The cognitive/sensorimotor distinction or Glover's three-part distinction can be applied to the oculomotor system, as Glover notes. A first step in this analysis is to differentiate planning and control functions in the oculomotor system. Somewhat surprisingly, the planning function is very limited in the oculomotor system – of all the types of eye movements, only saccades, and only some of them, engage the planning function. All other movements, including vergence, pursuit, and optokinetic movements, are under real-time control of the visual stimulus and do not require planning. Saccades of the fast phase of optokinetic and vestibular nystagmus are also executed without intevention of a planning system. Voluntary saccades can be planned, but are usually executed in connection with the directing of attention.

Vision can be used to plan action, to execute action, or just to store information for future use. In the latter case, activities such as reading have a goal of collecting information about the world, rather than driving behavior directly. The sensorimotor interactions of reading involve the oculomotor system in the service of collecting information, not doing things to objects or moving through the world.

Using the same information for planning and control is compatible with the dynamic illusion effect

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Abstract: We argue that one can explain why the influence of illusions decreases during a movement without assuming that different visual representations are used for planning and control. The basis for this is that movements are guided by a combination of correctly perceived information about certain attributes (such as a target's position) and illusory information about other attributes (such as the direction of motion). We explain how this can automatically lead to a decreasing effect of illusions when hitting discs that move in an illusory direction, and when grasping objects of which the apparent size or orientation has been changed by an illusion.

It is likely that more aspects of the available visual information are used to plan a movement than to control it. There are many attributes that normally cannot change during the short time that the movement is executed, such as the colour of a piece of fruit. Movements, therefore, usually need not be adjusted to such information. In this sense we agree with Glover that there are probably differences between the use of information for planning and for controlling movements. However, we doubt that the difference is more fundamental than this. In this commentary we argue that it is not necessary to assume that there are different visual representations for planning and control in order to explain the decreasing effect of illusions during human movements.

When participants grasp objects that are presented in illusion-inducing contexts, the effect of the illusion on the movement appears to decrease over time. Glover argues that this dynamic illusion effect is caused by the increasing influence of on-line control (using information about the target that is independent of the context), which eliminates the errors that are made when the movement is planned (using context-dependent information). Recently, we found a very clear decreasing effect of an illusion within a study in which participants hit discs that moved downwards across a structured background on a screen (Brouwer et al. 2003). The background could move to the right or the left, or it could remain static. A moving background affects the perceived direction of the target's motion (Smeets & Brenner 1995b). In accordance with the misperceived direction, we observed an effect of background motion on the direction in which the participants' hands started to move. This effect of the illusion had disappeared by the end of the movement, as indicated by a lack of effect of background motion on the hitting error.

Although this dynamic illusion effect is consistent with Glover's model, it can also be explained without assuming that different sources of information are used in the planning and the control phase of the movement. The basis for this explanation is the observation that the illusion does not affect the target's apparent position (Smeets & Brenner 1995b). We propose that participants use the same (misjudged) direction information and (correct) position information for planning and controlling the movement. If this information is used to extrapolate the target's movement during the time until impact, there will be a large effect of the illusion at the start of the movement, because the trajectory of the target that has to be extrapolated is still long. Near the end of the movement, the effect of the illusion will be negligible, because there is only a short distance from the most recent (correctly) perceived position across which the target's trajectory has to be extrapolated.

To illustrate how continuous extrapolation results in a dynamic illusion effect, we simulated the lateral movement of a hand hitting three moving discs. One disc moved straight down, one disc moved at an angle of 9.5 degrees from the vertical, and one disc moved straight down but had an illusory direction of motion of 9.5 degrees. For the latter case, as illustrated in Figure 1A, a new prediction is made at every point in time, based on the present target position and the (in this case, incorrectly) perceived direction of motion. We assume that the hand always moves straight towards the most recent prediction of the disc's final position. The resulting directions of hand movement are shown in Figure 1B. If the disc's direction of motion is perceived correctly, the predicted final position of the disc is correct from the moment that the hand starts to move; thus, the hand follows a straight path to that position. If the disc moves straight down but appears to move in a different direction, the hand follows a curved path. Figure 1C depicts the strength of the illusion according to the scheme of Glover and colleagues. This is the ratio between the effect of a disc that is actually moving at an angle of 9.5 degrees and the effect of a disc that only *seems* to move at an angle of 9.5 degrees (both relative to the vertical). At the start of the movement, the lateral movements of hands hitting these discs are very similar. During the movement, the lateral position of the hand hitting the disc with the illusory direction moves toward that of the hand hitting the disc that is (correctly) perceived to move straight down.

