# A bright future for the study of multiple cerebral asymmetries?: Comment on "Phenotypes in hemispheric functional segregation? Perspectives and challenges' by Guy Vingerhoets <br> Carey, David P; Karlsson, Emma M 

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# A bright future for the study of multiple cerebral asymmetries? 

# Comment on "Phenotypes in hemispheric functional segregation? Perspectives and challenges" by Guy Vingerhoets. 

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Before neuroimaging, scientists interested in asymmetry of the brain tended to resort to long-term studies of neurological cases with unilateral brain damage, charting intact versus disrupted processes with standardised tests. The only other option was administration of perceptual experiments tests to groups of right and left handers. The left handers need to be over-recruited in such experiments for two reasons: they are rare (so random sampling only gives you about $10 \%$ of them), but they also are more likely, in theory, to contain individuals with the relatively rare type of hemispheric specialisation. There is, at least, plenty of evidence that $\sim 15 \%$ of left handers would possess right hemispheric specialisation in speech and language, in comparison to $\sim 5 \%$ of their right-handed counterparts.

The "in theory" caveat above is crucial for lateralised functions that are not language or speech, as there is rather little evidence one way or another that shows that left handers are more likely to have an underlying atypical asymmetry for these functions. Finding these atypicals, we argue, apparently a "specialist sort of worry" has considerable implications (see [1]). Here, Vingerhoets [2] does the field a great service, by describing the proportions of right handers and left handers who show typical and atypical lateralisation for a host of different functions in addition to speech and language. His table 1, which provides these data for several non-language skills, is fascinating and provocative. It indeed suggests that all of the asymmetries are reduced in the left handed group. Where this is most surprising is for praxis (the supraordinate control of movements on both side of the body), as many left handers use their dominant hand for skilled tool use, such as writing, cutting and hammering. Yet Vingerhoets shows data suggesting that nearly $80 \%$ of them have left hemisphere dominance for the recognition of tools. These types of asymmetry deserve much more detailed study, given this paradox of left speech and praxis dominance in individuals' whose dominant hand is
controlled by the other hemisphere. Partial explanations of this unusual arrangement that depend on greater interhemispheric connectivity in the majority of left handers are not as of yet particularly convincing [3,4,5,6].

A second provocative aspect from these fascinating proportions is that they could, in theory, speak to the likelihood of complementary hemispheric specialisations with language. Any non-speech/language asymmetry can be tested in right-handed and left-handed samples. The obvious prediction is, if it is related to language in a causal fashion, a $15-20$ percent reduction in the breadth (i.e. frequency of occurrence) of typical dominance in the left-handed group. For example, right handers and left handers do not differ at all on one measure of right hemispheric dominance for spatial attention [7]. With a little digging, virtually identical right dominance estimates can be gleaned from recent neuroimaging studies ([8,9], in contrast with the data on attention summarised in table 1). Taken together, these data suggest that two stalwarts of cerebral asymmetry, language and visuospatial attention, are lateralised relative to one another by statistical accident.

Vingerhoets moves from these interesting data on the breadth of asymmetries and handedness to the crucial role that people with unusual cerebral dominance should play in testing models of complementary hemispheric specialisation (see also [1,10]). This point is worthy of re-emphasis. Claims regarding the natural constraints in hemispheric specialisation for multiple functions need to be tested in individuals with the rare forms of cerebral dominance. The use of the plural "forms" above is intentional: the recent, typically heroic attempts of this type usually focus on the unusual asymmetry in language and its consequences for the secondary function in question (e.g. [13]). Faces are the most frequent, due to their importance in recent models of how reading becomes left hemispheric which drives face and other types of visual processing to the right hemisphere $[8,11,12]$.

One issue is worthy of further discussion and exploration: the definition of a "bilateral" category (discussed on page 3 in Vingerhoets; although different papers use different +/- cutoffs: . 15 [13]; . 50 [14], and .60 [15]). In response to our comments, Vingerhoets suggest one data-driven way of justifying a sensible cut-off. He notes the lack of clearly right lateralised right handed individuals when a sentence generation task was used in [16], supporting the theoretically huge idea that right brain dominance is only seen in left handed individuals. In other words, the threshold for bilaterality would be defined by an LI value that separates the most atypically lateralised left handers from all of the atypically lateralised right handers. The criteria for bilaterality in this paper was .50 . We would argue that providing all the available

LIs calculated (as the authors mentioned do) and avoiding cut-offs (do not) for most analyses. When group composition is required by the analytic question, using a cut off of 0 is defensible (although some might argue, somewhat conservative). Models of hemispheric specialisation of more than one function need to be able to explain relationships in less strongly lateralised individuals just as much as in the strongly lateralised. In fact, the need is probably greater in the former case. A more pressing issue with the bilateral category is whether or not some individuals are actually bilateral (i.e. in a retest produce a similar LI not very different than 0 ) or if their asymmetry is indeterminate by that particular test and/or in that particular session.

An alternate approach could use a test-retest or split-half reliability analysis, wherein the range of uncertainty of categorical asymmetry can be established. For example, in some of our own data, verbal fluency LIs calculated with the laterality toolbox [17] produce more uncertainty the closer the average LIs from two runs are to zero: in the band of individuals with an average LI of $\pm .20$ or less, disagreement in side of dominance between the two runs reached $40 \%$. Several caveats apply here, including a split-half analysis versus a proper test-retest (hard to justify in MRI centres or the research grants that fund them), and a rather small number of people with mean LIs in the band around 0 ( 6 in our dataset of 90 individuals).

