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SWITCHING BETWEEN NOUN
AND VERB AGREEMENT RULES COMES AT A COST:
CROSS-SECTIONAL AND INTERVENTIONAL STUDIES
IN A DEVELOPMENTAL SAMPLE

This study clarifies the impact of switching context between noun and verb number agreement rules in written language production. In Experiment 1, children from grade 3 to 6 were asked to fill in sentences with nouns and verbs in either *a switching condition* (noun followed by verb) or *a repeating condition* (noun followed by noun). The results showed that third- and fourth-grade children produced more erroneous agreements in the switching condition than in the repeating condition, showing that switching between rules comes at a cost, whereas fifth- and sixth-grade participants' performance was not affected by the switching context. Based on these findings, Experiment 2 aimed to assess whether a switching treatment offers a greater opportunity to improve the acquisition of grammatical agreement production, as compared to a simple treatment. Teachers from grade 3 gave either *a switching treatment* (mixed noun and verb exercises) or *a simple treatment* (noun exercises followed by verb exercises). The results show that children learned better from the switching treatment than from the simple treatment. These findings highlight the cost of switching between noun and verb agreement rules during the acquisition of grammatical number agreement and also how grammatical spelling acquisition can be improved at school.

Key words: grammatical writing, number agreement, switching context, instructional practices

Introduction

Writing ability is one of the core foundations of school skills that are involved in plain learning situations in classrooms. Children in primary schools need to

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learn how to write spoken language. Phonological mediation leading children to discover and begin to manage sound-letter correspondences, which corresponds to the alphabetic stage (Frith, 1985), is specifically the first way of learning. However, to become an efficient writer, they also need to manage exceptions to correspondences that occur in 50 percent of words in French, which necessarily brings them to the orthographic stage (Frith, 1985). Indeed, French words are composed of inconsistencies on the lexical level (e.g. -en in *presence [attendance]*), as well as numerous exceptions to correspondences linked to the grammatical level, because certain agreement markers are silent letters. For example, in the sentence *ils mangent des escargots* (they eat snails), the number agreement markers of the pronoun *ils*, the verb *mangent* and the noun *escargots* are inaudible. Understanding those kinds of grammatical rules constitutes a real challenge for children and takes them a long time to acquire (Beers & Beers, 1992). And, this number agreement learning without any oral reference is a huge challenge in French because the agreement markers depend on the word's syntactic class: -*s* for plural nouns and -*nt* for the third person of verbs in plural. So far, several studies have focused on understanding the processes underlying the acquisition of these grammatical rules but, to the best of our knowledge, not one has tried to address the question across different rules and in relation to its cognitive underpinnings, more precisely the ability to efficiently switch between different grammatical rules of number agreement for nouns and verbs.

The acquisition of inflectional spelling

The acquisition of inflectional spelling is a particularly complex process in French as it requires children to remember to think about applying the rule (because some agreement markers are silent letters), to manage notions of syntactic class, and finally to manage various rules such as a range of flexional markers according to syntactic class (e.g. -*s* for nouns and -*nt* for French verbs). A few earlier findings present various steps in grammatical acquisition, looking at errors made by children going from a phonological transcription of noun or verb without inflectional marker through a correct inflected noun or verb punctuated by several transitional steps (Beers & Beers, 1992; Nunes, Bryant, & Bindman, 1997b; Nunes, Bryant, & Bindman, 1997a). Totereau, Fayol and Barrouillet (1998), for example, showed that French-speaking children make overgeneralization errors that consist in adding to a verb the inflectional marker of a noun (e.g. *ils manges* [they eat] instead of *ils mangent*) or vice versa. In grade 2, children make this kind of error in nouns, whereas in grade 3 they begin to add the verb marker to verbs but also to nouns (e.g. *les fillent* [the girls] instead of *les filles*). Those errors may be connected to French-speaking school instructions, as number agreement rules for nouns are usually taught in grade 2, while in contrast number agreement rules for verbs are often taught in grade 3. Similar overgeneralization errors in English for the adjective and past tense verb have also been documented (Nunes

et al., 1997a). In French, those overgeneralization errors shed light on one specific difficulty of inflectional spelling, namely the management of two different number agreement rules, which is the main topic of this paper.

Of particular interest to the current study is one of the hypotheses about the cognitive processes underlying the acquisition of inflectional spelling through algorithmic application of the grammatical rules that correspond to the instructions given at school (Fayol, Hupet, & Largy, 1999; Largy, 2001). This hypothesis is often interpreted in the theoretical framework of Anderson's *Adaptive Control of Thought* (1982; 1996). According to this framework of skill acquisition, children need to go through three stages in the development of a cognitive skill: i) a declarative stage in which children receive instruction about a skill and are able to name the various steps of the rule, for example: identify the context of the grammatical rule *IF the noun is plural* and to carry out an action *THEN add the agreement mark -s at the end*; ii) a knowledge compilation stage in which children go from interpreting the declarative knowledge to using procedures applying the knowledge (actions); iii) a procedural stage in which the knowledge is fully and quickly applied in procedures allowing to perform the skill. This progressive automatization occurs thanks to multiple productions requiring the repeated application of the agreement rule that necessitates more cognitive resources at the beginning. Learners must carefully apply the rules one after the other in order to gradually internalize these steps, reduce the number of steps necessary in production and reduce the number of conscious indicators. Fayol et al. (1999) supported this hypothesis with a dual-task experiment in which younger children manifested a laborious attention-demanding algorithmic computation of the agreement (leading to the absence of agreement markers in the dual task and markers in the simple task) whereas older children applied the rule more automatically (in both simple and dual tasks). This hypothesis of algorithmic application of the rule is also supported by recent temporal analyses of written production and of visual information fixed by the writer. Alamargot et al. (2014) confirmed the use of an algorithmic application of the rule by third-graders through the observation of regressive eye fixations on the subject noun while writing out the verb inflection. In Anderson's framework, in the transition from declarative to procedural knowledge, during procedural learning children need to develop a *discrimination process* which allows them to restrict one rule to specific conditions and to apply other rules in different conditions. This discrimination process can be related to grammatical number agreement acquisition in French with both agreement rules for nouns and verbs. In doing so, it could be hypothesized that children must learn to alternate between the two agreement rules during procedural learning. So far there is no experimental evidence showing that the alternation between inflectional rules for nouns and verbs in French comes at a cost. The present study aims to provide experimental evidence of a switching cost during the acquisition of grammatical number agreement.

