*Commentary*

# Microsaccades and Attention

## Does a Weak Correlation Make an Index? Reply to Laubrock, Engbert, Rolfs, and Kliegl (2007)

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In the recent literature on microsaccades and attention, two questions have been conflated. There is a broad question of whether microsaccades are related to attention, and there is a more specific question about whether microsaccades serve as an index of attention. We are happy to agree that microsaccades are related to attention. However, the claim that "microsaccades are an index of covert attention" (in the title of Laubrock, Engbert, Rolfs, & Kliegl, 2007, this issue) depends on a strong correlation. Were this claim true, a researcher might be able to conduct a study relying entirely upon microsaccade direction as a measure of attentional deployment. Although we would be delighted to be able to conduct such an experiment, both our data and those of Laubrock et al. suggest that microsaccades cannot be used as a reliable marker of covert attention.

Laubrock et al. make two arguments. First, reviewing our experiment (Horowitz, Fine, Fencsik, Yurgenson, & Wolfe, 2007, this issue), they criticize our selection of trials on which the directions of the cue and microsaccade disagreed, arguing that this selection would inevitably lead to a negative microsaccade-congruency (MC) effect. Second, they report new data demonstrating a correlation between MC and reaction time (RT). We deal with these points in reverse order.

Laubrock et al. have demonstrated a statistically reliable relationship between MC and RT. An incongruent microsaccade was associated with a 6-ms slowing of RT. This is a weak effect, an order of magnitude smaller than the 81-ms effect associated with an invalid cue. This effect may be statistically significant, but it suggests that microsaccade direction provides very little useful information about the spatial distribution of attention.

Also, Laubrock et al. argue, under a seemingly reasonable set of assumptions, that in our study, trials on which the microsaccade direction diverged from the cue direction were dominated by trials on which the microsaccade did not follow attention, even if microsaccades usually did follow attention. The argument is as follows. Assume that observers direct attention toward the cue with probability $w$, and that the microsaccade reflects the direction of attention with probability $x$. Let $v$ denote cue validity. There are two kinds of trials on which the cue is valid but the cue direction and microsaccade direction disagree: (a) valid trials ($v$) on which attention does not follow the cue ($1 - w$) and the microsaccade follows attention ($x$) and (b) valid trials ($v$) on which attention follows the cue ($w$) but the microsaccade does not reflect attention ($1 - x$). The proportion of trials of the first type is given by $p_1 = v(1 - w)x$, and the proportion of trials of the second type is given by $p_2 = vw(1 - x)$. Laubrock et al. note that if $w = v$ and $x = .75$ (i.e., the microsaccade is almost as good an index of attention as the cue), the predictions would be qualitatively consistent with our results.

However, this scenario is not *quantitatively* consistent with our results. Although $w$ and $x$ are not directly observable, one can observe the proportion of trials on which the cue direction and microsaccade direction disagree, $p = p_1 + p_2 = v(w + x - 2wx)$. Because $v$ is known (arrow cues were 80% valid, so $v = .80$), any observed $p$ is compatible with a line through $wx$ space. Figure 1 plots the $wx$ curves that could produce the observed $p$s in the manual-detection condition of our experiment for all 3 observers (data from the other two conditions lead to similar conclusions). The diamond represents the hypothetical point on which Laubrock et al. base their argument ($w = .80$, $x = .75$); this point is clearly not consistent with the data. In fact, if we assume that observers frequently shifted attention in the direction of the cue (i.e., $w \geq .60$), then the probability that the microsaccade followed attention must have been less than .55 (note that if $x = .50$, then the direction of the microsaccade is independent of attention). If observers were at least probability matching (i.e., $w \geq .80$), then $x$ would have been less than .52. Thus, the predictive power of microsaccades is, for practical purposes, negligible.

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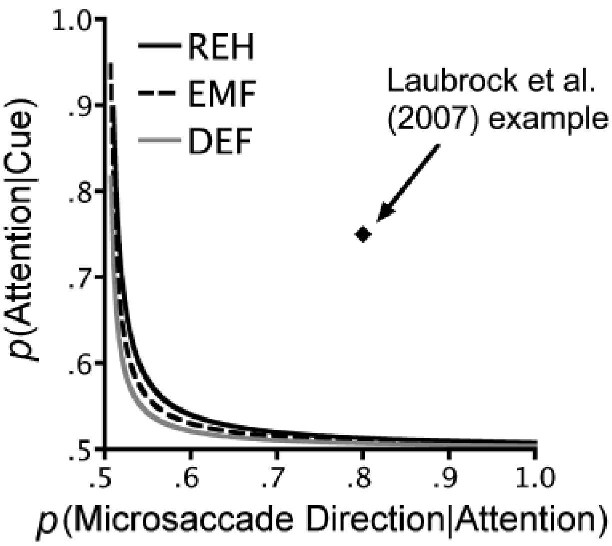


**Fig. 1.** Theoretical curves that could produce the data obtained in Horowitz, Fine, Fencsik, Yurgenson, and Wolfe (2007). The ordinate is the probability that attention will follow the cue, $w$ in our notation or $p$(attention|cue) in Laubrock, Engbert, Rolfs, and Kliegl's (2007) notation, and the abscissa is the probability that microsaccades will follow attention, $x$ or $p$(microsaccade direction|attention). Each curve represents data from a different observer. The diamond represents a hypothetical point suggested by Laubrock et al. to account qualitatively for our data.

Finally, we can derive an independent estimate of the effect of microsaccades on RT from control trials (i.e., trials with neutral cues or no cues), in which microsaccade direction could not have been influenced by any cues. In Figure 3 of our target article (Horowitz et al., 2007), we report RT from control trials as a function of microsaccade congruency. The figure shows that the pure MC effect was very small in every case, averaging about 2.3 ms (again, more than an order of magnitude smaller than the cue-validity effect, which was 58.9 ms, on average).

Laubrock et al. have reported data supporting a weak relationship between microsaccades and attention. This finding may be of use in elucidating the neural circuitry underlying attention and oculomotor control. However, the very weakness of that relationship indicates that microsaccades cannot be used as a reliable index of spatial attention.

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