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The Role of Children's Finger Counting History on Their Addition Skills

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It has been established that whereas young children who use their fingers to solve arithmetic problems outperform those who do not, this trend reverses in older children around the age of 7. One possible interpretation is that finger counting is helpful for solving simple problems but becomes inadequate as problem complexity increases, leaving finger users reliant on strategies that are no longer efficient. Another possibility is that nonfinger users after the age of 7 are, in fact, ex-finger users who have already transitioned to efficient mental strategies. These contrasting interpretations carry significant theoretical and educational implications. In the first case, finger counting may be viewed as an ultimately limiting tool, potentially trapping children in immature strategies, and, in the second, as a powerful tool that has not only immediate benefit but also long-term positive effect on children's arithmetic development. To disentangle these interpretations, 192 children from middle to high socioeconomic status (mainly White, 96 girls) were followed from the age of 4.5 to 7.5 across seven testing points. While virtually all children were observed using their fingers at some point during the study, most nonfinger users by age of 6.5 were in fact ex-finger users. Importantly, they presented higher arithmetic performance than finger users and genuine nonfinger users of the same age. These original findings provide the first empirical evidence that finger counting acts as a developmental scaffold toward efficient mental arithmetic, rather than as a mere useful but limiting strategy eventually hindering development.

Public Significance Statement

This study reveals that children who use finger counting early on during math development have the strongest addition skills later on. Finger counting is, therefore, not just a tool for immediate success but also a way to support the development of advanced abstract arithmetic skills.

Keywords: numerical cognition, finger counting, mental arithmetic, longitudinal design, embodied cognition

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> Cognitive configurations do not depend solely on the existing "field," but also on the whole previous history of the acting subject. (Piaget, 1947/1950, p. 4)

Finger counting is widely used by young children when they solve arithmetic problems (Berteletti & Booth, 2016; Butterworth, 1999; Neveu et al., 2023; Poletti et al., 2023). As thoroughly documented by Cipora et al. (2023), the use of finger counting by humans can be traced back by archaeologists to as early as 30,000 years ago (Wiese, 2003) and is still observed across a wide range of cultures today (Ifrah, 1985). Finger counting is likely the origin of the base-10 numerical system found in most cultures and is considered by many researchers to be a fundamental tool in helping children develop an understanding of the number concept. Fingers may indeed serve as a transitional tool between analog representations of quantity and their symbolic counterparts (Andres et al., 2008). They can also help children grasp key counting principles, such as the one-to-one correspondence between number words and objects and the concept of cardinality (Fayol & Seron, 2005).

Still, finger counting is sometimes disapproved by educators and researchers, who can view it as a backup used by children who struggle to abstract numerical concepts and remain reliant on concrete strategies (Albayrak, 2010; Meljac & Charron, 2002; see Moeller et al., 2011 for a review of the literature). More precisely, a recent survey showed that 20% of French kindergarten teachers believe that finger use is typical of children in their classrooms who experience difficulties in learning mathematics. This percentage rises to 30% among Grade 1 teachers (Poletti et al., 2023). This view contradicts several research findings indicating that between the ages of 4 and 7.5, children who use their fingers in arithmetic tasks perform better than those who do not (Dupont-Boime & Thevenot, 2018;

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The data necessary to reproduce the analyses presented here are publicly accessible at https://osf.io/ny3va/?view_only=9161b19693ba48168068539 61c48e868. Sharing codes or materials do not apply to the present study. The analyses presented here were not preregistered.

Marie Krenger played a lead role in data curation, formal analysis, and investigation and an equal role in conceptualization, methodology, and writing–original draft. Catherine Thevenot played a lead role in supervision and an equal role in conceptualization, methodology, and writing–original draft.

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Jordan et al., 2008; Krenger & Thevenot, 2024). It is only around the age of 7.5–8 that the frequency of finger use starts to be negatively correlated with arithmetic performance (Jordan et al., 2008; Poletti et al., 2022). Based on this result, Jordan et al. (2008) concluded that whereas young children should be encouraged to use their fingers to calculate, "they might eventually be better served by calculating in their heads rather than on their hands" (p. 667). This statement can be interpreted in two ways. First, finger counting may become an inadequate and even hindering strategy when children grow older and face problems that can no longer be represented on their fingers. Alternatively, it may suggest that finger counting should be replaced by mental strategies as part of optimal development. Whatever the authors' intended meaning, such a claim is sustainable only if children's individual histories with finger use is considered, that is, whether or not they have used their fingers in the past. Indeed, a group of nonfinger users at a given point may include both children who have never used their fingers to solve problems in the past (i.e., genuine nonfinger users) and children who previously relied on finger counting but have since internalized the strategy (i.e., ex-finger users). Similarly, finger users at a certain point can comprise children who have only recently discover the strategy (i.e., newly finger users) and children who have been using it for some time (i.e., confirmed-finger users). This heterogeneity in the history of finger use within both groups can obscure the interpretation of previous findings in the literature and potentially lead to misleading conclusions. For example, Jordan et al. (2008) showed a negative correlation of -.15 between the frequency of finger use and arithmetic performance at the age of 8, but it is not known whether nonfinger users who outperform finger users correspond to genuine finger users or ex-finger users. Therefore, it is impossible to figure out why, at this point of development, nonfinger users outperform finger users. It could be because finger users remain reliant on a strategy that is no longer suited to more complex problems or because nonfinger users are in fact ex-finger users who have already efficiently internalized the strategy (Bagnoud et al., 2025). This ambiguity has important theoretical and educational implications. In the first scenario, finger use is hypothesized to be detrimental, as it may confine young children to limited strategies suitable only for simple problems. Accordingly, finger use should be approached with caution in educational settings. In contrast, in the second scenario, finger use is hypothesized to be beneficial, not only as an effective strategy for immediate success, but also as a means of supporting the development of meaningful mental arithmetic. The aim of the present research is to determine which hypotheses should be retained by considering children's finger-counting history, rather than relying solely on their current use of the strategy at a given point in time.

