



Effects of parallel syntactic training in French plural spelling and German noun capitalization

Constanze Weth¹ · Carole Dording¹ · Lisa Klasen¹ · Michel Fayol² · Reinold Funke³ · Sonja Ugen⁴

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Abstract

French plural markers and German noun capitalization encode syntactic information. Both syntactic markers present the syntactic information needed reliably and saliently, and both are unrelated to phonology. A main difference between both is that French plural spelling is part of inflection morphology and encodes the plural morphemes in written French. German noun capitalization is not a morpheme or a grapheme, but an allograph licensed in a particular function of the sentence, the head of the NP. Although both are substantially different, studies have shown that syntactic training is effective at improving the spelling of these syntactic markers. The current study presents two intervention studies in Grade 4 ($N = 176$) to examine whether learners who become literate in German and French benefit from a syntactic training in French plural spelling and German noun capitalization. All participants were trained in both languages and tested at four test points. Instruction was provided through learner videos (10×10 minutes) shown in a classroom setting. In both languages, the main goal of the training was to raise awareness of the syntactic unit of the NP as well as the syntactic information encoded in spelling. The results show large, short-term and long-term effects of the French training. However, unlike in previous studies, no training effects were found in German when compared with the control group. The paper discusses the results with a focus on the detailed comparison of French plural spelling and German noun capitalization as well as the feedback of the participating teachers in order to provide hypothetical explanations of the mixed training results. The discussed findings have an impact on the conception of syntactic spelling, as well as its teaching and learning.

✉ C. Weth
constanze.weth@uni.lu

- ¹ Department of Humanities (DHUM), University of Luxembourg, Esch-sur-Alzette, Luxembourg
- ² University of Clermont Auvergne, Clermont-Ferrand, France
- ³ Heidelberg University of Education, Heidelberg, Germany
- ⁴ Luxembourg Centre for Educational Testing (LUCET), University of Luxembourg, Esch-sur-Alzette, Luxembourg

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1 Introduction

The purpose of this paper is to investigate two spelling domains involving the orthographic encoding of syntactic information: French plural spelling represents agreement of plural, requiring the repeated use of written plural suffixes across the phrase and sentence structure. German noun capitalization highlights the presence of a noun phrase (NP) by representing its head with a capital letter and thereby emphasizing the NP as an inflected unit (Fuhrhop, 2011). While both orthographic features encode syntactic information in the writing system, such that the spelling is unrelated to phonology, they differ syntactically and graphematically (Weth, 2020).

Orthographic encoding of syntactic information may cause considerable difficulties when the syntactic information is not encoded in phonology. This issue has been shown by previous research, for different orthographies. The focus of most research has generally been on morphosyntactic information, encoded in the form of inaudible, so-called “silent”, inflectional suffixes (e.g., for French: Fayol et al. 2005, 2006; Jaffré & Fayol, 2013; Morin et al., 2018; Pacton & Fayol, 2003; for Dutch: Chamalaun et al., 2017; Sandra & Abbenyen, 2009; for English: Bourassa et al., 2011; Nunes et al., 1997; for Danish: Juul & Elbro, 2004; for Greek: Aidinis & Nunes, 2001; Protopapas et al., 2013). Overall, words or word endings are often homophonic and require a particular suffix in the written inflection system. Spelling errors often result when the wrong word ending is produced, with frequency and regularity effects being widespread causes (Largy et al., 1996; Sandra et al., 1999).

Syntactic information that is not encoded in phonology is related to the choice of the right grapheme. Also, syntactic information can be highlighted in writing by “syntagmatic graphematic allography” (Meletis & Dürscheid, 2022: 157). This type of allography comprises positional allography such as in Arabic (Saiegh-Haddad et al., 2023) and Greek (Protopapas et al., 2013) and German (Maas, 1992). Moreover, encoding syntactic information in orthography refers not only to the spelling of inflectional morphemes but also to the visual emphasis of specific parts of a sentence, such as the NP and the capitalization of nouns in German related to it (Fuhrhop & Peters, 2013; Maas, 1992; Meletis, 2020).

1.1 Comparing French plural spelling and German noun capitalization

French encodes information about agreement that is not present in phonology in a highly systematic fashion (Catach, 1980; Meisenburg, 1996). Plural spelling involves the plural inflection of nouns, adjectives (suffixes <s>), and verbs (suffix <nt>) versus the unmarked singular form. French plural spelling is part of the written language’s inflection morphology, a phenomenon that is almost absent from spoken French (Meisenburg, 1996; Pomino & Stark, 2016). Most importantly, plural markers extend across the whole sentence and, with these markers, the same information is presented repeatedly. Table 1 illustrates this: A simple NP in French contains a determiner (D) and a noun (N) (a). It can be expanded by including two adjectives,

Table 1 Examples of NPs and sentences in the singular and with the visible features of plurality in written French. Plural morphemes are underlined.

Examples in singular	Examples in plural	Translation of the plural examples
a. <i>Le chien</i> [lə ʃjɛ̃]	<i>Le<u>s</u> chie<u>n</u>s</i> [lə ʃjɛ̃]	The dogs
b. <i>Le grand chien noir court.</i> [lə ɡʁɑ̃ ʃjɛ̃ nwaʁ kuʁ]	<i>Le<u>s</u> grand<u>s</u> chie<u>n</u>s noir<u>s</u> courent.</i> [lə ɡʁɑ̃ ʃjɛ̃ nwaʁ kuʁ]	The big dogs black run.
c. <i>Le chien est grand.</i> [lə ʃjɛ̃ ɛ ɡʁɑ̃]	<i>Le<u>s</u> chie<u>n</u>s so<u>nt</u> grand<u>s</u>.</i> [lə ʃjɛ̃ sɔ̃ ɡʁɑ̃]	The dogs are big.
d. <i>Le chien que j'ai vu court.</i> [lə ʃjɛ̃ kə ʒə vy kuʁ]	<i>Le<u>s</u> chie<u>n</u>s que j'ai vu<u>s</u> courent.</i> [lə ʃjɛ̃ kə ʒə vy kuʁ]	The dogs, that I have seen, run.

one in the prenominal, one in the postnominal position (b). Pre- and postnominal adjectives as well as predicative adjectives (c) get inflected. The information that a plural is given even reappears in a relative sentence referring to a plural entity (d). Additionally, subject-verb agreement is visually highlighted by the plural marker for verbs <nt>. Phonologically, sentences representing the singular and plural (Table 1) are identical with the exception of the determiner. In some cases, the suffix <s> can be present in spoken French in the contexts of liaison (Soum-Favaro et al., 2014), and there are some irregular verb forms that phonologically distinguish 3rd person singular from 3rd person plural (i.e., *être* 'to be': *il est/ils sont*, 'he is/they are').

In written German, the first letter of the syntactic noun, the head of the NP, is capitalized. Hence, the syntactic unit of the NP becomes visually structured. Though the capital spelling of nouns has often been explained lexically, namely in relation to single words belonging to the word class *noun* and its morphological properties (i.e., plurality) (Nerius, 2007), the use of uppercase can be more consistently explained with respect to syntax (Fuhrhop, 2011; Maas, 1992; Meletis & Dürscheid, 2022).