In summary, the aim of this study is to examine whether switching between distinct noun and verb agreement rules may influence the inflectional spelling performance of French-speaking schoolchildren. The present study reports two experiments. The first cross-sectional experiment aims to provide empirical evidence of the impact of switching context in a developmental perspective. Thus, third- to sixth-graders performed a sentence completion task involving two conditions: *a repeating condition* in which children had to make only nouns or only verbs agree, and *a switching condition* in which they had to switch between verb and noun agreement. The main goal of Experiment 2 is to train switching ability between both noun and verb inflectional spelling in order to estimate whether the cognitive cost can be reduced by the training instructions.

Experiment 1: Cross-sectional study

To address the question whether switching between two distinct agreement rules may influence inflectional spelling performance, children were asked to listen to sentences and to write down the missing words, nouns or verbs, in either a switching condition (noun followed by a verb or vice versa) or a repeating condition (noun followed by noun or verb followed by verb). Words were selected in order to match both switching and repeating conditions in frequency, word length, syllabic structure and level of acquisition of lexical spelling to ensure that differences between conditions were not due to various levels of difficulty of the words themselves. To investigate the developmental changes, we asked children from third grade, fourth grade, fifth grade and sixth grade to participate. Our predictions were as follows: (i) if switching context comes at a cost in learning inflectional spelling of nouns and verbs, we anticipate a task switch cost in the switching condition that leads children to make fewer words agree correctly in the switching condition than in the repeating condition; (ii) if switch costs vary depending on developmental changes, we assume that younger children will be more affected by the switching demands than their older counterparts.

Method

Participants

One hundred and thirty primary school children from third to sixth grades aged between 8;2 years and 12;1 years took part in the experiment. The children came from a rural school in Belgium from a middle social economic status. They came from two third-grade classes and one class each from fourth to sixth grade (the school composition). No selection criterion was used at school and all children from the selected grades participated in the experiment, but, in the analysis, exclusion criteria were used to ascertain that the children had normal abilities in written language. They were assessed with two control tasks: a reading comprehension

and a spelling test, and questions were addressed to the teachers to find out if the children had been receiving speech therapy. The reading comprehension test (Lobrot, 1967) was used to assess children's ability to process sentences at a morphosyntactic level. It consisted of a multiple-choice test involving the completion of 36 sentences; a word was missing from each sentence and the children had to select the missing word from five possible options. The options included distracters such as homophones, e.g. *mère* (mother) instead of *mer* (sea), while others included phonological distracters, e.g. *palais* (palace) instead of *balai* (broom) or semantic distracters, e.g. *pattes* (legs) instead of *oreilles* (ears). The children had 5 minutes to complete as many sentences as possible. The spelling test (Chevrie-Muller, Simon, & Fournier, 1997) involved dictation of a text entitled *Le Corbeau*; performance was rated on a phonological level (phoneme-grapheme correspondences), on a lexical level (lexical spelling of the words) and on a grammatical level (grammatical rules). On the basis of the following exclusion criteria, 23 children were eliminated from the initial sample, either because they had obtained a score of less than -2 standard deviations for their age in the spelling test ($N = 14$) or in the reading test ($N = 1$), or because they were or had been receiving speech therapy for difficulties with written language ($N = 8$). The final sample was made up of 107 children. Table 1 provides the details on the children's characteristics for the four school levels.

Materials and conditions

The experimental material consisted of 36 lexical items, 18 nouns and 18 verbs, to be written within sentences that were dictated by the experimenter. Within the 36 lexical items, two conditions were proposed: (i) *a repeating condition* ($N = 18$) where the two words to be written belonged to the same syntactic class: noun/noun or verb/verb (e.g. *Tous les soirs, les moutons rentrent vite à la ferme* [The *sheep* go back quickly to the farm every *evening*]); (ii) *a switching condition* ($N = 18$) where the two words belonged to two different syntactic classes: noun/verb or verb/noun (e.g. *Les cuisiniers* achètent *les* tomates *à la ferme du village* [The cooks *buy* the *tomatoes* at the village farm]).

All the words were commonly used, they were chosen on the basis of three selection criteria: a frequency above 48, which corresponds to the 75th percentile of the word-frequency distribution for Grades 3 to 5 according to Manulex (Lété, Sprenger-Charolles, & Colé, 2004); concrete and imageable words.