A first attempt in this direction was made by Krenger and Thevenot (2024), but their observations were limited to very young children aged from 4 to 5.5 across three testing points. The authors showed that children who had already abandoned the use of fingers to solve additions problems outperformed those who had not yet discovered the strategy. Still, at this stage of development, abandoning finger counting was always a bad strategic choice. It was attested by the fact that finger users always presented a higher level of performance compared with nonfinger users, whatever their history. Nonetheless, within a theoretical framework where finger counting paves the way toward mental strategies, it is possible that giving up the finger strategy later during development corresponds to a further step toward arithmetic fluency (Baroody, 1987; Berteletti & Booth, 2016; Thevenot et al., 2025). This hypothesis is tested in the present article by extending the longitudinal range of Krenger and Thevenot's observations to subsequent testing points.

Therefore, in the present study, the same children as in Krenger and Thevenot (2024) were followed further, with their behavior observed up to the age of 7.5 instead of 5.5. More precisely, they were first observed at their school entry (aged 4.5 at the start of 1 H in the Swiss education system) and were followed until the beginning of their fourth year of school (4 H in the Swiss education system, equivalent to Grade 2). Children were assessed on their performance and use of fingers in an addition task every 6 months, which resulted in seven testing points. This task consisted of four sets of additions, increasing in difficulty, with a stop criterion between sets. At each testing point, it was recorded whether children used their fingers to solve the problems, as well as whether they had done so at previous testing points. Thus, and as mentioned above, genuine nonfinger users as well as newly, confirmed- and ex-fingers users were identified at each testing point, and their performance in the addition task was compared.

We expect to replicate previous findings of the literature showing that, among young children, finger users outperform nonfinger users (Dupont-Boime & Thevenot, 2018; Jordan et al., 2008; Krenger & Thevenot, 2024). However, this pattern is expected to reverse later in development (Jordan et al., 2008; Poletti et al., 2022). More importantly, we hypothesize that the observed superiority of nonfinger users at later ages is driven by ex-finger users who have already internalized the finger strategy rather than by genuine nonfinger users. Our approach also enabled us to identify the typical age at which children begin and stop using their fingers to solve addition problems.

Method

Participants

A total of 211 children (108 girls) whose informed parental consent was obtained participated in our study. These children were predominantly White European and came from middle to relatively high socioeconomic backgrounds. They were recruited from schools in Vaud County, Switzerland. They were first observed at the beginning of their first year of school (prekindergarten; M_{age} = 4 years and 7 months, SD = 4 months) and tested every 6 months until the start of their fourth (Grade 2; M_{age} = 7 years and 7 months, SD = 4 months). Two children diagnosed with autism spectrum disorder did the activities playfully, and no data were collected. In addition, 15 children who did not speak French well enough to understand the tasks at the first testing point were excluded, but they could join the study once their French proficiency was deemed sufficient. The data from 13 of these children were kept in our analyses because they were nonfinger users at their first testing point. However, the data of two of these children were excluded because they used their fingers when we first tested them, and it was therefore impossible to determine whether they were newly or confirmed-finger users.

Due to the longitudinal design, some participants were lost as they moved away. However, children who were absent on the day of testing were assessed later during the same testing point session. In some testing points, technical issues with video recordings prevented data collection, resulting in the exclusion of the data from those participants. This data loss was entirely random and therefore did not bias the representativeness of our sample. The precise sample size, along with age and grade at each testing point, is presented in Table 1.

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Table 1

School Grade and Sample Description (Number of Females, Exclusion Details, Mean Age [Year; Month], Mean Age [Month] and Standard Deviation, Maximum, and Minimum Age) at Each Testing Point

	Prekindergarten		Kindergarten		Grade 1		Grade 2
Sample description	Beginning (T1)	End (T2)	Beginning (T3)	End (T4)	Beginning (T5)	End (T6)	Beginning (T7)
Sample size (*N*)	192	190	187	182	163	164	163
N female	96	98	97	93	89	87	88
N of exclusion	17	19	22	27	46	45	46
Limited French proficiency	15	10	2	1	1	1	1
Missing data	2	3	2	2	5	1	
Have moved out		4	16	22	38	41	43
Age							
Year; Month							
M	4; 7	5; 1	5; 7	6; 2	6; 7	7; 1	7; 7
Month							
M	55.68	60.94	66.74	74.34	78.96	84.73	91.30
SD	3.78	3.77	3.80	3.76	3.82	3.79	3.76
Min	46	51	57	65	70	75	82
Max	62	68	74	82	86	92	98

Note. One child was not proficient in French at T1 and T2 and moved away before T3. Their data were therefore not included in the analyses. T = testing time point; Min. = minimum; Max. = maximum.

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The study received ethical approval from the Ethics Committee of the Faculty of Social and Political Sciences at the University of Lausanne (Commission Interdisciplinaire d'Ethique de la Recherche; Project number: E_SSP_05202 1_00003) and from the Committee for Research in Education of the Vaud Canton (Comité de Coordination de la Recherche; Décision 102).

Material and Procedure

Addition Task

In the addition task, children were asked to orally solve addition problems, each presented in Arabic numerals on individual A5-sized article cards. No time limit was imposed, and no specific instructions were given regarding the use of fingers. If children inquired about using their fingers or if discrete finger use was observed, the experimenter stated that they were free to do so. Given the young age of children and their potential difficulty in reading numbers in a symbolic format in the first testing points, the additions were read aloud by the experimenter, except when children started to solve the addition as soon as the card was presented. When children said that they did not know the answer, the experimenter encouraged them to try to solve it by saying, "How could you know the answer?"

