeth? Please show me."). The resulting handedness score can range from -100 (strong left-handed dominance) to 100 (strong right-handed dominance). A score under -40 indicates left-handedness, a score between -40 to +40 indicates ambidexterity, and a score over +40 indicates right-handedness. We excluded children with a handedness score below 40 from the analyses to ensure right-handedness.

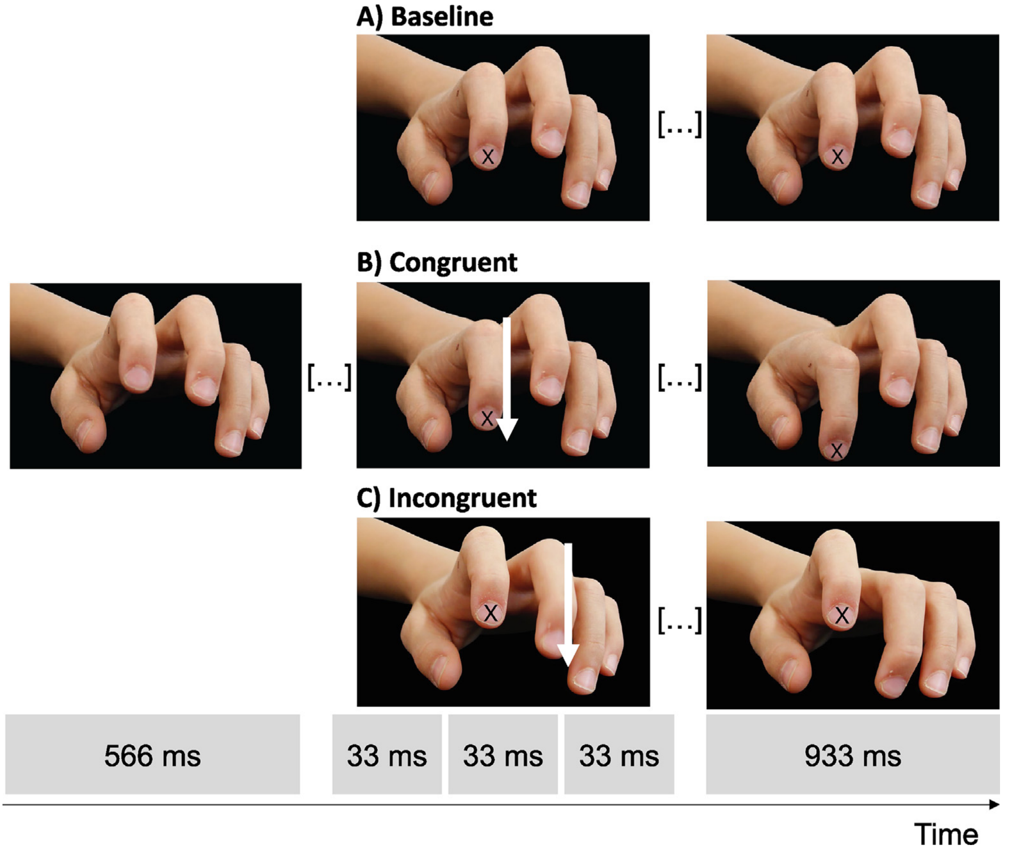

Fig. 1. Each trial had a duration of 1'600 ms and consisted of a sequence of five pictures. Between the trials, a fixation cross was shown in the middle of the screen for 1'840 ms. There were three different trial types: (A) baseline, (B) congruent, and (C) incongruent trials. Children were asked to respond with the finger on which the cross appeared. In the example illustrated, the index finger is the response finger in all trials. Please note that the white arrows indicate the finger movements and were not present in the stimuli shown to the children.

Analyses

To determine if there are significant differences in reaction times (RTs), error rates (ERs), and inverse efficiencies (IEs) among congruent, incongruent, and baseline trials, we utilised two repeated-measures ANOVAs (for RTs and IEs) and one Friedman test (for the ERs) for the child and adult data, respectively, because the normality assumption was not met. For post hoc pairwise comparisons, we calculated paired t-tests and Wilcoxon signed-rank tests applying Bonferroni correction for multiple testing. [3]

[3] We pre-registered to only evaluate children's reaction times with t-tests between congruent and incongruent trials (see https://osf.io/bneau). Because we were focusing on automatic imitation in our current analyses, we also included error rates and inverse efficiencies (in line with MacGowan et al., 2022), baseline trials (in line with Brass et al., 2000), and adults' behaviour for a more comprehensive picture.