To match the repeating and switching conditions as much as possible on the lexical level, the most relevant level here due to the fact that only words needed to be written, two parallel lists of lexical items were drawn up. The items in list A were administered in the repeating condition and those in list B in the switching condition. Matching of the two lists was based on the following variables: word length (number of letters), word frequency (Manulex, Lété et al., 2004), word syllabic structure (number of clusters) and level of acquisition of lexical spelling for the third grade (EOLE/Echelle d'acquisition en orthographe lexicale

Table 1. Participant characteristics

| Grade | N | Sex | | Age (months) | | Reading (Lobrot)[x] | | Spelling (Corbeau)[x] | | | | | |
| | | Male | Female | M | SD | M | SD | Phonology | | Lexical | | Grammatical | |
								M	SD	M	SD	M	SD
3rd	38	20	18	105.15	3.19	13.65	2.40	9.12	2.31	9.00	2.07	9.52	1.92
4th	23	10	13	116.05	3.96	14.76	1.79	9.26	2.73	9.14	2.95	9.19	2.78
5th	23	12	11	128.09	5.58	13.36	1.99	9.14	2.31	8.49	2.33	8.19	2.02
6th	23	13	10	137.73	5.88	12.66	1.61	10.51	1.74	10.98	1.68	12.56	2.04

Note: [x] Standardized scores with population average $M = 10$ and $SD = 3$

Table 2. Mean for variables controlled in the lexical items (*standard deviations*)

Type of items	Number of letters	Word acquisition level[a]	Word frequency[b]	Number of clusters (CCV)	Length of sentences[c]
Nouns – list A	6.0 *(0.0)*	88.1 *(8.5)*	57.9 *(3.8)*	1	58.4
Nouns – list B	6.0 *(0.0)*	88.1 *(12.0)*	58.7 *(3.8)*	1	57.8
Verbs – list A	8.1 *(0.3)*	81.2 *(12.9)*	55.8 *(5.2)*	8	66.5
Verbs – list B	8.1 *(0.3)*	81.7 *(10.4)*	54.4 *(3.9)*	8	66.0

Notes: [a] According to EOLE for 3rd grade (Echelle d'Acquisition en orthographe lexicale / Lexical spelling acquisition scale);
[b] According to Manulex;
[c] in number of characters.

[lexical spelling acquisition scale]; Pothier & Pothier, 2003). The words mainly contained consistent grapheme-phoneme correspondences (except for the agreement marker). The length of the sentences in which the words occurred was also checked (number of characters). Table 2 gives the averages of the controlled variables while Appendix A gives the full list of lexical items.

To avoid children's automatic way of answering by putting plural marks on every lexical item, words with singular agreement were introduced in each condition, as well as distracters. Thus, for example, the task for the noun switching condition involved 9 nouns to be agreed, of which 6 were plural and 3 were singular (hence a total of 36 items, of which 24 were plural and 12 were singular). Distracters were determinant, preposition or adverb (e.g. *Les* élèves observent *les* moulins avant *de les peindre* [Pupils *looked at* the *windmills before* painting them]). A random order was introduced in the repeating condition, separately for the noun and verb items, to establish item order. In the switching condition, a random order was also introduced (nouns and verbs mixed up).

Procedure

The children were tested in groups within their classroom over a session lasting around 45 minutes. Each participant completed the 36 lexical items within 36 sentences. To make sure the children understood the instructions well, an example was given, followed by a training item and individual corrective feedback. The procedure was identical in all classes. Children first had to listen to oral sentences and then write down the three missing words in the blank spaces of the same written sentences while the sentences were repeated. The instruction was that they should try to write down words even if they do not know how to write them. Children were not informed about the focus on grammatical spelling.

Results

Because we think that the underlying processes of our switching condition may be to some extent associated with mental shifting, we based our data analysis on previous studies of Dibbets and Jolles (2006) and Davidson et al. (2006), and we adapted a global and local switch value for our specific task. As there were pauses between the sentences in our task, whereas usually experiments are made up of two blocks of items with continuity between the items within the block (switching ABBABAB, repeated AAAA and BBBB), it was not possible to assess either a global switch cost (comparison between repeating and switching blocks) or a local switch cost (comparison between two items). This was because pauses made a break between the first item of the sentence and the previous one in the sentence before, and the introduction of pauses significantly reduced the repeating or switching status of the items. So, we chose to consider the accuracy of answers in a situation of local switch only for the second lexical item of the sentence. The dependent variable was the proportion of correct agreements in the second lexical items of the sentences, either in the repeating or in the switching condition. Only lexical items of which the first was agreed correctly were retained (70.1% of the items) to make sure that the performance was related to switching between rules, particularly when children needed to make first a verb then a noun agree. For example, if the child made the first item agree (e.g. *Tous les* jours, *les* pilotes' *entraînent pour la course* [The *drivers* train for the race *every day*]), the item was retained; if the child did not make the first item agree properly (e.g. *Les filles* préfère *les* madames *des classes maternelles* [The girls *prefer women* nursery-school teachers]), the item was not retained, although the agreement was correct for the second item.

Table 3 gives mean types of answer by grade. Overall, children correctly agreed the majority of the items (60.6%). In a third of the cases (29.9%), the chil-

Table 3. Mean percentages of types of answer by grade

| | | Correct agreements | | Agreement errors | | | | | | |
| | | | | Marker omissions | | Marker errors[a] | | Transcription errors | | Errors on the first lexical item | |
Grade	N	M	SE	M	SE	M	SE	M	SE	M	SE
3rd	38	42.54	1.33	8.85	0.77	1.17	0.29	0.44	0.18	47.00	1.35
4th	23	57.97	1.72	7.61	0.92	3.14	0.61	0.60	0.27	30.68	1.60
5th	23	67.75	1.62	7.37	0.91	2.17	0.51	0.48	0.24	22.22	1.44
6th	23	87.56	1.15	4.11	0.69	1.09	0.36	0.00	0.00	7.25	0.90

Note: [a] Marker errors correspond to overgeneralization errors

Table 4. Estimated means of correct agreements by grade

		Nouns				Verbs					
		Repeating		Switching		Repeating		Switching			
Grade	N	M	SE	M	SE	M	SE	M	SE	Repeating	Switching
3rd	38	0.54	0.05	0.39	0.04	0.40	0.04	0.39	0.04	0.47	0.39
4th	23	0.68	0.05	0.55	0.06	0.67	0.05	0.47	0.06	0.68	0.51
5th	23	0.75	0.05	0.74	0.05	0.69	0.05	0.63	0.06	0.73	0.69
6th	23	0.91	0.02	0.91	0.02	0.90	0.03	0.89	0.03	0.90	0.90

dren did not agree the first lexical items correctly; these items were not taken into consideration. For less than 10% of the items, children answered incorrectly: they omitted the markers in 7.5% of the cases (marker omissions); they made marker agreement errors in 1.5%, which corresponds to overgeneralization errors (e.g. *Ils manges*), and they made only few transcription mistakes (e.g. writing a wrong word). Table 4 provides estimated means of correct agreements by grade, condition (repeating vs. switching) and word syntactic class.