The addition task consisted of four sets of addition of increasing difficulty, but only the first two sets were used to determine whether children were finger users. All children were presented with a first set consisting of 10 addition problems, with both operands ranging from 1 to 5. All five tie additions in this range were included (i.e., 1 + 1, 2 + 2, 3 + 3, 4 + 4, and 5 + 5). For nontie additions, each digit was presented twice across problems, and the smaller operand was always presented first (i.e., 1 + 2, 2 + 3, 3 + 4, 4 + 5, 1 + 5). Only children who solved correctly at least eight additions out of 10 were presented with the second set. This second set consisted of eight additions with the first operand between 1 and 5 and the second operand between 6 and 9, with sums ranging from 8 to 13. All complements to 10 within this range were included (i.e., 1 + 9, 2 + 8, 3 + 7, and 4 + 6), and the remaining additions were selected to ensure that each operand appeared the same number of times (e.g., 2 + 6, 3 + 8, 4 + 9, and 5 + 7). Only children who solved correctly at least six additions out of eight were presented with the next set. This third set consisted of eight additions with both operands between 6 and 9. Children who solved correctly at least six additions out of eight were presented with the last set of problems consisting of 20 additions with at least one two-digit number and sums up to 37. The score in the addition task corresponded to the number of correctly solved additions across all four sets, with a maximum score of 46 points.

The task was videotaped to allow for retrospective analysis of the strategies children used to solve the additions. Their answers and their use of fingers were coded using the software BORIS (v. 7.4.11—2019–02-28; Friard & Gamba, 2016). Children were classified as finger users when they visibly moved their fingers while solving the problems at least once on the two first sets of additions. To ensure coding reliability, an independent rater was asked to code 1,140 observations (6.35% of our observations). The interrater agreement was 99% on the identification of whether the addition was solved with fingers ($k = .968$, $z = 32.7$, $p < .001$), indicating a high level of coding reliability.

Moreover, the specific type of finger strategy used was identified for each problem. A *counting-all* strategy was coded when the child represented both operands on their fingers and determined the total in a separate step (e.g., for 3 + 2, the child raised three fingers on one hand, two fingers on the other, then counted all the raised fingers: 1, 2, 3, 4, 5). A *concrete counting-on* strategy was coded when both operands were represented on fingers, but the child continued counting from the first operand in a single, continuous process to reach the sum (e.g., for 3 + 2, the child raised three fingers, then raised two more while counting: 4, 5). Finally, a *counting-on* strategy was coded when only one operand was represented on fingers, and counting started from the other operand to directly reach the sum (e.g., for 3 + 2, the child started from 3 and counted 4, 5 while raising two fingers). When the strategy did not fit into this accepted

classification (Baroody, 1987; Carpenter & Moser, 1984), it was coded as *other*.

Transparency and Openness Statements

The sample size was determined by the number of children whose informed parental consent was obtained. All data exclusions and manipulations are fully described here. Data analysis was conducted using Jamovi (Version 2.6.26.0). Neither the study design nor the analyses were preregistered. As noted in the introduction, part of the data, specifically related to the first three testing points (out of seven in the present research), was previously presented in Krenger and Thevenot (2024) for different purposes. The data set used for the following analyses is accessible on the Open Science Framework at Krenger and Thevenot (2025b, https://osf.io/ny3va/?view_only=9161b19693ba4816806853961c48e868).

Results

Numbers of Children Across Addition Sets

The numbers of children who were presented with one, two, three, or four sets in the addition task are reported in Table 2. Until T3, the majority of children completed only Set 1 (94% at T1, 81% at T2, 63% at T3). At T4 and T5, most children completed at least Set 1 and Set 2 (70% at T4 and 80% at T5). By T6, the majority reached Set 3 (84%) and at T7, most children completed all four addition sets (81%).

Numbers of Finger Users and Nonfinger Users Across Testing Points

The numbers of finger users and nonfinger users at each testing point are presented in Table 3. For each testing point, Table 3 also details whether nonfinger users had been observed using their fingers in a previous testing point (i.e., ex-finger users) or not (i.e., genuine nonfinger users). Similarly, it indicates whether finger users had already been observed using their fingers in a previous testing point (i.e., confirmed-finger users) or were using them for the first time (i.e., newly finger users).

A series of binomial tests on proportions revealed that nonfinger users outnumbered finger users until T3, when children were 5.5 years old (82.8% of nonfinger users vs. 17.2% of finger users at T1, $p < .001$; 76.3% of nonfinger users vs. 23.7% of finger users at T2, $p < .001$; 60.4% of nonfinger users vs. 39.6% of finger users at T3, $p = .005$). On the opposite, at T4 and T5, when children were aged 6 to 6.5, the majority of our sample was constituted of finger users (39% of nonfinger users vs. 61% of finger users at T4, $p = .004$; 33.1% of nonfinger users vs. 66.9% of finger users at T5, $p < .001$). At T6 and T7, the proportions of finger users and nonfinger users were approximately equal (50.6% of nonfinger users vs. 49.4% of finger users at T6, $p = .938$; 50.9% of nonfinger users vs. 49.1% of finger users at T7, $p = .876$).

Out of curiosity, we examined whether the number of boys and girls using their fingers differed across testing points. Whereas it was not significantly the case until T5, 20 boys versus 13 girls at T1, $\chi^2(1, N = 192) = 1.79$, $p = .181$; 26 boys versus 19 girls at T2, $\chi^2(1, N = 190) = 1.63$, $p = .202$; 40 boys versus 34 girls at T3, $\chi^2(1, N = 187) = 1.16$, $p = .282$; 61 girls versus 50 boys at T4, $\chi^2(1, N = 182) = 2.79$, $p = .095$; and 63 girls versus 46 boys at T5, $\chi^2(1, N = 163) = 2.59$, $p = .108$), the number of girls using their fingers was higher than the numbers of boys at T6 and T7, 49 girls versus 32 boys at T6, $\chi^2(1, N = 164) = 4.81$, $p = .014$, and 50 girls versus 30 boys at T7, $\chi^2(1, N = 163) = 5.98$, $p = .014$.