Examples of a dynamic effect of illusion on action that were provided to support Glover's model (cf. target article; Glover 2002), are focused on grasping: grasping the central disc in the Ebbinghaus illusion (Glover & Dixon 2002a), the central bar of the Müller-Lyer illusion (Westwood et al. 2000c; 2001b), and a bar affected by an orientation illusion (Glover & Dixon 2001a; 2001b). These results can also be explained without assuming that different information is used for planning and control if one realises that related physical attributes (such as a target's size and the positions of its edges) might be processed independently (Smeets et al. 2002).

To explain the dynamic illusion effect for the examples above, we can look at the predictions of a model for grasping (Smeets & Brenner 1999; 2001). This model describes the movement of the digits by the intended contact positions, which are assumed to be perceived correctly, and the approach parameter, which describes how much of the digits' final trajectories is orthogonal to the surfaces around the intended contact positions. The approach parameter increases with required accuracy. A larger approach parameter results in a larger maximum grip aperture.

Smeets et al. (2003) have demonstrated that the influence of the Ebbinghaus illusion on grasping could be caused by considering the grasp to require a higher accuracy (and therefore to have a larger approach parameter) if the target circle is surrounded by small circles than if it is surrounded by large circles. The dynamic

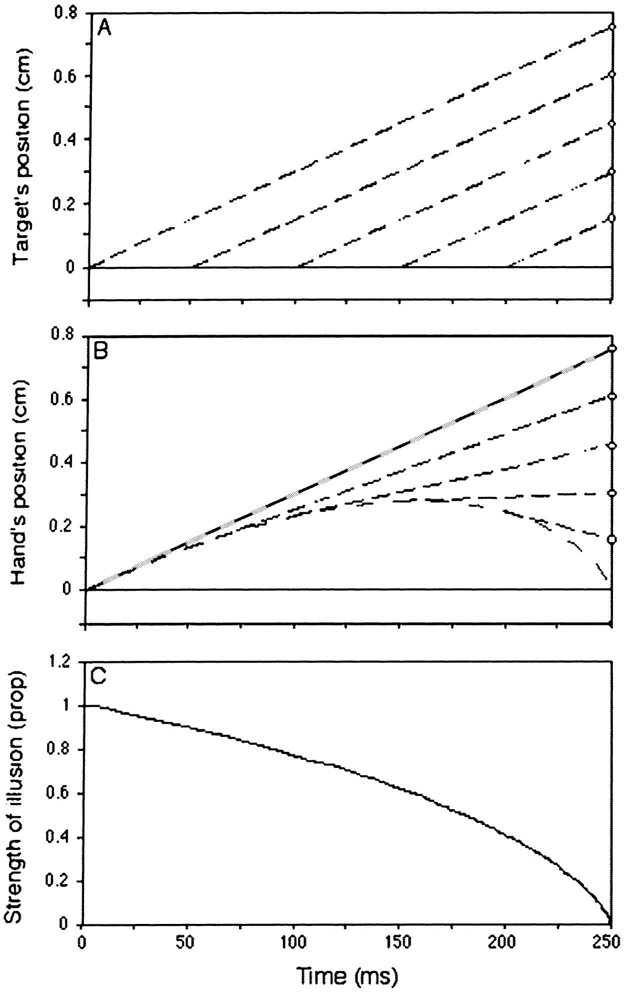

Figure 1 (Brouwer et al.). Hitting a moving disc when the direction of motion is misperceived. Schematic illustration of the disc's predicted final positions (A), the direction of hand movement (B), and the scaled magnitude of the effect of the illusion (C). The hand was simulated to move for 250 msec (which was about the average movement time in our experiment). **A:** The solid line indicates the lateral position over time of a disc that moves straight down but is perceived to move at an angle of 9.5 degrees from the vertical. The dashed lines indicate the disc's extrapolated movement at time samples of 0, 50, 100, 150, and 200 msec after the hand started to move. The disc's correctly perceived position and its misperceived direction of motion are used for the extrapolation. The white dots represent the disc's predicted final positions. **B:** The lateral position of the hand over time when hitting (a) a disc that moves straight down (vertical velocity of 18 cm/sec, horizontal velocity of 0 cm/sec) with a correctly perceived direction of motion, indicated by the black solid line, (b) a disc that moves at an angle of 9.5 degrees (vertical velocity of 18 cm/sec, horizontal velocity of 3 cm/sec) with a correctly perceived direction of motion, indicated by the grey solid line, and (c) a disc that moves straight down, but is perceived to move at an angle of 9.5 degrees (an illusory horizontal velocity of 3 cm/sec), indicated by the curved dashed line. For this disc, the straight dashed lines indicate that at each time sample, the hand moves straight towards the disc's final position as predicted at that time sample. The dashed line for the first time sample overlaps the solid grey line. **C:** The effect of the illusion over time. This is the lateral hand position for hitting a disc with an illusory direction of motion of 9.5 degrees divided by the lateral hand position for hitting a disc with an actual direction of motion of 9.5 degrees. The effect of the illusion decreases during the movement.

