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Inhibitory control is needed to overcome written verb inflection errors: Evidence from a developmental negative priming study

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ABSTRACT

Systematic written verb inflection errors occur in sentences such as *the dog of the neighbors come* (*instead of comes*). In French, similar verb inflection errors are observed in sentences such as *I eat them* because the plural pronoun is placed between the subject pronoun and the verb and has the same written morphology as the determiner providing the noun inflection. Thus, subjects can erroneously inflect the verb with the plural mark for nouns. We investigated whether these verb inflection errors are related to the ability to inhibit this misleading strategy. We designed a variant of the negative priming (NP) paradigm with children, adolescents and adults. NP effects are observed in all participants. Critically, the magnitude of the NP effects decreased between children and adolescents. These results suggest that learning verb inflections relies not only on the acquisition of declarative grammatical knowledge but also on the ability to inhibit an overlearned strategy.

1. Introduction

One of the primary goals of the elementary school curriculum is to teach children to write, which includes learning how to inflect verbs to agree with the number of the subject (singular vs. plural) in the sentence (Beers & Beers, 1992; Fayol, Hupet, & Largy, 1999; Frisson & Sandra, 2002; Kemp & Bryant, 2003; Largy, 2001; Nunes, Bryant, & Bindman, 1997a; Nunes, Bryant, & Bindman, 1997b; Totereau, Thevenin, & Fayol, 1997). By the fifth grade, children have largely automatized the verb inflection rules (Fayol et al., 1999) and no longer make errors when they have to use plural inflections in simple cases of subject-verb agreement. However, the automatization of the verb inflection rules leads children and adults to make systematic verb inflection errors in certain linguistic contexts both in English (Bock, 1995; Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Nunes, Bryant, & Bindman, 1997c; Vigliocco, Butterworth, & Semenza, 1996) and in French (Chanquoy & Negro 1996; Fayol & Got, 1991; Fayol, Largy, & Lemaire 1994; Hupet, Fayol, & Schelstraete 1998; Hupet, Schelstraete, Demaeght, & Fayol 1996; Largy, Dédéyan, & Hupet, 2004; Largy, Fayol, & Lemaire 1996). In English and in French, verb inflection errors typically occur in noun phrases of the type "Noun 1 (N1) + Noun 2 (N2) + Verb (V)" (e.g., *the*

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dog of the neighbors come instead of *the dog of the neighbors comes*) because one makes the verb agree with the nearest noun (N2), especially when this noun is in its plural form (Bock, 1995; Bock & Cutting, 1992; Bock & Eberhard, 1993; Bock & Miller, 1991; Fayol et al., 1994; Fayol et al., 1999; Largy et al., 1996). However, note that the verb inflection errors in English and in French are not exactly the same: verb inflection errors in English involve the omission of the third person singular mark (-s), whereas those in French involve using the plural mark for nouns (-s) as the plural mark for the verb. In addition, this verb inflection error is audible in English, but not in French. That said, these verb inflection errors consist of inflecting the verb with the plural mark of the nearest noun in both languages. Notably, in a sentence-transcription task, fifth-graders commit more verb inflection errors and require more cognitive resources to overcome such errors than adults—i.e., a secondary task (i.e., memorization of monosyllabic words) has a larger disruptive effect on children's performance than adults' performance (Fayol et al., 1999). Finally, children learn about the number inflection of nouns before the number inflection of verbs in English in which the singular/plural distinction is audible (Berko, 1958; Cazden, 1968) and in French in which this distinction is usually not audible (Bassano, 2000). The written morphology of the number inflections follows the same developmental pattern: the plural inflection of nouns is mastered and automatized before the plural inflection of verbs (Totereau et al., 1997), in part because the plural inflection of nouns occurs more often than the plural inflection of verbs (at least in French, see Fayol, Totereau, & Barrouillet, 2006). In French, this early automatization of the plural inflection of nouns can lead children and adults to use the plural mark for nouns (-s) as the plural mark for the verb, especially in sentences with an anaphora (Totereau, Barouillet, & Fayol, 1998), (*He brings blueberries. I eat them,* In French: *Il apporte des myrtilles. Je les mange*). Note that in French, the plural pronoun (*them*) is placed between the subject pronoun (*I*) and the verb (*eat*) and has the same written morphology as the determiner that provides the critical information about the number inflection of the nouns. Therefore, in French, verb inflection errors occur not only in sentences such as "N1 of N2 + V" – in which one makes the verb agree with the nearest noun (N2), especially when this noun is in its plural form – but also in sentences such as "Singular Subject Pronoun + Plural Pronoun + Verb"—in which the plural mark of the noun (-s) is used to inflect the verb.