Results

The descriptive statistics for the reaction times, error rates, and inverse efficiencies of the child and adult samples are reported in Table 2. For graphical depictions, see Figs. 2 and 3.

Child sample

For children's reaction times, there was an overall effect of trial type, $F(2,184) = 99.91, p < .001, \eta_p^2 = 0.52$. Post-hoc pairwise comparisons revealed significantly faster reaction times in congruent than incongruent trials, $t(93) = -11.57, p < .001, d = -1.19$, and in base-

Table 2
Descriptive statistics for the reaction times, error rates, and inverse efficiencies of the child and adults samples.

Indicator	$M(SD)_{base}$	$M(SD)_{cong}$	$M(SD)_{incong}$
		Child Sample	
Reaction Times	558.84(65.53)	554.92(64.11)	604.07(69.55)
Error Rates	0.03(0.05)	0.03(0.05)	0.07(0.07)
Inverse Efficiencies	576.18(68.71)	573.04(62.33)	647.95(70.62)
		Adult Sample	
Reaction Times	402.56(40.70)	406.71(44.48)	434.95(50.15)
Error Rates	<0.01(0.01)	0.01(0.01)	0.01(0.02)
Inverse Efficiencies	404.01(41.13)	409.60(45.88)	438.76(44.23)

Note. "base", "cong" and "incong" indicate the mean and standard deviation of the baseline, congruent and incongruent trial types respectively.

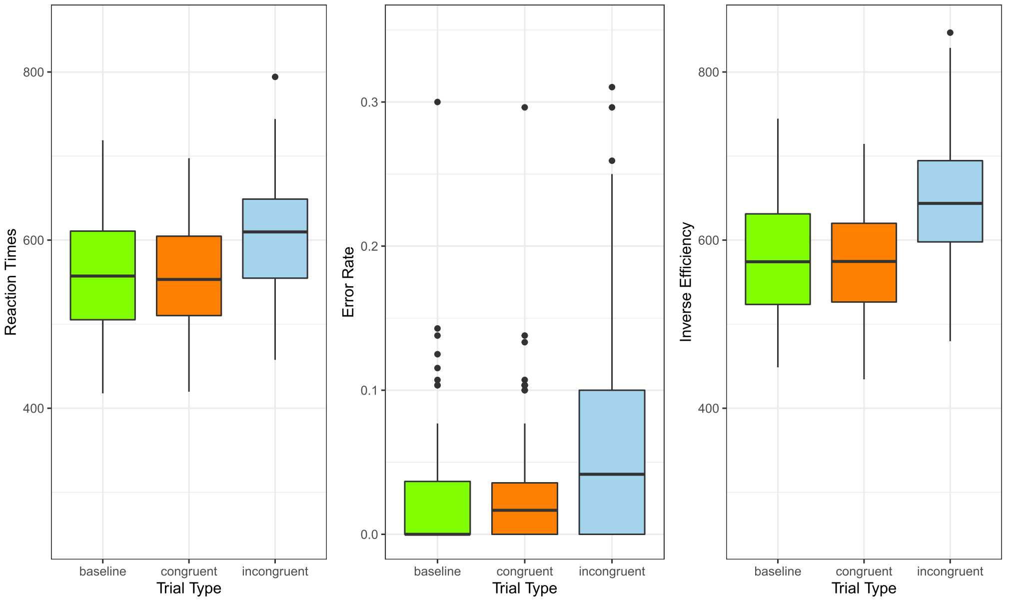

Fig. 2. Overview of children's reaction times, error rates, and inverse efficiencies by trial type.