Statistical analyses were run with SPSS 20. A Generalized Linear Mixed Model (GLMM) was run instead of a classical analysis of variance, which does not allow to account for both the variability induced by participants and the variability induced by items in the same analysis, which could possibly lead to high Type 1 error rates (Baayen, Davidson, & Bates, 2008). So, GLLM was chosen because it allows us to consider the variability of the items and the variability of the participants. Analyses were run on the proportion of agreements of the second items (when the first item was correctly agreed) with grade (third, fourth, fifth vs. sixth), switching condition (switching vs. repeating) and word syntactic class (nouns vs. verbs) as fixed main effects. The model also included interactions between grade and switching condition, between grade and word syntactic class, and between grade, word syntactic class and switching condition. Furthermore, one random factor was included in the model for participants, allowing us to consider the dependence between our observations due to repeated measures.

The effect of switching condition was significant, $F(1, 3836) = 12.37$, $p < 0.001$. Children agreed words better in the repeating condition ($M = 0.72$, $SE = 0.02$) than in the switching condition ($M = 0.66$, $SE = 0.02$), revealing a task switch cost or a rule switch cost. The effect of grade was significant, $F(3, 3836) = 29.11$, $p < 0.001$. A sequential Bonferroni post-hoc test showed that third-graders agreed fewer items correctly ($M = 0.43$, $SE = 0.04$) than fourth-graders ($M = 0.60$, $SE = 0.05$) who, statistically speaking, agreed as many items correctly as fifth-graders ($M = 0.71$, $SE = 0.04$), who themselves agreed fewer items correctly than sixth-

graders ($M = 0.90$, $SE = 0.02$; each comparison was significant at $p < 0.01$, except between fourth-graders and fifth-graders, $p = 0.08$). The grade × switching condition interaction was also significant, $F(3, 3836) = 2.72$, $p < 0.05$, showing that the switch cost varied depending on the grade. More specifically, post-hoc analyses showed that the switching condition effect or rule switch cost was significant in the third (sequential Bonferroni: $p < 0.01$) and fourth grades ($p < 0.001$), but not in the fifth nor in the sixth grades.

Analyses also revealed a significant effect of word syntactic class, $F(1, 3836) = 9.74$, $p < 0.01$. Children agreed nouns ($M = 0.72$, $SE = 0.02$) more correctly than verbs ($M = 0.66$, $SE = 0.02$). The word syntactic class × grade interaction was not significant, $F < 1$. The grade × word syntactic class × switching condition interaction was as follows: $F(3, 3836) = 2.01$, $p = 0.11$. For nouns, the rule switch cost was significant in the third and fourth grades (sequential Bonferroni: $p < 0.001$ and $p < 0.01$) but not in the fifth nor in the sixth grades. For verbs, the rule switch cost was significant in the fourth grade only, $p < 0.001$.

Discussion

The aim of the experiment was to further understand whether switching between grammatical rules for nouns and verbs in French would possibly constitute a cost during the acquisition of grammatical spelling. Children from third to sixth grades were asked to fill in sentences under dictation with nouns and/or verbs in two conditions: either a repeating condition, where they needed to fill in and possibly agree two nouns or two verbs, or a switching condition, where they needed to fill in a noun followed by a verb or vice versa. Both conditions allowed us to assess a rule switch cost when performance was lower in the switching condition compared to the repeating condition. Interestingly, the results showed that children were influenced by the switching condition: they made fewer correct agreements on nouns and verbs in the switching condition where they were forced to alternate between the two rules, compared to the repeating condition. Thus, in line with our predictions, the results show that switching between verb and noun agreement comes at a cost. Moreover, this effect of switching was different depending on the grade level: younger children in the experiment, third-graders and fourth-graders, were significantly affected by the task switch cost, whereas fifth-graders and sixth-graders showed the same level of performance in either the switching or repeating condition. Thus, in accordance with our second prediction, the involvement of switching was significant among young children and was not implied in older children. Specifically, the task switch cost was observed for third-graders for the nouns only and not for the verbs, which can be explained by the fact that their acquisition of the verb agreement rule is just starting, the number of correct answers mainly corresponding to singular lexical items. In contrast, the task switch cost was observed for fourth-graders for the nouns and for the verbs. On the basis of these results we can infer that

task-switching cost is one of the components to be dealt with during the acquisition of both agreement rules in French for third- and fourth-grade children. But we still do not know whether it would be efficient to offer students switching training for their acquisition of both agreement rules, or if instruction on nouns in a first step and on verbs in a second step, which is commonly done at schools, could have the same efficacy.

Experiment 2: Intervention study

In order to test this hypothesis, we conducted a second experiment, which was an intervention aiming to assess the extent to which a switching treatment in spelling may be more beneficial for the acquisition of number agreement for nouns and verbs compared to a simple treatment (control group) where children receive the same exercises in a simple condition in which nouns are practiced separately from verbs. Children were randomly assigned to two experimental groups trained either in *a switching treatment* composed of exercises where children were asked to manage both rules for nouns and verbs in the same exercises, or *a simple treatment* composed of the same exercises with nouns in the first half of the treatment and verbs in the second half of the treatment. Our predictions were as follows: (i) if switching training constitutes a beneficial instructional practice and task switching a component that should be drilled for learning both grammatical rules, we should observe greater improvement in number agreement performance for children in the switching treatment than for children in the control simple treatment. On the other hand, if children can improve their production of inflected nouns and verbs no matter whether exercises are presented in a switching context or not, children from both treatments should improve in the same way.