More precisely, the syntagmatic graphematic allography of capitalization is used to highlight the head of the NP. The NP is a linguistic unit that has a particular function in a sentence (Funke, 2022; Maas, 1992; Meletis & Dürscheid, 2022). The German NP is inflected on the basis of gender, number, and case. Specifically, as the noun (N) is the head of the NP, it is the source of the gender and number feature of the NP. However, these features can rarely be identified in the noun's form. Also, the inflectional suffix on the determiner (D) and the adjective (A) are not unambiguously fixated by these features (Eisenberg, 2013; Gunkel et al., 2017; van Riemsdijk, 1980). Eventually, German has a broad spectrum of NP forms, including NPs without a determiner. Many of these NPs consist of a bare N. Examples in Table 2 present (a) role labels such as professional designations, (b) indefinite singular mass nouns, (c) abstract nouns, (d) nominalized verbs, and (e) indefinite plurals. All examples are given as bare nouns and as NPs extended by including an adjective. Taking the morphological opacity and the syntactic variability of German NPs into account, the capitalization of nouns indicates the presence of an inflected NP (Ágel, 1996; Fourquet, 1970). The capitalized word indeed demarcates the boundary between the inflected

Table 2 Examples of NPs consisting of a bare noun (N) in German and expanded by including an adjective. Inflection information: gender (masculine (m), feminine (f), neuter (n)), number (singular (s), plural (p)), case (nominative (nom), accusative (acc), dative (dat))

	Examples with bare N and expanded NP	Semantic classification of N	Inflection information	Translation of the examples
a.	Er ist _{NP} [Arzt]. Er ist _{NP} [ein guter Arzt].	Proper name	m, s, nom	He is a doctor. He is a good doctor.
b.	Sie finden _{NP} [Gold]. Sie finden _{NP} [altes Gold].	Mass noun	n, s, acc	They find gold. They find old gold.
c.	Sie haben _{NP} [Angst]. Sie haben _{NP} [große Angst].	Abstract noun	f, s, acc	They have fear. They have big fear.
e.	Sie mögen _{NP} [Tanzen]. Sie mögen _{NP} [schnelles Tanzen]	Nominalized verb	n, s, acc	They like dancing. They like fast dancing.
d.	Sie helfen _{NP} [Hunden]. Sie helfen _{NP} [alten Hunden].	Concrete noun	m, p, dat	They help dogs. They help old dogs.

NP, as presented in Table 2, and the additional parts that appear post-nominally (i.e., *Er ist* _{NP}[*ein guter Arzt*] _{PP}[*mit viel Erfahrung*]). ('He is a good doctor with a lot of experience').

Studies have reported that learning to correctly spell French plurals and to capitalize nouns in German is a long and laborious process. A lot of research has explored how learning to produce the syntactic spelling in these two domains develops.

In French, expert writers have no trouble with plural spelling in general, but they might have trouble producing the plural markers in unusual grammatical contexts (Alamargot & Morin, 2022; Chanquoy & Negro, 1996; Fayol et al. 1994, 1999; Hupet et al., 1996; Lanoë et al., 2017; Largy et al., 1996). Learning plural spelling begins with the plural marking of concrete nouns, the word category that is spelled best across primary and secondary school (Brissaud et al., 2014; Totereau et al. 1997, 1998). Noun plural in French is spelled best because the plural marker refers to the abstract grammatical category of plurals, but also because plural nouns are semantically grounded (Fayol et al., 2006). A writer can relate the plural marker to the plurality of tangible objects, distinguishing between, for example, *le chien* 'the dog' and *les chiens* 'the dogs'. The plural spellings of adjectives and verbs, by contrast, refer to the formal grammatical category of number inflection, but are not semantically grounded. The plural spelling of all three word categories is on its way to being automatized for some learners in fifth grade and has become automatized for most learners by the end of secondary school (Alamargot et al., 2015; Bosse et al., 2021). The learning of plural spelling in French differs for learners who are native speakers of French (L1 learners) and learners who are learning French as a foreign language (L2 learners). The latter learn French in an institutional context that includes lessons on how to write in French from the beginning in contrast to L1 learners who have learned French orally first. Nevertheless, studies have shown that L2 learners also pluralize nouns more accurately than they pluralize adjectives and verbs. Subject-

verb agreement is produced earlier and better than plural agreement with the adjective (Ågren & van de Weijer, 2013; Weth et al., 2021), a spelling pattern that is in line with what is observed in French L1 learners at the end of primary school.

In German, expert writers have no trouble with noun capitalization in most cases. Corpus studies that analyzed spelling errors in school-leaving examinations after Grade 12 (the highest degree in Germany: Abitur) showed that writers erroneously used lower case for some complex foreign word nouns (Fuhrhop & Romstadt, 2021). Additionally, writers had some trouble with adjectives: Notably, so-called “nominalized adjectives” and to a lesser extent “nominalized verbs” were written in lower case. Additionally, some adjectives, mainly adjectives that followed an article, were written in upper case (Fuhrhop & Romstadt, 2021; Pießnack & Schübel, 2005; Ransmeyer, 2022).

During the process of learning to spelling in German, however, noun capitalization tends to be one of the most fault-prone areas in German orthography (Steinig & Betzel, 2014). At the beginning of Grade 2, learners begin to correctly capitalize familiar concrete nouns, whereas abstract nouns and nominalized verbs and adjectives are prone to errors across schooling. Accordingly, in large-scale competency models, capitalizing is modeled across four out of five levels with the capitalization of concrete nouns being referred to as the “minimum standard” (Level 2) and the capitalization of nominalized verbs being referred to as the “optimal standard” (Level 5) (Stanat et al., 2022:50). The norm standard (Level 3) refers to concrete nouns as well as to abstract nouns that are presented in an NP context with a determiner or inflected adjective. Most importantly, longitudinal studies have identified stagnation in the weakest learners in grade 6. Such learners reach only the minimum standard or less (Betzel, 2015). If learners get stuck on capitalizing only concrete nouns, they believe capitalization refers only to concrete tangible units, such as animals or objects. This semantic interpretation of noun capitalization may obstruct their perspective on any reflection that refers to the NP as a syntactic unity.

French plural spelling and German noun capitalization are both domains that require syntactic information to be used in spelling. However, as the syntactic information related to the writing system differs between the two languages, the condition of readiness for the attention on the respective syntactic structure required to engage in automatic, syntax-driven anticipatory processing for spelling also may differ. French orthography encodes syntactic relationships between the words in the sentence by means of written morphemes. In the case of number morphology, the plural requires a morpheme, whereas the singular does not. Phonologically, these word forms are usually homophones. According to Fayol and colleagues, the production of plural forms in writing refers to simple rules that, drawing on Anderson (1982), may be stated as production rules, such as: if a noun or adjective is plural, add <s>; and if a verb is plural, add <nt> (Fayol et al., 2006; Jaffré & Fayol, 2013). Hence, to use syntactic information in relation to plural spelling, the writer must (a) detect the salient surface characteristics of plural spelling (i.e., <s> and <nt>), (b) realize that the information about plurality represented in these written forms presents the same information (i.e., plural), repeatedly across each word in the NP and across the whole sentence, and (c) keep this information activated while writing (Sandra & Fayol, 2003).

German orthography highlights the head of the NP with the use of a capital letter and hence structures syntactic units visually. Indeed, noun capitalization is highly

regular when it is explained as referring to syntax and as highlighting the head of an NP (Bredel, 2010; Fuhrhop, 2011; Maas, 1992; Meletis & Dürscheid, 2022). From this perspective, in order to capitalize correctly, a writer must continuously observe whether a given syntactic context is an NP, and if it is, they must determine its head (Fuhrhop, 2011; Funke, 2005). Syntactic learning in relation to the capitalization of nouns therefore means becoming aware of the presence of an NP in the sentence, regardless of the semantic properties of the noun (concrete noun, abstract noun, nominalized adjectives or verbs) or the structure of the NP (with/without determiner and/or adjectives). It appears that strong learners – with German as an L1 or L2 – implicitly learn to identify the intrasentential capital letter as a structural feature. But weak learners, possibly due to insufficient language skills or a deficit in their syntactic knowledge, might need teaching support in order to notice the information conveyed by the upper case letter and to build an awareness of the syntactic context in which it appears (Bredel, 2006; Funke, 2005; Mangelschots et al., 2023).

As syntactic spelling is laborious and as both syntactic markers are salient in the respective writing systems, the teaching of plural spelling in French and noun capitalization in German is highly prominent in primary school education from the early years until the end of secondary school.