Back to the whole sample of children and concerning our central question, Figure 1 shows that the numbers of newly finger users increased steadily across testing points, peaking at T4 when children were aged 6. Indeed, more than half of the genuine nonfinger users at T3 became newly finger users at T4 (53.7%). This important increase in newly finger users gave rise to 60.8% of children being classified as finger users at T4. This proportion of finger users continued to rise, reaching its peak at T5, with 67% of finger users. By T5, when children were 6.5, nearly all children (87.9% at T5, 92.2% at T6, and 92.7% at T7) had used their fingers at least one testing point before. Between T5 and T6, when children are 7 years old, the population of ex-finger users doubled (from 34 children at T5 to 70 at T6). Consequently, from T5 onward, the group of nonfinger users primarily consisted of ex-finger users. In fact, only 12 children out of 165 at T7 (7.3% of the sample) had never been observed using their fingers across testing points (see Appendix for a description of their performance at an individual level).

To describe our object of study precisely, Table 4 reports the percentages of the different finger strategies used by children. Up to T5, the most frequently used strategy was counting-all, followed by concrete counting-on. Until this point, the counting-on strategy was almost never used, but it became dominant at T7. Table 5 presents the percentages of finger use depending on various problem characteristics (i.e., problems with both or one operand under five, problems with sum under or above 10, tie or nontie problems, complement to 10 problems, or "+1" problems).

Table 2
Numbers of Children Presented With Sets 1, 2, 3, and 4 at Each Testing Point

Number	T1	T2	T3	T4	T5	T6	T7
Total	192	190	187	182	163	164	163
Set 1 only	180	154	118	55	33	4	1
Sets 1 and 2	8	30	47	66	62	22	4
Sets 1, 2, and 3	4	4	16	38	30	41	26
Sets 1, 2, 3, and 4		2	6	23	38	97	132

Note. All children were presented with Set 1. Only those who solved eight additions out of 10 in Set 1 were presented with Set 2. Then, only those who solved six additions out of eight in Set 2 were presented with Set 3. Finally, only those who solved six additions out of eight in Set 3 were presented with Set 4. T = time.

Accuracy in the Addition Task

A 2 (finger use: finger users, nonfinger users) × 7 (testing point: T1–T7) analysis of variance (ANOVA) was conducted on the percentages of correct responses in the addition task, with both variables considered as fixed factors. The main effect of testing point was significant, $F(6, 1217) = 305.29$, $\eta_p^2 = 0.601$, $p < .001$, showing that children's performance increased across testing points. The main effect of finger use was also significant, $F(1, 1217) = 9.42$, $\eta_p^2 = 0.008$, $p = .002$, indicating that finger users outperformed nonfinger users. Moreover, the interaction between testing point and finger use was significant, $F(6, 1217) = 9.77$, $\eta_p^2 = 0.046$, $p < .001$, indicating

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Table 3

Numbers of Fingers Users, Among Which Newly Finger Users and Confirmed-Finger Users, and Numbers of Nonfinger Users, Among Which Genuine Nonfinger Users and Ex-Finger Users, at Each Testing Point

Number of children	T1 4.5 years old	T2 5 years old	T3 5.5 years old	T4 6 years old	T5 6.5 years old	T6 7 years old	T7 7.5 years old
Total	192	190	187	182	163	164	163
Nonfinger users	159	145	113	71	54	83	83
Ex-finger users		13	18	28	34	70	71
Genuine nonfinger users	159	132	95	43	20	13	12
Finger users	33	45	74	111	109	81	80
Newly finger users	33	27	36	51	17	7	1
Confirmed-finger users		18	38	60	92	74	79

Note. Among nonfinger users, *ex-finger users* are children who were observed using their fingers at a previous testing point, whereas *genuine nonfinger users* have never been observed using their fingers. Among finger users, *newly finger users* are children who had not been observed using their fingers at any previous testing point, whereas *confirmed-finger users* had already been observed using them before. T = time.

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that finger users outperformed nonfinger users up to T5, but it is the opposite from T6, when children are 7 years old, with nonfinger users outperforming finger users (see Figure 2).

The previous analysis did not take into account children's history. In other words, whether or not nonfinger users had used their fingers in a previous testing point (i.e., ex-finger users or genuine nonfinger users), or whether or not finger users used their fingers for the first time (i.e., newly finger users or confirmed-finger users) was not considered. However, as shown in Figure 1 and described in the previous section, the sample of nonfinger users from T5 onward was mainly composed of ex-finger users. Therefore, to take into account the history of children's concerning finger use, a series of one-way ANOVA was conducted on the percentage of correct responses in the addition task at each testing point from T2 to T5, with group (i.e., genuine nonfinger users, ex-finger users, confirmed-finger users, newly finger users) considered as fixed factor. As described in the previous section, a small group of 12 children never used their fingers across all testing points. Since this group might include two distinct profiles (i.e., children who mastered addition mentally before the beginning of our study and children who experienced difficulties with addition), they were excluded from the analyses (note that the analyses have also been conducted including this particular group, and the results remained consistent with those that will be presented in the following paragraph).[1] At T6, there was only one genuine nonfinger user left, who became a newly finger user at T7. As the unique representative of genuine nonfinger users at T6 and newly finger users at T7, this child had to be excluded from the analysis at both testing points. Consequently, the ANOVA at T6 included only ex-finger users, confirmed-finger users, and newly finger users, while at T7, a *t* test compared the percentages of correct responses of ex-finger users and confirmed-finger users.

At T2, when children were 5 years old, the effect of group was significant, $F(3, 175) = 23.3$, $\eta_p^2 = 0.285$, $p < .001$, showing that genuine nonfinger users were outperformed (4.2%) by confirmed-finger users, 21.1%, −17.0%, $t(175) = 6.445$, $d = 1.628$, $p < .001$; newly finger users, 16.6%, −12.4%, $t(175) = 5.601$, $d = 1.192$, $p < .001$; and ex-finger users, 15.7%, -11.6%, $t(175) = 3.799$, $d = 1.108$, $p = .001$. There was no significant difference between newly, confirmed-, or ex-finger users (see Figure 3). At T3, the effect of group was significant, $F(3, 172) = 28.3$, $\eta_p^2 = 0.330$, $p < .001$, showing that genuine nonfinger users were outperformed (5.0%) by confirmed-finger users, 26.7%, −21.7%, $t(172) = 8.119$, $d = 1.587$, $p < .001$; newly finger users, 19.8%, -14.7%, $t(172) = 5.408$, $d = 1.077$, $p < .001$; and ex-finger users, 24.0%, −19.0%, $t(172) = 5.356$, $d = 1.391$, $p < .001$. There was no significant difference between newly, confirmed-, or ex-finger users.

