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Learning to Name Uppercase and Lowercase Letters in Preschoolers and Kindergarteners: An Investigation of the Effects of Child- and Letter-Related Factors

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ABSTRACT

Research Findings: Letter name knowledge (LNK) is essential for a good start in learning to read. However, the literature shows conflicting results. Using an associative learning theory framework, the present study examined the influence of child and letter characteristics on LNK in French-speaking children. Children aged 3 to 5–6 years were asked to name the 26 letters of the alphabet printed in uppercase (Study 1) or printed or cursive lowercase (Study 2). Several effects on their naming scores were tested: gender, letters in the first name, letter frequency in print, letter rank in the alphabet, shape similarity between letter cases, and phonological effects related to letter name type. Learning to name uppercase letters relied primarily on knowledge of the personal name letters, whereas learning to name lowercase letters relied heavily on the similarity in shape of these letters to their uppercase counterparts (or for cursive letters, to their lowercase printed analogs). *Practice or Policy:* Some practical consequences are drawn from the associative learning perspective, such as pairing uppercase and lowercase letters with their name and sound at the same time. In addition, grouping letters according to their shape stability through their case may be an advantageous strategy for teaching letter names.

Letter name knowledge (LNK) in young children has been of interest to psychologists for over 50 years (Piasta et al., 2022; Smythe et al., 1971) and remains an active area of research (Carr et al., 2020; Roberts et al., 2020; Zhang & Treiman, 2021). A major motivation for this interest is that a substantial body of research has shown that LNK assessed during the preschool years is a reliable predictor of later reading ability (e.g., Catts et al., 2002; Foulin, 2005). It can even be used to identify children at risk for reading difficulties (Ecalle et al., 2020). This early literacy skill has been studied in children of different native languages, although most research has focused on English-speaking children. However, among the recently published studies, one looked at Swedish (Herkner et al., 2021), another at Norwegian (Sigmundsson et al., 2020), and another compared English, Hebrew, Portuguese and Korean (Kim et al., 2021). Each language has its own peculiarities, each country has its own cultural and educational traditions and curricula, and this is likely to influence the way the LNK is developed during early childhood. The present research will contribute to our knowledge of the development of LNK in French-speaking children aged 3–4 to 5–6 years by investigating the effects of child- and letter-related factors as a function of letter case. The more the factors influencing the development of LNK are scientifically objectified, the more educational community will be able to build on this knowledge in defining its programs. This is what Roberts (2021) calls for in her "science of reading perspective."

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LNK and Child-Related Factors

Among the child-related factors that influence LNK, in addition to the child's age and its correlated variable, grade level (Bouchière et al., 2010; Worden & Boettcher, 1990), the advantage of the letters that make up the child's first name has been repeatedly confirmed (Ecalle, 2004; Justice et al., 2006; Philips et al., 2012; Treiman & Broderick, 1998). This factor reveals a clear idiosyncratic effect of exposure to specific letters and suggests the involvement of emotional dimensions attached to these letters through the personal significance of one's first name. Treiman et al. (2007) established in American and Israeli 5–6-year-olds that the first letter of the first name (initial), printed in uppercase, was the best-known letter, followed by the other letters in the first name, and then by the letters not in the first name. The same results were found in Brazilian children (Treiman et al., 2006). When printed in lowercase, the superiority of the first name letters over others has been found (Huang & Invernizzi, 2014), as well as that of the initial (Treiman & Kessler, 2004). This last finding is less intuitive, as children are usually exposed to the initial written in capital letters. The own-name advantage has also been reported in French-speaking children with uppercase letters (Bouchière et al., 2010). However, to our knowledge, the robustness of the own-name advantage to case sensitivity has not been tested in French-speaking children.

Another well-studied child-related factor in LNK development concerns the role of gender. Several findings confirm that girls outperform boys in various language related skills, such as vocabulary growth (Huttenlocher et al., 1991) or reading performance (Mullis et al., 2012). Knowing whether gender also affects LNK could prompt teachers to pay special attention to boys' acquisition of this preliteracy skill. However, conflicting findings have been reported. Some experiments indicated that girls outperformed boys (Ecalle et al., 2020; Evans et al., 2006; Sigmundsson et al., 2020; Treiman et al., 2007), while others reported no significant difference between girls and boys (Herkner et al., 2021; Worden & Boettcher, 1990). Further research therefore seems warranted.

LNK and Letter-Related Factors

Several factors that affect LNK in children are related to letter characteristics. Higher naming scores have been reported for uppercase letters than for lowercase letters in print or cursive (Evans et al., 2006; Helal, 2012; Treiman & Kessler, 2004; Worden & Boettcher, 1990). Uppercase letters do indeed tend to be more discriminative (Bowles et al., 2014), although there is a debate about whether uppercase letter names should be taught before or after lowercase letter names (e.g., Berninger & Wolf, 2009). With regard to cursive letters, little is known about the factors that influence the development of their knowledge of letter names, as the assessment of LNK with these letters is still rare, especially for French-speaking children (but see Ecalle, 2004; Helal & Weil-Barais, 2015).

The phonological properties of letter names have received attention from researchers. Vowels are better known than consonants among French-speaking kindergartners (Bouchière et al., 2010; Cormier, 2006), probably because of their high sonority and the direct correspondence between their name and their sound (except for Y). The "letter-name pronunciation effect" (Justice et al., 2006) states that letters whose names are included in their pronunciation, either at the beginning (e.g., B,/bɛ/in French, referred to as a Consonant-Vowel or CV-name letter) or at the end (e.g., M,/ɛm/in French, referred to as a Vowel-Consonant or VC-name letter), are learned earlier than those (e.g., W in English and French) that are unrelated or inconsistently related to their pronunciation (Evans et al., 2006 for lowercase letters; Justice et al., 2006; Philips et al., 2012). However, the literature is inconsistent regarding this effect. It has not been replicated in some studies with English-speaking children (e.g., Evans et al., 2006 for uppercase letters; Piasta & Wagner, 2010) or French-speaking children (Bouchière et al., 2010; Helal, 2012). Still with respect to consonants, some studies have shown that consonants with CV-names are better known than consonants with VC-names (McBride Chang, 1999), but others have not (Justice et al., 2006; Philips et al., 2012). Studies with French-speaking children added to the confusion, as most of them described an inverse effect, where consonants with VC-names were better named than those with CV-names (Bouchière et al., 2010; Cormier, 2006; Helal, 2012). However, Ecalle (2004) found a superiority for consonants with CV-names. Clearly, more research with French-speaking children is needed on all these effects, which demonstrate the close relationship between letter name and letter sound.

With reference to the "ABC song" and some school curricula, the idea that the rank of letters in the alphabet chain may influence LNK has been tested. Some studies have shown that letter names in the first half of the alphabet are better known than those in the second half (e.g., Bouchière et al., 2010; Justice et al., 2006). However, the opposite effect was reported by Huang and Invernizzi (2014) for lowercase letters. At a finer level, the correlation between the rank of letters in the alphabet and their naming scores was found to be significant in Bouchière et al. (2010), moderate in McBride Chang (1999), but not significant in other studies (Evans et al., 2006; Helal, 2012; Kim et al., 2021; Treiman & Kessler, 2003). Further research is therefore still needed.

Conflicting results also emerged when considering the potential influence of letter frequency in print, typically assessed by their occurrence in children's textbooks. Several studies have indicated that the more frequent a letter is in print materials, the higher its naming score, revealing a clear exposure effect (Bouchière et al., 2010; Kim et al., 2021; Treiman et al., 2006, 2007; Turnbull et al., 2010). However, other studies have not reported significant positive correlations between letter frequency and naming scores (Ecalle, 2004; Evans et al., 2006; Kim & Petscher, 2013). Further investigation of the impact of letter frequency in print on LNK is therefore warranted.