Participants and design

Forty primary school children from two third-grade classes participated in the second experiment. They came from a rural school in Belgium from a middle social economic status. All children in each class took part in the experiment and the same exclusion criteria as for experiment 1 were used for the analysis, including written language impairment and the two control tasks (reading comprehension and spelling). After these exclusion criteria, the sample was made up of 33 children: five children scored below two standard deviations in the spelling test, one child scored below two standard deviations in the reading test and one child had been receiving language therapy. Due to our intervention design, the equivalence between classes was assessed in a pretest to ensure that results of diverse experimental groups were not linked to dissimilar levels of the groups at the beginning. The means of correct agreements in the experimental task of both third-grade classes did not differ, $t(31) = 0.25$, $p = 0.80$. Table 5 provides participant

Table 5. Participant characteristics by grade in experiment 2

Treatment condition	N	Sex		Age (months)		Reading (Lobrot)[x]		Spelling (Corbeau)[x]						Grammatical spelling experiment[y]	
		Male	Female	M	SD	M	SD	Phonology		Lexical		Grammatical		M	SD
								M	SD	M	SD	M	SD		
Simple	16	10	6	104.11[a]	4.59	11.73[a]	2.20	9.49[a]	2.72	8.07[a]	2.79	8.69[a]	1.36	0.49[a]	0.20
Switching	17	8	9	100.81[b]	3.78	12.48[a]	2.41	8.31[a]	4.83	8.46[a]	2.31	9.87[b]	1.67	0.50[a]	0.18

Note: [y] Grammatical spelling experiment corresponds to the experimental material at pretest;
[x] Standardized scores with population average *M* = 10 and *SD* = 3.
Pairs with different superscript letters (a, b) differ significantly (t-test, $p < 0.05$).

characteristics for both experimental groups. Both treatment groups were equal in reading and in the phonology and lexical spelling control tests (all $t < 1$). They differed significantly in age, $t(31) = 2.26$; $p = 0.03$, and in the grammatical spelling control test, $t(31) = -2.20$; $p = 0.04$, which includes diverse grammatical rules such as past participle, articles and auxiliaries (maximum: 13). The two groups did not differ on the experimental material of grammatical spelling evaluating only number agreement for nouns and verbs (maximum: 36).

Treatment conditions

The two treatments were carried out during eight sessions of French lessons (each lesson lasted 30 minutes) during a period of seven weeks, one lesson per week except for the last week when two lessons were given. The two experimental treatments were constructed to assess the impact of switching on grammatical spelling by comparing the *switching treatment* (switching exercises) to the *simple treatment* (simple exercises constituting the control treatment). In both treatments, lessons were conducted in the same way: instruction reading and explanation, individual learning phase, collective feedback with the whole class where each child corrected another child's sheet with a colored pen. The two teachers administered the entire treatment with the two classes during the same time.

The switching treatment was composed of eight lessons (8 larger-version exercises including noun and verb agreements together) whereas the simple treatment was also composed of eight lessons including the same 8 exercises duplicated in shorter versions for nouns in the first half of the treatment and in shorter versions for verbs in the second half of the treatment. In both treatments, children were faced with exactly the same number of nouns and verbs to practice. For example, lesson 1 in switching treatment was composed of exercise 1 for 21 nouns and 10 verbs mixed together, while lesson 1 in simple treatment was composed of exercise 1 for 21 nouns and exercise 2 for 23 nouns; exercise 1 for 10 verbs was done in lesson 5. Table 6 provides the number of nouns and verbs to be trained in each lesson with the treatment condition.

The eight exercises for switching treatment as well as for simple treatment gradually increased in difficulty, and in cognitive load to allow the children to progressively automatize the procedure to make the noun or the verb agree. The first two exercises aimed to give children practice at identifying the context of the grammatical agreement, with neither production of words nor production of grammatical marks. This constitutes the first condition in the development of a procedural skill, according Anderson's framework (1982). In the first exercises, *grammatical category*, children had to color corresponding circles in blue, below nouns, and/or in red, below verbs, in various sentences. In the second exercise, *agreement context identification*, children needed to underline the context, either the determiner for noun agreement or the noun for verb agreement. In the next five exercises, children had to produce grammatical agreement marks in a way

Table 6. Number of nouns or verbs in each lesson

Exercise	Lesson	Switching treatment		Lesson	Simple treatment	
		Nouns	Verbs		Nouns	Verbs
1	1	21	1	1	21	
				5		10
2	2	23	12	1	23	
				5		12
3	3	20	13	2	20	
				6		13
4	4	20	18	2	20	
				6		18
5	5	9	13	3	9	
				7		13
6	6	16	14	3	15	
				7		14
7	7	20	14	4	20	
				8		14
8	8	14	14	4	14	
				8		14

that gradually increased the required cognitive resources. In the third exercise, *correct marked word choice*, children needed to fill in a text with the correct marked noun or the correct marked verb in choosing between various propositions (singular and plural were offered). This exercise requires the selection of the marked word and constitutes a higher cognitive cost for the agreement process, but the lexical process is easier as the word needs only to be copied. Also, the agreement process requires comparing marks when both are provided, which is easier than finding a mark (e.g. plural) on the basis of another (e.g. singular), as shown by Totereau, Thevenin and Fayol (1997). The fourth exercise, *completion of endings of words*, required children to add the agreement mark when necessary (e.g. *Eve pouss.... de profonds soupirs* [Eve let... out a deep sigh]). This instruction is less consuming in terms of cognitive resources than the production of the word under dictation, which implies retrieving the representation in the orthographic lexicon. Indeed, this production of words can impact the cognitive resources possibly available for grammatical agreement (Van Reybroeck & Hupet, 2009). In the fifth exercise, *transposition between grammatical marks*, children had to copy words and to transpose them from one grammatical mark (e.g. singular) to the