In the present study, we investigated whether verb inflection errors in sentences such as 'Singular Subject Pronoun + Plural Pronoun + Verb' might be related to an executive failure to inhibit an overlearned (automatized) grammatical strategy. Indeed, children and adults use the '*-s inflection after a plural determiner*' heuristic to quickly and automatically determine the inflections of nouns. This heuristic works well in most linguistic contexts. However, in linguistic contexts such as "Singular Subject Pronoun + Plural Pronoun + Verb", using the '*-s inflection after a plural determiner*' heuristic will produce attraction errors such as inflecting the verb with an -s. Thus, in linguistic contexts in which there is a conflict, one must inhibit this heuristic to determine the correct inflection of the verb. Given the gradual development of inhibitory control (Levin, Culhane, Hartmann, Evankovich, & Mattson, 1991; Luna, Garver, Urban, Lazar, & Sweeney, 2004; Ridderinkhof, Band, & Logan, 1999; Ridderinkhof, Van der Molen, Band, & Bashore, 1997; Zelazo & Müller, 2011), which is partially attributable to the late maturation of the prefrontal cortex (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002; Giedd et al., 2009; Gogtay et al., 2004), the diminution of attraction errors between fifth grade and adulthood (Fayol et al., 1999; Totereau et al., 1998) might be rooted in the increased ability to inhibit an automatized strategy or heuristic (in this case, the '*-s inflection after a plural determiner*' heuristic).

To determine (a) whether inhibitory control is necessary to avoid verb inflection errors and (b) whether the diminution of verb inflection errors is related to an increase in the ability to inhibit a misleading heuristic, we designed a variant of the negative priming (NP) paradigm. The NP approach was originally designed to provide evidence that inhibition processes are at play in situations in which different types of visual information are in conflict (Tipper, 1985). In the NP paradigm, the experimental logic is as follows: if an item was previously ignored (or inhibited), then the subsequent processing of that item will be disrupted, resulting in slower or less accurate responses (Neill, Valdes, & Terry, 1995; Tipper, 2001). In the NP paradigm, the participants respond to pairs of stimuli: the first stimulus is the prime, and the second one is the probe. The participant's performance on test probes (in which the target is a distractor inhibited on the first stimulus [i.e., prime]) is compared with the performance on control probes (in which the target bears no relation to a distractor inhibited in the priming task). NP is typically observed when the response times or the number of errors is greater on the test probes than on the control probes. NP is generally viewed as reflecting the cognitive cost associated with activating information that was just inhibited (Tipper, 2001 but see Neill et al., 1995, for a discussion). NP may also be used to reveal inhibition of overlearned strategies in Piagetian logico-mathematical tasks (class inclusion and number conservation, (Borst, Moutier, & Houdé, 2013; Borst, Poirel, Pineau, Cassotti, & Houdé, 2012; Borst, Poirel, Pineau, Cassotti, & Houdé, 2013; Houdé, 2001; Houdé & Guichard, 2001; Perret, Paour, & Blaye, 2003) and in typical school arithmetic word problems (Lubin, Vidal, Lanoë, Houdé, & Borst, 2013). The rationale of these studies is identical to the rationale of Tipper's seminal study (Tipper, 1985) except that a strategy, rather than visual information, is assumed to be inhibited. If an overlearned strategy (or heuristic) is inhibited to activate the appropriate logical strategy, then the participants should require more time to activate a heuristic on the probe when it is preceded by a prime that required the heuristic to be inhibited. A similar rationale is used in the present study to determine whether the '*-s inflection after a plural determiner*' heuristic needs to be inhibited to avoid verb inflection errors.

We designed three types of items: incongruent prime, congruent prime and probe items. The incongruent prime sentences were of the form "singular subject pronoun + plural pronoun + verb" (*I eat them*, in French: *je les mange*). The congruent prime sentences were of the form "singular subject pronoun + singular pronoun + verb" (*I eat it*, in French: *je la mange*). For both the incongruent and congruent prime items, we instructed the participants to indicate which of the two sentences contained the correct inflection of the verb. Finally, the probe sentences were of the form "singular subject pronoun + verb + plural