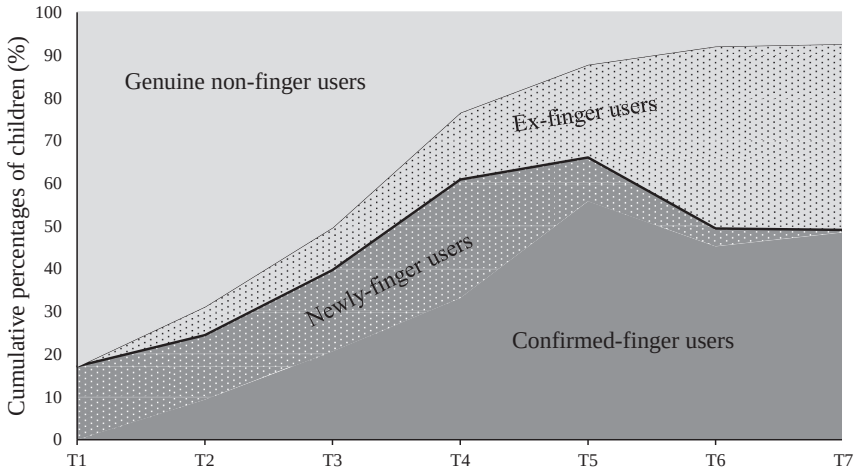
At T4, the effect of group was significant, $F(3, 164) = 21.2$, $\eta_p^2 = 0.280$, $p < .001$, showing that genuine nonfinger users were outperformed (10.7%) by confirmed-finger users, 40.6%, −29.8% pts, $t(164) = 7.053$, $d = 1.565$, $p < .001$; newly finger users, 25.0%, −14.3%, $t(164) = 3.291$, $d = 0.749$, $p = .007$; and ex-finger users, 41.9%, −31.2%, $t(164) = 6.219$, $d = 1.637$, $p < .001$. As illustrated in Figure 3, the newly finger users were outperformed by confirmed, −15.6%, $t(164) = 4.263$, $d = 0.815$, $p < .001$, and ex-finger users, −16.9%, $t(164) = 3.729$, $d = 0.888$, $p = .001$. There was no significant difference between confirmed- and ex-finger users, $t(164) = 0.312$, $d = 0.072$, $p = .989$. At T5, when children are 6.5 years old, the effect of group was significant, $F(3, 141) = 4.13$, $\eta_p^2 = 0.081$, $p = .008$, showing that genuine nonfinger users were outperformed (11.7%) by confirmed-finger users, 41.5%, -29.8%, $t(141) = 3.159$, $d = 1.166$, $p = .010$, and ex-finger users, 44.7%, -33.1% pts, $t(141) = 3.283$, $d = 1.294$, $p = .007$. The difference between genuine nonfinger users and newly finger users was not significant, 33.2%, -21.5%, $t(141) = 1.941$, $d = 0.840$, $p = .216$, nor was the difference between newly finger users and confirmed-finger users, −8.3%, $t(141) = 1.199$, $d = 0.326$, $p = .628$; between newly finger users and ex-finger users, −11.6%, $t(141) = 1.488$, $d = 0.447$, $p = .453$; and between confirmed-finger users and ex-finger users, −3.3%, $t(141) = 0.624$, $d = 0.127$, $p = .924$.

At T6, when children were 7 years old, there was only one genuine nonfinger user (33% of the additions solved correctly), who had therefore to be excluded from the ANOVA. The effect of group was significant, $F(2, 147) = 5.13$, $\eta_p^2 = 0.065$, $p = .007$, showing that ex-finger users outperformed (71.4%) confirmed-finger users,

[1] The following analysis has also been conducted with the 12 children as part of the genuine nonfinger user group whose scores in that addition task can be found in the Appendix. Results showed a significant effect of group at all testing points, $F(3, 186) = 22.2$, $\eta_p^2 = 0.263$, $p < .001$ at T2; $F(3, 183) = 17.8$, $\eta_p^2 = 0.226$, $p < .001$ at T3; $F(3, 175) = 15.3$, $\eta_p^2 = 0.207$, $p < .001$ at T4; $F(3, 152) = 3.17$, $\eta_p^2 = 0.059$, $p = .026$ at T5; $F(3, 132) = 3.43$, $\eta_p^2 = 0.061$, $p = .019$ at T6; $F(2, 159) = 3.62$, $\eta_p^2 = 0.044$, $p = .029$ at T7. The results of post hoc group comparisons are the same as described in the text, except that the difference between nonfinger users and newly finger users becomes non significance already from T4, $t(176) = 1.916$, $d = 0.397$, $p = .225$.

Figure 1

Cumulative Percentages of Finger Users (Among Which Newly Finger Users and Confirmed-Finger Users) and Nonfingers Users (Among Which Ex-Finger Users and Genuine Nonfinger Users) at Each Testing Point



60.6%, +10.8%, $t(147) = 2.66$, $d = 0.446$, $p = .023$, and newly finger users, 49.1%, +22.4%, $t(147) = 2.32$, $d = 0.921$, $p = .056$. The difference between newly and confirmed-finger user was not significant, −11.5%, $t(147) = 1.20$ $d = 0.475$, $p = .454$, see Figure 3. Finally, at T7, there was only one newly finger user (93% of the additions solved correctly), so he was excluded from the analysis. As attested by a t test, the confirmed-finger users were outperformed (73.9%) by the ex-finger users, 83.2%, −9.3%, $t(148) = 2.98$, $d = 0.488$, $p = .003$.