In French, the regular teaching of plural spelling refers to the written morphemes and the encoded syntactic information (Brissaud & Fayol, 2018). The main aim is to emphasize the syntactic relationships between the words in a sentence with respect to the written inflection morphology that is not realized orally. This emphasis means that teachers are used to reflecting on orthography syntactically. Additionally, researchers have been searching for methods to introduce (meta)linguistic reasoning into the teaching-learning process in recent decades. There are several methods that train writers to focus on the grammatical structure of a sentence in relation to the presence of the written morphemes and to keep this syntactic information structure present while writing (Arseneau & Nadeau, 2018; Brissaud, 2022; Cogis et al., 2015). Several intervention studies in French L1 and L2 contexts have shown that raising attention to the syntactic structure in relation to the spelling morphology is beneficial for plural spelling (Bilici et al., 2018; Totereau et al., 1997).

In German, the regular teaching of noun capitalization is, in general, taught via a simple word-class-related approach. At the beginning of schooling, students learn that capitalized words refer to concrete, tangible entities. In later years, the students are additionally told that words related to abstract concepts are also capitalized, and even later they are told that occasionally, verbs and adjectives can also be capitalized. This approach has been highly criticized as it does not highlight the regularity of noun capitalization (Bredel, 2010). Nevertheless, teachers tend to consider noun capitalization semantically or in relation to the prototypical characteristics of the word class noun. There are alternative training methods that are aimed at developing writers' ability to pay attention to the presence of an inflected NP in a given sentence by focusing on the capitalized noun as an indicator of the NP structure. Training emphasizes the structure and variability of the NP, in which NPs are modified from containing only a bare noun to an expanded structure that includes a determiner, adjective(s) or both. Inserting inflected adjectives into the NP illuminates the flexibility of the NP and its inner structure. Inserting one or more adjective(s) into a sentence

(*Ich sehe* $_{NP}$ [*Hunde*] – $_{NP}$ [*große Hunde*], ‘I see dogs – big dogs’, see also the examples in Table 2) alerts learners to the presence of gender and number features in the NP. Then they can conclude that the unit that determines that feature is a noun that must be capitalized (Funke, 1995, 2017; Röber-Siekmeyer, 1999). Importantly, in a syntactic training lesson in German noun capitalization, in order to determine whether a given word is the head of the NP, learners must take a detour by think about words (i.e., inflected adjectives), that are not present in the sentence but could potentially be present. Several intervention studies in German have shown that a syntactic training based on this approach is beneficial for noun capitalization when carried out in small group settings (Bilici et al., 2019; Brucher et al., 2020) and can also be beneficial in the classroom (Gaebert, 2012; Melzer, 2011; Wahl et al., 2017a).

1.2 This study

As the literature indicates that competent writers have learned to identify French plural spelling and German noun capitalization as structural features in relation to syntactic information and that syntactic training can successfully foster both of these skills, this paper presents two interrelated intervention studies, one for French plural spelling and one for German noun capitalization.

The hypothesis that guides this study is that syntactic training that provides explicit teaching on syntactic information is beneficial for French plural spelling and for German noun capitalization, the two spelling domains being unrelated to phonology encoding syntactic information. To test this hypothesis, the two studies were designed in parallel and carried out with one cohort of grade 4 students who had learned to read and write in German and French and had previous knowledge of plural spelling in French and noun capitalization in German. All participating students were tested in French and German at each test point and were given syntactic training in both languages, one after the other, carried out in the classroom. The group trained in the other language acted as the control group.

The training methods that were used for French plural spelling and German noun capitalization have been applied successfully in previous studies. Most importantly, the syntactic training in each language and spelling domain differed on the basis of the syntactic and orthographic differences between the French and German writing systems in how syntactic information is encoded in spelling.

To foster French plural spelling, the training aimed to increase the amount of attention that was paid to the grammatical category plural and its relationship with the written plural morphemes <s> and <nt>. The operations used in the French training drew on the students’ ability to reason about the NP and syntactic information on the levels of phrases and clauses (subject-NP and verb) and how plurals are represented in the writing system. Crucially, reflecting on plurals allows a direct mapping between the syntactic information (plural) and the spelled units (<s>, <nt>).

To foster German noun capitalization, the training aimed to increase the amount of attention that was paid to the NP as a syntactic unit so that the students would be more successful in identifying the NP while writing and would accordingly capitalize its head. The example sentences and tasks used in the German training demonstrated the variability of the NP. The training showed that the general property of an NP is that it

must be possible to expand it by including inflected adjectives. A successful syntactic training for noun capitalization hence requires that the students realize that they must take the detour that we mentioned above, by thinking about words (i.e., inflected adjectives) that are not present in the sentence but could be potentially included in order to determine whether a given word is the head of the NP and must therefore be capitalized.

The rationale behind this study is that competent writers successfully learned to identify syntactic markers as structural features with respect to syntactic information in French plural spelling and German noun capitalization. Starting from this idea, we assumed that learners would benefit from syntactic training in both languages. Although French plural spelling and German noun capitalization both encode syntactic information and are unrelated to phonology, the two types of syntactic training differ markedly. This difference is due to the syntactic and graphematic differences between the two languages and writing systems. For the learners, it might seem more difficult to identify the head of an NP in a sentence and check the assumed hypothetical structure by inserting words (adjectives) in order to perform the operations that are required to check for plurality across the sentence. The German training possibly might employ working memory resources more, and in different ways, than the French training (cf. Berninger et al., 2011; Sandra & Fayol, 2003; Vanderberg & Lee Swanson, 2007). Different difficulty levels in the two spelling domains might have an impact on the way spelling problems are dealt with in regular teaching. By contrasting the two spelling domains in an intervention study, this study seeks to advance knowledge about the effects of syntactic training on syntactic spelling in two languages with different syntactic and orthographic structures.

2 Method

2.1 Study design

With the present study, we aim to provide evidence that a syntactic training has positive effects on syntactic spelling in French and German. To do so, we tested the performances, in French and German, before and after training. The study design included syntactic training in French and German, both provided at two different time points, so that all participants could participate in both trainings, either first in French and then in German or vice versa. Training in both languages was provided via educational videos, 10 videos per 10 minutes throughout two weeks per language. The first training point was between T1 and T2. A week later, after T2, the participants were trained in the respective other language. T3 was tested immediately after the second training point to replicate the training effects measured at T2. The follow-up test (T4) was carried out eight weeks after T3. As all participants were always tested in both languages, the design allowed to compare the results of those participants who were trained first in French with those who were trained first in German and acted as control group (T1-T2) (see Table 3).

All participants first participated in preliminary tests (T0), evaluating general spelling, vocabulary and syntactic perception, the latter consisting in a decision task

Table 3 Overview of the study with all test points (T0 and T1–T4), the two training groups (FR1-GE2, GE1-FR2), the two trainings (counterbalanced French, German), the tests (always in French and German), and the teacher feedback in form of questionnaires

Timeline	Preliminary test	Group assignment	Pretest	2 weeks	Posttest 1	2 weeks	Posttest 2	8 weeks	Follow-up
	T0		T1	T2	T3	T4			
Trainings (German, French counter-balanced)				Syntactic training 1		Syntactic training 2			
Groups		FR1-GE2 (<i>N</i> = 80)	French			German		–	
		GE1-FR2 (<i>N</i> = 96)	German			French		–	
Tests (always German and French)	General spelling Vocabulary Syntactic perception		Syntactic spelling		Syntactic spelling		Syntactic spelling		Syntactic spelling
Teacher feedback			Questionnaire on instruction practices		Questionnaire on syntactic training 1		Questionnaire on syntactic training 2		

Table 4 Means (*M*), and standard deviations (*SD*) for the preliminary tests (*T0*): general spelling, vocabulary, syntactic perception in French and German for the two groups FR1-GE2 and GE1-FR2 in percent. The *p*-values are from the Wilcoxon (WRS) statistical test to check for group

Test performance	Language	FR1-GE2		GE1-FR2		<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
General spelling	French	79.28	14.35	80.46	15.78	.2772
	German	45.74	26.21	50.28	22.60	.1637
Vocabulary	French	84.77	16.44	79.99	22.18	.3459
	German	63.88	21.51	65.64	21.79	.5645
Syntactic perception	French	60.52	17.61	61.26	17.94	.9427
	German	44.81	25.83	43.16	26.57	.7158

to control for whether students detected the syntactic marker. All tests were carried out in French and German (see 2.3). The participants were assigned to one of two different experimental groups in which they either started the training in French followed by German (FR1-GE2 group) or vice versa (GE1-FR2 group). As the training took place in class, the student's entire class was assigned to this group. The group assignment was done on the basis of the class' mean and median on the battery of tests conducted at test point T0. The results of the preliminary tests (T0) are provided in Table 4. There were no significant performance differences between the two groups at T0.

