

Commentary on “From mouth to hand: Gesture, speech, and the evolution of right-handedness” by Michael C. Corballis, published in *Behavioral and Brain Sciences* Volume 26 - Issue 02 - April 2003, pp 240-241.

Misleading asymmetries of brain structure

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Abstract: I do not disagree with the argument that human population right-handedness may in some way be a consequence of the population-level left-lateralization of language. But I suggest that the human functional lateralization is not dependent on the structural left-right brain asymmetries to which Corballis refers.

There are two separate sources of evidence for this. First, as discussed by Corballis, great apes and possibly other large primates such as baboons (Cain & Wada 1979) have left-right asymmetries in homologues of the human language areas, but evidence for either population-handedness or language capacities in apes remains extremely weak. Second, although there is a weak association between handedness and language lateralization, recent data suggest little correlation between functional lateralization and human anatomical left-right brain asymmetries.

In addition to the studies by Gannon et al. (1998) and Cantalupo and Hopkins (2001), Pilcher and colleagues (2001) have reported volumetric studies of non-human primates which have revealed a pattern of rightward frontal and leftward occipital structural asymmetries similar to that observed in humans (known as “torque” or the frontal and occipital petalia). However, although some, such as Bodamer and Gardner (2002), continue to suggest that great apes may have precursors to human conversational ability, the content of the conversations is entirely consistent with the conclusions of Premack (1986) and Terrace et al. (1979) that the linguistic capacities of even extensively trained apes are best regarded as nonexistent. Humanlike structural left-right brain asymmetries are therefore present in great apes without any related functional specializations for language.

Corballis proposes that there should be some degree of association between handedness and degree and direction of language lateralization, and he is able to cite the study by Knecht et al. (2000) in support of this long-held view. That a small but otherwise normal fraction of the population is nevertheless expected to have language in a different hemisphere from that which is used for the preferred hand suggests a rather indirect association. Knecht et al. (2001) have emphasized that atypical language lateralization is not necessarily pathological, and they found no relation between the direction or degree of language lateralization and a variety of measures such as academic achievement and language fluency, whereas strong lateralization has the potential disadvantage of increasing susceptibility to unilateral capacity decrements (as tested with transcranial magnetic stimulation; Knecht et al. 2002).

Given the variability in functional specialization, it is perhaps less surprising than the authors suggest that Good et al. (2001) did not detect any correlation

whatsoever between handedness and features of brain structure in a voxel-based study of cerebral asymmetry which was sensitive enough to reveal significant sex differences. Language lateralization was not assessed in this study, and it would be interesting to see if statistically significant results would emerge for anatomical correlates of language dominance with this fully automated procedure, which is less sensitive to bias than postmortem or “region of interest” methods.

The study by Good et al. (2001) used a large sample (465 normal brains). The report by Kennedy et al. (1999) involved only three subjects but is useful because it demonstrated a dissociation between functional and structural brain asymmetries, measured using magnetic resonance imaging (MRI) techniques. The subjects had mirror-image reversal of the internal organs (*situs inversus totalis*) but were in normal health. Anatomically, left-right brain asymmetries followed the mirror reversal of the internal organs – there were reversed frontal and occipital petalia in all three subjects. Inspecting the details of the Sylvian fissure revealed that two thirds of participants with SI (*situs inversus*) had a larger planum temporale on the left, with an earlier Sylvian fissure upturn on the right (i.e., not reversed). However, in the 15 normal controls in this study, only eight had a larger left planum temporale, and so it is difficult to draw firm conclusions about the degree of association between “typical” planum temporale differences and frontal and occipital petalia. The measurement of language lateralization via functional magnetic resonance imaging (fMRI) during behavioral tasks such as word-stem completion disclosed that all three SI individuals had normal left-side language dominances as well as strong right-handedness assessed by questionnaires.

Kennedy et al. (1999) concluded that the factors responsible for typical brain petalia are not the same as those that govern the lateralization of language. This report is consistent with others that have suggested that SI individuals are usually right-handed and show a “right ear advantage” in dichotic listening tasks (used as a measure of left-hemisphere dominance of language before brain scanning tools became available; e.g., Tanaka et al. 1999). Although as Good et al. (2001) point out, there is a strong presumption throughout the neuroanatomical literature that all structural left- right asymmetries strongly indicate functional asymmetries, there are many inconsistencies in textbook accounts, including the larger frontal lobe of the nondominant hemisphere and the lack of gender differences in language performance to parallel the sex differences found in degree of structural asymmetry (Good et al. 2001; Walker 1980). The most reasonable conjecture based on the studies above would, I suggest, be the acceptance of the null hypothesis for the relationship between structural and functional left-right asymmetries in the human brain. This in itself would have little impact on Corballis’s claim that functional asymmetries for spoken language lead the human population asymmetry in hand preference. Indeed, accepting that some of the volume asymmetries in human and great ape brains are unrelated in either case to functional language specializations would solve problems that Corballis otherwise has with Cantalupo and Hopkins (2001) and Pilcher et al. (2001). Kennedy et al. (1998) suggested that the major source of variance in human cortical volume is individual differences applying to individual gyri, which is relatively independent of larger scale variation; and that, in particular, local variations in the frontal and temporal language specific regions do not correlate well with total cortical volume. Much of the target article is speculation which may never be disconfirmed by evidence. But there are accumulating data on the (largely conserved)

genetic factors that control structural asymmetries of the kind that are disturbed in *situs inversus* (Hamada et al. 2002; Hobert et al. 2002; Mercola & Levin 2001) and the faint beginnings of knowledge of the genetic factors responsible for uniquely human capacities, some of which often, but not always, display left-right asymmetry (Enard et al. 2002; though see, e.g., Meaburn et al. 2002). A detailed molecular account of the extent to which speech entails handedness may therefore be eventually attainable, but it is unlikely to correspond very closely to Corballis's narrative.

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