Discussion

The primary aim of the present study was to examine how children's history of finger counting relates to the progression of their performance in addition. As outlined in the introduction of this article, taking into account children's history is essential for drawing valid conclusions about the specific role that fingers may play in the development of mathematical abilities. Our approach also allowed us to determine at what age most children use their fingers, when they start using them, and when they stop.

Our results show that up to the age of 5.5, more children solved addition problems without using their fingers than with them. From this age until 6.5, this pattern reversed, with finger users outnumbering nonfinger users. In fact, the highest proportion of finger users across our testing points was observed at age 6.5. By ages 7 and 7.5, the number of finger users declined, eventually equaling the number of nonfinger users. This pattern of results suggests that some finger users had already shifted to mental strategies during the course of our study. This was confirmed by the fact that at the age of 6.5, the population of nonfinger users consisted mainly of ex-finger users. From this point onwards, children were either finger users or ex-finger users, with only a small number being genuine nonfinger users. As a matter of fact, at the end of our observations, when children were aged 7.5, only 12 had never been observed using their fingers at any testing point. Therefore, at least 93% of children between the ages of 4.5 and 7.5 used their fingers to calculate at some point during their development. Consequently, when researchers referred to "nonfinger users" in the previous literature, their classification was misleading or, at the very least, ambiguous, because genuine nonfinger users are virtually nonexistent after the age of 6.5. Our results reveal that rather than relying on a crude and imprecise classification of children as finger users or nonfinger users, it is more important to identify when, during development, the finger strategy emerges and when it is subsequently replaced by mental strategies.

Our study answers these questions by showing that it is at the age of 6 that the largest number of newly finger users is observed. In other words, it is at this stage of development that children most commonly begin using their fingers to solve addition problems. It remains unclear whether this stage corresponds to the point at which most children have acquired the necessary numerical knowledge and cognitive abilities to discover the strategy (Dupont-Boime & Thevenot, 2018; Krenger & Thevenot, 2024), or rather to a point when the strategy is commonly taught explicitly in the classroom. It should be noted, however, that in the French-speaking part of Switzerland where the research was conducted, the school curriculum does not include any explicit instruction in finger counting. Moreover, both the culture and the curriculum in this region are very similar to those in France. As previously mentioned, 20% of French kindergarten teachers and nearly one third of Grade 1 teachers believe that finger counting is specific to children with mathematical difficulties. This suggests that

Table 4

Percentages of the Different Finger Strategies (Counting-All, Concrete Counting-On, Counting-On) Used Among Finger Users at Each Testing Point on the First Two Sets of the Addition Task

Finger strategy	T1	T2	T3	T4	T5	T6	T7
Counting-all	42%	52%	56%	55%	54%	34%	16%
Concrete counting-on	24%	32%	25%	22%	17%	13%	5%
Counting-on	2%	3%	5%	9%	13%	29%	62%
Other	31%	13%	15%	14%	17%	24%	16%

Note. T = time.

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Table 5
Percentages of Finger Use Depending on Problem's Characteristics in Finger Users at Each Testing Point

Problem characteristic	T1	T2	T3	T4	T5	T6	T7	Total
Both operand ≤5	44%	46%	42%	34%	27%	15%	8%	28%
One operand >5	71%	75%	69%	64%	53%	44%	33%	54%
Sum <10 (small)	44%	48%	46%	38%	30%	18%	10%	31%
Sum = 10	57%	62%	56%	51%	41%	24%	14%	39%
Sum >10 (large)	81%	78%	72%	70%	64%	65%	58%	66%
Tie problems	39%	36%	26%	17%	10%	3%	1%	15%
Non tie problems	56%	65%	64%	59%	49%	37%	26%	49%
"+1" problems	39%	40%	37%	29%	20%	5%	1%	21%

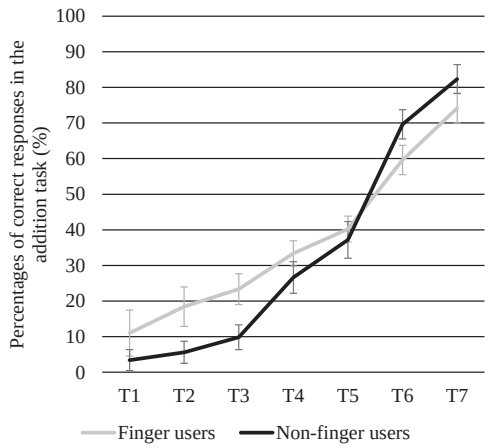
Note. T = time.

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the high proportion of children using their fingers to count at age 6 is unlikely to result from explicit teaching at school. However, less is known about practices at home, and it remains possible that parents may either encourage or discourage finger use in ways that influence the development of children's strategies. Still, and regardless of whether the strategy is taught or discovered, age 6 appears to be a key developmental point at which children can appropriate and begin to use the finger-counting strategy massively. Conversely, the most substantial decrease in the number of finger users during the study period was observed between the ages of 6.5 and 7. Nonetheless, given that half of the children were still finger users at our final testing point, this suggests that the most significant transition away from finger counting may still lie ahead. To explore this possibility, future studies with a longer longitudinal scope, including older children, will be necessary.

Regarding children's performance on the addition task, our results replicate previous findings in the literature showing that younger finger users tend to outperform nonfinger users, whereas the opposite pattern is observed in older children (Jordan et al., 2008; Poletti et al., 2022). Specifically, in our study, the reversal in performance occurred at around 6.5 years of age, which is earlier than what was reported by Jordan et al. (2008), where it was observed approximately 1 year later. This apparent discrepancy is likely due to differences in the materials used and in the analyses conducted in the two studies. Indeed, Jordan et al. included both addition and subtraction tasks, whereas our study focused exclusively on addition. Moreover, Jordan et al. based their conclusions on correlations between the frequency of finger use and accuracy in the arithmetic task, while we based ours on the number of children using their fingers versus those who did not. Therefore, the differences in the age of reversal between the two studies are likely attributable to the specific experimental designs used, without suggesting any contradiction between the findings. Anyway, as explained in our introduction, these observations cannot be fully understood without considering the history of children's concerning finger counting.

