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A longitudinal investigation of letter-name knowledge in a semi-transparent orthography

Linda Larsen [a], Hanne Næss Hjetland [a] and Stefan Kilian Schauber [b]

[a]The Department of Special Needs Education, Faculty of Educational Science, University of Oslo, Oslo, Norway; [b]Centre for Health Science Education, Faculty of Medicine, University of Oslo, Oslo, Norway

ABSTRACT

Children's ability to correctly name letters is a key predictor of later reading abilities and skills, but research on letter naming from Scandinavian orthographies is scarce. The aim of this study is to explore how child- and letter-related factors (i.e., gender, child name, phonemic awareness, letter position in the alphabet and frequency, and speech sound development) are associated with Norwegian children's letter-name knowledge over time. The sample comprises 185 Norwegian children with an average age of 51.59 months ($SD = 2.12$) who completed a letter-naming task on three separate occasions one year apart. Results from mixed-effects models show that children were more likely to name the first letter of their own name, however, this effect diminished over time. Further, letter frequency significantly predicted letter naming, and the letter frequency and letter position in alphabet effects were larger in older children. This study contributes important and relevant information for teachers and educators.

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Letter-name knowledge; children; own-name; letter-frequency; Norwegian; mixed-effects modelling

As soon as children start showing an interest in the alphabet and begin to learn the names of letters, they have begun the process of learning to read. Children's ability to name letters, also called letter-name knowledge, has consistently been shown to be positively related to and a strong predictor of later reading ability across different orthographies (e.g., Caravolas et al., 2013; Kim, 2007; Lervåg et al., 2009; Torppa et al., 2006). This relationship has been explained by the role that letter-name knowledge plays in the development of phonological awareness skills (particularly phonemic awareness) and letter-sound knowledge (Foulin, 2005; Share, 2004), which are both crucial for reading development (Adams, 1994). What do children bring to the task of letter learning and what other factors might affect letter name learning? These questions have been addressed in several studies focusing on English (Evans et al., 2006; Treiman et al., 1997; Treiman & Broderick, 1998), although some have focused on Portuguese (Kim et al., 2021; Treiman et al., 2006), Hebrew (Kim et al., 2021; Levin et al., 2006; Treiman et al., 2007, 2012), Arabic (Tibi et al., 2022), Korean (Kim et al., 2021), and Spanish (De la Calle et al., 2018).

In this study, we wish to add to the literature on letter knowledge by investigating the association of three child-related factors, namely, child gender, the initial letter of the child's name and phonemic awareness skills and three letter-related factors, namely, letter frequency, letter position in the alphabet and consonant speech-sound acquisition order, with letter-name knowledge in a sample of

CONTACT Linda Larsen linda.larsen@fhi.no Division of Mental and Physical Health, Norwegian Institute of Public Health, Oslo, Norway

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Norwegian preschool children. This research is important for three reasons: first, it is the only study that we are aware of that investigates both child- and letter-related factors on Norwegian children's letter-name knowledge, although we note that two Norwegian studies have investigated gender effects (Karlsdottir, 1998; Sigmundsson et al., 2017; Sigmundsson et al., 2018); second, it contributes to the cross-linguistic study of letter-name knowledge; and third, it explores letter-name knowledge in a Scandinavian context where learning of letter names is not encouraged prior to starting school.

Early childhood education and care pedagogy and Norwegian orthography

In Norway, most children attend early childhood education and care (ECEC; Statistics Norway, 2016) and ECEC is seen as a way to reduce social inequality and promote child development. Children attend ECEC from the age of one and by age three, more than 95% of children attend ECEC for five days per week (Norwegian Directorate for Education and Training, 2018). Children start primary school (Grades 1–6) in the autumn of the year they turn six. The national curriculum for ECEC in Norway places particular emphasis on care, play and learning – in that order, although learning has in recent years been given more emphasis (Otterstad & Braathe, 2010). The Norwegian ECEC pedagogy views learning as *informal*, happening through curiosity, exploration, and creative activity, and directed by the children themselves or in concert with early childhood teachers. *Formal* learning with clear benchmarks, for example, the number of letters children should be able to name by the end of ECEC and before starting school, is not part of the ECEC pedagogical programme. This contrast with for example, the United States where this benchmark is knowledge of 16–19 letter names (U.S. Department of Education, 2009).

The Norwegian orthography is different to other alphabetic orthographies in that the Norwegian alphabet has 29 letters (20 consonants and 9 vowels). The additional vowels are *æ*, *ø*, and *å*, which appear at the end of the alphabet in this order. Further, the letters *c*, *q*, *w*, *x*, and *z* are considered foreign and used only in few loan words (e.g., taxi, weekend), and mostly these letters are replaced, for example, *zebra* → *sebra*. The Norwegian orthography is semi-transparent with some complexities in the spelling-to-pronunciation relationship and thus, lies in-between shallow orthographies such as Finnish and Italian, and deep orthographies such as English and French (Landerl et al., 2013). For example, Norwegian has a number of silent consonants (e.g., *d* in *blid*, "happy/cheerful", and *h* in *hjelp*, "help", are not pronounced) and vowel length is generally indicated by the consonants following the vowel (i.e., short: *takk*-/tɑk/, "thanks" and long: *tak*-/tɑ:k/, "roof"), rather than by a multiple-letter spelling as seen in English (see Hagtvet et al. [2006] for a more extensive description of the complexities of the Norwegian orthography).