2.2 Participants

The study took place in Luxembourg and examined the performance of Luxembourgish fourth graders in French plural spelling and German noun capitalization. A total of 284 fourth graders from 19 different classes in five different schools participated in this study. For all students, the language of instruction and language of literacy had been German since Grade 1. French had been taught orally since Grade 2 as a foreign language and had become a second language of literacy in Grade 3. For the analyses, we retained only students who had been in the Luxembourg school system since Grade 1. Moreover, students were excluded if they did not participate in all tests from T1 to T3. Concerning the preliminary test (T0) and the follow-up test (T4), missing data were accepted in order to avoid excluding more participants. All in all, our sample consisted of 176 students nested within 16 classes.

Background variables were collected with a parent questionnaire. As shown in Table 5, the two groups were matched ($p > .05$) in age, gender, background of the main home language and mean socio-economic status (SES). The measure of SES was provided by the data of the parent with the highest socio-economic index (HISEI) as well as five closed questions about home literacy measured with a 5-point Likert Scale question with answers ranging from 1 (*no literacy*) to 5 (*much literacy*).

As presented in Table 5, the sample included learners growing up in multilingual contexts and learning at least two languages since early childhood. Though over

Table 5 Student background variables: age, gender, main home languages, and Socio-Economic Status (SES). SES was measured with the HISEI and Home Literacy. The p-values came from the Wilcoxon (WRS) test, Pearson's χ^2 test, and Fisher's Exact Test to check for group differences

			FR1-GE2 (<i>N</i> = 80 out of 8 classes)	GE1-FR2 (<i>N</i> = 96 out of 8 classes)	Statistical tests	<i>p</i>
Age	Months	<i>M</i>	120.80	121.58	WRS	.6302
Gender	Female	<i>N</i> (%)	43 (53.75)	46 (47.92)	Pearson's χ^2	.5357
	Male	<i>N</i> (%)	37 (46.25)	50 (52.08)		
Main home languages	French	<i>N</i> (%)	12 (15.00)	19 (19.79)	Fisher's Exact Test	.7013
	German	<i>N</i> (%)	1 (1.25)	3 (3.12)		
	Luxembourgish	<i>N</i> (%)	30 (37.50)	33 (34.38)		
	Portuguese	<i>N</i> (%)	25 (31.25)	24 (25.00)		
	Other languages	<i>N</i> (%)	12 (15.00)	15 (15.62)		
	Missing	<i>N</i> (%)	0	2 (2.08)		
Socio- Economic Status (SES)	HISEI (scale 16 to 90)	<i>M</i> (<i>SD</i>)	47.66 (19.58)	46.39 (17.55)	WRS	.8245
	Home Literacy (scale 1 to 5)	<i>M</i> (<i>SD</i>)	2.02 (0.90)	2.22 (1.10)	WRS	.2017

30% of the sample grew up with Luxembourgish, a Germanic variety, for about 15% French and about 25% Portuguese was the main home language.

The tests of general language proficiency revealed that the scores were, on mean level, always better in French than in German (see Table 4). This indicates a better overall language proficiency in French compared to German, although the students have been learning to read and write in German at school and have one year more German instruction compared to French. Caution is advised for a too strong interpretation as the test measures of the background variables were not conceived to allow direct comparison. The levels of difficulty were chosen according to the expected competence levels of schooling.

2.3 Test materials

All tests were administered in German and French. The study included preliminary tests administered at test point T0 on general spelling, vocabulary and syntactic perception. The latter consisted in a decision task to control for whether students detected the syntactic marker in both languages. Syntactic spellings tasks were administered at the test points T1, T2, T3, and T4. For all tests, correct answers were coded 1, and incorrect answers were coded 0. For all measures in this study, Cronbach's α was used to assess internal consistency.

2.3.1 Background measures for French and German

General spelling in German and French was assessed in order to match the two training groups. It consisted of one gap test per language filled in on dictation. The

participants listened to sentences read by a native speaker and had to fill in one or two missing words per sentence. On both tests, every sentence was dictated once, and then the missing word was repeated. Sentences with two missing words were repeated twice. In German, a shortened version of the standardized German spelling test DRT 4 (Grund et al., 2017) was used. The test included 30 dictated sentences with 30 gaps. The score was the number of correct word spellings ($\alpha = .91$). In French, an adapted version of the BELEC (Bodé et al., 2009; Mousty et al., 1994) was administered. The test included 20 dictated sentences with 28 gaps, analyzed for 41 target graphemes ($\alpha = .85$).

A self-constructed C-Test was assessed to test students' **vocabulary** (Eckes & Grotjahn, 2006). It was self-constructed on the basis of schoolbook texts of the corresponding school level of the Grade 4. Correct completion was coded as 1, missing or incorrect items as 0. Spelling errors were not taken into account. The C-Test in French consisted of two short texts with a total of 105 words and 18 words to complete ($\alpha = .93$); the C-Test in German consisted of two short texts with a total of 148 words and 28 words to complete ($\alpha = .97$).

Syntactic perception consisted in a decision task to control for whether students detected the syntactic marker in both languages. For each language, the test consisted of sentences in which some words were presented twice: In French, three words in the sentence were presented in singular and in plural form and the learners had to decide which forms were correct in the sentence context (i.e., *Les grand/grands chat/chats noir/noirs mangent*). Hence, syntactic perception was assessed as the categorical difference between the French singular and plural with no marker being singular and the graphemes <s> or <nt> being plural.

In German, one word in the sentence was presented with lower- and upper-case letter and the learners had to decide which form was correct in the sentence context (i.e., *Ich habe immer großen hunger/Hunger nach der Schule.*). Hence, it assessed if learners perceive the categorical difference between a given word written with upper case or lower case and to opt for the correct form in a given sentence context. (Wahl et al., 2017b). The German version had a maximal score of 6 responses ($\alpha = .59$), whereas the French version had a maximal score of 8 responses ($\alpha = .82$).

2.3.2 Experimental measures for French and German

The experimental tests on syntactic spelling were taken at four test points: T1 (pretest), T2 and T3 (two posttests), and T4 (follow-up test) in each language. The syntactic spelling tests consisted of one gap test per language filled in on dictation. The participants heard sentences read by a native speaker and had to fill in the missing words, one per sentence. Every sentence was dictated twice. The tests were self-constructed. For all tests, the calculated score consisted of the number of correctly spelled syntactic markers. Other orthographic errors were not considered. Words that were included in the training were excluded from the tests. The German test assessed noun capitalization in three lexical-semantic subcategories (concrete, abstract, and nominalized nouns) equally distributed across three NP contexts (with determiner, with adjective, as bare noun). To ensure the comparability of the different test levels, we controlled for word frequency (childLEX: Schroeder et al., 2015) and the students' schoolbooks. The total number of test items was 36, divided into 12 items per

lexical-semantic subcategory and six items per position within a subcategory. The test contained 24 control items (verbs and adjectives). The total number of dictated sentences was 60. Test and control items were equal from T1 to T4 but integrated in different sentence contexts and presented in a new font and order. For this analysis, we retained only the mean of the target nouns' capitalization, with a maximum score of $N = 36$ ($\alpha = .90$).

The French test assessed plural spelling in three word-classes (concrete nouns, adjectives, verbs). Each word class was tested in two positions relative to the determiner. The plurals for all word classes were regular endings with <s> for nouns and adjectives and <nt> for verbs, excluding audible plural forms (such as irregular verbs or contexts of *liaison*). To ensure the comparability of the different test items, we controlled for word occurrence in the French schoolbook from Grades 3 and 4 as well as for sentence structure and the function of the tested NPs within the sentences (subject, object). Moreover, we controlled for word frequency (Manulex: Lété et al., 2004). The test contained only words whose singular and plural forms occurred with the same frequency. Any pronouns or proper names were excluded. The total number of test items was 36, divided into 12 items per word class. The test contained 18 control items (singular forms). Test and control items were equal from T1 to T4 but presented in a new font and order. For this analysis, we retained only the mean of the target plural spelling with a maximum score of $N = 36$ ($\alpha = .92$).