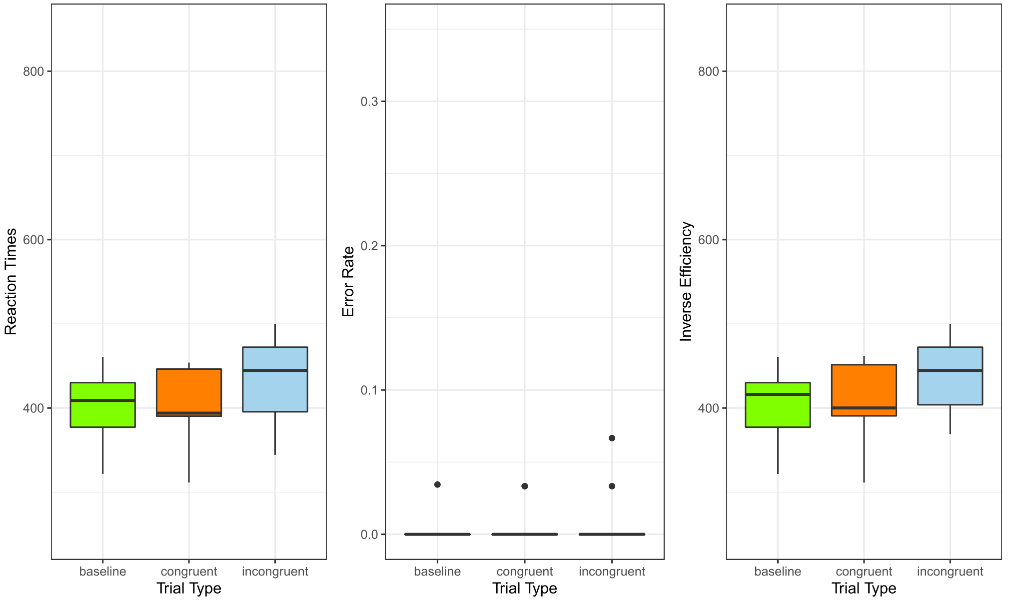

Fig. 3. Overview of adults' reaction times, error rates, and inverse efficiencies by trial type.

line compared to incongruent trials, $t(93) = -12.00, p < .001, d = -1.24$, but no significant difference between congruent and baseline trials, $t(93) = 1.05, p = .888, d = 0.11$ (see Fig. 2)[4].

Similarly, the error rates differed between trial types, $\chi^2(2) = 32.2, p < .001, W = 0.17$. Post-hoc pairwise comparisons showed significantly smaller error rates in congruent than incongruent trials, $z = -5.39, p < .001, r = .58$, and in baseline than incongruent trials, $z = -5.16, p < .001, r = .52$, but no significant difference between congruent and baseline trials, $z < 0.001, p = 1.00, r = .03$.

Finally, the inverse efficiencies also differed between trial types, $F(1.82, 186.92) = 118.68, p < .001, \eta_p^2 = 0.56$ (after sphericity correction). More specifically, inverse efficiencies were significantly lower in congruent than incongruent trials, $t(93) = -13.57, p < .001, d = -1.40$, and in baseline than incongruent trials, $t(93) = -11.57, p < .001, d = -1.19$, but not significantly different between congruent and baseline trials, $t(93) = 0.67, p = 1.00, d = 0.07$.

Adult sample

In the adult sample, reaction times differed overall between trial types, $F(2, 18) = 8.07$, $p = .003, \eta_p^2 = 0.47$. Post-hoc pairwise comparisons revealed significantly faster reaction times in baseline than incongruent trials, $t(9) = -3.37, p = .025, d = -1.06$, but no significant difference between congruent and incongruent trials, $t(9) = -2.70, p = .074, d = -0.85$, and congruent and baseline trials, $t(9) = -0.78, p = 1.00, d = -0.25$, after correcting for multiple testing (see Fig. 3).

The overall error rates did not significantly differ between trial types, $\chi^2(2) = 0.4, p = .819$, $W = 0.03$. The inverse efficiencies differed between trial types, $F(2, 18) = 8.01, p = .003, \eta_p^2 = 0.47$. Specifically, inverse efficiencies were significantly lower in baseline than incongruent trials, $t(9) = -3.79, p = .013, d = -1.20$, but did not differ significantly between congruent and incongruent

[4] Differences in trial type were also present when considering both groups of children of the full project (Similar and Dissimilar Condition) separately. However, the difference between congruent and incongruent trials was significantly larger in the Similar compared to the Dissimilar Condition, and the RTs in baseline compared to congruent trials only differed significantly in children in the Similar Condition. As reported elsewhere (see https://psyarxiv.com/6k5hy), this was due to differences in baseline RTs.

trials, $t(9) = -2.49, p = .103, d = -0.79$, or congruent and baseline trials, $t(9) = -0.89, p = 1.00$, $d = -0.28$, after correcting for multiple testing.