other (e.g. plural). The grammatical process involves finding a mark when one is provided, which is easier than finding a mark without this support (Totereau et al., 1997). In the sixth exercise, *context identification and word production under dictation*, children had to underline the context of agreements, which was either the determiner in a noun agreement or the subject in a verb agreement, exactly as in the second exercise for context identification. At the same time, they had to complete the text with a noun or a verb produced under dictation and in this way to retrieve the orthographic representation of the words. This instruction consumes more cognitive resources in the lexical part of the production and in the grammatical part, but support is provided to help children to identify the context of the agreement. In the seventh exercise, *word production under dictation*, children needed to complete the text with nouns or verbs under dictation, without support to identify the context, but with help provided by spaces in the text for words to be filled in. In the eighth exercise, *text to correct*, children did not have to produce words, but they needed to find grammatical agreement errors in the text. This is more difficult because they have to identify the context of the agreement without the help of spaces provided before. This is considered to be a control stage of the agreement process.

Treatment fidelity

Two primary school teachers instructed the treatments. Before the beginning of the treatment, both teachers and the first author collaborated on creating the treatment to conform to usual instructional practices as well as research objectives. A manual was made including the exercises mentioned above and the precise instructions to be given to the children. The teachers were informed about the importance of instructing the children in being as similar as possible through both treatments, and they were blind to the research hypothesis as we told them that both treatments may possibly be effective with children. During the treatment both teachers, who had close classrooms, had regular meetings to ensure that the realization was as similar as possible between the two classes. The teachers and the first author also had twice-weekly meetings to discuss the previous lesson and plan the future. We also asked the teachers to minimize their usual written grammar lessons during the treatment and, when they carried out some exercises, to control that the same exercise was also done in the other class, which was their usual way of teaching in this school as they frequently prepare lessons for both classes together. All exercises were accomplished, the teachers moving on to the next exercise when the children had finished the previous one. Each child's sheet of the treatment was given to the first author at the end.

Measures

An experimental test evaluating the agreement of nouns and verbs was given to all children in the pretest and the posttest one week before and one week

after the treatment. Two control measures assessing reading and spelling were administered only at pretest. Those measures were identical to the ones of the first experiment.

Procedure

The procedure was identical to the first experiment. The researcher conducted a pretest and posttest with the whole class. The pretest lasted approximately 45 minutes and the posttest approximately 20 minutes in each class.

Results

As in the first experiment, the dependent variable was the proportion of correct agreements in the second lexical item of the sentences, either in the repeating or in the switching condition. Thus, as in the first experiment, to be sure to observe switching between rules, only data for sentences where the first item was correctly agreed were taken into account in the analysis (31.8% of the items were excluded from the data). Table 7 shows the estimated mean proportions of nouns and verbs correctly agreed per treatment group (switching treatment, simple treatment), time (pretest and posttest) and switching condition (switching condition, repeating condition), and Table 8 gives the means of types of answer. Overall, children correctly agreed a large part of the items (57.2%). The mistakes were omissions of the agreement mark (8.5%), wrong agreement marks (2.1%), or transcription errors (e.g. translating the word wrongly, 0.4%). The number of overgeneralization errors was significantly similar in both treatment groups and in the pretest and posttest (repeated measures Anova, effect of treatment, effect of time and interaction treatment × time not significant, $F < 1$) even if descriptive data shows an increase of the number of overgeneralization errors from pretest to posttest. Table 9 provides Pearson correlation coefficients among pretest and posttest measures. Grammatical spelling for noun and verb agreements is only correlated with the same measure at pretest.

Table 7. Estimated means of correct agreement (*standard error*)

Treatment condition	Pretest				Posttest					
	Repeating[x]		Switching[x]		Repeating		Switching		Pretest	Posttest
	M	SE	M	SE	M	SE	M	SE		
Simple	0.54	0.06	0.48	0.06	0.62	0.06	0.64	0.06	0.51	0.63
Switching	0.53	0.06	0.45	0.06	0.71	0.05	0.73	0.05	0.49	0.72

Note: [x] Repeating and switching refers to switching condition for the lexical items.

Table 8. Mean percentages of types of answer by condition

	Correct agreements		Agreement errors							
			Marker omissions		Marker errors[a]		Transcription errors		Errors on the first lexical item	
Treatment	M	SE	M	SE	M	SE	M	SE	M	SE
Simple – pretest	50.53	2.11	10.14	1.27	2.31	0.63	0.18	0.18	36.83	2.04
Simple – posttest	61.11	2.03	8.68	1.17	2.60	0.66	0.52	0.30	27.08	1.85
Switching – pretest	48.33	2.09	9.14	1.21	1.58	0.52	0.53	0.30	40.42	2.06
Switching – posttest	68.40	1.94	6.08	0.99	2.08	0.59	0.35	0.24	23.09	1.76

Note: [a] Marker errors correspond to overgeneralization errors

Table 9. Correlation coefficients among pretest and posttest measures

	(1)	(2)	(3)	(4)	(5)
(1) Spelling phonology (pretest)	–				
(2) Spelling lexical (pretest)	0.47**	–			
(3) Spelling grammatical (pretest)	0.08	.037*	–		
(4) Reading (pretest)	0.14	0.50**	0.22	–	
(5) Grammatical spelling experiment (pretest)	-0.28	0.04	-0.29	-0.38*	–
(6) Grammatical spelling experiment (posttest)	-0.17	0.13	-0.10	-0.07	0.71***