2.4 Training

The training in each language consisted of 10 educational videos with a duration of 10 minutes each, presented over two weeks. The main goal of both was to raise attention to the syntactic unit of the NP and the syntactic information encoded in spelling: one training on French plural spelling, the other one on German noun capitalization. Both trainings used one to three sentences per unit to provide time for the (meta)linguistic tasks. Students had to write, correct, analyze, and manipulate the sentences. In addition, both trainings used building blocks (Weth, 2017; Zwitserlood et al., 2015) in order to highlight the construction of the NP. They also used the metaphor of a game team to introduce the words within the NP.

The French training was constructed in line with previous studies (Arseneau & Nadeau, 2018; Cogis, 2004): Students had to write a sentence that was dictated to them. To explain the correct way to write the sentence, the video highlighted the plural markers <s> for nouns and adjectives and <nt> for verbs. It further explained that one can test for whether a given word was pluralized and had to be written with <s> or <nt>. The given rule was presented as a kind of ball game in which the audibility of the determiner (*lella* [lə, la] for the singular, *les* [le] for the plural) signaled the start of the game, and every word that followed and was part of the game (i.e., the given NP) got the plural marker <s>. If the given pluralized NP was the subject of the sentence, the verb had to get the suffix <nt>. The French training focused on noticing the NP and the subject-verb agreement in a given sentence.

The German training was constructed in line with previous studies (Funke, 1995; Röber-Siekmeier, 1999): Students had to write a sentence that was dictated to them. To explain the correct way to write the sentence, the video emphasized the capital

spelling of a noun. The videos then showed the syntactic context of the noun, the NP. It further explained that one can test for whether a given word was a noun and had to be written with capital letter. The rule taught to them was: If one (or more) adjective(s) modifying a given word get(s) inflected, then that word must get capitalized. To check, the learner could verify if the inflection suffix was identical in all adjectives put in front of the noun, and if the order of adjectives was interchangeable. The following example might illustrate this process. In the sentence *Die Katze hat Spaß und springt hoch* ('The cat has fun and jumps high') a learner might have memorized the orthographic word *Katze* and will therefore capitalize it without any further consideration. However, the word *Spaß* is less likely to be discerned as a noun due to its abstractness and because it may appear as a bare noun in an NP. Moreover, the learner also might wonder whether *hoch* is a noun. If the learners test their assumptions according to the rule, they will realize that *Spaß* can be expanded by inflected adjectives (i.e., *Die Katze hat großen, tollen Spaß*). Hence, there must be an NP, and *Spaß*, being the head of the NP, must be written with capital letter. To the contrary, the word *hoch* can only be modified by an uninflected adjective: *Die Katze springt schön hoch*. Hence, the German training focused on noticing the NP, and its head, in different syntactic contexts.

The trainings in the two languages were constructed in parallel in terms of the tasks, the paper-pencil materials, the introduction of the building blocks, and the overall design of the videos. Both had the same structure and included explanations about the relationship between the syntactic marker and the information encoded (plural in French, head of the NP in German). Both videos included paper-pencil exercises, and the correct answers were provided in the videos. On the one hand, instructions were given orally by the video to the whole group, and on the other hand, they were also written into the paper-pencil material so that all the students could read them as many times as needed. The videos explained that the students would become language explorers who needed to identify the information underlying the capitalization in German or the plural spelling in French. Two exercises per session were exclusively based on the written modality. Each exercise required the students to write a dictated sentence first and then to analyze the NP in order to highlight the syntactic marker. In some sessions, the order was reversed so that students had to analyze a written sentence first and then produce a second one.

2.5 Procedure

All tests took place between December 2020 and May 2021. Test administration was standardized as a group test in the classroom. The dictation tests were presented by an audio CD. At each test point (T0 and T1-T4), the tests were administered in both languages, German and French. The order of the test languages was counterbalanced across the groups, FR1-GE2 and GE1-FR2.

Syntactic spelling was assessed at four test points with gap dictation tests. The pre-test (T1) was administered before the training, and there were two posttests and one follow-up test. One posttest (T2) took place immediately after the training for the first language ended (French for FR1-GE2 group; German for GE1-FR2 group). The next posttest (T3) followed immediately after the end of the second training

(German for FR1-GE2 group; French for GE1-FR2 group). The follow-up test (T4) took place at least eight weeks after the last training (see the timeline in Table 3). The sentences dictated were recorded by a native speaker. Every sentence was repeated twice. The time between the first reading and repetitions of it was 3 seconds, and there were 5 seconds between the different sentences. The audio recordings also included a greeting and introductory information to the tests.

The training was carried out in the classroom, administered by the teachers. At each session, teachers provided children with an educational video and the supplementary paper-pencil material. They started and stopped the videos when indicated in the video. They also distributed and collected the materials accompanying the video and corrected the exercises after each session. The teachers had to follow a strict script and were instructed not to intervene in the training.

2.6 Treatment fidelity: teacher feedback

A total of 16 teachers participated in this study, providing the regular teaching in class in French and in German, and also administering the training of this study in both languages. Our study included two teacher questionnaires to control for treatment fidelity (see Table 3).

The first questionnaire was filled in before the training by all teachers. It asked about the teaching practices in relation to French plural spelling and German noun capitalization. The answers supported that all teachers' instruction methods followed the common methods in the schoolbooks. Concerning French plural spelling common teaching explicitly refers to inflection morphology with an emphasis of the exceptions to the rule (Brissaud & Fayol, 2018). German noun capitalization is usually taught with a simple word-class related approach unrelated to the encoded syntactic information (for a critical view, see (Betzel, 2015; Bredel, 2010)). The second questionnaire was filled in after the training in French and German. This questionnaire asked for feedback to our videos. It included questions about the involvement of the teachers in the training sessions. Fewer teachers returned the questionnaires after the training: for French ($N = 14$), for German ($N = 12$).

3 Results

3.1 Descriptive statistics

The dependent variables of the analyses are the correct student responses in French plural spelling and German noun capitalization. They were analyzed in relation to the independent variables on the language (French, German), the two training groups (FR1-GE2, GE1-FR2) and the four test points (T1, T2, T3, T4). Descriptive statistics for the syntactic spelling test in French and German for both training groups across the four test points are presented in Table 6. At T1, the two groups showed comparable performance in French but not in German on a descriptive level. Furthermore, the group mean seemed to indicate a performance increase in French after the French training (from T1 to T2 for FR1-GE2 and from T2 to T3 for GE1-FR2) but little to

Table 6 Mean (*M*) percentages of correct answers and sample standard deviations (*SD*) on the syntactic spelling test across the four test points (T1–T4) in both languages (French, German) for the two groups (FR1-GE2, GE1-FR2)

Test point	French plural spelling				German noun capitalization			
	FR1-GE2		GE1-FR2		FR1-GE2		GE1-FR2	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
T1	47.64	29.99	49.31	31.52	44.65	21.83	50.81	22.42
T2	69.44	27.08	56.13	32.59	51.77	22.24	59.11	23.59
T3	70.73	27.62	69.30	29.94	53.26	23.87	59.69	26.50
T4	71.08	29.11	69.36	29.97	51.22	24.73	58.83	27.14

no increase in German after the German training (from T1 to T2 for GE1-FR2 and from T2 to T3 for FR1-GE2).

The high standard deviations in the results reflect the heterogeneity of the learning population in primary school. The high variance might be pronounced due to the multilingual background of the students, and because the sample includes the entire population of students out of 16 classes all over Luxembourg out of districts characterized by a population with a higher or lower socio-economic background. The heterogeneity of the participating students was controlled in the statistical analyses, the Generalized Linear Mixed Model (GLMM).