Child-related factors

At least two Norwegian studies have found that girls outperform boys on naming upper- and lowercase letters (Karlsdottir, 1998; Sigmundsson et al., 2017; Sigmundsson et al., 2018). This corroborates research conducted in both shallow and deep orthographies. For example, Treiman et al. (2006) found that girls outperformed boys in American-English and Portuguese (using a sample of Brazilian children), although this was not statistically reliable for American-English. In a follow-up study, with American-English and Hebrew, the Hebrew sample showed a statistically significant gender difference in letter-name knowledge favouring girls (Treiman et al., 2007). Similar gender effects have been found with French children (Bouchière et al., 2010) and American- and Canadian-English children (Deasley et al., 2018; Iversen et al., 1970). It is conceivable that a gender effect might attenuate by including older children as older boys might have "caught up" with girls over time.

Another child-related factor that is associated with letter-name knowledge is a child's own name. For example, there is evidence that children's ability to write their own name is related to letter-name knowledge (Arrow & McLachlan, 2014). Another line of research has consistently demonstrated that children are more likely to correctly name a letter if the letter is in the child's name and especially, if the letter is in the initial position of the child's name (Bloodgood, 1999; Huang & Invernizzi, 2014; Justice et al., 2006; Phillips et al., 2012; Treiman et al., 2006; Treiman et al., 2007; Treiman & Broderick, 1998; Treiman & Kessler, 2004). This is referred to as the own-name advantage and has been explained as a type of frequency effect. That is, children are exposed to the letters in their name more frequently than other letters as they see their own name more often compared to other words including other children's names. The initial letter is more salient simply as it is at the beginning of the child's name.

A third child-related factor, which has a close relationship with letter-name knowledge, is phonological awareness (i.e., the awareness of and ability to segment and manipulate speech sounds of different size units). Awareness at the phoneme level is called phonemic awareness, and research from English suggests that letter-name knowledge is related to phonemic awareness (Arrow & McLachlan, 2014; Burgess & Lonigan, 1998). Further, a longitudinal study has found letter-name knowledge is associated with awareness of phonemic- and supra-phonemic-level units (e.g., syllables, rimes) and the nature of this relationship appears to be bidirectional (Lerner & Lonigan, 2016). While this study is the first to demonstrate this in English, an earlier study with Korean pre-schoolers have found a similar result (Kim, 2009).

Letter-related factors

While the own-name advantage can be understood as a type of frequency effect specific to each child, there is a more general frequency effect that may affect letter naming, namely, the frequency with which letters occur in written text. Different letters occur with different frequency in text and these letter-specific frequencies vary between orthographies. In the literature, the evidence for a letter frequency effect on letter naming is mixed. On the one hand, non-significant associations have been found in French-speaking (Ecalle, 2004) and English-speaking Canadian kindergarteners (Evans et al., 2006). On the other hand, a recent study employing item response modelling showed that letter frequency was related to letter naming in four languages varying in orthographic depth, namely, English, Portuguese, Korean and Hebrew (Kim et al., 2021). This replicates earlier studies from English, Portuguese, and Hebrew (Treiman et al., 2006; Treiman et al., 2007). Furthermore, Huang and Invernizzi (2014) found that U.S. kindergarteners from economically disadvantaged homes had a higher probability of correctly naming (lowercase) letters that appear more frequently in text.

There is another way in which we can think of letter frequency. It has been proposed that children may have greater informal exposure to letters occurring earlier compared to later in the alphabet, for example, through alphabet games and television programs. If exposure to letters plays a role in letter name learning, it follows that children should find letters earlier in the alphabet easier than letters later in the alphabet. This has been referred to as the letter-order effect and has received some support in the literature. For example, Justice et al. (2006) found evidence to support the letter-order effect and children in their study were 1.02 times more likely to know a letter one position earlier in the alphabet (e.g., A was 1.02 times more likely to be known than B). Interestingly, other studies investigating both shallow and deep orthographies have not found evidence to support the letter-order effect (De la Calle et al., 2018; Evans et al., 2006; Kim et al., 2021) and one study has found support for the letter-order effect, but in the opposite direction. This may, however, be a "recency effect". If children had been taught the alphabet from A to Z, they would at the time of testing most recently have learned the letters at the end of the alphabet and therefore performed better on these (Huang & Invernizzi, 2014).

