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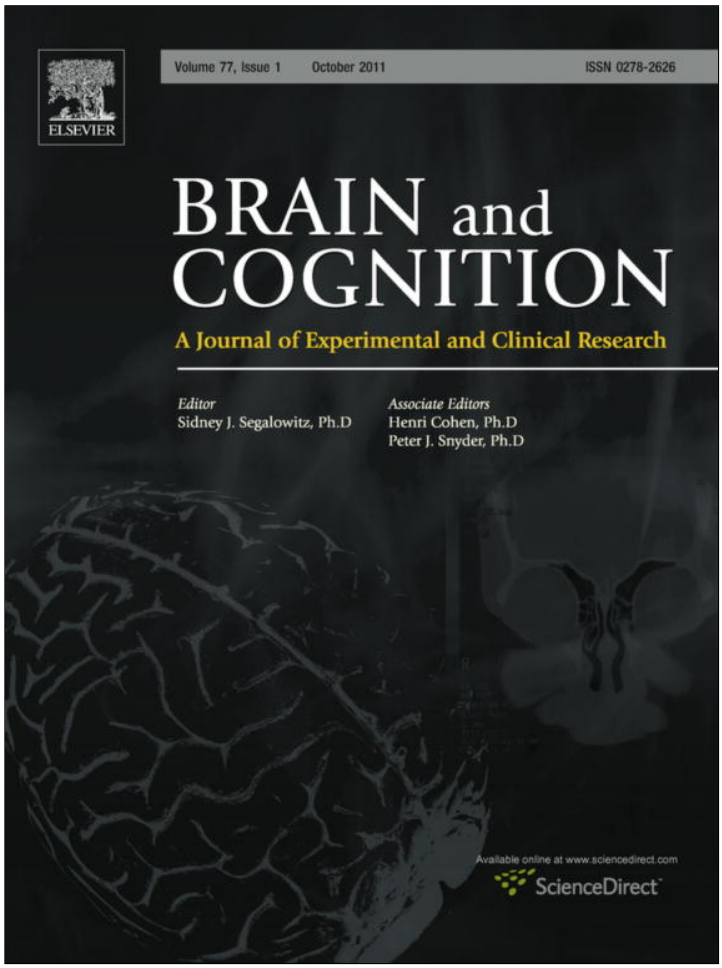

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Does degree of asymmetry relate to performance? A reply to Boles and Barth

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ABSTRACT

In a recent critique Boles and Barth (2011) argue that their prior study investigating asymmetry/performance relationships (Boles, Barth, & Merrill, 2008) uncovered the "true" association (i.e., negative correlation) between lateralization of visual lexical processes and word recognition performance. They contend that our study reporting positive correlations of lexical asymmetry and reading performance (Chiarello et al., 2009) was flawed and hence inconclusive. In this response we address the two major objections raised by Boles and Barth (2011) regarding our selection of tasks and asymmetry measures. We conclude that the Boles and Barth principle of task purity is not relevant to the stated aims of our investigation, and that our linear regression method of measuring asymmetry is valid given the high level of accuracy for the tasks we reported. Because the aims of each investigation differed, we argue that it is unwise to attempt to fit each study into the framework favored by Boles and Barth (2011).

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1. Introduction

Regardless of how lateralization is measured, individuals differ in the direction and extent of asymmetry. Does this matter? In other words, is it advantageous to be strongly or weakly lateralized, when one considers actual performance of cognitive tasks? Surprisingly little empirical work has addressed this question, despite decades of research on lateralized function. Two large-scale multi-task investigations of asymmetry/performance relations have recently appeared (Boles et al., 2008; Chiarello et al., 2009), and each reached somewhat different conclusions regarding the cognitive consequences of degree of asymmetry for visual word processing tasks.[1] Boles et al. (2008) report negative asymmetry/performance correlations, while Chiarello et al. (2009) report positive correlations. In a recent critique Boles and Barth (2011) examined the differences between these studies in methodology and data analyses and conclude that flaws in the Chiarello et al. (2009) study render their findings inconclusive. They further state that the Boles et al. (2008) findings "reflect the true nature of the relationship between a left-hemisphere based visual lexical process, and word recognition performance" (p. 13). In this response, we argue that the latter conclusion is premature and that the criticisms raised by Boles and Barth are unfounded and cannot account for the differing results.

Before addressing the specific issues of the Boles and Barth critique we think it is important to recognize that the prior studies of Boles and Chiarello stem from very different research programs that necessarily inform their methodological choices. Although both investigators have for decades utilized divided visual field tasks to explore cerebral asymmetries in healthy adults, the questions they seek to answer are quite different. One cannot adequately compare one study from each laboratory without considering the wider context within which each research study was conducted. It is evident from their research that Boles and colleagues are interested in lateralization qua lateralization. They have explored how various asymmetries that cross informational domains (e.g., visuospatial, verbal, emotional) may relate to one another in order to understand brain asymmetry as a general phenomenon. To this end, they select tasks and methods that produce the largest and most reliable asymmetries, and the resulting experiments are well controlled. A number of the tasks Boles and colleagues employ are not widely studied outside of their laboratory, and therefore little independent work has examined their information processing requirements. Instead, the processing demands of the measures are inferred from factor analyses (Boles, 1991, 1992, 1996). The programmatic nature of this research is impressive, and it has culminated in some intriguing theoretical proposals about the nature of cerebral asymmetries.