3.2 Statistical analyses

To test our hypothesis, we applied the following Generalized Linear Mixed Model (GLMM) calculated with the R package *glmmTMB* (1.1.3) and illustrated with the R package *ggplot2* (3.3.6), both from RStudio (2022.02.3 Build 492):

$$perc \sim test_point * language * group + (1|class/child_in_class)$$

With the abbreviation *perc*, we refer to all spelling performances in percent across the four test points (*T1*, *T2*, *T3*, *T4*), across both languages (*German*, *French*), and across both groups (*FR1-GE2*, *GE1-FR2*), which are the three fixed factors of the model. We controlled for class as the interventions were carried out in the students' classrooms as well as for each student in the corresponding classroom, i.e., the children nested within the classes. The expression $(1|class/child_in_class)$ denotes these two random effects included in the model. A two-level nested structure is used in which children at level 1 are grouped within classes at level 2.

The response variable *perc* was a percentage data, i.e., a variable expected to be continuous and taking values between 0 and 100. Like many other dependent data of this kind in social and behavioral sciences, its distributions were very poorly represented by the normal distribution (Verkuilen & Smithson, 2012). For that reason, the *beta* distribution was used with the default link function *logit* (Salinas Ruíz et al., 2023; Schmettow, 2021; Verkuilen & Smithson, 2012). For all other *glmmTMB* options, the default setting was used. The standard mathematical matrix form of a

Table 7 Complete specification of a GLMM model and its corresponding variables in the present study

	Standard specification	In the present study
The observations (dependent variable)	y	$perc$
The random effects	b	$b \equiv (class, child_in_class)$
The observations conditional on the random effects	$y b \sim$ general distribution	$perc b \sim$ beta distribution
Conditional expectations	$E(y b)$	$E(perc b)$
The link function	$g(\cdot)$	$logit(\cdot)$
Model for the conditional expectations	$\eta = g(E(y b))$ η is the linear predictor	$\eta = logit(E(perc b))$ η is the linear predictor
Design matrix for the GLMM fixed effects	X	matrix of ($test_point$, $language$, $group$)
Design matrix for the GLMM random effects	Z	matrix of ($class$, $child_in_class$)
Vector of regression parameters for fixed effects	β	β
The random complement to β	$b \sim N(0, G)$ probability distribution for b	$b \sim N(0, G)$ probability distribution for b
Variance-covariance matrix of the random effects	G	G (only random intercepts included)

GLMM is given below, and the elements of the form are given in Table 7:

$$g(E(y|b)) = X * \beta + Z * b$$

The R formula spelled out for each child i_j , i.e., for child i in class j ($j = 1, 2, 3, \dots, 16$), and for each language l_t , i.e., for language l ($l = 1, 2, 3, 4$), to:

$$\begin{aligned}
 &logit(E(perc_{(i_j l_t)} | b_{n(n=1,2)})) = \beta_0 \\
 &+ \beta_1 * test_point_{(i_j l_t)} + \beta_2 * language_{(i_j l_t)} + \beta_3 * group_{(i_j l_t)} \\
 &+ \beta_4 * test_point_{(i_j l_t)} * language_{(i_j l_t)} + \beta_5 * test_point_{(i_j l_t)} * group_{(i_j l_t)} \\
 &+ \beta_6 * language_{(i_j l_t)} * group_{(i_j l_t)} \\
 &+ \beta_7 * test_point_{(i_j l_t)} * language_{(i_j l_t)} * group_{(i_j l_t)} \\
 &+ b_{1(j)} + b_{2(i_j)}
 \end{aligned}$$

where $perc_{(i_j l_t)}$ represents the achievement of child i in class j in language l at time point t . β_0 is the regression intercept. β_k ($k = 1, 2, 3, \dots, 7$) are the regression parameters for fixed effects. $b_{1(j)}$ is the effect of class j , interpreted as the effect of class j on the child’s progress, i.e., class j is ‘associated’ to the child’s achievement

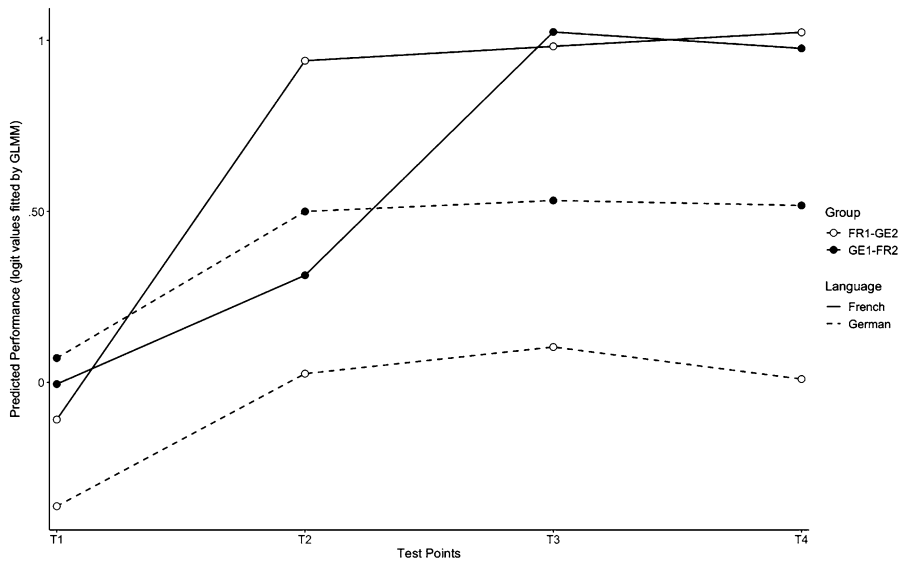


Fig. 1 Illustration of the effects of the GLMM representing the students' spelling performances across the four test points (T1–T4) in both languages (French, German) for both groups (FR1-GE2, GE1-FR2).

(Clarke et al., 2010). $b_{2(i_j)}$ denotes a random effect representing the specific impact of the intervention on child i_j .

The Analysis of Deviance Table shows that the effects of all the fixed factors were significant. The variability between the classes was smaller (.2874) than the variability between the children nested within the classes (.9093) across all test points for both languages and both groups. The integration of the fixed factors and the random effects resulted in the model with the smallest AIC value (−1255.90) and BIC value (−1156.20).

The results of the GLMM representing predicted spelling performances across the four test points (T1, T2, T3, T4) in both languages (French, German) for both groups (FR1-GE2, GE1-FR2) are illustrated in Fig. 1 and refer to Table 8. In the following sections, we report only the line number (Line no.) from Table 8.

3.2.1 Training effects on French plural spelling

To test the short- and long-term training effects (H1), we analyzed the syntactic spelling performance differences between the groups immediately after the training at T2 or T3 depending on the trained language and at least eight weeks after the training at T4. We first report the results for French and then for German.

French syntactic training effects: short-term first training At T1, there was no significant difference in performance in French syntactic spelling between the groups FR1-GE2 and GE1-FR2 (line 1). Although, the French syntactic spelling performance of both groups increased significantly from T1 to T2 (FR1-GE2: line 2; GE1-FR2: line 3), the interaction (test point * group) showed that the increase in French was significantly higher for the FR1-GE2 group compared to the GE1-FR2 group (line 4).

Table 8 Summary of the reported effects: estimate (*B*), standard error (*SE*), *z*-value and *p*-value according to the reference levels needed for the analyses. The complete output is published on [Weth et al. Effects_parallel_syntactic-training_RefLevels.pdf](#). The line number (Line no.) was included in the table to guide the reader through the text, and the reference levels (Ref. level) to link each line with the full reference level summary published on the website.