Another letter-related factor that has been found to influence letter naming is the acquisition order of speech sounds. It is believed that the frequent articulation of earlier-acquired sounds influences the robustness of the phonological representations of these sounds. In turn, the more robust a phonological representation is, the easier it will be to learn and therefore, name the letter associated with the phonological representation. Few empirical studies have tested this, but Justice and colleagues (2006), who focused on consonant speech sounds in English and grouped consonant letters into categories based on the time of acquisition (in 6-month intervals) of the associated speech sounds, found a significant effect of consonant-order. That is, letters that correspond to earlier-acquired consonant speech sounds (e.g., /b/, /m/, /t/) were learned more readily and thus, were more likely to be named correctly. They reported an odds ratio of 1.09, suggesting that for a one Category increase (e.g., from Category I to Category II) children were 1.09 times more likely to correctly name letters in that Category. The only other study to explore the speech sound order of acquisition effects used a sample of four- and five-year-old Spanish children, but in this study, the effects were not statistically significant (De la Calle et al., 2018). To our knowledge, the consonant-order effect on children's letter naming has never been investigated in a semi-transparent orthography like Norwegian.

The present study

In the present study, we focus on Norwegian children's letter knowledge from age 4 to age 6, and we extend a recent Norwegian study reporting gender differences in children's letter knowledge. Specifically, we investigate if letter knowledge is associated with three child-related factors (i.e., child gender, the initial letter of a child's name, phonemic awareness skills) and three letter-related factors (letter frequency, letter position in the alphabet, consonant acquisition order). This is the first study to investigate, in such detail, the letter-name knowledge of Norwegian pre-schoolers and based on previous research, primarily focusing on English and to a lesser extent other orthographies, we hypothesise that Norwegian children's letter knowledge is associated with all of the factors under investigation. However, we have no clear hypotheses about how these factors may related to letter knowledge across time, that is, from when children are assessed for letter knowledge at age 4 up to age 6 (the year the start school).

Materials and methods

The present study is based on new analyses of data from a longitudinal study, which has previously been reported elsewhere (Brinchmann et al., 2018; Hjetland et al., 2019; Klem et al., 2016; Melby-Lervåg et al., 2012). There is no overlap in aims between the present study and any of those previously reported from the original longitudinal study. In the original study, children entered the study when they were 4 years of age and were followed until they were 9 years of age. Children were assessed on a range of cognitive, language and literacy measures annually in December through to February. When children were younger, and an extensive test battery was used, testing was performed in three different sessions of shorter duration, but when children were older, and a reduced test battery was used, there was only one testing session (of slightly longer duration). As expected with any longitudinal study, there was some attrition due to children moving to remote school areas, but overall, the attrition rate was small as previously reported (Hjetland et al., 2019). Below we outline the method for the present study.

Participants

The sample comprised 185 monolingual Norwegian-speaking children (98 boys and 87 girls), who were between 47 and 57 months old ($M = 51.59$, $SD = 2.12$) when they entered the study. Children had average nonverbal IQ and none had a diagnosis of severe learning or developmental disorder (e.g., autism, sensory impairments, and intellectual disability). Children were recruited from ECECs in a district in Norway that was close to the national average in terms of parent education level (Norway: 26.5% junior high school, 40.6% high school, 32.9% university and recruitment area: 28.1% junior high school, 40.9% high school, 31.1% university; Statistics Norway, 2016). Research permission from the Norwegian Centre for Research Data and parental consent were obtained before testing commenced.

Procedure

As mentioned above, children were assessed when they were 4 (Time 1), 5 (Time 2) and 6 years of age (Time 3), respectively, by trained research assistants. The assessment took place in a quiet room at the child's ECEC centre. In the present study, we use letter knowledge assessed at all three time-points and phonemic awareness assessed at T1 (see Measures below). The administration of tests took around 10–20 minutes to complete. After the child completed the testing, they were praised for their efforts and received a small reward (e.g., a sticker, a small toy).

Measures

Letter knowledge

Letter knowledge was measured by asking the child to give the name (or sound)[1] of 24 upper case letters arranged in a fixed random order. As mentioned earlier the Norwegian alphabet has 29 letters, but the letters *C, Q, W, Z* and *X* were not included. The research assistant marked children's responses for each letter on a scoresheet, and incorrect responses or "don't know" responses were marked by drawing a slash (or cross) through the misidentified or unidentified letters. Children did not receive corrective feedback on the task nor were they given praise or encouragement during the task. Internal consistency for the letter knowledge test was $\alpha = .94$ for T1, .95 for T2, and .93 for T3.