The final letter feature influencing LNK that we were interested in also reflects an exposure effect. It concerns the visual similarity between printed uppercase and lowercase letters, or between printed and cursive lowercase letters. Given that the names of uppercase letters are known before those of lowercase letters in children from most countries (Helal, 2012; Worden & Boettcher, 1990), the shape similarity effect posits that lowercase letters that strongly resemble their uppercase counterparts are more likely to be named correctly than those with less visual similarity. Despite discrepancies in how visual letter similarity has been assessed, the few studies that have examined the role of this factor have all found it to be positive (Evans et al., 2006; Huang & Invernizzi, 2014; Treiman & Kessler, 2003, 2004; Turnbull et al., 2010). However, none of these studies involved French-speaking children. None of them tested this effect by comparing cursive lowercase letters with their printed analogs, although the same reasoning could apply in this case.

LNK within the Framework of Associative Learning Theory

The empirical evidence reviewed above for LNK in children primarily reflect implicit general exposure effects (letter frequency, letter shape similarity), idiosyncratic exposure effects (personal name advantage), explicit instructional effects (alphabetic order, order of exposure to different letter cases and to different categories of letters, explicit visual analysis of letter shapes, focus on personal name letters), and linguistic phonological effects (phoneme in letter name and its location). The factors underlying the gender effect are more difficult to delineate because motivation, education, and maturation can all contribute to differences between boys and girls. In addition, all of these factors can interact with children's age. It is very likely that most of the conflicting results found in this literature are consequences of explicit instructional effects that vary from country to country, from teacher to teacher, despite general instructional guidelines in each country, and from family to family. Our main theoretical interest in the present research was to examine the extent to which general or specific exposure effects could account for the impact of most of the child and letter-related factors mentioned above, making of associative learning a unifying theoretical framework, that must surely be combined with the phonological influences linked to each language. In line with this approach, Nilsen and Bourassa (2008) have shown that paired-associate learning skills account for children's learning of both regular and irregular words, while phonological awareness uniquely accounts for the acquisition of regular words.

Thus, consistent with the statistical learning view of literacy development advocated by Zhang and Treiman (2021), and more generally with the learning model promoted by Perruchet and Vinter (2002), we adopted an associative learning framework for the acquisition of LNK in the present work. According to the latter learning model, associative learning processes are mandatorily triggered whenever multiple stimuli enter the attentional focus of participants, binding them together to form a new cognitive unit. The more often these stimuli occur together, the more fluidly the newly formed cognitive unit will guide participants' perception of the learning situation and nourish their knowledge. Thus, repeated exposure to associations between letter shapes (visual information) and letter names (verbal information), either implicitly or explicitly, at school or in their surrounding environment, should gradually produce consistent learning with frequency and familiarity effects in children. This would demonstrate an essential role for experiential learning mechanisms in LNK acquisition. In line with this view, Hulme et al. (2007) emphasized the important role of visual-verbal associations in reading acquisition, and Roberts et al. (2018) showed the role of paired associate learning skills in alphabet knowledge. Ehm et al. (2019) confirmed that the acquisition of letter knowledge may indeed depend on a visual-verbal associative learning mechanism. Also consistent with an associative learning view, Roberts et al. (2020) found a better learning effect when the letter-shape/letter-name associations were presented to children in a decontextualized manner rather than embedded in meaningful, but more complex, contexts.

The present studies therefore aimed to contribute to this growing but still conflicting body of research by testing the LNK in young French-speaking children when they were asked to name uppercase or lowercase letters (printed or cursive). Preprimary school in France is divided into three grades, the first two of which correspond to preschool in the United States (3–4 year olds/4–5 year olds), and the third to kindergarten (5–6 year olds). Uppercase letters are introduced in 1st preschool, printed lowercase letters in 2nd preschool, and the correspondence between uppercase and lowercase letters (printed and cursive) in kindergarten. Study 1 examined the development of LNK for uppercase letters between the 3–4 year olds and the 5–6 year olds. Study 2 focused on the development of LNK for lowercase letters between 4–5 years of age (2nd preschool year) and 5–6 years of age (kindergarten year). In fact, at the time the data were collected, just after the start of the school year (October – November), virtually no 3–4 year olds knew the names of the lowercase letters. For this reason, we decided to combine the data on uppercase LNK in a first study and the data on lowercase LNK in a second study. We investigated whether three child-related factors (school year, gender, letters in the child's first name) and three factors related to letter characteristics (rank in the alphabet, letter frequency in print, phonological properties of letter names) influenced LNK as a function of the letter case used. The role of letter shape similarity across letter cases was also examined in Study 2. We did not analyze the role of letter confusability, which has been recognized in the literature as important in determining LNK (Kim & Petscher, 2013; Kim et al., 2021; Treiman & Kessler, 2003), and therefore did not record naming errors. Specific hypotheses will be developed in each study.

Study 1: Knowledge of Uppercase Letter Names

Conflicting results have been reported for most of the previously mentioned effects on the LNK of uppercase letters in studies with French-speaking children. The role of letter frequency in print and letter rank in the alphabet was found to be positive in Bouchière et al. (2010) but not in other studies (Ecalle, 2004; Helal, 2012). The phonological effect of consonant names has been shown to favor those with CV-names, as in English studies (Ecalle, 2004). However, an advantage in favor of consonants with VC-names has been reported more frequently (Bouchière et al., 2010; Cormier, 2006; Helal, 2012). All of these studies differed in various factors, such as how the naming task was administered and how many other literacy tasks were given in addition to the participants. In the present study, children received only the letter naming task, which was administered by showing each letter randomly, in isolation, and one at a time. We decided not to include a letter sound task, in order to minimize interference effects.

The hypotheses that guided the present research were consistent with some key tenets of associative learning theory regarding pervasive exposure effects, as reflected in frequency and familiarity effects (e.g., Ambridge et al., 2015; Krueger, 1975). Because children's repeated exposure to the letters of their own name occurs very early, we expected to confirm the first name advantage in children as young as 3–4 years of age. Emotional factors certainly contribute in parallel to the strength of this effect through the salience and personal significance of the first name (Carmody & Lewis, 2006). We expected to observe a letter frequency effect in print later, not before 4–5 or even 5–6 years of age, because it requires many exposures to all printed letters of the alphabet to emerge, not just to a few as in the personal name effect. Since most studies with French-speaking children have found that VC-name consonants are better known than CV-name consonants in contrast to the Anglo-Saxon studies mentioned above, we expected to replicate this result. This may be related to differences in phonemic perception between nonreading French and English-speaking children, which is better in the latter than in the former (Duncan et al., 2006), demonstrating the importance of linguistic influences on LNK in children. However, children must gain sufficient experience with the variety of letter-name /letter-sound correspondences to allow the emergence of distinct phonological categories of letter names. Therefore, this effect should not be present in younger children, showing how linguistic factors and experience combine to affect LNK.