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[1] Hirnstein, Leask, Rose, and Hausmann (2010) also report a large-scale asymmetry/performance study. However, they investigated only one task involving words in which participants determined whether a central word matched a following lateralized word. Procedures are not described in detail, and one can question whether lexical processes were involved for the identity matches. Asymmetry scores were negatively correlated with the average of the LVF and RVF scores.

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Our laboratory, in contrast, seeks to understand how various language processes are represented in the brain, and more recently, how these representations may differ across individuals (e.g., Chiarello, 1988, 1991; Chiarello, Welcome, & Leonard, in press). We have used cerebral lateralization as a vehicle to explore some of these questions, because it is experimentally tractable: divided visual field methods enable us to examine a variety of reading tasks in large numbers of subjects. Because we are interested in teasing apart various linguistic processes, we select tasks and methods whose processing requirements have been well studied by psycholinguists. If some of these measures produce weaker asymmetries than others that is to be expected since not all language processes are strongly lateralized to the left hemisphere. Indeed, variation in the strengths of various language asymmetries is precisely what we wish to discover. Our research program, then, is quite different from that of Boles and colleagues in that we do not investigate lateralization as a general phenomenon, but rather exploit hemisphere differences as a tool to explore language processing in the brain. As we argue below, the differing goals of each research program need to be kept in mind as we consider the meaning of apparently contradictory results.

Boles and Barth (2011) raise two major objections to our prior study. They argue against our selection of tasks and the asymmetry index we employed to adjust for individual differences in performance level. We address each of these concerns in turn.

2. Task selection and task "purity"

In their critique, Boles and Barth (2011) introduce the notion of task purity, namely "the influence of the same mental processes on both the asymmetry and performance measures" (p. 4). According to this principle, the Boles et al. (2008) study had a high degree of task purity because the same tasks were used both to measure asymmetry and to estimate performance levels. In fact, the same numbers entered into the calculation of asymmetry and overall performance as the latter was simply the average of left and right visual field scores. Four tasks were examined: two presented digit words (e.g., ONE, FOUR) and required either naming responses or odd/even key press decisions; the other two tasks presented either strings of three digits or three-letter words and subjects were required to type the stimulus they had been shown. Across all tasks, a very small set of stimuli was employed and hence items were repeatedly presented to the participants. Although the authors argue that visual lexical processes were involved in these tasks, the repetition and simplicity of the stimuli might reduce the amount of lexical processing required. When the absolute value of the asymmetry was examined, negative performance-asymmetry correlations were obtained in all four tasks (3 reaching statistical significance). On the basis of the absolute value data, the authors argued that larger asymmetries were associated with poorer overall performance. However, only one correlation was significant when the direction of the asymmetry was preserved (typing words) and here a *positive* association was observed.[2]

The Chiarello et al. (2009) methods were certainly not intended to be task pure. We utilized a variety of lateralized word recognition tasks (word and nonword naming, lexical decision, masked word recognition, semantic decision, category and verb generation) that have been extensively studied by psycholinguists. This enabled us to appeal to a wider literature in order to infer the information processing requirements of these measures. The goal of the study was to determine "whether observed asymmetry across a variety of visual lexical tasks would predict reading skill as assessed by standardized (i.e., nonlateralized) reading measures" (p. 522). Hence the objective was not to uncover a general principle of laterality, but rather to assess whether observed lateralized performance could predict reading skill. This is an important question given the repeated claims that reading impairments might be attributable to anomalous lateralization (see Eckert & Leonard, 2003 for review). Had we adopted the task purity approach advocated by Boles and Barth we would not have been able to generalize our findings to actual reading performance, which was the stated purpose of our investigation.

In addition to task "purity" one might also wish to consider task "relevance." According to the latter principle, selected tasks should be relevant to the domain of investigation, and to cognitive performance outside of the laboratory. We argue that the Chiarello et al. (2009) investigation had a high degree of task relevance in that their lateralized lexical tasks are known to measure important dimensions of word recognition in reading (e.g., lexical and semantic access, early phonological processes, meaning selection), and the standardized reading assessments have been independently validated. A composite measure across all seven tasks was used so as to include a variety of lexical processes in the predictor variable. In contrast, the measures used by Boles et al. have low task relevance. Their four word/digit tasks were shown to load on the same factor in prior factor analyses and the investigators named this factor "visual lexical" (Boles 1991, 1992, 1996). However, there is no independent verification that the so-named "lexical" factor in fact measures lexical processes used in reading. The tasks were developed by Boles and colleagues to produce strong reliable asymmetries, but they have not been subject to scrutiny in ways that would verify their psycholinguistic underpinnings. There are reasons to question whether markers of lexical processing such as word frequency, word superiority, or semantic access effects could be demonstrated for these tasks. For example, the typing tasks could have been performed using overlearned letter-keypress associations without necessitating typical word recognition processes (see Chiarello et al., 2009 for further discussion of this point). Hence the relevance of the Boles visual lexical factor for cognitive performance outside the laboratory remains uncertain.