Phonemic awareness

The phonemic awareness task is adapted from the phoneme matching task used by Carroll et al. (2003). In this task, children were introduced to a hand puppet called "Benny the beaver", who collected words that started with the same sound (phoneme). For each trial, Benny held one picture card and the children were presented with picture cards of two other objects. For example, Benny holds a picture of a lamb (in Norwegian: lam) and asks the child: "Which of these words 'light' (in Norwegian: lys) or 'wheel' (in Norwegian: hjul) begins with the same sound as the word lamb?" The child makes his/her choice by pointing to one of the two picture cards and the picture cards are turned over to see what the right answer was as indicated by a colour sticker on the back of the picture cards. Children received feedback on each trial, for example: "Yes, that's correct. Lamb and light begin with the same sound. Wheel is the word that does not fit in/begin with the same sound" or "No, it is lamb and light that begin with the same sound. It is wheel that does not fit in." A correct trial was awarded a score of 1, while an incorrect or "don't know" trial was awarded a score of 0 (maximum score of 16). Internal consistency for the phonemic awareness test was $\alpha = .44$.

Own-name

The own-name variable used is based on the letter in the initial position of a child's first name. Thus, for each child, each letter of the alphabet was dummy coded such that if a letter occurred in the initial position of a child's first name it was coded 1, otherwise letters were coded 0.

Letter frequency

There have been several analyses of large written word corpora in English from which letter frequency counts have been tabulated (e.g., Jones & Mewhort, 2004; Mayzner & Tresselt, 1965). We

[1]It is unlikely that children gave a letter's sound, as they were quite young (i.e., pre-schoolers) and further, they had not yet received formal instruction in letter-sounds due to the tradition of the Norwegian pedagogical preschool program. Thus, we feel confident that our letter knowledge task adequately taps pre-schoolers' letter-name knowledge.

are not aware of any published letter frequency count data in Norwegian. As letter frequency counts are orthography-specific, we calculated these based on the largest Norwegian lexical database – the Norwegian Web as Corpus (NoWaC) – which is a web-based corpus with about 700 million tokens (Guevara, 2010).

Alphabet position

The 24 letters included in the letter knowledge task were coded according to their rank order in the alphabet such that the A was coded 1 and Å was coded 29.

Consonant order

Considering the absence of any data delineating the learning sequence of speech sounds in Norwegian, the categorisation of consonant speech sounds in the present study followed that of Justice et al. (2006). In Category I were B, H, M N, P, N and W with their associated consonant speech sounds mastered by 50% of children by around 18 months of age. Category II included D, G, K and T, their associated consonant speech sound mastered by 50% of children by about 2 years of age. In Category III was F, in Category IV were L, R, and S, in Category V was Z, and finally in Category VI were J and V, their associated consonant speech sounds acquired by about 4 years of age. See Appendix A for an overview of letters' coding for frequency, alphabet position, and consonant speech sounds category.

Data analysis

All analyses were performed in R, version 3.6.0 (RDC Team, 2019). The lme4 package (Bates et al., 2014) was used to perform generalised linear mixed models (GLMM) analyses, the sjPlot package (Lüdecke & Lüdecke, 2019) was used to generate results tables, and the ggplot2 package (Wickham, 2016) was used to visually present the data in a scatterplot. Our analyses were performed in a two-step approach. In Step One, we performed preliminary multilevel analyses to determine the most appropriate random effects structure by implementing a series of increasingly complex base models. We included the intercept and time (as the data is longitudinal) as fixed effects and random effects for student intercept, student slope and item intercept both with and without the student intercept-slope correlation parameter. Differences between models were assessed using likelihood ratio tests. In Step Two, we estimated the base model determined in Step One and included additional fixed effects for gender, own-name, and phonemic awareness, and the interaction terms between time and gender, own-name and phonemic awareness, respectively (child-related factors models). We then performed a similar analysis but replacing child-related factors with letter-related factors – letter frequency, alphabet position and consonant-order – and their interactions with time.

Results

Descriptive results (see Tables 1 and 2, and Figure 1) show that children's letter-name knowledge improved markedly from age 4 to 6 (i.e., from Time 1 to Time 3). While children named more

Table 1. Descriptive statistics for letter-name knowledge by total sample and gender, and phonemic awareness.

	Time 1		Time 2		Time 3	
	M	*SD*	*M*	*SD*	*M*	*SD*
LNK (/24)	3.83 (16%)	5.64	9.69 (40%)	7.53	21.84 (91%)	4.31
LNK – Cons. (/15)	2.41 (16%)	3.80	6.19 (41%)	5.11	13.71 (91%)	2.91
LNK – Vow. (/9)	1.42 (16%)	1.99	3.50 (38%)	2.60	8.13 (90%)	1.64
PA (/16)	9.52 (59.5%)	2.47	–	–	–	–
LNK (/24) Boys	3.80 (16%)	5.71	8.54 (35%)	7.19	21.54 (90%)	4.73
LNK (/24) Girls	3.86 (16%)	5.60	10.94 (45%)	7.73	22.18 (93%)	3.80

LNK = letter-name knowledge; Cons. = consonants; Vow. = vowels; PA = phonemic awareness.

Table 2. Bivariate correlations for gender, letter-name knowledge and phonemic awareness.