Method

Participants

Six public schools for preschoolers and kindergartners located in middle-class urban neighborhoods were recruited for Studies 1 and 2. Children in 1st preschool year were included in Study 1 only. Each of the 12 classrooms corresponding to the 2nd preschool and kindergarten years was divided into three groups assigned to uppercase letters (Study 1), printed or cursive lowercase letters (Study 2) to control for the possible effect of classroom instruction. Table 1 shows the main characteristics of each group for the two studies by grade level, and by gender for some descriptive letter naming scores. It was not possible to achieve a balanced distribution of participants across the three letter-case groups due to several constraints. For example, some children refused to participate in Study 2, saying in advance that it was too difficult for them (16 of them were reassigned to Study 1). Some in Study 2 dropped out midway through the task ($n = 15$). Therefore, we did not compare naming performance between Study 1 and Study 2. There were no significant differences between the mean ages of the different groups in the 2nd preschool or kindergarten year, $p_s > .30$.

One hundred and forty-seven preschool and kindergarten children (74 girls, see Table 1) participated in Study 1. They attended either the first ($n = 48$) or second level of preschool ($n = 53$) or kindergarten ($n = 46$). None of the children were educationally advanced or delayed. They were nonreaders, as reported by their teachers and parents. They had normal or corrected-to-normal vision. All were native French speakers, although 29 of the 147 children came from families where another language was spoken at home in addition to French. The study was conducted in accordance with the tenets of the World Medical Association's Declaration of Helsinki on Ethical Principles for Medical Research Involving Human Subjects. Written informed consent was obtained from the parents. No parental refusals were reported, and only willing children participated in the study. The study was approved by a local ethics committee (N° UBFC2021-03-30-002).

Material and Procedure

The material used to assess the children's LNK consisted of 26 small 3 × 3 cm, cards with a centered uppercase letter printed in black ink. Children were tested between October and November of the school year, prior to the start of letter-name instruction at each grade level. Children were tested individually in a quiet room located in their school. The cards were presented in a random order and a different random order was used for each child. The experimenter showed the child a card with an uppercase letter printed on it and asked: "Do you know the name of this letter? Can you tell me its

Table 1. Main characteristics of each group for the two studies by grade level, and also gender for some descriptive letter naming scores.

	Age		*N*		LNK Entire alphabet				LNK Personal name				LNK Other letters			
					Girls		Boys		Girls		Boys		Girls		Boys	
Grade level	Mean (yr)	Range (yr;mth)	Girls	Boys	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*
Study 1 (uppercase letters)																
1st preschool year (3–4 years)	3.7	2;11–3;11	26	22	15.53	31.50	5.24	14.70	22.24	39.35	10.10	23.20	14.35	31.00	5.26	15.50
2nd preschool year (4–5 years)	4.6	3;11–4;10	27	26	34.04	28.23	33.14	29.66	75.06	33.20	70.06	37.44	23.84	30.10	24.56	30.87
Kindergarten (5–6 years)	5.6	4;10–5;11	21	25	54.94	23.80	51.38	25.75	93.33	10.13	85.86	22.16	47.25	28.23	44.60	28.16
Study 2 (printed lowercase letters)																
2nd preschool year (4–5 years)	4.6	3;11–4;11	12	17	24.35	22.80	16.74	21.10	36.90	27.90	17.44	19.10	22.44	23.40	16.12	23.12
Kindergarten (5–6 years)	5.7	5;0–5;11	19	18	43.38	26.67	34.40	26.46	62.89	31.00	39.62	31.78	38.89	27.05	33.24	26.54
Study 2 (cursive lowercase letters)																
2nd preschool year (4–5 years)	4.7	4;0–4;11	11	14	4.54	5.38	2.74	5.52	12.72	21.95	4.76	9.64	2.47	3.72	2.38	6.12
Kindergarten (5–6 years)	5.6	4;11–5;10	17	14	16.86	15.10	8.33	10.90	32.75	28.12	22.22	23.47	13.07	13.41	5.22	8.22

LNK = Letter name knowledge; yr = years; mth = months.

name?" The child's response was recorded and coded as correct (1) or incorrect (0) if there was an error or no response.

Data Analysis

Several measures were calculated for each participant.

Child-Related Measures

(1) Child's uppercase letter naming score: Overall percentage of LNK (for each child, sum of correct responses divided by 26, multiplied by 100), also broken down into percentage of LNK for the first and second halves of the alphabet. The Cronbach's α reliability coefficient reached .94.
(2) Personal name letter naming: The total percentage of LNK of the letters that make up the child's first name (also broken down into knowledge of the initial, knowledge of the other letters in the first name, and knowledge of the letters not in the first name). The Cronbach's α reliability coefficient attained .90.

Letter-Related Measures

(1) Vowel naming: The percentage of knowledge of the vowel names, A, E, I, O, U (for each child, sum of correct responses divided by 5, multiplied by 100); Y was not included because it has a complex name. Cronbach's α reliability coefficient was .79.
(2) Consonant naming: The percentage of knowledge of consonant names (for each child, sum of correct responses divided by 20, multiplied by 100). This percentage was broken down into letters whose pronunciation was at the beginning of their name (CV names: B, D, J, K, P, Q, T, V, Z), or at the end of their name (VC names: F, L, M, N, R, S, X), or other consonants unrelated or inconsistently related to their sound (C, G, W, H). Cronbach's α reliability coefficient attained .93.
(3) Letter naming scores: The percentage of correct naming by letter (for each letter, the sum of correct naming occurrences divided by the number of participants in each grade).
(4) Letter occurrences in personal names: The percentage of occurrences of each letter in the first names of the participating children (for each letter, the sum of its occurrences divided by the number of participants in each grade).

An arcsine transformation was applied to the raw data in percentages before all statistical tests were performed, but descriptive data are reported in percentages in the text. Univariate ANOVAs were carried out with grade level (1st, 2nd preschool, kindergarten) and gender (female, male) as factors on children's uppercase letter naming responses for the entire alphabet or for the personal name as dependent variables. Student's t tests were performed for the other variables. Bonferroni's correction for multiple comparisons was applied, and corrected α values are reported in the text, for an initial α value fixed at .05. Correlations were computed between letter naming scores and the rank of letters in the alphabet (from 1 to 26), the frequency of letters in children's textbooks using the Manulex database (Lété et al., 2004), and the mean occurrence of letters in the first names of the participating children. Comparisons were also made with previous studies that provided naming scores for each uppercase letter collected at the same grade levels as ours.

Results

Analysis Centered on Child-Related Factors

Children's Letter Naming. Table 1 presents mean LNK scores for the entire alphabet by grade level and gender for Study 1. As has been widely demonstrated in the literature, LNK scores increased from 1st preschool ($M = 10.82\%$, $SD = 25.50$) to kindergarten ($M = 53.00\%$, $SD = 24.60$), $F(2, 141) = 23.15$, $p < .001$, $\eta_p^2 = .25$. Gender was not significant, $F(1, 141) = 1.17$, $p = .28$, $\eta_p^2 = .008$, nor was the interaction between grade level and gender, $F(2, 141) < 1$. Shortly after the start of the school year, 1st grade preschoolers knew an average of 2.8 uppercase letters, 2nd grade preschoolers knew 8.7 letters, and kindergartners knew 13.8 letters. Given that the LNK was assessed at the beginning of the school year, these performances are somewhat lower but close to those reported in other studies with French-speaking children who were tested later or throughout the school year, thus benefiting from more schooling and exposure time to letters (Bouchière et al., 2010; Helal, 2012).