A final caveat about these very interesting and important proportions of typical and atypical dominance estimated using fMRI: 95\% confidence intervals around these estimates are indeed large, even in the huge datasets painstakingly created by our colleagues in Ghent, Bordeaux, Oxford [18] and Auckland. This problem is in part generated by the highly skewed nature of the underlying data structures: atypical types of specialisation are rare, so certainty of their direction (let alone magnitude) will be higher in the rare forms of dominance. Nevertheless, these pioneering efforts point the way forward for several much-needed analyses of validity and reliability, performed across multiple centres using standardized tasks. Much remains to be done, but the future looks bright.

## References

[1] Carey DP, Johnstone LT. Quantifying cerebral asymmetries for language in dextrals and adextrals with random-effects meta analysis. Frontiers in Psychology 2014;5:1128. https://doi.org/10.3389/fpsyg.2014.01128.
[2] Vingerhoets G. Phenotypes in hemispheric functional segregation? Perspectives and challenges. Phys Life Rev 2016. https://doi.org/10.1016/j.plrev.2019.06.002 [in this issue].
[3] O'Kusky J, Strauss E, Kosaka B, Wada J, Li D, Druhan M, Petrie J. The corpus callosum is larger with right-hemisphere cerebral speech dominance. Annals of Neurology 1988;24:379-383. https://doi.org/10.1002/ana.410240305.
[4] Moffat SD, Hampson E, Lee DH. Morphology of the planum temporale and corpus callosum in left handers with evidence of left and right hemisphere speech representation. Brain: a journal of neurology 1998;121:2369-2379. https://doi.org/10.1093/brain/121.12.2369.
[5] Westerhausen R, Hugdahl K. The corpus callosum in dichotic listening studies of hemispheric asymmetry: a review of clinical and experimental evidence. Neuroscience \& Biobehavioral Reviews 2008;32:1044-1054. https://doi.org/10.1016/j.neubiorev.2008.04.005.
[6] Karolis VR, Corbetta M, De Schotten MT. The architecture of functional lateralisation and its relationship to callosal connectivity in the human brain. Nature communications 2019;10:1417. https://doi.org/10.1038/s41467-019-09344-1.
[7] Karlsson EM, Johnstone LT, Carey DP. The depth and breadth of multiple perceptual asymmetries in right handers and non-right handers. Laterality: Asymmetries of Body, Brain and Cognition (in press). https://doi.org/10.1080/1357650X.2019.1652308.
[8] Badzakova-Trajkov G, Häberling IS, Roberts RP, Corballis MC. Cerebral asymmetries: Complementary and independent processes. PloS one 2010;5:e9682. https://doi.org/10.1371/journal.pone.0009682.
[9] Zago L, Petit L, Mellet E, Jobard G, Crivello F, Joliot M, Mazoyer B, Tzourio-Mazoyer N . The association between hemispheric specialization for language production and for spatial attention depends on left-hand preference strength. Neuropsychologia 2016;93b:394-406. https://doi.org/10.1016/j.neuropsychologia.2015.11.018.
[10] Vingerhoets, G. Praxis, language, and handedness: a tricky triad. Cortex 2014;57:294. https://doi.org/10.1016/j.cortex.2014.01.019.
[11] Dehaene S, Cohen L, Morais J, Kolinsky R. Illiterate to literate: behavioural and cerebral changes induced by reading acquisition. Nature Reviews Neuroscience 2015;16:234244. https://doi.org/10.1038/nrn3924.
[12] Plaut DC, Behrmann M. Complementary neural representations for faces and words: A computational exploration. Cognitive Neuropsychology 2011;28:251-275. https://doi.org/10.1080/02643294.2011.609812.
[13] Gerrits R, Van der Haegen L, Brysbaert M, Vingerhoets G. Laterality for recognizing written words and faces in the fusiform gyrus covaries with language dominance. Cortex 2019;117:196-204. https://doi.org/10.1016/j.cortex.2019.03.010.
[14] Cai Q, Van der Haegen L, Brysbaert M. Complementary hemispheric specialization for language production and visuospatial attention. Proceedings of the National Academy of Sciences 2013;110:E322-E330. https://doi.org/10.1073/pnas. 1212956110.
[15] Van der Haegen L, Cai Q, Seurinck R, Brysbaert M. Further fMRI validation of the visual half field technique as an indicator of language laterality: A large-group
analysis. Neuropsychologia 2011;49:2879-2888.
https://doi.org/10.1016/j.neuropsychologia.2011.06.014.
[16] Mazoyer B, Zago L, Jobard G, Crivello F, Joliot M, Perchey G, et al. Gaussian mixture modeling of hemispheric lateralization for language in a large sample of healthy individuals balanced for handedness. PLoS ONE 2014;9:e101165. https://doi.org/10.1371/journal.pone.0101165.
[17] Wilke M, Lidzba K. LI-tool: a new toolbox to assess lateralization in functional MRdata. Journal of neuroscience methods 2007;163:128-136. https://doi.org/10.1016/j.jneumeth.2007.01.026.
[18] Whitehouse AJ, Bishop DV. Hemispheric division of function is the result of independent probabilistic biases. Neuropsychologia 2009;47:1938-1943. https://doi.org/10.1016/j.neuropsychologia.2009.03.005.

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