of IFGtri and IFGop during linguistic reasoning might thus reflect this additional burden on syntactic processing in linguistic as compared to algebraic tasks.

Concerning the algebraic reasoning task, does the absence of increased activity in IFGop and IFGtri imply an absence of involvement of linguistic syntax during algebraic reasoning? This would be true if the grammatical tasks did not require syntactic processing to be performed. Contrary to the authors' claim, the grammatical evaluation of sentences cannot be considered a simple reading task, but involves semantic and syntactic processes. The analysis of the grammatical structure of a sentence is a task that has been used to target brain regions involved in syntactic processing [5,7]). Although the activations observed during the grammatical tasks were not reported, it appears from Figure 3 [1] that IFGop and IFGtri are indeed activated during all tasks. Activity modulations across linguistic and algebraic reasoning tasks thus take place on top of a strong recruitment of these syntactic processing areas.

An interesting observation in Monti *et al.*'s study, however, is that, although the algebraic equivalence task is based on sentences with mathematical relations (e.g., 'greater than', 'divided by') without numbers, the task elicited maximal activation in bilateral parietal areas when compared to all other tasks. These regions are known to be involved in arithmetic tasks [8,9]. As shown in Figure 3 [1], the right parietal areas, including the right horizontal segment of the anterior part of the intraparietal sulcus (hIPS) and the right superior parietal regions, are the only ones that showed increased activity specifically related to algebraic reasoning. This finding is in line with a recent study by Maruyama *et al.*, which demonstrated that activation varies with syntactic mathematical expression complexity only in the right hIPS, whereas bilateral hIPS activations are observed during subtraction [10]. Concerning the left parietal areas, Monti *et al.*'s study showed an increase in activity during both linguistic and algebraic reasoning tasks as compared to their respective control tasks. These results thus underline the finding that the nature (linguistic or algebraic) of the reasoning process modulates the hemispheric contribution of parietal areas.

On the whole, Monti *et al.*'s study does not demonstrate a strict dissociation between language and reasoning areas. Instead, to us, it suggests that algebraic reasoning could be supported by interactions between left hemisphere linguistic-syntax-related areas and right parietal arithmetic-related areas. Network analysis might be a fruitful method for further investigation of this question, by testing in the same individuals the variation of inter-hemispheric interactions and correlations between areas involved in syntactic, calculation and algebraic reasoning tasks.

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Response to Tzourio-Mazoyer and Zago: yes, there is a neural dissociation between language and reasoning

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In their commentary, Tzourio-Mazoyer and Zago caution against the conclusion, presented in Monti *et al.* (2012), that there exists a dissociation between algebraic and linguistic reasoning. In what follows we briefly summarize our experimental design and then show that Tzourio-Mazoyer and Zago's concerns spring from an inaccurate reading of our methods.

In [1], we visually presented participants with two sets of arguments (i.e., pairs of sentences). One set featured 'linguistic' arguments, as in: 'X gave Y to Z.' and 'Z was given to Y by X.', whereas the other featured 'algebraic' arguments, as in: 'X plus Y is smaller than Z.' and 'Z minus Y is greater than X.' Participants saw each argument twice, once to judge whether the sentences in a given pair were logically equivalent (equivalence/reasoning task) and once to assess whether the two sentences were grammatically correct

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(grammar task). The subtraction of grammar trials from equivalence trials uncovered extensive activations in left inferior frontal gyrus (IFG) and posterior temporal cortex (among others) for linguistic arguments, but not for algebraic arguments (as confirmed with an independent ROI analysis [1]).

In their commentary on our article, Tzourio-Mazoyer and Zago (henceforth, TMZ) [2] note that '[...] it appears from Figure 3 [1] that IFGop and IFGtri are indeed activated during all tasks.' In this comment, TMZ fail to consider that our stimuli are verbal in nature and need to be read and comprehended before any manipulation can occur. As stated in the introduction of our article: 'It is uncontroversial that language mechanisms are required to encode the two statements of an argument. We tested the more substantive claim that language accompanies reasoning beyond the point of encoding in both the linguistic and algebraic domains' [1]. Therefore, the fact that, as compared to looking at a fixation cross, algebraic trials exhibit greater than zero activation in linguistic regions does not allow one to conclude that language is required for algebraic reasoning because one cannot tell whether the linguistic activation is due to reading and encoding verbally presented statements or whether it is also required for manipulating algebraic variables and operators. To eliminate this confound we assessed whether algebraic reasoning elicited any more linguistic activity than is necessary for reading and comprehending individual sentences in the absence of any reasoning (i.e., the grammar task). As shown by our results, 'algebraic operations did not recruit any more language resources than did simple reading' [1], implying that 'beyond initial reading and comprehension of stimuli, the neural substrate of language does not intervene in algebraic reasoning'. This result is consistent with the finding that some aphasic (agrammatic) patients are able to comprehend the syntactic structure of algebraic expressions (presented in algebraic symbols) despite being unable to comprehend the syntax of language [3].

TMZ also argue that 'One difficulty stems from differences in the syntactic complexity of the sentences used for linguistic and algebraic tasks.' This comment does not recognize that the main contrasts (as well as the ROI analysis) upon which our results are predicated are based on the comparison of the very same arguments when evaluated for grammaticality versus equivalence. Of course, as TMZ note, 'the grammatical evaluation of sentences [...] involves semantic and syntactic processes'. However, crucially, even if processing the individual sentences of linguistic arguments required greater grammatical effort, this would equally affect grammar and equivalence judgments (because the same sentences are used), and would thus be cancelled by the subtraction of grammar from equivalence.

TMZ further note that 'In the introduction of the present paper [1], the authors focus on the inferior frontal gyrus (IFG) [; ... i]t is thus the involvement of inferior frontal areas [...] that appears to be under investigation, rather than the involvement of any perisylvian language areas.' As is evident in our text and figures (in [1] and in our previous work [4–6]), we always report full brain results and show activity for several regions traditionally associated with language processing (including, for example, IFG, superior and middle posterior temporal gyri, and angular gyrus) (see [4] for more discussion). Our text focuses on the IFG because of our interest in testing the 'proposal that the left inferior frontal gyrus (IFG) acts 'supramodally' to forge complex hierarchical dependencies for nonlinguistic domains' [7,8].

In sum, we stand by our conclusion that our data point to a 'neural dissociation between the syntax-like operations of algebra and those of natural language' [1].

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