Variables	1.	2.	3.	4.
1. Gender[a]	–			
2. T1 LNK	.006	–		
3. T2 LNK	.159*	.691**	–	
4. T3 LNK	.074	.276**	.460**	–
5. PA	.039	.155*	.310**	.230**

LNK = letter-name knowledge; PA = phonemic awareness.
[a]Boys = 0 and girls = 1.
* < .05. ** < .01.

consonants relative to vowels, in terms of the percentage of consonants correctly named and vowels correctly named, respectively, this was in fact similar. At Time 3, children generally performed well on the letter knowledge test, but there was still some variability in performance although it was less marked than at Time 2 (see Figure 1).

When inspecting performance on individual letters (see Table 3), the letters A, O, S and E were those that children found the easiest (Time 1), with 38%, 32%, 27% and 23% of children correctly naming these letters, respectively. The letters that children found the most difficult (Time 1) were Y, Æ, Ø, and Å, with only 3% of children correctly naming Æ and 6% of children correctly named the other three letters, respectively. At Time 3, when children were 6 years of age, all letters were correctly named by at least 80% of children except Æ, which was correctly named by 76% of children.

We now turn to the main analyses, which sought to investigate the effect of child- and letter-related factors on letter-name knowledge in Norwegian preschool children from age 4 to age 6. A two-step approach was used to perform the mixed effects analyses with the main results presented in Tables 4 and 5. In Step One, we determined the most appropriate random effects structure for our data by fitting a series of (base) models with increasingly complex random effects structures (see Appendix B). Results show that each successive model was a better fit compared to its preceding model, with the most appropriate (i.e., best fitting) model including random effects for child intercept, child slope, child intercept-slope correlation and item intercept (Base Model 5: AIC = 8165.9 and BIC = 8211.0). However, using this random effect structure led to convergence problems

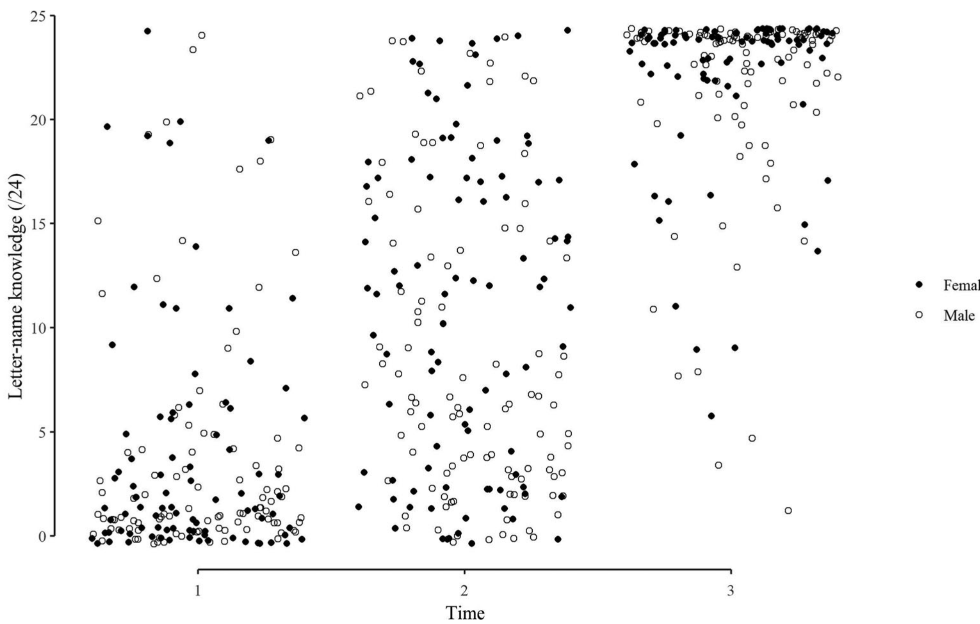

Figure 1. Scatterplot of children's letter-name knowledge over time (from age 4–6).

Table 3. Percentage of children knowing letters from age 4 (Time 1) to age 6 (Time 3)

	Time 1	Time 2	Time 3
A	38	78	99
B	15	44	95
D	9	24	86
E	23	50	97
F	11	38	93
G	9	25	85
H	15	37	89
I	15	49	96
J	10	30	85
K	19	48	91
L	15	43	96
M	22	46	95
N	19	43	93
O	27	65	97
P	11	35	89
R	20	52	94
S	32	66	96
T	20	50	95
U	17	40	95
V	7	30	91
Y	6	18	84
Æ	3	10	76
Ø	7	18	84
Å	7	22	85

when fixed effects were added. Following recommendations by Barr et al. (2013), we removed the random interaction and thus, used the next best random effects structure in our subsequent analyses (i.e., Base Model 4: AIC = 8288.1 and BIC = 8325.6). This alleviated the convergence problems without affecting the parameter estimates of the models.

