Letter

Why do some perceptual illusions affect visually guided action, when others don't?

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In 1995, Aglioti and his colleagues [1] reported that the powerful Ebbinghaus–Titchener size-contrast illusion had no effect on visually guided grasping. Pairs of discs were presented within annular arrays of (respectively) smaller or larger circles, generating a strong perceptual-size illusion; yet the illusion did not affect the extent of hand opening during reaches made to pick up one or other of the discs. Milner and Goodale [2] interpreted these data within their proposed association of the cortical ventral and dorsal visual streams with 'perceptual' and 'visuomotor' processing, respectively. Ventral-stream processing would be contextually relative, they argued, in order to provide suitably coded visual information for purposes of recognition and storage. In contrast, size and location would need to be coded in absolute metrics in the dorsal stream, in order to be readily translated into motor coordinates. Since 1995, several studies have produced similar dissociations to those of Aglioti *et al.*, but others have found a significant effect, albeit generally a weak one, of perceptual illusions on action [3–5].

Most, if not all, of these results can be encompassed within the two-visual-streams framework. For example, the effect sometimes found of the Ebbinghaus illusion on grasp aperture might be an artefact of the different spaces 'available' around the target discs, if the surrounds are treated by the visuomotor system as 'obstacles'. The preparatory hand posture appears to be highly sensitive to this factor of 'grasp space' [6]. When grasp space is equalized between the two targets, the effect of the illusion on grasp disappears [7].

A quite different reason why a perceptual illusion might influence a visually guided action relates to where in the brain the illusion originates. It is likely that 'contextual' illusions like the Ebbinghaus have their effects chiefly within the depths of the ventral stream. But other illusions are likely to originate in primary visual cortex (V1), or in one of the other retinotopic areas, which feed not only into the ventral stream but also into the dorsal stream.

There are two ways of deceiving the visual system about the orientation of a central stimulus. The rod-and-frame illusion (RFI, Fig. 1a) appears to be due to a 'contextual' effect, in which the whole visual frame of reference becomes rotated. The surrounding features of the scene induce a *relative* percept of the target object, which dominates our conscious judgements [8]. By contrast, the simultaneous-tilt illusion (STI, Fig. 1b) depends on *local* interactions within the visual field, most probably mediated by short-range inhibitory connections between cortical columns in V1 that respond to different orientations. These interactions would predict a shift in the distribution of neurons responding to a target grating pattern when surrounded by a grating set at an orientation a few degrees away [9].

The two-streams theory [2] must predict a dissociation between perception and action in the RFI, because the frame is most unlikely to influence the target through local interactions in retinotopic visual areas. The STI, however, should not only affect activity in the perceptual system, but

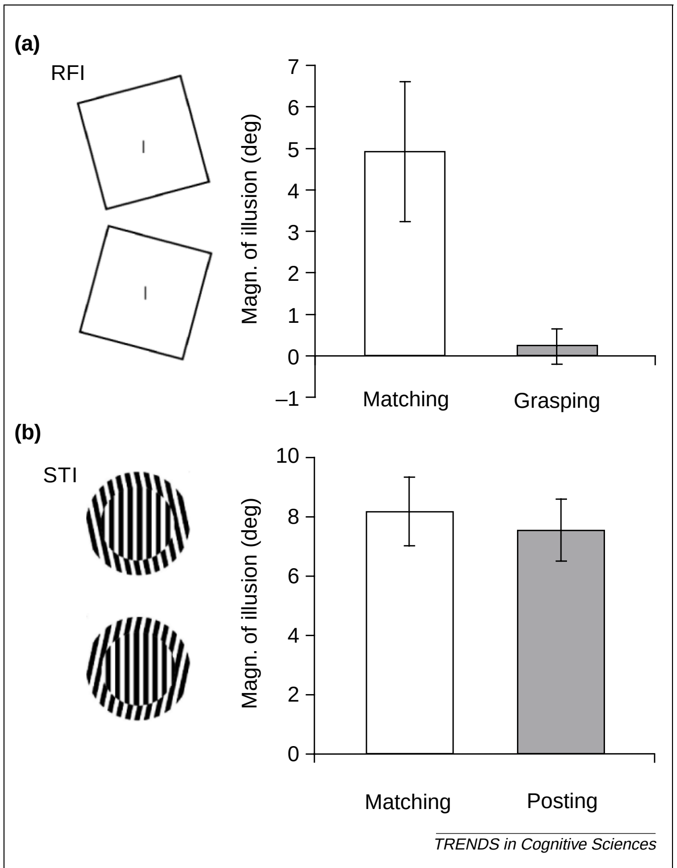

Fig. 1. (a) The rod-and-frame illusion (RFI) and (b) the simultaneous-tilt illusion (STI). There is a strong association between the perceptual (matching) and action (posting) measures of the STI, but a strong *dissociation* between the perceptual and action measures of the RFI [10] (See text for further details).

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also in the visuomotor system, as both systems depend principally on V1 and neighbouring retinotopic areas for their visual inputs. We have found exactly this pattern of results [10]. When subjects 'post' a card towards the STI central grating, their wrist turns to an angle corresponding closely to their illusory perception. However when they reach out to grasp a solid rod in the RFI, their wrist moves veridically, even though their perception is clearly deceived just as in the STI. (Note that in neither case is the display visible during the actual reach.)

These different outcomes are not simply due to differences between the acts of posting and grasping, nor between seeing a single target rod versus seeing a grating. A similar dissociation between perception and action in the RFI occurs when subjects post a card against a grating set in the centre of a large tilted frame. Moreover, when the two illusions are set in opposition to one another, by placing the STI display in the centre of a counter-tilted frame, the opposite dissociation can be seen. In this case, there is a net visuomotor illusion that significantly exceeds the perceptually experienced illusion (which has been largely nulled out) [10].

Our results carry an important message for investigators within this area of study. It is no longer enough to select an illusion, select a visuomotor task, and then test whether the former affects the latter. We need to ask first where the likely locus of the illusion is going to be within the brain. Unless the illusion operates deep within the ventral stream, it is likely to affect both dorsal and ventral streams. Illusions like the STI and the spatial-frequency-contrast illusion are most probably located in area V1. Indeed, some of the best-known illusions, like the Müller-Lyer and the Zöllner, may well be mediated in part by such an 'early' mechanism.

References

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