Personal Name Letter Naming. As shown in Table 1, children's knowledge of their personal name letters increased sharply between the 1st and 2nd preschool years, reaching about 90% by the start of kindergarten, $F(2, 141) = 56.90$, $p < .001$, $\eta_p^2 = .45$. There was no significant effect of gender, $F(1, 141) = 2.60$, $p = .11$, $\eta_p^2 = .018$. The percentage of correct naming responses for the letters of the first name ($M = 59.60\%$, $SD = 42.80$) was significantly higher than for the other letters ($M = 26.40\%$, $SD = 31.2$), $t(146) = 13.6$, $p < .0125$. Children's knowledge of the initial of their personal name was significantly higher ($M = 62.60\%$, $SD = 48.60$) than that of the other letters of the alphabet ($M = 29.80\%$, $SD = 30$), $t(146) = 13$, $p < .006$. However, it was not higher than that of the other letters of the first name ($M = 59.30\%$, $SD = 44$), $t(146) = 2.45$, $p = .02$. All of these effects were confirmed at every grade level.

Analysis Centered on Letter-Related Factors

Table 2 presents the results of the correlation analyses. The naming scores for the 26 letters were highly correlated across grade levels, ranging from $r(24) = .76$ to $r(24) = .92$, $p_s < .001$. The letters A and O were consistently among the best named, and letters F and G among the worst named. Our data were significantly correlated with other equivalent data from French-speaking children (Bouchière et al., 2010; Helal, 2012). The correlation was particularly high between our kindergarten scores and those of the Helal study in kindergarten, $p < .001$. This was also the case between our 2nd preschool data and Bouchière et al.'s corresponding data, $p < .001$. The correlations were weaker, but still significant, between our kindergarten data and those collected on English-speaking kindergartners by Justice et al. (2006), $r(24) = .47$, $p = .015$, or by Evans et al. (2006), $r(24) = .52$, $p = .006$.

Letter Frequency in Print. The results regarding the effect of letter frequency in print confirmed our expectations. As Table 2 reveals, while the correlation between letter frequency and letter naming scores was not significant in the youngest children, $p = .26$, this correlation became significant in 2nd preschool and kindergarten, $p_s < .01$. Table 2 also confirms the important role played by personal name letters. Letter naming scores were significantly correlated with the occurrence of letters in the first names of participating children at each grade level, $p_s < .05$.

Vowel and Consonant Naming. Table 3 shows the mean LNK scores for different letter categories by grade level for the two studies. For uppercase letters (Study 1), vowels ($M = 44.2\%$, $SD = 35$) were named better than consonants ($M = 28.7\%$, $SD = 31.2$), $t(146) = 9.65$, $p < .0125$. This superiority was observed at each grade level, $p < .0125$. The effect of letter-name pronunciation was confirmed. Consonants whose names (VC or CV names) were included in their pronunciation ($M = 30.5\%$, $SD = 32$) outperformed consonants that were unrelated or inconsistently related to their pronunciation

Table 2. Correlations between letter naming scores collected in Study 1 and different other variables.

	Pre2	Kind.	Bou.Pre1	Bou.Pre2	Bou.Kind.	Hel.Kind.	Let. Freq.	Pers. Name	Let. Rank
Pre1	.83***	.76***	.64***	–	–	–	.23	.46*	−.29
Pre2	–	.92***	–	.80***	–	–	.57**	.86***	−.29
Kind.		–	–	–	.63**	.87***	.57**	.78***	−.32

*p < .05.**p < .01.***p < .001.
Correlations between letter naming scores collected in Study 1 (Pre1: 1st preschool year; Pre2: 2nd preschool year; Kind.: kindergarten) and data from Bouchière et al. (2010; Bou.Pre1, Bou.Pre2, Bou.Kind.), data from Helal (2012; Hel.Kind.), letter rank (Let.Rank), letter frequency in written textbooks (Let.Freq.), letter occurrence in our participants' personal names (Pers.Name).

($M = 23.5\%$, $SD = 31.4$), $t(146) = 2.6$, $p < .0125$. However, as shown in Table 3, this effect was only significant for kindergartners, $t(45) = 3.7$, $p < .0125$. Finally, on average, consonants with VC names were named significantly more often correctly ($M = 32.4\%$, $SD = 34.8$) than those with CV names ($M = 28.2\%$, $SD = 32.5$), $t(146) = 2.8$, $p < .0125$, but this difference was not significant in the 1st preschool year, $p > .0125$.

Letter Rank. Letters in the first half of the alphabet were named better overall ($M = 33.9\%$, $SD = 31.6$) than those in the second half ($M = 30.5\%$, $SD = 32.2$), $t(146) = 2.6$, $p < .0125$. However (see Table 3), this slight advantage was not significant at either grade level when Bonferroni correction was applied, all $p > .0125$. Consistently, nonsignificant correlations between letter rank in the alphabet and naming scores characterized each grade level, as shown in Table 2, $p_s > .12$.

Finally, stepwise hierarchical regressions were conducted with letter rank, letter frequency in print, and letter occurrence in the participating children's first names as potential continuous predictors of letter naming scores. For each grade level, entering letter occurrence in children's first names as the first predictor alone accounted for a significant amount of variance (1st preschool: 21.4% of variance, $ß = .46$, $p = .017$; 2nd preschool: 73.3% of variance, $ß = .85$, $p < .001$; Kindergarten: 61.5% of variance explained, $ß = .78$, $p < .001$). In addition, the other two predictors together increased the amount of variance explained to 27.2%, 75.4%, and 65.1%, respectively. However, at each grade level, none of these predictors had significant unique predictive power, $p_s > .20$.

These results are discussed along with those of Study 2.

Study 2: Knowledge of Lowercase Printed and Cursive Letter Names

By changing the case of the letters, we can expect some discrepancies with the results reported above. Although they increase with age (Bouchière et al., 2010), naming scores for lowercase letters were expected to be lower than for uppercase letters (Evans et al., 2006; Helal, 2012; Treiman & Kessler, 2004). Despite the consistent superiority of girls' naming scores over boys', the gender effect failed to reach significance in Study 1, demonstrating its fragility (Ecalle et al., 2020; Herkner et al., 2021; Sigmundsson et al., 2020; Treiman et al., 2007). In this context, it remains an open question whether gender affects lowercase letter naming scores. The own-name advantage should be observed for lowercase letters (Huang & Invernizzi, 2014). However, consistent with associative learning theory, we did not expect an advantage for the initial of the first name, since children are not usually exposed to their personal name with the initial in lowercase. The generalization of the first-name advantage to lowercase letters in cursive may also be questionable, given the reduced exposure of children to this letter case, even in kindergarten.

Part of the literature (e.g., Kim et al., 2021; Treiman et al., 2006) has shown that the more frequently a letter appears in children's textbooks, the higher its naming score. Because this frequency effect reflects an exposure effect to print materials, it should a priori apply to a lesser extent, if not at all, to lowercase cursive letters, which are less common in the print environment of preschoolers and kindergartners. Study 1 suggested that letter rank in the alphabet may play a minor role in children's LNK, with a tendency for letters in the first half of the alphabet to be named better than those in the second half. The opposite effect was reported by Huang and Invernizzi (2014) for lowercase letters. Study 2 sought to determine whether the same opposite effect could be observed in French-speaking children attending 2nd preschool and kindergarten.

The literature on the letter-name pronunciation effect suggests that this effect may be sensitive to letter case, but in a potentially contradictory way. It was found with uppercase but not lowercase cursive letters by Ecalle (2004) with French-speaking children, whereas it was observed with lowercase but not uppercase printed letters by Evans et al. (2006) with English-speaking children. Thus, our expectations were open, although we might expect phonological influences to decrease as children are exposed to new letter cases (lowercase, cursive). Interference with visual analysis of letter shape may

Table 3. Mean LNK scores for different letter categories by grade level for the two studies.