In Step Two, we carried out a series of mixed effects analyses using the random effect structure determined in Step One (see Table 4). Firstly, there was a highly significant effect of time on children's letter knowledge (OR = 49.23). Secondly, when we added the child-related factors – gender, own-name and phonemic awareness – to the model (see Model 2), we found a significant effect of time (OR = 63.94) and own-name (OR = 29.61). Thus, children's letter-name knowledge improved

Table 4. Modelling the effects of child-related factors on letter-name knowledge.

	Model 1 (Base Model 4)			Model 2			Model 3		
	OR	CI	*p*	OR	CI	*p*	OR	CI	*p*
Fixed effects									
(Intercept)	0.02	0.01–0.03	**<0.001**	0.01	0.00–0.02	**<0.001**	0.01	0.00–0.02	**<0.001**
Time	49.34	38.76–62.80	**<0.001**	63.94	49.08–83.31	**<0.001**	61.15	43.19–86.56	**<0.001**
Gender				1.24	0.50–3.08	0.638	1.17	0.47–2.96	0.734
Own-name				29.61	20.17–43.45	**<0.001**	69.43	42.48–113.47	**<0.001**
PA				1.24	0.78–1.95	0.364	1.23	0.77–1.96	0.384
Time×Gender							1.26	0.78–2.03	0.339
Time×Own-name							0.23	0.14–0.38	**<0.001**
Time×PA							1.05	0.81–1.35	0.724
Random effects									
Child Intercept	8.00			9.33			9.40		
Child Slope	1.59			1.89			1.91		
Item Intercept	1.43			1.45			1.45		
Residual	3.29			3.29			3.29		
Marginal R^2/Conditional R^2		0.440/0.855			0.458/0.873			0.457/0.874	

PA = Phonemic Awareness with a scale transformation.
Bold values are indicates *p*-values for significant effects.

Table 5. Modelling the Effects of Letter-related Factors on Letter-name Knowledge.

	Model 4			Model 5			Model 6		
	OR	CI	*p*	OR	CI	*p*	OR	CI	*p*
Fixed effects									
(Intercept)	0.10	0.04–0.24	**<0.001**	0.19	0.08–0.48	**<0.001**	0.02	0.01–0.05	**<0.001**
Time	49.34	38.76–62.80	**<0.001**	27.12	19.96–36.85	**<0.001**	42.74	30.59–59.71	**<0.001**
Letter frequency[a]	0.90	0.85–0.94	**<0.001**	0.87	0.82–0.91	**<0.001**			
Position Alphabet	0.97	0.93–1.01	0.153	0.95	0.91–0.99	**0.026**			
Time×Letter frequency				1.03	1.02–1.05	**<0.001**			
Time×Position alphabet				1.01	1.00–1.03	**0.038**			
Consonant-order							0.93	0.69–1.25	0.621
Time×Consonant-order							1.08	1.00–1.16	0.059
Random effects									
Child Intercept	7.98			7.97			8.10		
Child Slope	1.59			1.54			1.55		
Item Intercept	0.64			0.65			0.67		
Residual	3.29			3.29			3.29		
Marginal R^2/Conditional R^2		0.476/0.855			0.480/0.856			0.460/0.853	

[a]Letter frequency rank order.

significantly from age 4–6 and children were significantly more likely to name a letter if the letters was the first letter in their name. Gender and phonemic awareness were not significant predictors in the model. We then added the interaction terms between child-related factors and time (see Model 3). This did not affect the overall results; time and own-name remained significant predictors of letter-name knowledge (time: OR = 61.15 and own-name: OR = 69.43). Only the time by own-name interaction was significant in the model (OR = 0.23), suggesting that the advantage for the initial letter in a child's name diminished as children got older (i.e., smaller own-name effect across time). When comparing the overall fit of the two models, we found that the interaction model (i.e., Model 3) was significantly better ($X^2 = 30.062$, df = 3, $p < .05$) although fit indices were very similar (Model 2: AIC = 7894.4 and BIC = 7894.4 and Model 3: AIC = 7892.9 and BIC = 7892.9) and both models explain around 87% of the variance at the letter-knowledge level.

Secondly, we performed a similar analysis but substituting child-related factors with two letter-related factors – letter frequency and letter position in the alphabet (see Table 5). There was a significant effect of time (OR = 49.34) and of letter frequency (OR = 0.90), which shows that for a one unit increase in frequency rank order (i.e., a decrease in letter frequency as the most frequent letter was coded 1) there was a 10% decrease in the likelihood of the letter being named correctly (see Model 4). The letter position in alphabet factor was not significant. Next the interaction terms between item-related factors and time were added to the model and again; time and letter frequency remained significant in the model (time: OR = 27.12 and letter frequency: OR = 0.87). Further, letter position in alphabet was now significant (OR = 0.95), suggesting that for each subsequent letter in the alphabet (e.g., from D to E or H to I) there was a 5% decrease in the likelihood of the letter being named correctly. Finally, both the time by letter frequency (OR = 1.03) and time by letter position in alphabet (OR = 1.01) interactions were significant, suggesting that the effect of letter frequency and letter position in alphabet on letter-name knowledge was somewhat stronger the older children were. When comparing the overall fit of the two models, we found that the interaction model was significantly better ($X^2 = 31.804$, df = 2, $p < .05$) although fit indices are very similar (Model 3: AIC = 8273.2 and BIC = 8325.8 and Model 4: AIC = 8245.4 and BIC = 8313.0) and both models explain around 85% of the variance at the letter-knowledge level.