It will be difficult to optimize both task purity and task relevance in the same study, since the former requires the use of laboratory tasks while the latter is best achieved by examining more "real world" measures. There are many ways to assess asymmetry-performance associations, and we do not agree that adherence to a single principle is the best approach. By optimizing task purity one necessarily limits generalizability. This may well be preferable for the sorts of questions Boles and colleagues are addressing. However, we would note that the task-pure procedures that Boles and Barth report could be improved upon. Requiring asymmetry and performance to be estimated using the same task does not mean that one should rely on the same numbers for these estimates (i.e., averaging over LVF and RVF scores to derive the performance score). It would be preferable to have participants perform the same task under both lateralized and nonlateralized conditions, so that the performance estimate can truly be independent from the asymmetry score. The direction of the asymmetry-performance correlation under these conditions remains to be demonstrated.

In sum, we strongly question the view that "one size fits all," when it comes to task selection.

3. Performance-free indices of laterality

Because accuracy is subject to floor and ceiling effects, various methods have been suggested to de-confound such effects from

[2] Thirteen different tasks were examined by Boles et al. (2008) and for 4 of these the asymmetry-performance correlations were significant but opposite in sign for absolute value vs. directional asymmetries. This finding was not discussed and interpretations were based on the correlations with absolute value of the asymmetry.

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laterality quotients, and Boles & Barth review some of the relevant issues. They advocate the laterality coefficient (LC) that employs different corrections when overall accuracy exceeds or falls below 50%. Chiarello et al. (2009) instead regressed out overall accuracy from their laterality measure to be certain that it would not vary with performance level. Boles and Barth point out that this regression approach only removes the linear effects of overall accuracy, and they suggest that the Chiarello et al. (2009) results may be attributable to improper measurement.

Boles and Barth state repeatedly that linear regression is appropriate if the majority of the participants score above 50% correct: if "the great majority of participants score above or below 50%...whether a correction is linear or nonlinear does not much matter" (p. 10); if "accuracy was always above 50%, linear regression could be a defensible correction procedure" (p. 11). We acknowledge that we did not report overall task accuracy in our 2009 paper, and we particularly regret this omission given the misimpression this apparently produced in astute readers of our paper. In fact, our mean task accuracies varied between 73.4% correct (nonword naming) and 88.8% correct (verb generation), and remarkably few participants had scores at or below 50% correct. We have since counted the number of scores falling at or below 50% correct across all seven tasks; out of 1400 scores only 37 (0.26%) were this low. According to Boles and Barth, then, using linear regression to control for overall accuracy is perfectly acceptable, and unlikely to result in a measurement problem.

Boles and Barth (2011) also suggest that our findings might not reflect a direct association between lexical asymmetry and reading, but rather the influence of some third variable that might not be lexical in nature. This is of course a limitation of any correlational study, including that of Boles et al. (2008).

4. Conclusions

We conclude that there is little basis for the two major criticisms aired by Boles and Barth (2011). Our tasks were selected to measure well-accepted dimensions of word recognition and reading in order to investigate whether visual lexical lateralization could predict reading skill. Task purity, while an important consideration for some research questions, is not, in our view, relevant to the assessment of our work. The asymmetry measurement issue turned out to be a red herring, although we take responsibility for not reporting the accuracy data that would have obviated this concern. Although our research program has very different aims from that of Boles and colleagues, we believe that each body of research can stand on its own and provide insights into the complex relationships between lateralization, in its many manifestations, and cognitive performance. It is neither necessary nor advisable, in our opinion, to attempt to fit every research study into a single predetermined framework.

What then to make of the differing results? How can lexical lateralization have both positive and negative correlations with performance? Putting aside additional methodological differences between the two bodies of research that Boles and Barth did not consider (e.g., bilateral vs. unilateral presentation, vertical vs. horizontal strings, subject characteristics, etc.), we think it likely that the two research programs are in fact measuring different aspects of asymmetry-performance relationships. Lateralization of the visual lexical factor identified by Boles and colleagues may well have a negative correlation with overall performance of the tasks identified with that factor, and lateralization of standard word recognition tasks may also positively correlate with reading skill. We cannot rule out this possibility given the very different approaches taken by each group. Both research groups agree that the observed asymmetry-performance relationships are extremely modest which suggests that many important moderators of that relationship remain to be identified. A more collaborative effort may be needed to more definitively tackle this theoretically important issue.

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