Grade level	Vowels		Consonants		Cons. With CV- or VC-names		Inconsist. Cons.		1st half alphabet		2nd half alphabet		High-shape similarity		Low-shape similarity	
	M%	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*	*M%*	*SD*
Study 1 (uppercase letters)																
1st preschool year (3–4 years)	13.88	29.20	9.90	24.70	9.50	24.30	11.46	27.70	11.70	25.90	9.93	25.50	—	—	—	—
2nd preschool year (4–5 years)	49.05	29.40	28.96	29.40	30.07	30.40	24.53	31.50	35.85	27.10	31.35	31.70	—	—	—	—
Kindergarten (5–6 years)	69.56	20.27	48.04	27.60	51.35	28.10	34.78	30.90	54.85	26.70	51.17	25.34	—	—	—	—
Study 2 (printed lowercase letters)																
2nd preschool year (4–5 years)	29.88	29.33	16.90	20.54	16.38	20.90	18.97	21.80	15.65	18.78	24.14	25.65	34.21	36.17	5.57	9.39
Kindergarten (5–6 years)	50.45	27.90	40.00	28.28	36.82	27.90	30.41	27.72	32.64	26.97	45.32	28.13	56.34	35.89	21.62	23.41
Study 2 (cursive lowercase letters)																
2nd preschool year (4–5 years)	4.00	7.26	3.40	5.34	2.00	3.47	9.00	14.20	6.15	9.15	0.92	3.38	8.40	12.40	0.50	1.73
Kindergarten (5–6 years)	20.96	22.75	9.19	11.70	7.05	11.03	17.74	20.60	14.64	16.17	9.18	12.14	22.60	24.08	5.24	8.85

Cons. = consonant; Inconsist. = inconsistent.

indeed help or hinder LNK acquisition, depending on the degree of similarity of letter shape across letter cases, regardless of the phonological structure of the letter name.

Therefore, Study 2 tested the letter shape similarity hypothesis. It states that lowercase letters are more likely to be named correctly when their visual similarity to their uppercase analogs is high (Treiman & Kessler, 2003, 2004). We extended this hypothesis to cursive letters, some of which should also benefit in naming learning from their high shape similarity to their printed lowercase counterparts. Indeed, familiarity with letter shapes acquired through experience should induce the transfer of letter naming knowledge, as predicted by the stimulus generalization law in associative learning (e.g., Shepard, 1987).

Method

Participants

Table 1 provides information on the one hundred and twenty-two children who participated in Study 2 (59 girls and 63 boys). Fifty-four attended the 2nd preschool year (mean age of 4.6 years), 68 kindergarten (mean age of 5.7 years). As mentioned above, they were recruited from the same schools and classrooms as in the previous study. In each classroom, children were randomly assigned to printed lowercase letters (n = 66, 31 girls and 35 boys) or cursive lowercase letters (n = 56, 28 girls and 28 boys). Fourteen children spoke at home another language, in addition to French. All other items were identical to those reported in Study 1.

Material, Procedure and Data Analysis

The material used to assess the children's LNK was identical to that described in Study 1, except that the letters to be named were printed or cursive lowercase letters. The procedure was also the same as previously reported. The dependent variables listed in the previous study were calculated for both letter case groups, and the same statistical analyses were performed using an arcsine transformation on the percentage data. The internal consistency of the dependent variables (Cronbach's α reliability coefficient) reached .89 for printed letters and .86 for cursive letters.

An additional letter characteristic was included in the correlation and regression analyses, namely, letter shape similarity, either between printed uppercase and lowercase letters (high for c, i, j, k, o, p, s, u, v, w, x, y, z, lower for others), or between printed and cursive lowercase letters (high for a, c, d, e, i, m, o, q, t, u, lower for others). The categorization of printed lowercase letters into the high similarity category incorporated four more letters (i, j, u, y) than that proposed by Treiman and Kessler (2003). To classify letters based on their shape similarity, we gave 30 young adults either the 52 uppercase and lowercase printed letter cards (n = 15) or the 52 lowercase printed and cursive letter cards (n = 15). We asked them to look at each pair of identical letters and form two categories: letters with high shape similarity between the shown letter cases (coded 1), and letters with lower shape similarity (coded 0). Two letters (f, j) received an average percentage of similarity comprised between 40 and 60% when comparing uppercase and lowercase letters. The same was true for the letters g, j, and n when comparing lowercase printed and cursive letters. We decided to assign letters with a percentage greater than 50% to the high shape similarity group (M = 91.30%, SD = 13.70 for printed letters and M = 90.00%, SD = 13.80 for cursive letters) and those with a percentage less than 50% to the other group (M = 4.60%, SD = 13.10 for printed letters and M = 16.3%, SD = 18.50 for cursive letters). Cohen's κ coefficients were calculated to assess inter-rater reliability and were substantial for printed letters, $\kappa = .80$, $p < .001$, and for cursive letters, $\kappa = .71$, $p < .001$.

Results

Analysis Centered on Child-Related Factors

Children's Letter Naming. Table 1 reports the mean letter naming scores for the entire alphabet as a function of grade level and gender for Study 2. An ANOVA with letter case (printed lowercase, cursive lowercase), grade level (2nd preschool, kindergarten), and gender (female, male) was performed on the arcsine values of these scores. They were higher for printed letters (M = 30.60%,

$SD = 26.20$) than for cursive letters ($M = 8.20\%$, $SD = 11.20$), $F(1, 114) = 35.1$, $p < .001$, $\eta_p^2 = .24$. They increased significantly between 2nd preschool ($M = 12.32\%$, $SD = 18.20$) and kindergarten ($M = 26.64\%$, $SD = 25.30$), $F(1, 114) = 14.1$, $p < .001$, $\eta_p^2 = .11$. Shortly after the start of the school year, 4–to 5-year-olds knew the names of an average of 5.3 printed lowercase letters and 0.93 cursive letters, and 5–6-year-olds knew 10 and 3.3 letters, respectively. A slight advantage of girls ($M = 25.20\%$, $SD = 24.80$) over boys ($M = 16.30\%$, $SD = 21.70$) was observed, but gender did not reach significance, $F(1, 114) = 3.3$, $p = .07$, $\eta_p^2 = .03$. There was no significant interaction, $p_s > .10$.

Personal Name Letter Naming. Also shown in detail in Table 1, children's LNK for their personal name was higher for printed lowercase letters ($M = 40.10\%$, $SD = 32.00$) than for cursive letters ($M = 18.40\%$, $SD = 23.60$), $F(1, 114) = 19.3$, $p < .001$, $\eta_p^2 = .14$. They were higher in kindergarten ($M = 40.20\%$, $SD = 32.20$) than in 2nd preschool ($M = 17.50\%$, $SD = 22.70$), $F(1, 114) = 19.9$, $p < .001$, $\eta_p^2 = .15$. Girls performed significantly better ($M = 40.10\%$, $SD = 33.10$) than boys ($M = 22.00\%$, $SD = 25.70$), $F(1, 114) = 10$, $p = .002$, $\eta_p^2 = .08$. There was no significant interaction, $p_s > .10$.

The own-name advantage was globally significant for the printed lowercase letters (first names: $M = 40.12\%$, $SD = 32.26$; other letters: $M = 28.50\%$, $SD = 26.38$), $t(65) = 4.24$, $p < .0166$. However, this was only observed in kindergarten, $p < .0166$, not in 2nd preschool, $p = .09$. The same pattern of results was found for cursive (see Table 1 for detailed means). Finally, there was no advantage for the initial of the first name (printed letters: $M = 34.85\%$, $SD = 48.00$; cursive letters: $M = 17.86\%$, $SD = 38.66$), whether the comparison was made with all other letters of the alphabet (printed letters: $M = 29.25\%$, $SD = 25.60$; cursive letters: $M = 7.48\%$, $SD = 10.53$), or with the other letters of the personal name (printed letters: $M = 41.64\%$, $SD = 36.90$; cursive letters: $M = 19.63\%$, $SD = 26.13$), $p_s > .008$. This was true at each grade level, $p_s > .008$.