Finally, we explored the effect of consonant-order on children's letter-name knowledge (see Model 5 in Table 5). Here we asked if children were more likely to correctly name consonant letters that were associated with earlier acquired consonant speech sounds. We did not find evidence to suggest this (OR = .93, $p = .62$), although the odds ratio was in the right direction. Further, the time by consonant-order interaction was non-significant (OR = 1.08, $p = .06$). We note that in none of the models for letter-related factors did the results change when gender was included as a control variable, and we, therefore, report results based on the most parsimonious model structure (i.e., without including gender).

Discussion

Children's knowledge of letter names is associated with several child- and letter-related factors such as gender and the frequency of occurrence of letters in written text. Although much of the research on letter-name knowledge comes from English, a deep orthography with many complexities in spelling-to-pronunciation relationships, a recent Norwegian study has shown that gender plays a role in Norwegian preshoolers' letter-name knowledge with girls outperforming boys (Sigmundsson et al., 2017; Sigmundsson et al., 2018). Norwegian preschool children's letter-name knowledge may be differently associated with child- and letter-related factors by virtue of the national ECEC curriculum and characteristics of the orthography, a semi-transparent orthography. The present study investigated this and thereby adds to the cross-linguistic study of letter knowledge.

Child-related factors and letter knowledge

We included three child-related factors in this study; gender to replicate the gender effect reported by Sigmundsson and colleagues (2017, 2018), own-name and phonemic awareness, which have also been found to be associated with letter-name knowledge (e.g., Huang & Invernizzi, 2014; Treiman et al., 2006). We failed to replicate Sigmundsson and colleagues' gender effect and found instead that gender was not a significant predictor of letter-name knowledge, nor did we find a significant gender by time interaction (which was in fact also non-significant in the Sigmundsson study). The children in the present study were younger (at least at the beginning of the study) and from urban areas in Norway, whereas the children in the Sigmundsson study were already in school and from both urban and rural areas of Norway. Thus, the two samples differ in at least two ways that may have influenced the results. Moreover, our results showed that Norwegian preschool children had an advantage for, that is, they were more likely to correctly name, the first letter of their first name. This is the first time that the own-name advantage has been demonstrated for Norwegian and adds to the literature where the effect has previously been shown for English, Hebrew, and Portuguese (Treiman et al., 2006; Treiman et al., 2007). That Norwegian pre-schoolers should show an advantage for the first letter of their name is not entirely surprising as they (like most, if not all children) are frequently exposed to their own name both at preschool and at home, and it is often the first word they learn to write (and recognise). Our dataset allowed us to explore the own-name advantage over time, and here we found a significant interaction effect indicating a diminishing own-name advantage as children got older. This finding may be explained by children's letter-name knowledge improving with age generally and thus, the own-name advantage washes out. Finally, and somewhat surprising we did not find phonemic awareness to be a significant predictor of letter-name knowledge. The association between phonemic awareness and letter-name knowledge has consistently been demonstrated (e.g., Arrow & McLachlan, 2014), but our phonemic awareness task may not have tapped the construct adequately and we acknowledge that the phonemic awareness task had a limited number of item (16). In addition, children generally performed quite well on the task (i.e., not quite at ceiling, but close to ceiling) and together, these things may have influenced our results.

Letter-related factors and letter knowledge

Turning to the letter-related factors, we here asked if children were more likely to correctly name letters that occur more frequently in text or appear earlier in the alphabet. Further, for consonants only, we were interested to see if letters that correspond to speech sounds acquired earlier in development are easier for children than those corresponding to speech sound acquired later in development. Children in the present study showed an advantage for letters that occur more frequently in written text, and in fact, for each increase in rank order (i.e., a decrease in letter frequency) children had a 15% decrease in odds of correctly naming the letter. The interaction with time was also significant (OR = 1.04) and indicates that the letter frequency effect was stronger across time. That is, the older children were, the more they benefitted from the letter-frequency effect when naming letters. This might be expected as older children have had more exposure to texts and thus, more likely to reap the benefits of this on their letter naming skills. Our results demonstrate the letter-frequency effect on letter naming in Norwegian for the first time and are in line with previous findings from English (Huang & Invernizzi, 2014; Treiman et al., 2006: Treiman et al., 2007), Hebrew (Treiman et al., 2007) and Portuguese (Treiman et al., 2006) that are closer to either end of the continuum of orthographic depth. We also found a significant interaction effect between letter position in alphabet and time, and older children benefitted more from letters' position in the alphabet. While formal teaching of letters is not standard pedagogical practice in the Norwegian preschool setting, it is possible, and even likely, that parents talk to their child(ren) about letters and sing alphabet songs together especially when children near school-age. This might explain why the letter position effect was larger in older children relative to younger children. In English, when children are taught the alphabet, this is often called "learning your ABCs" and it follows that these three letters might be more salient to children. Indeed, studies have shown that children are more likely to correctly name these letters compared to the other letters in the alphabet (Phillips et al., 2012; Treiman et al., 2006: Treiman et al., 2007). We were curious to explore if a similar ABC effect would be evident in our data, but we did not find this to be the case and this may simply be due to the fact that the alphabet is not colloquially referred to as "your ABCs" in Norwegian.

