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Letter to the Editor

Motion Capture and Visual Attention: a Reply to Ramachandran (1996)

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In our previous paper, we proposed that when attention is used to track salient features of a moving object, other weaker motion signals can be captured and appear to move in synchrony with the tracked features (Culham & Cavanagh, 1994b). In one experiment, when observers used attention to track the bars of an ambiguous counterphase grating in either direction, superimposed dynamic luminance dots followed in the direction of tracking. This led us to suggest that motion capture may be attention-based.‡

Ramachandran (1996) now provides examples which both support and contradict our claim of attention-based motion capture. We are encouraged by Ramachandran's supporting examples of attentional shifts which cause motion capture and we provide further evidence that these shifts do not generate capture simply by modulating low-level motion signals. However, after first agreeing that attention plays a role in motion capture, Ramachandran then offers evidence for the contrary view that capture is preattentive and asks how the effect can be "both preattentive and attention-based at the same time?" We do not find the evidence for preattentive motion capture (Plummer, 1992) compelling. Nonetheless, preattentive, low-level motion interactions may also be involved in motion capture, along with the attentional factors that we and Ramachandran have demonstrated. That is, attentive and preattentive influences on motion capture need not be mutually exclusive as suggested by Ramachandran's closing argument, but rather, both may be involved depending on the nature of the task.

ROLE OF ATTENTION

Our results and those described by Ramachandran (1996) now provide several examples showing that attention may affect motion capture, though there are two possible means by which it could occur. One possibility is that attention simply modulates the strength of underlying low-level motion signals which then capture other signals through low-level motion interactions. Alternatively, the movement of attention in one direction might itself yield a high-level motion signal (Wertheimer, 1912) which could then capture nearby, weak motion signals. Such attentional capture might even occur intermodally as in the capture of a visual stimulus by attention to one of two oppositely moving sounds, as described by Ramachandran, Intriligator and Cavanagh (unpublished). Although those authors initially interpreted these results in terms of cross-modal (auditory-visual) capture, Ramachandran now agrees with us that the effect may be due to "the very act of 'moving' one's attention between the two spatial locations."

We have suggestive new evidence that shifts of attention may produce motion signals independent of modulatory effects on low-level signals. We have recently shown that adaptation to attentive tracking produces a motion after-effect (MAE) for flickering test stimuli which cannot be explained by the selective adaptation of low-level motion signals (Culham & Cavanagh, 1994a, 1995). Unlike MAEs from smooth motion, those from attentive tracking showed little dependence on the contrast of the adaptation pattern and were not retinotopic (e.g. clockwise attentive tracking produced counter-clockwise MAEs regardless of the retinal location of the test). These results from MAEs suggest that attention's influence on motion capture arises from the actual shifts of attention rather than from low-level motion signals which are simply modulated by attentive tracking.

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‡We also reported that equiluminant color gratings captured luminance dots, but this was not our main evidence for attention-based capture, as Ramachandran (1996) implies. He states that color is a poor source of motion signals, citing an earlier paper from our laboratory (Cavanagh & Anstis, 1991). In fact, this study showed that high-contrast color contributes a robust signal to low-level motion, (see also Chichilnsky, Heeger & Wandell, 1993; Cropper & Derrington, 1994). Attentive tracking may be one possible explanation for capture by color contours, but low-level motion factors cannot be ruled out.

Further evidence of capture from sources other than low-level motion comes from the intriguing phenomenon of "action capture" described by Ishimura and Shimojo (1994). They demonstrated that motor movements lead to capture of ambiguous visual motion and suggested motor action might influence visual perception directly or via attentional mechanisms.

PREATTENTIVE CAPTURE?

Certainly, there is converging evidence that attentional shifts *can* produce motion capture; however, the issue of whether capture is *necessarily* attentive has not yet been resolved. After providing a number of examples in agreement with our claims of attention-based motion capture, Ramachandran (1996) proceeds to make the counterclaim that motion capture is preattentive. This claim is based upon Plummer's (1992) observations of "popout" and grouping of stationary squares captured by superimposed moving black dots. In the key demonstration, a single yellow square captured by moving black dots is seen to "popout" from among similarly captured purple squares and "uncaptured" yellow squares (with stationary black dots superimposed). However, no popout is said to occur when all squares contain luminance contrast which prevents their capture. In informal observations, we have been unable to replicate this finding. Rather, we found that visual search was as rapid for luminant (uncaptured) yellow squares as it was for equiluminant (captured) squares. Although the capture differed between these two conditions, the results did not, suggesting that it was not capture which led to the "popout" in Plummer's experiments, but rather the salience of the superimposed moving dots.

Whether or not Plummer's (1992) demonstrations of preattentive capture hold up with further testing, we do not wish to rule out the possibility that low-level factors may play a role in motion capture. In particular, motion capture has come to encompass a heterogeneous range of phenomena, some of which may be modelled by relative motion detectors (see Murakami & Shimojo, 1993). We wish to stress that attention plays a significant role and on its own can cause motion capture. In sum, motion capture is not simply a preattentive process based on low-level motion interactions but rather, it is influenced or even generated by attention (Culham & Cavanagh, 1994b; Ramachandran, 1996).

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