Analysis Centered on Letter-Related Factors

Table 4 presents the results of the correlational analyses conducted with printed and cursive mean letter naming scores. Data from children in 2nd preschool for cursive letters were excluded from the analyses because of too many cases of floor performance. Naming performance was highly correlated between the two grade levels for printed letters, $p < .001$. The best named lowercase printed letters were o, i, j, s, and c, m, e, o in cursive. The least named printed letters were q, b, g, h, and b, h, k, p, q, r, v in cursive. As shown in Table 4, our data were strongly consistent with those reported by Helal (2012) for lowercase letters in kindergarten, for printed letters, $p < .001$, and for cursive letters, $p < .001$. This was also the case with the Evans et al. (2006) data for printed lowercase letters collected in kindergarten, $r(24) = .86$, $p < .001$. These high correlations with other studies attest to the consistency of our data.

Table 4. Correlations between letter naming scores collected in Study 2 and different other variables.

	Kind. print.	Kind. curs.	Hel.Kind. print.	Hel.Kind. curs.	Let. Freq.	Pers. Name	Let. Rank	Simil. upp-print	Simil. print-curs.
Pre2 print.	.83***	—	—	—	−.06	.11	.34	.85***	—
Kind. print.	—	—	.84***	—	.41*	.40*	.20	.62**	—
Kind. curs.	—	—	—	.80***	.44*	.50**	−.26	—	.63***

*p < .05.**p < .01.***p < .001.

Correlations between printed (print.) or cursive (curs.) lowercase letter naming scores collected in Study 2 (Pre2: 2nd preschool year; Kind.: kindergarten) and data from Helal (2012; Hel.Kind.), letter rank (Let.Rank), letter frequency (Let.Freq.), letter occurrence in our participants' personal names (Pers.Name), shape similarity between printed uppercase and lowercase letters (Simil.upp-print.) or between printed and cursive lowercase letters (Simil.print-curs).

Letter Frequency in Print

Table 4 confirms that the effect of letter frequency in print was observed in kindergarten, with significant correlations between letter frequency and naming scores for both printed and cursive letters, $p_s < .05$. This was not the case in 2nd preschool, $p = .83$ (printed letters only). In addition, consistent with the previously mentioned results, the hypothesis of an own-name advantage was not supported by the correlations with letter occurrence in children's own name in 2nd preschool for printed letters, $p = .87$, in contrast to what was observed in kindergarten for both printed and cursive letters, $p_s \leq .05$.

Vowel and Consonant Naming

As detailed in Table 3 for Study 2, children knew vowel names better (printed: $M = 44.20\%$, $SD = 31$; cursive: $M = 16.40\%$, $SD = 23$) than consonant names (printed: $M = 27.10\%$, $SD = 26$; cursive: $M = 6.40\%$, $SD = 9.8$), for both types of letter case, $t(65) = 6.5$, $p < .016$ and $t(55) = 3.6$, $p < .016$ respectively. This was true at each grade level, $p_s < .016$. The letter-name pronunciation effect was not significant for the lowercase printed letters, whether or not grade levels were differentiated, $p_s > .016$. Unexpectedly, an effect opposite to the letter-name pronunciation effect was found for cursive letters. Consonants whose names were unrelated to their pronunciation were better named ($M = 13.84\%$, $SD = 18.40$) than those whose names were related to their pronunciation ($M = 4.80\%$, $SD = 8.80$), $t(55) = 4.47$, $p < .016$. This comparison was significant in kindergarten, $t(30) = 3.4$, $p < .016$, and in 2nd preschool, $t(24) = 3$, $p < .016$. In addition, the superiority of VC-name consonants ($M = 8.42\%$, $SD = 13.5$) over CV-name consonants ($M = 1.98\%$, $SD = 7$) was significant for cursive letters, $t(55) = 4.3$, $p < .016$. This was true at each grade level, $p_s < .016$. However, the same comparisons did not reach significance for printed letters in 2nd preschool and kindergarten, $p_s > .016$.

Letter Rank

Cursive letters in the first half of the alphabet ($M = 10.85\%$, $SD = 14.00$) were named better than those in the second half ($M = 5.49\%$, $SD = 10.10$), $t(55) = 4.2$, $p < .016$. As shown in Table 3, this was true for each grade level, $p_s < .016$. However, the opposite effect was found for printed letters, with the second half being named better ($M = 36\%$, $SD = 28.8$) than the first half ($M = 25.2\%$, $SD = 25$), $t(65) = 6.2$, $p < .016$, also at every grade level, $p_s < .016$. Consistently, Table 4 shows that the correlation between letter rank and letter naming scores was negative for cursive letters but positive for printed letters, although not significant in all cases, $p_s > .09$.

Letter Shape Similarity

Printed lowercase letters with high shape similarity to their uppercase counterparts were named better ($M = 46.60\%$, $SD = 37.40$) than those with low shape similarity ($M = 14.60\%$, $SD = 20.10$), $t(65) = 8$, $p < .016$, also at each grade level, $p_s < .016$. Shape similarity likewise had a significant effect on cursive letter naming scores, which were significantly higher with high shape similarity to their printed analogs ($M = 16.00\%$, $SD = 20.00$) than with low similarity ($M = 3.00\%$, $SD = 7.00$), $t(55) = 5.5$, $p < .016$. This again characterized each grade level, $p_s < .016$.These results are confirmed by the correlation analysis in Table 4. The greater the shape similarity to their uppercase counterparts, the higher the naming scores for lowercase printed letters at each grade level, $p_s < .01$. Similarly, naming scores for cursive letters were higher for those with high shape similarity to their printed analogs, $p < .001$.

Four potential continuous predictors of printed or cursive letter naming scores were entered into stepwise hierarchical regressions: letter occurrence in the participating children's personal names, letter frequency in print, letter rank, degree of shape similarity between uppercase and lowercase printed letters, or between lowercase printed letters and cursive letters. Shape similarity to uppercase counterparts was the most significant predictor of lowercase printed letter naming scores in 2nd preschool (65.30% of variance explained, $\beta = .81$, $p < .001$) and kindergarten (39.40% of variance explained, $\beta = .63$, $p = .001$). The other three predictors did not contribute significantly to the model as single predictors in 2nd preschool, $p_s > .10$. In kindergarten, letter occurrence in children's first names, $ß = .39$, $p = .02$, significantly improved the model, as did letter frequency in print, $ß = .35$, $p = .03$, which together increased the explained variance to 76.80%. For cursive letters, in kindergarten, the only significant predictor was shape similarity to their printed counterparts, with 36.70% of the variance explained, $ß = .61$, $p < .001$. The other three predictors increased the amount of variance explained to 46.60%, but none added significant unique predictive power, $p_s > .20$.

Discussion

Acknowledging the conflicting literature on the effects of various factors influencing LNK in young children and the paucity of studies involving French-speaking children, the present studies tested the impact of several child- and letter-related factors on naming knowledge of uppercase and lowercase letters. They showed that learning the names of uppercase letters in the preschool and kindergarten periods relies primarily on knowledge of the personal name letters, whereas learning the names of lowercase letters relies heavily on their visual similarity to their uppercase counterparts, and for cursive letters, to their lowercase printed analogs. The other major consistent finding revealed by our studies was that repetition effects, as captured by frequency analyses, take time to emerge regardless of the content being learned (e.g., personal name letters, lowercase letters). Therefore, it was not until a certain age (or school year), when a sufficient amount of exposure to a particular learning content had been achieved, that children's LNK became congruent with the characteristics of that learning content.