Finally, we explored if children were more likely to correctly name consonant letters associated with earlier acquired consonant speech sounds. We are aware of only two previous studies (one focusing on both vowels and consonants) exploring this and showing mixed results (De la Calle et al., 2018; Justice et al., 2006). Using a similar approach to Justice and colleagues, we aimed to replicate their result that children were 9% more likely to know consonant letters in one category (e.g., Category I) compared to the next category (Category II). While we found that children were 7% more likely to know letter in a preceding category relative to the next, our result was non-significant as was the interaction with time. In using Justice and colleagues' approach, we assumed that the development of consonant speech sounds is equivalent across English and Norwegian. This assumption seems to be at least partially supported, as certain categories (manner/place) of consonant speech sounds seem to have similar developmental patterns across languages (McLeod & Crowe, 2018). Yet, we cannot rule out that our approach may not have been ideally suited. Moreover, differences between studies may also help to explain the differing results; namely, Justice and colleagues used a sample of 4-year-olds from low-income families whereas our sample of children came from families recruited from a district with near-national representative SES based on parents' education level. Thus, there was more variability in SES in our sample and given the importance of SES for literacy development this is another possibly explain the diverging results.

Implications for early childhood educators and teachers

Letter-name knowledge is an important precursor and predictor of later reading ability and shows links with other reading-related skills such as letter-sounding and phonemic awareness (although the latter was not demonstrated in this study). Letter naming showed large variability among children in our sample, especially at T2 when children were 5 years of age (see Table 1 and Figure 1). In view of other research demonstrating advanced letter-name knowledge trajectories in children with better oral language skills (expressive and receptive; Carr et al., 2020), educators should be vigilant in monitoring and stimulating children's language development as well as letter-name knowledge. This is not to say though, that the Norwegian ECEC pedagogy should start introducing more formal learning and benchmarking, rather this could still be achieved within the curriculum as it is. Further, while we surprisingly did not find a link between phonemic awareness and letter-name knowledge, we still think this is an important pre-reading skill for children to acquire and encourage educators to continue to focusing on language and word play with children to aid children's development of this skill.

Limitations

The present study has at least three limitations that deserve mentioning. Firstly, our results are based on a re-analysis of data. This means that we had no control over the assessments that children completed or for that matter the administration of assessments such as the letter knowledge test. While this is regrettable, we have no reason to believe that children responded with letter sounds on the letter knowledge test, as instruction in letter sounds is not part of the preschool programme in Norway. Further, we did not have access to error data and were thus not able to explore any error patterns that might be informative for letter learning more generally. Secondly, we relied on a consonant acquisition order that is based on English (Justice et al., 2006) as we are not aware of anything similar in Norwegian. The associated results should be viewed with some caution, but we nonetheless feel reassured as research showing similarities in speech sound development – consonant features and phonetic features – across several languages including Norwegian (McLeod & Crowe, 2018; Locke, 1983). Finally, it would have been interesting to probe further the own-name advantage to include, for example, letters in the second and third position of children's names or even children's last names, but we did not have access to this information.

Conclusion

In this study, we performed a detailed investigation of Norwegian preschool children's letter name knowledge by exploring its association with several child- and letter-related factors. As far as we are aware, this is the first study of its kind focusing on Norwegian. Our results show that children had a special relationship with the first letter of their own name and were significantly more likely name this letter, however, this effect diminished over time. Contrary to previous research, we did not find that girls outperformed boys nor was letter naming associated with phonemic awareness. Further, letter frequency significantly predicted letter naming, and the letter frequency and letter position in alphabet effects were larger in older children. We did not replicate the consonant order effect, previously demonstrated by Justice and colleagues (2006). In summary, our results both confirm and contrast with previous findings from (predominantly) English studies of children's letter name knowledge.

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No potential conflict of interest was reported by the author(s).

ORCID

Linda Larsen http://orcid.org/0000-0002-6910-4946
Hanne Næss Hjetland http://orcid.org/0000-0002-8072-402X
Stefan Kilian Schauber http://orcid.org/0000-0002-1832-2732

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