LETTER

Reply to Gorea and Tyler: Casting light on previous bumps in the dark

In their reply (1) to our study (2), Gorea and Tyler assert that our results are trivial, that they are wrong, and that Gorea and Tyler discovered them first anyway. Here we describe the problems with their logic and previous related research, and resolve that our results and conclusions stand.

According to Gorea and Tyler (1), intrinsic expertise bias (IEB) is implausible because it lacks a defined direction or magnitude. It follows from this logic that their counter argument, that our findings are the result of some unspecified aspect of block order, must be implausible because the mechanism lacks defined magnitude and direction. The critical point that Gorea and Tyler miss is that block order was both a main design feature and an internal control in our study. Naive subjects ran in the unblocked conditions first to avoid the confounding effects of criterion that could have applied had the experiment started with the blocked conditions. Furthermore, IEB's direction and magnitude must naturally depend on the subjects' expertise and experience, as is the case with other forms of experimenter bias caused by using expert subjects (such as when the experimenters themselves are the subjects, as in ref. 3).

It is important to note that IEB does indeed affect the Broca-Sulzer effect, contrary to Gorea and Tyler's (1) misinterpretation. We show that it is because of IEB that the Broca-Sulzer effect becomes Bloch's Law in the absence of criterion controls. That is, only when subjects could glean information about the stimuli through blocking did their perceptual reports follow Bloch's Law.

We also point out that the Broca-Sulzer Effect and Bloch's Law have been in conflict since their original 19th century descriptions. Most recently, Georgeson (4) stated that the Broca-Sulzer effect occurs under specific circumstances, but has an unkown origin. Bowen and Markell (5) reported that the effect was observer-dependent, but they fell short of explaining the cause of the intersubject differences. Gorea and Tyler (1) now assert that Bloch's Law occurs at threshold, whereas Broca-Sulzer occurs at suprathreshold. However, the authors contradict themselves by then claiming that threshold phenomena should also apply to suprathreshold perception. They further state to have discovered that the Broca-Sulzer effect dominates at low spatial frequencies, even though their measurements were made at threshold (3), adding to the confusion. Our study resolves the long-standing discrepancy between Bloch's Law and the Broca-Sulzer effect, including the noted inconsistencies in Gorea and Tyler's research.

We also note that our effect size is larger than previously reported in Gorea and Tyler (figures 1 and 7 in ref. 3).

Finally, no previous study has found the Broca-Sulzer effect and Bloch's Law to occur with the same stimuli as a function of criterion. Problematic experimental design, lack of criterion controls, and frank misinterpretation of data may explain this oversight. For example, in Gorea and Tyler (figure 7 in ref. 3), Tyler's perception exhibited the Broca-Sulzer effect but Gorea's followed Bloch's Law. This discrepancy—which the authors ignored both in the interpretation and the mathematical modeling of the data—typifies the need to control IEB and other experimenter biases in future perceptual research.

***Hector Rieiro*[a,b,c], *Susana Martinez-Conde*[a], *and Stephen L. Macknik*[a,b,1]**

Departments of [a]Neurobiology and [b]Neurosurgery, Barrow Neurological Institute, Phoenix, AZ 85013; and [c]Department of Signal Theory and Communications, University of Vigo, 36310 Vigo, Spain

1 Gorea A, Tyler CW (2013) Dips and bumps: On Bloch's law and the Broca-Sulzer phenomenon. *Proc Natl Acad Sci USA* 110: E1330.

2 Rieiro H, et al. (2012) Optimizing the temporal dynamics of light to human perception. *Proc Natl Acad Sci USA* 109(48): 19828–19833.

3 Gorea A, Tyler CW (1986) New look at Bloch's law for contrast. *J Opt Soc Am A* 3(1):52–61.

4 Georgeson MA (1987) Temporal properties of spatial contrast vision. *Vision Res* 27(5):765–780.

5 Bowen RW, Markell KA (1980) Temporal brigtness enhancement studied with a large sample of observers: Evidence for individual differences in brightness perception. *Percept Psychophys* 27(5): 465–476.

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The authors declare no conflict of interest.

[1]To whom correspondence should be addressed. E-mail: macknik@neuralcorrelate.com.