Several authors have outlined the important role of paired-associate learning processes in early literacy (e.g., Hulme et al., 2007, Nilsen & Bourassa, 2008; Roberts et al., 2018). To our knowledge, the present work is the first to provide a consistent view of LNK development as a function of letter case, following the guiding principles of associative learning as developed by Perruchet and Vinter (2002). Indeed, most of our findings can be accounted for by an associative learning framework that posits that repeated exposure to associations between letter shapes and letter names progressively produces consistent learning in children (Perruchet & Vinter, 2002). Within this framework, in order to more fully capture the development of letter naming skills, it is important to qualify the relevant characteristics of the surrounding environment in which this basic learning mechanism operates. In this respect, two points have been outlined: that letter naming instruction at school in France introduces children first to uppercase letters, followed by printed and then cursive lowercase letters; and that the very first letters presented by teachers and parents are generally those of the child's personal name. Direct interactions between these environmental features and those of associative learning at work in young children engaged in emotional, social, and cognitive construction are likely to account for many of our findings, as will be discussed in the next sections. However, our studies have also shown that a linguistic account of some results is necessary.

LNK and Child-Related Factors within an Associative Learning Framework

Like most children in many countries (Treiman & Kessler, 2003), the first letters that French children are exposed to during implicit or explicit letter naming instruction are generally the letters of their personal name, written in uppercase letters. The repetition of these specific letter-name associations creates an idiosyncratic frequency effect that contributes to the emergence of an initial LNK reduced to these letters, which will have an "advantage" over the others. Consistent with the literature (Bouchière et al., 2010; Justice et al., 2006; Treiman & Broderick, 1998; Treiman et al., 2007), Study 1 confirmed the advantage of personal name letters. This factor was the main explanatory factor for the LNK of uppercase letters in children of all ages, perhaps because of the enduring special emotional and social significance of personal names in developing children. Study 2 generalized this effect to printed lowercase letters at ages 5–6, but not at ages 4–5. Indeed, a substantial amount of exposure to the associations to be learned is required to create new cognitive units: On average, only 5–6 printed lowercase letters were known in the 2nd preschool year. The same pattern of results was found for lowercase cursive. However, this original finding of Study 2 was unexpected in terms of our learning framework, since kindergartners knew only the names of only 3.3 cursive letters on average. As will be suggested later, this contradictory result may be, at least in part, a byproduct of the shape similarity effect between printed and cursive lowercase letters. Contrary to what Huang and Invernizzi (2014) found, the impact of the own-name advantage on lowercase LNK was not strong enough to emerge as a significant explanatory factor in Study 2. Consistently, the superiority of the first name initial over other letters, reported by several authors (Justice et al., 2006; Philips et al., 2012; Treiman et al., 2007) was found in Study 1 with uppercase letters, but not in Study 2 with lowercase letters. In our view, this finding makes sense because the initial of first name is usually written, and thus seen by children, in uppercase rather than lowercase letters.

The effect of gender on children's LNK was clearly weak. As in Treiman et al. (2006), a consistent but generally nonsignificant descriptive outperformance of girls relative to boys was found in our studies. It is likely that a significant effect of gender can be demonstrated with large samples of participants, as was the case in Ecalle et al. (2020) or Sigmundsson et al. (2018). However, a significant effect of gender in favor of girls was observed in Study 2 when analyzing LNK for personal names. This could be due to a deeper engagement of girls in prewriting literacy acquisition (Zhang et al., 2019), possibly caused by a maturational factor such as faster fine motor skills development in girls. Hypothesizing that girls write their first name letters earlier and more regularly than boys, it would accelerate letter name learning if they (or the adults around them) were likely to name the letters of their first name at the same time. This hypothesis would imply that the observed gender effect is a byproduct of a practice and repetition effect, consistent with our associative learning framework.

LNK and Letter-Related Factors within an Associative Learning Framework

One clear experience-based factor emphasized by any view of associative learning is the frequency effect. The more we hear and see an event, the more we learn about it (e.g., Fiser & Aslin, 2001; Saffran et al., 1996). Our results support this view. Correlations between letter frequency and letter naming scores were significant at ages 4–5 and 5–6, but not at ages 3–4, for uppercase letters (Study 1). They were significant for lowercase letters at ages 5–6, but not at ages 4–5 (Study 2). As has been pointed out several times, a significant amount of experience is required for a frequency effect to appear. The literature is conflicting on the role of this factor on the LNK, with positive (Bouchière et al., 2010; Kim et al., 2021; Treiman et al., 2006; Turnbull et al., 2010) and negative (Ecalle, 2004; Evans et al., 2006; Kim & Petscher, 2013) results. The age of the children cannot explain these discrepant results, as most of these studies involved children between 4 and 6 years of age. The consistency of the database used to index letter frequency in print may play a role, which further research may clarify. However, in Study 1, the effect of letter frequency was not strong enough for this factor to explain a significant proportion of the variance in uppercase letter naming scores. In Study 2, at ages 5–6, letter frequency accounted for a significant proportion of the variance in printed lowercase letter naming scores, i.e. when the letters were shown with the very same visual shapes that children experience when looking at books. This finding makes sense within our associative learning framework.

Another experience-based factor tested in the present research was found by Turnbull et al. (2010) and Huang and Invernizzi (2014) to be the main predictor of LNK for printed lowercase letters, namely the similarity of the visual shape of lowercase letters to their uppercase analogs. Study 2 confirms this finding and it is the first study to extend this result to cursive letters. Their shape similarity to their printed lowercase analogs was the only significant explanatory factor for cursive letter naming scores. As is well documented in the theory of associative learning as stimulus generalization (e.g., Rescorla, 1976; Shepard, 1987), naming knowledge would be transferred between letters that have very similar shapes, so that previously learned associations (e.g., uppercase letters) would directly guide learning in novel situations (e.g., lowercase letters) based on the degree of shape similarity between letters, short-circuiting the possible effects of other factors, especially linguistic ones. Thus, although different predictors act as major predictors of LNK for uppercase letters (the letters of the first name) and for lowercase letters (visual shape similarity with presumed previously learned analogs), the learning mechanisms would be unified in both cases, relying on properties of associative learning. A recent research confirms that preschoolers know lowercase letters better when they already know their uppercase analogs (Park, 2022). Note that the impact of shape similarity across letter cases may possibly explain the unexpected finding in Study 2 mentioned above, which demonstrated the first name advantage for cursive letters even though preschoolers are not frequently exposed to their first name written in cursive. One can hypothesize that a sufficient number of cursive letters with high visual similarity to their printed analogs were included in the names of the children tested.

Letter rank in the alphabet had an overall weak effect on LNK, with nonsignificant correlations with naming performance. However, better global performance was found for the first than the second half of the alphabet for uppercase letters (Bouchière et al., 2010; Justice et al., 2006), and for cursive lowercase letters, an original finding in our research. Study 2 revealed the opposite effect for printed lowercase letters, with better naming performance for the second half of the alphabet, a result also reported by Huang and Invernizzi (2014). However, these seemingly odd results may be due to the fact that letter shape similarity across letter cases largely determines lowercase naming scores. Indeed (see the method section of Study 2), only 4 printed lowercase letters showed strong shape similarity with their uppercase analogs in the first half of the alphabet, while 9 did so in the second half. This distribution tended to be reversed for cursive letters: 6 in the first half of the alphabet, 4 in the second half. Thus, we suggest that part of this letter rank effect for lowercase letters may be a byproduct of the letter shape similarity effect.