Note: *p < 0.05; **p < 0.01; ***p < 0.001

A generalized linear mixed model (GLMM) was run on the proportion of correct agreements on the second lexical item of the sentences with time (pretest vs. posttest), treatment (switching treatment vs. simple treatment), word syntactic class (nouns vs. verbs) and switching condition in the sentence (switching vs. repeating) as fixed main effects. Interactions and double interactions between time, treatment and switching condition in the sentence were also included in the model, as well as one random factor for participants linked to our repeated measures. The effect of time was significant, $F(1, 2268) = 62.78$, $p < 0.001$, showing an improvement of performance between the pretest ($M = 0.50$, $SE = 0.04$) and the posttest ($M = 0.68$, $SE = 0.04$). The effect of treatment was not significant, $F < 1$,

but the time × treatment interaction was significant $F(1, 2268) = 7.28$, $p < 0.01$ in the sense that children benefited more from the switching treatment (pretest: $M = 0.49$, $SE = 0.06$; posttest: $M = 0.72$, $SE = 0.05$) than from the simple treatment (pretest: $M = 0.51$, $SE = 0.06$; posttest: $M = 0.63$, $SE = 0.06$). The effect of syntactic class was also significant, $F(1, 2268) = 38.85$, $p < 0.001$, due to higher performance for nouns ($M = 0.66$, $SE = 0.04$) than for verbs ($M = 0.52$, $SE = 0.04$). The effect of switching condition in the sentence failed to be significant $F < 1$, while the switching condition × time interaction was significant, $F(1, 2268) = 4.29$, $p = 0.04$. This was linked to a significant difference between the switching and repeating conditions at pretest (sequential Bonferroni: $p = 0.03$; switching: $M = 0.46$, $SE = 0.05$; repeating: $M = 0.54$, $SE = 0.05$) and no statistical difference between the two conditions at posttest (switching: $M = 0.69$, $SE = 0.04$; repeating: $M = 0.67$, $SE = 0.04$).

Discussion

The purpose of the second experiment was to assess if a switching context of exercises leads to greater improvement in the production of noun and verb grammatical spelling rules compared to a simple context where nouns are drilled before verbs. One half of the third-grade participants followed a *switching treatment*, where they did exercises on noun and verb agreement at the same time, whereas the other half did a *simple treatment*, where they were drilled in the first part of the treatment with noun grammatical agreements and in the second part with verb grammatical agreements. Both groups completed pretest and posttest measures on grammatical spelling and followed one of the two treatments over a period of 7 weeks.

The results showed that children benefited more from the switching treatment than from the simple treatment. The global performance for agreement production improved more for children who were faced with noun and verb agreement exercises at the same time than for children who received exercises for nouns before and verbs afterwards.

Our results do support the idea that switching instruction at school is beneficial for children from third grade as compared to simple intervention. It suggests that a switching context of exercises offers children conditions to learn several agreement rules, such as nouns and verbs in French, more efficiently.

Our results also support the hypothesis of a discrimination process within the theoretical framework of Anderson (1982), where children need to discover and create new rules for new conditions and to manage several rules at the same time. The evidence of a switching cost prior to the treatment among third-graders can be related to a costly discrimination process that has to be acquired to manage various grammatical rules. After the treatment, children did not show any switching cost, which can be interpreted as a mastering of the discrimination process.

The data do not provide empirical evidence of the efficacy of the intervention as a whole (for simple and switching treatment together) because the main

focus was on the switching context. However, substantial improvement in the production of noun and verb grammatical agreement was observed, constituting one piece of evidence for the global efficacy of the intervention. Indeed, after the treatment, children from the switching treatment who were still in grade three at posttest reached approximately the level of performance of fifth-graders in the first experiment ($M = 0.72$). Children from the simple intervention also improved their level of production of agreement rules even if to a lesser extent ($M = 0.63$), which is still around the level of performance of fourth-graders in the first experiment. Furthermore, in one of our earlier studies we demonstrated the efficacy of one similar intervention only based on the progressivity of the cognitive load for past participle inflection rules among ninth-grade students from secondary school (Van Reybroeck et al., in press). This way, this efficacy supports the Cognitive Load Theory (Sweller, 1994), in that treatment exercises were designed in a simple to complex sequence (Van Merriënboer & Sweller, 2005) in order to increase progressively both extraneous cognitive load and in-trinsic cognitive load. Extraneous cognitive load was increased through the level of difficulty of the exercises, whereas intrinsic cognitive load was progressively raised by giving a context at the beginning allowing children to progressively automatize the grammatical agreement rules.

General discussion

For fifteen years the authors have tried to understand the underlying pro-cesses that enable children to acquire grammatical agreement rules. In line with Anderson's framework, this paper is the first demonstration of the cognitive cost linked to switching context between noun and verb agreement rules in French, through two experiments giving a cross-sectional perspective from third to sixth grade and a treatment point of view. The two experiments in this paper point towards the impact of a switching context among children from third and fourth grades, both in a production task indicating how children manage noun and verb agreement rules depending on the sentence context, but also when they are faced with treatment exercises allowing them to improve their grammatical agreement performance.