Figure 2
Percentages of Correct Responses in the Addition Task Across Testing Points for Finger Users and Nonfinger Users



Note. The error bar corresponds to the confidence interval set at 95%. T = time.

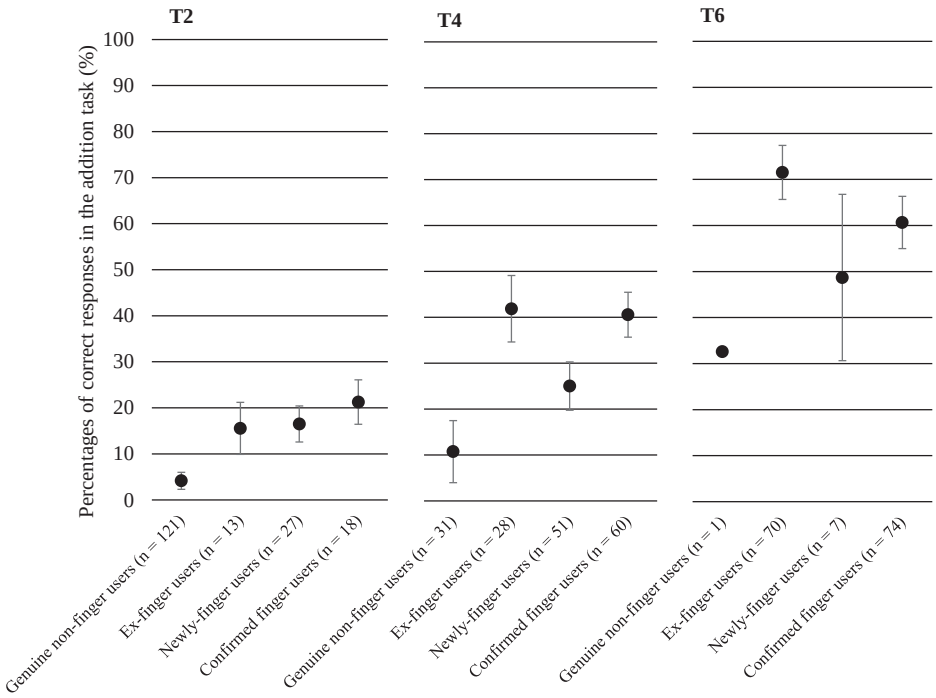
This is the approach we adopted, and our analyses reveal that young children who have never been observed using their fingers during our first two testing points (i.e., genuine nonfinger users) were less accurate on the addition task than all other categories of children. Noticeably, right from the start, ex-finger users already outperform genuine finger users, even though both groups of children did not use their fingers to solve the problems. This performance gap between genuine nonfinger users and ex-finger users continued to widen as development progressed, ultimately resulting in genuine nonfinger users becoming the least efficient group and ex-finger users emerging as the most efficient. This conclusion is particularly striking when we consider that, in previous studies, these two populations were treated as a single group.

Another point to be discussed here is that at the age of 6, children who had previously used their fingers to solve the problems (i.e., confirmed-finger users) outperformed newly finger users. Prior experience with finger use might therefore provide an advantage in terms of accuracy. Another interpretation is that children who discover the finger strategy earlier in development may possess stronger mathematical and cognitive skills than those who discover it later (Krenger & Thevenot, 2025a). While this superiority was descriptively similar in children at the age of 7, it was no longer significant. Whether this is due to a lack of statistical power (with only 7 newly finger users identified at this point) or reflects a true developmental effect remains unclear. To answer this question, future studies will need to follow a larger cohort of children than the present study in order to ensure sufficient sample sizes in each group.

All in all, our results highlight that finger counting offers a performance advantage over mental strategies for solving addition problems in the initial stages of arithmetic skill development.

Figure 3

Percentages of Correct Responses of Genuine Nonfinger Users, Ex-Finger Users, Newly Finger Users, and Confirmed-Finger Users in the Addition Task Across at T2, T4, and T6



Note. The error bar corresponds to the confidence interval set at 95%. T = time.

Moreover, the earlier children adopt this strategy, the more likely they are to move beyond it and ultimately become the most efficient performers. Therefore, it is as if, by building on their finger-counting experience, children progress from a fuzzy and unreliable numerical mental universe to a clearer and reliable form of abstract arithmetical thinking. This conclusion aligns with previous theoretical claims that finger counting scaffolds later numerical skills (e.g., Baroody, 1987; Fayol & Seron, 2005). Our study provides the first empirical support for this perspective. Demonstrating that finger counting plays a beneficial role on the development of mental calculation skills has important educational implications. Specifically, it suggests that encouraging finger use at early developmental stages could provide children with the necessary foundation for more sophisticated numerical thinking. It is indeed established that proficiency in addition lays the foundation for success in all other arithmetic operations (e.g., Thevenot et al., 2023). Furthermore, arithmetic skills themselves are strong predictors of more advanced mathematical abilities, such as comprehension of rational numbers or word problems solving (Geary et al., 2017; Lin, 2021).

Thus, our results may usefully complement the recent effort by McNeil et al. (2025) to identify approaches and best practices, grounded in findings from the science of learning, that can enhance children's arithmetic fluency. Specifically, our results suggest that explicitly teaching finger counting to children who have not spontaneously adopted this strategy may help them not only solve problems accurately, but even more importantly, transition more effectively toward meaningful, internalized strategies. An additional analysis on our data set demonstrates that this kind of interventional approaches might be central in helping children who present math difficulties at school entrance. Indeed, we observed a negative correlation between the scores in the addition task at 4.5 and the use of fingers at 7.5 ($r = -.217$, $p = .007$). Thus, low performing children in kindergarten are more likely to still rely on finger strategies when their higher performing peers have already shifted to more mature procedures. Intervening as early as possible seems therefore crucial to disrupt persistent learning difficulties.