Reported effect	B	SE	z	p	sig.	Ref. level	Line no.
French plural spelling							
(FR1-GE2 vs. GE1-FR2) at T1	.1037	.3245	.3196	.7494		(I)	1
(T1 vs. T2) for FR1-GE2	1.0488	.1184	8.8575	<.001	***	(I)	2
(T1 vs. T2) for GE1-FR2	.3181	.1050	3.0283	.0025	**	(III)	3
(T1 vs. T2) for FR1-GE2 compared to GE1-FR2	.7307	.1581	4.6219	<.001	***	(III)	4
(FR1-GE2 vs. GE1-FR2) at T2	-.6270	.3255	-1.9267	.0540	‘.’	(V)	5
(T2 vs. T3) for FR1-GE2	.0420	.1200	.3500	.7264		(V)	6
(T2 vs. T3) for GE1-FR2	.7110	.1068	6.6544	<.001	***	(VII)	7
(T2 vs. T3) for FR1-GE2 compared to GE1-FR2	-.6690	.1607	-4.1641	<.001	***	(VII)	8
(FR1-GE2 vs. GE1-FR2) at T3	.0420	.3261	.1286	.8976		(IX)	9
(T3 vs. T4) for FR1-GE2	.0410	.1196	.3429	.7317		(IX)	10
(T3 vs. T4) for GE1-FR2	-.0479	.1098	-.4365	.6625		(XI)	11
German noun capitalization							
(GE1-FR2 vs. FR1-GE2) at T1	-.4331	.3292	-1.3158	.1882		(IV)	12
(T1 vs. T2) for GE1-FR2	.4282	.1197	3.5772	<.001	***	(IV)	13
(T1 vs. T2) for FR1-GE2	.3875	.1249	3.1022	.0019	**	(II)	14
(T1 vs. T2) for GE1-FR2 compared to FR1-GE2	.0407	.1729	.2355	.8138		(II)	15
(GE1-FR2 vs. FR1-GE2) at T2	-.4739	.3289	-1.4409	.1496		(VIII)	16
(T2 vs. T3) for GE1-FR2	.0320	.1165	.2749	.7834		(VIII)	17
(T2 vs. T3) for FR1-GE2	.0779	.1240	.6286	.5296		(VI)	18
(T2 vs. T3) for GE1-FR2 compared to FR1-GE2	-.0459	.1701	-.2696	.7874		(VI)	19
(GE1-FR2 vs. FR1-GE2) at T3	-.4280	.3276	-1.3065	.1914		(XII)	20
(T3 vs. T4) for GE1-FR2	-.0144	.1132	-.1276	.8984		(XII)	21
(T3 vs. T4) for FR1-GE2	-.0938	.1221	-.7682	.4424		(X)	22

Thus, the French syntactic training between T1 and T2 for the FR1-GE2 group had a positive effect on French syntactic spelling performance at T2 for this group.

French syntactic training effects: short-term replication At T2, the FR1-GE2 group obtained a higher French syntactic spelling score than the GE1-FR2 group, although barely significant (line 5). The GE1-FR2 group participated in the French training between T2 and T3. From T2 to T3, the French spelling score of the GE1-FR2 group increased significantly (line 7), and the interaction showed that the French spelling score of the GE1-FR2 group improved significantly more than the FR1-GE2 group

(line 8). Indeed, the GE1-FR2 group reached a score close to that of the FR1-GE2 group; no significant difference appeared in French spelling performance between the groups at T3 (line 9). Thus, French syntactic training between T2 and T3 had a positive effect on French syntactic spelling performance for the GE1-FR2 group.

French syntactic training effects: long-term To assess the long-term effects of French syntactic training on French syntactic spelling, we analyzed the performance pattern following the French training phase until T4 for both groups (FR1-GE2: from T2 to T4, ten weeks after the French training; GE1-FR2: from T3 to T4, eight weeks after the French training). For the FR1-GE2 group, the analyses showed no significant difference in French syntactic spelling performance between T2 and T3 (line 6) and between T3 and T4 (line 10). The positive effect of the French training at T2 remained stable until 10 weeks after the French training phase (at T4). For the GE1-FR2 group, the analyses showed no significant difference in French syntactic spelling performance between T3 and T4 (line 11). The positive effect of the French training at T3 remained stable until eight weeks after the French training phase (at T4).

3.2.2 Training effects on German noun capitalization

German syntactic training effects: short-term first training At T1, the GE1-FR2 group did not obtain significantly higher German syntactic spelling scores than the FR1-GE2 group (line 12). From T1 to T2, the German syntactic spelling scores improved significantly for both groups (GE1-FR2: line 13; FR1-GE2: line 14). The interaction (test point * group) did not show a significantly higher increase for the intervention group compared with the control group (line 15). The increase in German syntactic spelling therefore cannot be explained by the German syntactic training per se.

German syntactic training effects: short-term replication At T2, the German syntactic spelling scores of the GE1-FR2 group were not significantly higher than those of the FR1-GE2 group (line 16). The FR1-GE2 group participated in the German training between T2 and T3. However, the German spelling performance of this group did not improve significantly from T2 to T3 (line 18), and the interaction (test point * group) was not significant (line 19). No significant difference appeared in German spelling performance between the groups at T3 (line 20). So, the intervention group again did not benefit from German syntactic training.

German syntactic training effects: long-term To assess the long-term effects of German syntactic training on German syntactic spelling, we analyzed the performance pattern following the training phase until T4 for both groups (GE1-FR2: from T2 to T4, ten weeks after the German training; FR1-GE2: from T3 to T4, eight weeks after the German training). The analyses showed no significant difference in German syntactic spelling performance, neither for the GE1-FR2 group from T2 to T3 (line 17), or from T3 to T4 (line 21), nor for the FR1-GE2 group from T3 to T4 (line 22). The slight increase in German syntactic spelling measured at T2 in both groups remained stable until T4. However, this long-term effect cannot be explained by the German syntactic training per se.

4 Discussion

The hypothesis that guided this study postulated that a syntactic training, providing explicit instruction on syntactic information is beneficial for French plural spelling and for German noun capitalization, two spelling domains related to syntax and unrelated to phonology. We tested this hypothesis with two intervention studies, one for each spelling domain. The training of both studies aimed to raise attention to the interrelationship between the syntactic information and its representation in spelling. Despite both French plural spelling and German noun capitalization encoding syntactic information and being unrelated to phonology, the two syntactic trainings differed considerably. These differences arose from the syntactic and graphematic distinctions between the two languages and writing systems.

The discussion of the results is structured into three parts. The first part presents the effects of the French training on plural spelling. Subsequently, the results of the German training on noun capitalization are discussed. Finally, differences between the outcomes in French and German are explored before presenting conclusions and implications for teaching.

4.1 Effects of training on French plural spelling

As predicted, the French syntactic training proved to be highly effective for French plural spelling compared with the control group, regardless of whether French was trained first or second in the study design. The significant results obtained shortly after training persisted at the follow-up test, conducted eight to ten weeks after training. These results align with previous intervention studies using syntactic training to enhance plural spelling (Arseneau & Nadeau, 2018; Bîlici et al., 2018; Totereau et al., 1997). Our study suggests that a training approach utilizing educational videos in the classroom can yield positive effects. It is noteworthy that the effectiveness of the training may depend on teachers exhibiting positive attitudes towards the videos. Teacher feedback indicated that the participating teachers were accustomed to reflecting on plural spelling syntactically and that they endorsed the approach used in the training.

4.2 Effects of training on German noun capitalization

In contrast to our predictions, the German intervention group showed no significant effects compared to the control group. The following paragraph aims to provide possible reasons for why the training did not yield positive results compared to previous syntactic training approaches that were successful for noun capitalization.

The training delivered through educational videos in the classroom shared comparable content and structure with two successful intervention studies involving similar Grade 5 cohorts in Luxembourg. However, these studies implemented the training in small groups, in person, and outside the classroom (Bîlici et al., 2019; Brucher et al., 2020). Both small-group studies demonstrated significant overall training effects. Studies that carried out the syntactic training in the classroom (in Grade 2: Wahl et al., 2017a; in Grade 5 and 6: Gaebert, 2012; Melzer, 2011) showed positive results,

but were not successful in every respect. In our study, the influence of the classroom might have been reinforced by the use of videos and by the teachers' administration of the videos. Notably, the present study, using educational videos, lacked interactivity inherently, although group interactions were supported. Furthermore, the teachers' attitudes toward the videos, partially not being convinced by the syntactic training, as well as their interference in the training might have influenced the outcomes. The training appeared to conflict with many teachers' views of noun capitalization. Indeed, if teachers were able to understand the approach presented by the educational videos only in part, they might have felt insecure and uneasy in the training context (Van Rijt et al., 2023). This teacher effect was previously observed in syntactic training carried out in the classroom (Rautenberg et al., 2017).