The current data show that managing two grammatical agreement rules in the same sentence constitutes an additional difficulty for children from third and fourth grades, while the production of grammatical agreement markers in itself is already a real challenge for them (Nadeau, 1995). Our results and the rule switch cost observed can offer a possible explanation for the underlying cognitive pro-cesses involved in production, and specifically in the case of *overgeneralization errors*, where children are usually thought to confuse the noun and the verb rules and apply the noun rule to a verb (e.g. *ils manges* instead of *ils mangent*) or vice versa (e.g. *les arbrent*). Indeed, Totereau et al. (1998) observed that when children

are beginning to acquire grammatical spelling rules, they overgeneralize them by adding the plural marker for nouns *-s* to verbs: at this stage, they use only one marker, *-s*, and use it indiscriminately for nouns and verbs without distinguishing between the two syntactic classes. A few months later, children learn that the plural marker for verbs is *-nt*; they will use it for verbs but also, although to a lesser degree, for nouns (e.g. *les billent* instead of *billes*). The current data provides empirical evidence of the impact of switching context in the production of agreement rules in third and fourth grades. In doing so, we can infer that some of the overgeneralization errors are due to the difficulty of managing both rules within the same sentence context. Further understanding of this process may be provided by studying the impact of the sentence context on the number of overgeneralization errors.

In line with the cognitive load involved in the production of grammatical agreement rules, our results can give a further explanation of the potential sources of the cognitive load demonstrated in the development of number agreement production (Fayol et al., 1999). These authors showed that second-grade children produced more agreement errors when they were faced with a production task with a cognitive overload caused by a secondary task (click count). In this case, children were in an attention-demanding dual task and were easily disrupted, leading to more agreement errors. Our results allow us to understand that the production process may also be overloaded by a switching demand of the sentence. In this way, those results can explain one source of cognitive overload coming from the production task itself, as was also demonstrated in one of our previous studies about the handwriting process or the lexical process: both needed to be managed in parallel and can lead to agreement errors (Van Reybroeck & Hupet, 2009).

From a developmental perspective, our results do address the question of the underlying processes potentially used by children at specific times. The impact of switching context observed for third- and fourth-graders and not for fifth- and sixth-graders, and not for children after the treatment, can presumably be attributed to the level of acquisition of the grammatical agreement production rules, where children are supposed to use different production processes to make grammatical agreements. In accordance with previous studies (Fayol et al., 1999), on the one hand, the majority of the third- and fourth-grade children used an algorithm of agreement production that requires rule recall in the procedural stage; proceeding in this way could lead to mistakes when two different rules had to be applied one after the other. On the other hand, most of the fifth- and sixth-grade children seem to use an automatized production process; this automatized process may not be influenced by switching between different rules. In order to confirm the kind of process used along the developmental pathway, it would be worth doing a real-time study (with production time recording, for method see: Alamargot, Caporossi, Chesnet, & Ros, 2011) to find out whether

switching context is a determinant when a specific type of process of agreement production is applied.

The present study further questions the nature of the cognitive processes involved in switching context between agreement rules, which are probably related to mental-set shifting or *shifting*, one of the three postulated executive functions according to Miyake et al. (Miyake et al., 2000). Shifting concerns shifting back and forth between multiple tasks, operations or mental sets (Miyake et al., 2000) and is assessed by a wide variety of non-linguistic tasks such as shifting between two reaction time tasks requiring decisions about the shape, color, magnitude parity of bivalent stimuli and several other tasks (Crone, Bunge, van der Molen, & Ridderinkhof, 2006; Crone, Somsen, Zanolie, & Van der Molen, 2006; Dibbets & Jolles, 2006; Yehene & Meiran, 2007). Task shift costs are assumed to originate from two sources: the first is the requirement to activate the task-set and rules of the novel forthcoming task (Ellefson, Shapiro, & Chater, 2006), and the second refers to attentional inertia which is the tendency to continue focusing on the current task-set and rules (Kirkham, Cruess, & Diamond, 2003). Furthermore, and of particular interest for this study, larger task shift costs are found in young children and older adults compared to older children and adults, with the largest improvement occurring between 6 and 10 years, and this improvement is associated with the maturation of (pre-)frontal brain regions (Cepeda, Kramer, & de Sather, 2001). So, even if the situation is still different for grammatical agreement rules compared to the management of two non-verbal tasks, notably due to the acquisition of those abilities, the procedural or implicit nature of the knowledge, the fact that rules are drilled at school, it is probably the case that switching context for grammatical rules is to some extent related to mental-set shifting. One interesting avenue for future research may be to investigate the question of the proximity between a general mental-set shifting capacity compared to the specificity of this control ability for grammatical agreement rules, and to further refine the understanding of the developmental profile linked to the maturation of the frontal regions.

Conclusion

The present research shows that switching context does influence the acquisition of grammatical spelling, specifically for a difficulty for French-speaking children who need to manage silent letters and diverse agreement markers for nouns and verbs. It allowed us to identify that switching between noun and verb agreement markers comes at a cost among third- and fourth-graders and that a switching treatment is more beneficial for young children than a simple treatment. These results have a clear practical implication for teachers' instructional practice at schools and for our understanding of grammatical spelling acquisition.

Acknowledgements

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Appendix A
Lexical items used in Experiment 1

Nouns List A	Nouns List B	Verbs List A	Verbs List B
poudre (powder)	*jardin* (garden)	*délivrer* (deliver)	*parfumer* (make fragrant)
limite (limit)	*pirate* (pirate)	*insister* (insist)	*informer* (inform)
navire (ship)	*banane* (banana)	*démonter* (take apart)	*remonter* (rewind)
domino (domino)	*tomate* (tomato)	*bavarder* (chat)	*déborder* (overflow)
pilote (pilot)	*tulipe* (tulip)	*déchirer* (tear)	*détacher* remove)
minute (minute)	*madame* (madam/woman)	*profiter* (take advantage)	*promener* (walk)
voleur (thief)	*moteur* (motor)	*redouter* (fear)	*dérouler* (spread)
mouton (sheep)	*moulin* (mill)	*vérifier* (check)	*diminuer* (dwindle)
salade (salad)	*malade* (ill)	*retrouver* (find again)	*regrouper* (gather up)