To consider how these interventions should be implemented, we can draw on our observations of the strategies children use. The strategy in which both operands are represented on fingers and then recounted from 1 (i.e., counting-all strategy) is the one most commonly used at the beginning of learning. Because this is the strategy naturally adopted by children and because it is also the most meaningful, given that it provides a concrete representation of the problem and closely models the addition process, it seems the wisest strategy to teach to young children. A first attempt in this direction by Poletti et al. (2025) has already proven effective in enhancing children's immediate performance. However, future studies combining educational intervention with longitudinal follow-up will be necessary to determine whether these positive effects lead to long-term gains and foster a shift toward more efficient mental strategies. Our observations also revealed that children most commonly use their fingers to solve nontie problems with sums greater than 10. This is likely because such problems place a higher demand on working memory, making it more challenging to solve them mentally without external support (Crollen & Noël, 2015). Nevertheless, our results also reveal that smaller problems, with both operands below 5 (e.g., 3 + 4) or sums below 10 (e.g., 2 + 6),

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particularly well suited to the counting-all strategy, are also often solved using fingers by young children. These simple problems could therefore serve as an entry point for teaching finger-based strategies, starting with the counting-all approach, with the expectation that children will naturally progress to more advanced and efficient strategies (such as counting-on) as they encounter more complex problems. For those who do not make this transition spontaneously and persist with initial finger strategies that become inefficient as problem difficulty increases, explicit teaching of alternative strategies could be considered. To support this line of reasoning, future studies will need to examine the relationship between specific problem types and the finger strategies most frequently associated with them, as well as the accuracy associated with each combination. Such detailed investigations, proven already fruitful in other domain of arithmetic (e.g., Lemaire & Siegler, 1995; Lemaire et al., 2004), would be worth pursuing through a dedicated and comprehensive research program and would address the question of children's strategy adaptivity in relation to problem characteristics.

The question of whether the benefits of finger use in children's numerical development are specific to fingers or could also apply to other external manipulatives is also worth considering. As a matter of fact, Lê et al. (2024) found that among arithmetic-skilled children aged 4 to 5, performance was no better when they used their fingers or tokens that were available to them. Nonetheless, as the authors emphasize, this does not mean that fingers will not acquire additional value over the course of development. Indeed, fingers are always available to children, allowing them to develop increasing expertise with finger-based strategies. Moreover, their sensorimotor and kinesthetic dimensions may offer a unique advantage over other external manipulatives, as they engage the body directly and could help children form stronger, more embodied representations of numerical quantities (Thevenot et al., 2014; Wasner et al., 2014). Moreover, the fact that, unlike tokens, finger use does not necessitate continuous visual monitoring frees up attentional resources that can then be devoted to the cognitive demands of problem solving (de Chambrier et al., 2018). Therefore, although future experimental studies are needed to investigate this issue more thoroughly, the embodied nature of fingers suggests they may hold a distinct advantage over other manipulatives throughout arithmetic development.

Another path for future research is related to the question of gender differences in the use of fingers to solve arithmetic problems. This line of inquiry would allow for a deeper exploration of a secondary finding from our study that, at the final testing points of our investigation (T6 and T7), a higher number of girls were observed using their fingers compared to boys. Interestingly, this replicates a pattern previously reported by Jordan et al. (2008) in the United States. Given that one of our central conclusions is that, from T6 onward (around age 7), children who have ceased relying on finger counting (ex-finger users) outperform those who continue to use their fingers (both confirmed- and newly finger users), this raises important questions about whether girls may be at greater risk of falling behind in arithmetic performance due to a prolonged reliance on finger-based strategies.

Finally, as mentioned above, another key contribution of the present research is that it identifies a major limitation of earlier works and their interpretations. Our results reveal indeed that what has previously been treated as a single population of nonfinger users (e.g., Dupont-Boime & Thevenot, 2018; Geary et al., 2004; Jordan et al., 2008) actually consists of two distinct populations of children with opposite developmental profiles, that is, ex-finger users and genuine nonfinger users. This confusion can easily lead to the erroneous interpretation that, from a certain developmental point, nonfinger users outperform finger users because finger counting is no longer an adapted strategy, ultimately hindering the performance of finger users. In contrast, we show in the present study that until the very end of our testing period, that is, when children are 7.5, finger users consistently outperform genuine nonfinger users (Figure 3). The higher average performance of nonfinger users compared to finger users after the age of 6.5 is, in fact, driven by the ex-finger users, who have already internalized the finger-counting strategy. Therefore, we conclude that fully capturing a child's cognitive state at any given point requires considering the developmental history of their cognitive processes because this history often plays a crucial role in shaping both their current abilities and overall cognitive development.

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(*Appendix follows*)

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Appendix

Scores (Maximum of 46 Points) in the Additions Task of the 12 Children Who Never Used Their Fingers at Any Testing Point

ID	T1	T2	T3	T4	T5	T6	T7
A96	**18**	14	44	45		46	45
E02		**14**	34	19	14	41	42
A17	5	**10**	17	22	41	21	43
A56	0	1	2	**14**	19	12	30
A58	1	0		**20**	19	44	43
E06	3	1	7	**23**	33	45	38
A06	0	4	3	**22**	21	39	40
B08	0	2	3	5	5	**33**	39
C04	0	1	3	7	6	**11**	22
A86	2	1	1	5	6	**31**	35
X15			0	1	3	**21**	38
F10	0	0	3	0	0	1	2
Group mean	**2**	**4**	**7**	**14**	**18**	**30**	**35**

Note. The scores in bold correspond to the child's first score above 8, which means that they have been presented with both sets of addition. Missing scores are either due to the lack of French fluency (X15), or missing data (A96, E02, A58). T = time.

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