Another potential reason for the inconclusive results is the relatively low general language proficiency in German among the study's participants. The tests for general language proficiency suggested that the general language scores were, on group level, better in French than in German. This might indicate a better overall language proficiency in French as compared to German, although the students learned to read and write in German and had more instruction time in German at school compared to French. Please note that the language proficiency tests (see Table 4) were not conceived to be directly comparable across languages. Still, the general language proficiency of the learners who participated in the present study was lower compared to the successful intervention study of Brucher et al. (2020) on German noun capitalization. Brucher et al. (2020) used the same measure to control for general spelling (DRT 4) with results above 55% correct, whereas the mean results in the present study remained under 50% with the learners having had one year less German instruction. So, we leave it open as to whether lower language performance in German could have prevented students to do the training successfully in this language.

At least, the explanations in the German training, involving a three-step procedure with high demands on working memory, may have caused problems for the students. The syntactic training directed the attention on words (i.e., inflected adjectives) that are not present in the sentence but could be potentially included in order to determine whether a given word is the head of the NP and must therefore be capitalized. The training might have made the task seem more complicated than it actually was. Together with the lack of interactive metatalk interactions during the video-based tasks, this three-step procedure could have affected the learning process.

4.3 Comparison of the effects of training in French and German

The study revealed that the students' syntactic spelling did not benefit in the same way from the French and German training. The following paragraphs aim to provide an indication of why the training was successful in French but not in German.

This study had used instructional videos in the classroom, with teachers administering the educational videos. The teachers' interference in the video training, not anticipated in the standardized procedure of the study, seem to have either amplified (for French) or hampered (for German) the training effects. In general, the same teacher provided both training in each group, actively participating in the training process. The teachers' attitudes and beliefs could have had a notable effect on the outcome. Thus, one explanation involves the question of whether the syntactic training

represented a continuation of previous regular teaching. The French training complemented the curriculum, placing a stronger emphasis on the encoded syntactic information on plurality provided in the writing system. Hence, the training remained consistent with instruction given in class and the teachers' perceptions of plural spelling. As the French results are convincing and comparable to previous face-to-face training using metalanguage (Arseneau & Nadeau, 2018; Bîlici et al., 2018; Fisher & Nadeau, 2014; Mauroux & Morin, 2018), the training via the medium of educational videos did not seem to impact the training. The smooth transition between the regular teaching and the syntactic training was confirmed in the teacher feedback. The questionnaires after the training indicated that all the teachers believed that the students had benefited from the training in French ($N = 14$ out of 14). Moreover, most teachers ($N = 12$) stated that they wanted to integrate aspects of the videos into their regular classes. In contrast, the German training introduced a new concept of capital spelling to the Grade 4 learners, deviating from their previous three years of noun capitalization in relation to semantic information and word class properties. The syntactic training forced them to unlearn a previously acquired concept and to learn a new concept, as it was observed in previous studies (Bredel, 2010; Funke, 2005). Moreover, the discrepancy in teacher attitudes toward the syntactic training, and its conflict with their usual teaching approach, might have influenced the effectiveness of the German training. Although the questionnaires after the training indicated that most teachers believed that the children had benefited from the syntactic training in German ($N = 9$ out of 12) and that half of the teachers ($N = 7$) wanted to integrate aspects of the German videos into their regular classes, another half of the teachers ($N = 6$) reported that they had interfered in the training with the usual simple word-class related approach. The lack of alignment between the video training and teachers' practices and beliefs may be a significant reason why the German training was ineffective compared to the French training.

A last factor that might account for the different training results is the syntactic and graphematic properties of French plural spelling and German noun capitalization. The study began with the assumption that both are comparable as both present reliably and saliently the syntactic information that is needed, and that neither is related to phonology (Weth, 2020). The different outcomes of the study, however, emphasize the differences. A primary difference is that French plural spelling is part of French inflection morphology, repeatedly representing plural information across each word in the NP and the whole sentence. This recurrence of the same marker may help learners understand the information about the plurality overall the NP and sentence structure, and the training could point attention to the plural markers mapping the syntactic information "plural". In contrast, German noun capitalization visually highlights the NP, a syntactic unit. When writing, one must hence continuously observe whether a given syntactic context is an NP, and if so, the writer must determine its head. In consequence, a training that aims to foster syntactic spelling in German should train how to detect an NP in the sentence, regardless of the semantic properties of the noun or the structure of the NP.

Comparing both spelling domains, learners of French plural spelling could rely on the plural markers to understand that information about plurality is a graphematic feature appearing in multiple places in the NP and the sentence. In contrast, learners

of German noun capitalization had to learn how to recognize whether a given word should be capitalized through a necessary detour.

4.4 Conclusion and consequences for teaching

Our hypothesis suggested that syntactic training providing explicit teaching on the syntactic information visually highlighted by a writing system and unrelated to phonology, would be beneficial for syntactic spelling. The training of French plural spelling likely made the information accessible to students, as evidenced by their more reliable production of the plural marker after training. These effects were sustained several weeks later. It appears that even young learners with relatively little exposure to French were sensitive to the systematicity of plural spelling. A consequence for regular teaching is to emphasize only regular plural forms and to make explicit the connection between the repeated feature of the plural marker and the syntactic information (Brissaud & Fayol, 2018).

Although this study did not show positive results for German, we do not conclude that syntactic training might not be beneficial for German noun capitalization. Previous successful syntactic intervention studies in German have demonstrated improvement even with very short, in-person training sessions (Bilici et al., 2019; Brucher et al., 2020). The complexity of the video explanations in German, the lack of interactive metatalk interactions during the video-based tasks, and the unwanted interference of teachers during the syntactic training might have led to inconsistencies in the training and provoked insecurity in the students. Indeed, the outcome of this study reveals the importance of coherence between the training and the classroom teaching (Jin et al., 2019; Richmond et al., 2019). Despite the lack of positive results for the German syntactic training, syntactic training might still be useful if applied without teacher interference and if coherence with previous teaching input is ensured.

Furthermore, learning noun capitalization requires attention to the expansion of the NP with inflected adjectives in order to recognize whether a given word has to be capitalized. Young learners and learners with relatively little exposure to German might benefit from training that fosters attention to noun capitalization and the context of the NP while reading before focusing on its production (Mangelschots et al., 2023). The sensitivity of young learners to noun capitalization in reading after a syntactic training was confirmed by the intervention study by Wahl & Rautenberg (2017a) with Grade 2 learners.

5 Limitations

One limitation of this study is the observed high standard deviation in the scores within our sample, reflecting the heterogeneity of the learning population in primary school. The high variance may be pronounced due to the multilingual backgrounds of the students. Additionally, the sample comprises the entire student population from 16 classes across Luxembourg, representing districts characterized by varying socio-economic backgrounds. To address the variance in our analyses, we integrated the variable *child_in_class* as random factor in the Generalized Linear Mixed Model

(GLMM). Furthermore, we controlled for balanced proficiency in the two training groups (Tables 4 and 5). In ongoing analyses, we are preparing a cluster analysis on the French and German pretest data to provide more detailed insights into the language proficiency of the learners and its consequence for learning syntactic spelling.

Second, the training employed educational videos and was administered by teachers. Despite clear instructions to refrain from intervention, teacher questionnaires revealed instances of interference in the syntactic training. Exploring the practices and attitudes of the participating teachers enabled us to uncover the potential impact of incoherence within a given training program.

Third, our analysis of French plural spelling and German noun capitalization relied on total mean scores and did not differentiate between underlying factors, such as word class and position. However, this approach allowed us to focus on the overarching categories and to highlight the similarities and differences in the French and German syntactic markers. The language-related specific factors will be explored and discussed in separate analyses.

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Declarations

Competing Interests The authors declare no competing interests.

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