Discussion

Humans strive to be part of a group (Baumeister & Leary, 1995). This need to belong can explain why we affiliate with others, for instance through imitation (Nielsen & Blank, 2011; Over & Carpenter, 2009; Hopkins & Branigan, 2020). So far, researchers have measured imitation using different methods in children and adults. In this study, we investigated whether one form of imitation, that is automatic imitation, can be measured with a classical imitation-inhibition task (Brass et al., 2000; Brass et al., 2001) in school-aged children as in adults. In line with the typical findings of adult studies (Cracco et al., 2018), children's results show significantly faster reaction times, lower error rates, and inverse efficiencies in congruent than incongruent trials, and in baseline compared to incongruent trials. We found a similar pattern for adults' behaviour in the same task, with significant differences in reaction times and inverse efficiencies between baseline and incongruent trials. While the reaction times of congruent and incongruent trials failed to show significant differences after correcting for multiple testing (uncorrected $p = .025$, corrected $p = .074$), they were numerically in line with the original findings by Brass et al. (2000).

Compared to previous work (Brezack et al., 2021; MacGowan et al., 2022), we substantially increased the size of the child sample, increasing the power to detect effect sizes reported in adult literature (Cracco et al., 2018). Furthermore, we used stimuli with children's hands and ensured that children were right-handed to increase the perception–action link (Greenwald, 1970; Prinz, 1990; Prinz, 1997; Brass & Heyes, 2005). These changes probably increased the perceived similarity between the observer and the model, and strengthened the perception–action link. They may also explain, why our results differ from previous work (Brezack et al., 2021; MacGowan et al., 2022) using adult hands as stimuli. That is, in contrast to previous work with slightly younger children (6.5-year-olds; MacGowan et al., 2022), the children's responses in the current study differed between congruent and incongruent trials in both their reaction times and their error rates. Additionally, we included baseline trials, in which no finger movement occurred, similar to the original paradigm (Brass et al., 2000; Brass et al., 2001). Looking at children's behaviour in baseline, congruent, and incongruent trials showed that the differences between trials were mainly driven by slower reaction times and more errors in the incongruent trials than by faster reaction times and fewer errors in the congruent trials. Put differently, the participants exhibited an interference effect in incongruent trials but no facilitation effect in congruent trials (in line with Wermelinger et al., 2017). This was also mirrored in the adult sample. In sum, we found support that the imitation-inhibition task (Brass et al., 2000; Brass et al., 2001), originally designed for adults, feasibly measures automatic imitation in school-aged children. This provides the possibility to compare the behaviour of different age groups with the same task. For instance, future research may further investigate the proposed influences of motor abilities (Wermelinger et al., 2017), perceived similarity (Butler et al., 2015; Genschow et al., 2021), or prosociality (Leighton et al., 2010) on automatic imitation in participants from childhood to late adulthood.

Limitations

Some of the direct comparisons of trial types did not withstand correction for multiple comparisons (i.e., the difference between congruent and incongruent trials in the adult sample). This may be due to the small sample size of the adult sample (which is, however, comparable to Brass et al., 2000; Brass et al., 2001). But because previous work did not report whether such corrections were applied (e.g., Brass et al., 2000; Brass et al., 2001; MacGowan et al., 2022), it is not possible to determine if our results differ from their findings. Furthermore, we had to reduce the number of trials compared to previous studies (30 trials per trial type compared to 40 in Brass et al., 2000; 50 in MacGowan et al., 2022) to make the task more appealing for children and prevent exhaustion and boredom. Because we were able to replicate results typically found with adults, this reduction of trial number is unlikely to have had a substantial effect on the validity of the task.

Conclusion

The aim of this study was to develop a task to assess imitation via automatic imitation in children and adults. Our results suggest that this attempt was successful, as indicated by automatic imitation in 7–8-year-olds based on their reaction times and error rates. Using this task across the lifespan will help shed light on the development of automatic imitation.

Data availability

The collected data and analysis codes available on the Open Science Framework.

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