effect of the illusion arises because of a timing difference between the increase in grip aperture caused by a larger approach parameter and that caused by a larger target. Additionally, the illusion necessarily decreases to zero because the digits continue to move to the intended contact positions. In a similar vein, the model can account for the dynamic effect of the Müller-Lyer illusion (a larger approach parameter for the line with the inward directed arrows, to avoid the protrusions). The model is also consistent with the observed decrease in the effect of an orientation illusion on the hand's orientation during grasping (Smeets et al. 2002).

In conclusion, we believe that the dynamic illusion effect in action does not justify the assumption of different visual representations for planning and control, or even the use of different sources of information before and during a movement. We have shown that the dynamic illusion in both interception and grasping can be explained without assuming a change in the information used.

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Planning and controlling action in a structured environment: Visual illusion without dorsal stream

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Abstract: Some data concerning visual illusions are hardly compatible with the perception–action model, assuming that only the perception system is influenced by visual context. The planning–control dichotomy offers an alternative that better accounts for some controversy in experimental data. We tested the two models by submitting the patient I. G. to the induced Roelofs effect. The similitude of the results of I. G. and control subjects favoured Glover's model, which, however, presents a paradox that needs to be clarified.

Since the pioneering work carried out by Woodworth (1899), a recurrent issue in the studies relating to visuomotor control concerns the way visual inputs are used to locate a target in the reaching space. A large body of data in the recent scientific literature has underlined the fact that planning a movement requires that many spatial aspects of not only the target but also of the surrounding contextual elements have been previously considered together. As an illustration, a luminous target in a dark context is perceived as being closer than its actual position and is undershot when reached manually with no visual feedback about the hand trajectory (Conti & Beaubaton 1980; Foley 1980). By contrast, spatial performance improves when the visual environment is structured; merely adding a textured background in the workspace improves movement terminal accuracy (Coello et al. 2000).

Another line of evidence is the fact that having the hand and the target in the visual field simultaneously improves the visuomotor performance, which indicates that an accurate assessment of the gap separating the hand and the target is one of the main determinants of spatial performance (Rossetti et al. 1994). In agreement with the latter point, the location of contextual information in relation to the self and the target plays a crucial role in determining reaching accuracy, with elements placed in the space through which the reach occurs conferring the most benefit (Coello 2002; Grealy et al. 2003). Interestingly, structuring the visual field has a broad effect on the control of movement amplitude but leaves the control of movement direction unaffected (Coello & Magne 2000). We recently reported that unexpectedly append-