Response to the commentary by Patrick G. Bissett

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Patrick Bissett concludes that our recently published model of the countermanding task (Salinas and Stanford, 2013) "does not improve on existing race models of the stop-signal task", because (1) while mathematically similar to previous models, ours does not assume any specific inhibitory mechanism, and (2) an experiment that we proposed may not distinguish between certain variants of the race model and ours. We briefly comment on why we believe that our inhibition-agnostic approach does have advantages (point 1), even if our proposed experiment turns out to provide merely a crude distinction between models (point 2), but mostly we wish to emphasize that the criticisms appear to miss the whole point of constructing models in the first place, which is to gain insight into the phenomenon under study and move forward with its empirical investigation. It is important to keep in mind that *all* models are wrong, only some are wrong for trivial reasons and others for interesting reasons.

Our "cancellable rise-to-threshold" model shows that, with regard to psychophysical performance, many manipulations of the countermanding task can be understood and quantitatively explained with a very simple conceptual framework in which an ongoing motor plan is gradually decelerated, or slowed down, once the key sensory signal (the stop) is detected. Whether the deceleration is precisely the result of mutual inhibition between just two populations of neurons, as proposed by Boucher et al. (2007), or whether it results from complex interactions between 20 types of neurons distributed across brain areas is a separate empirical question, which we do not address. Our work shows that, to successfully account for a wide variety of behavioral effects, all that matters about those interactions is the magnitude and effective time constant of the resulting deceleration. All other details, and even the exact form of the deceleration equations, are unimportant. We think that, if one is interested in identifying the critical factors that determine performance in the task, then this realization is certainly a meaningful step.

By itself, however, this aspect of our study is relatively minor; after all, the purpose of modeling is not only to quantitatively match data points, but also to generate an intuitive framework for analyzing and understanding the phenomenon at hand, in this case, how an imminent movement is stopped. So, having developed such a simplified model, what did we learn? Mainly three things. First, that the SSRT, the quantity that is universally assumed to measure inhibitory capacity in the countermanding task, does not necessarily do so, and in fact, is highly unlikely to indicate anything about inhibition under most experimental circumstances studied so far. Furthermore, the SSRT is not an ideal metric because it is well defined exclusively within the context of the independent race model (Logan and Cowan, 1984) and not in relation to the empirical data themselves. Second, we identified an alternative behavioral metric, the (empirical) tachometric curve, that is model-independent, well-defined, easy to interpret, and more informative than the SSRT. Whatever neural mechanisms are invoked to account for task performance, this curve should be a critical point of comparison to experimental data. Finally, we found that the perceptual detection of the stop signal plays a key role in the task, and that the time course of this perceptual process is revealed by the tachometric curve. Thus, any change in the properties of the stop signal — in its modality, intensity, or frequency, for instance — as well as in other factors such as the subject's motivation, may affect how quickly and how reliably the stop is detected, and this in turn is directly reflected in the subject's behavior, as revealed by the tachometric curve. These observations, which are highly relevant for understanding the neural underpinnings of the task (and, more generally, the functional flexibility of sensory circuits), had not been reported before. To a good degree, we were able to articulate them because of our model's simplicity.

References

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