Letter name type also influenced uppercase and lowercase letter naming scores, but at a lower level than personal name letters, letter shape similarity, or letter frequency in print. The opposite was reported by Kim and Petscher (2013) in their study with Korean-speaking children. This highlights the role of intrinsic properties of the language under study. Consistent with the literature involving French-speaking children (Bouchière et al., 2010; Cormier, 2006; Helal, 2012), vowel naming scores were systematically higher than consonant naming scores, regardless of letter case and grade level. The high sonority of vowels and the fact that vowel names correspond to their sounds (no speech segmentation required) are commonly invoked to explain this vowel superiority, showing that phonology directly acts on LNK acquisition. The letter-name pronunciation effect (Justice et al., 2006) was only confirmed in kindergarten for uppercase letters, not for printed lowercase letters. Indeed, children need to know a sufficient number of consonant letter names for phonological categories to emerge, suggesting that experience and phonology combine their effects on consonant name knowledge. However, replication is needed because other French studies have not observed this pronunciation effect at all (Bouchière et al., 2010; Helal, 2012). The fact that the opposite effect (better naming performance for consonants whose names are inconsistent with their pronunciation) was found for lowercase cursive letters was not expected. But again, this could be a side-effect of the shape similarity effect. In fact, the letter “c” (consonant with an inconsistent name in relation to its pronunciation, and with high shape similarity across letter cases) was the best cursive-named letter. This could have a direct impact on the average naming score of consonants with names unrelated to their pronunciation, due to the otherwise small number of known lowercase cursive letter names.

Finally, in line with most of the Francophone literature (Bouchière et al., 2010; Cormier, 2006; Helal, 2012) but in contrast to most of the Anglophone literature (Evans et al., 2006; Justice et al., 2006; McBride Chang, 1999; Philips et al., 2012), we found that, on average, uppercase consonants with VC names were better named than those with CV names, except in the 1st preschool year. Again, we suggest that the emergence of these consonant categories requires sufficient exposure time to a significant range of consonant names, thus explaining the developmental effect. The difference between French- and English-speaking children could be related to differences in the phonemic segmentation abilities of nonreading young children in both languages, with the latter having better phonemic perception than the former (Duncan et al., 2006). This would make the consonants with a CV name perceptually more salient for English children (relevant phoneme in first position). The same superiority of consonants with VC names was observed for lowercase cursive letters. However, this result deserves to be replicated with children who show a higher level of performance in cursive letter naming than our sample. Further investigation is required to clarify this issue also for printed lowercase letters, as the observed superiority of naming scores for consonants with VC names over CV names failed to reach significance.

Conclusion

Limitations of the Studies

In conclusion, before considering the practical implications that can be drawn from our results, it is worth pointing out the more important limitations of the studies. A first limitation is due to our decision to examine only the letter naming task. This choice was methodologically justified, but it remains that it would have been interesting to introduce other preliteracy tasks related to letter knowledge, in particular a letter sound task. This limitation prevents us from relating our results to other aspects of emergent literacy learning. A second limitation of our studies concerns our decision to use a between-subjects design to investigate the effects of letter cases. This makes our interpretation of the role of letter shape similarity across letter cases rather hypothetical. We analyzed differences in mean correct letter naming scores as a function of their high or low visual similarity to their uppercase analogs for printed lowercase letters, or to their printed lowercase analogs for cursive letters. Our claim that letter naming knowledge is transferred at least in part, on the basis of shape similarity from uppercase to lowercase, or from print to cursive, would have been more directly supported if we had used a within-subject design. Finally, we regret that we were not able to ensure an equal number of participants across grade levels and cases. This weakens the statistical analysis to some extent.

Practical Implications

Several authors have argued that LNK is an important preliteracy skill that helps children to connect written and spoken symbols and prepares them for reading and spelling (Treiman & Kessler, 2003). Anticipating the "science-of-reading" called for by Roberts (2021). Jones et al. (2013) have developed letter-name and letter-sound teaching strategies that derive directly from what they have retained as scientific evidence, such as following the alphabetical order of letters, focusing on the first letters of children's first names in a class, starting with the least common letters to give them more instructional time, and so on. Of course, such an approach requires that the scientific evidence on which it is based is valid for the language in question. For example, our results do not support the alphabetical order strategy or the first letter of the first name strategy. However, the idea that different amounts of instructional time might be needed for different letters is clearly a correct consequence of the fact that more practice is required as task complexity increases. Letters can show different degrees of complexity for learning their name according to several factors (e.g., their frequency in print, their shape similarity across letter cases, etc). The teacher has two opposing strategies: to start with the easiest letters in order to maximize the child's success and satisfaction (law of effect), or to start with the most difficult letters in order to ensure sufficient teaching time. For our part, we find it preferable to favor the first strategy with the younger children, in order to maintain their motivation and engagement in preliteracy tasks, and then gradually adopt the second.

The associative learning perspective that we have adopted in this paper allows us to consider other implications. The pairing of letter shape and letter name (and sound) is the basic mechanism that needs to be automated through repetition and practice (see also Ehm et al., 2019), and this learning is facilitated when the associations are presented in isolation. Note that the well-known blocking effect in associative learning (e.g., Rescorla, 1999) might allow going a step further in drawing practical consequences. Learning might benefit from pairing both uppercase and lowercase letters with their name or sound at the same time, rather than starting with only one of these letter cases, thus avoiding blocking the learning of the second association. This prediction could be tested in future research. We can also ask whether the same prediction could be made about learning the name of the letter, or the sound of the letter, or both together. Roberts et al. (2018) showed a trend toward more effective learning when name and sound were combined (which corresponds to the teaching strategy advised in France). However, combining uppercase, lowercase, name, and sound can quickly become complex and counterproductive to effective learning. Acknowledging the role of visual analysis of letter shape when dealing with uppercase and lowercase letters, on the one hand, and the power of implicit learning processes in young children when faced with complex situations, on the other hand (e.g., Perruchet & Vinter, 2002), our proposal would be as follows: systematically expose children to both upper and lower case letter forms at the same time (leading to automatic activation of implicit visual learning processes), and explicitly teach the association between letter shape, letter name, and letter sound, focusing the child's attention only on the uppercase form of the letter. Only later should all these associations be explicitly taught. This teaching strategy deserves to be tested.

Finally, a couple of other points can be drawn from our results. The first, related to the importance of the letters of the personal name, is now largely implemented in the curricula of most countries, which advise to start letter name/sound learning with these specific letters. They are fewer in number and positively engage children in the learning process. Much less used to guide alphabetic instruction, at least in France, are the consequences related to our second main finding, the importance of visual shape similarity between corresponding uppercase and printed lowercase letters on the one hand, and between printed and cursive lowercase letters on the other. When teaching letter names and/or sounds, teachers should pay particular attention to letters whose shapes vary according to their case, since they cannot benefit from a learning facilitation effect due to the phenomenon of stimulus generalization. Grouping letters according to their shape stability through their case, starting with the most stable letters, might be beneficial for this teaching. At the same time, it is important to avoid mixing letters whose shapes may be confused, at least in the initial steps of learning (Kim et al., 2021). The combination of these different constraints suggests that it may be possible to propose a facilitating sequence of letters in alphabet instruction, definitively far from the "ABC" sequence. An instructional study testing the strength of letter shape similarity in learning letter names would be interesting to conduct.

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