kinematics. Subjects' grip aperture is increased when reaching for a dowel sitting on a larger as opposed to a smaller sphere, even though the target dowel does not differ between conditions. Similarly, when attention is diverted, individuals have been observed to unwittingly engage in behavioral mimicry (Chartrand & Bargh 1999; Stengel 1947). Hommel (2000) reviews evidence of at least four distinct forms of automatic stimulus response translation which appear to arise from different processes.

Such automatic activation is most apparent when inhibitory control is lacking, either following brain insult or during early infancy. Denny-Brown (1958), for example, observed that following lesions of the medial frontal lobes, patients showed a compulsive drive to interact with objects in their environment, what he termed *magnetic apraxia.* Similar compulsivity was observed by Lhermitte (1983; Lhermitte et al. 1986) following frontal lobe damage. These patients demonstrated a total dependence on environmental stimuli to guide their actions, compulsively using objects (utilization behaviors) and mimicking the experimenter (imitation behavior). Similar behaviors can be observed in infancy. Baldwin (1892) described the young infant as "suggestible," in that environmental stimuli would automatically evoke congruent behavior. Such behaviors were observed by McGraw (1941), who found early reaching movements in response to objects notable for their "autonomous quality," in that these reactions seemed "in no way connected with a desire on the part of the child to possess or manipulate the object" (p. 130).

Our own work (Longo 2003) demonstrates that perseverative search can be elicited in nine-month-old infants to a location where they had seen the experimenter reach is but had not reached to themselves, suggesting that the perception of the experimenter's action had activated analogous motor responses in the infant. This is consonant, as well, with findings of imitation in very young infants (e.g., Meltzoff & Moore 1977), which can also be explained in terms of motor priming (Kinsbourne 2002), followed by a decline over the first few months of life (Fontaine 1984; Maratos 1982), presumably on account of increased inhibitory control.

Glover describes planning as having "the goal of selecting and initiating an adaptive motor program" (sect. 1.1.2, para. 1). In complex ecological situations, however, planning frequently has the goal not only of selecting adaptive motor programs, but also *inhibiting non-adaptive* motor programs which have been automatically activated by environmental stimuli. Consider, for example, the mostly automated actions of a skilled baseball player hitting a pitched ball, relative to the tentative and uncoordinated actions of a novice. The former player not only does a better job of anticipating and coordinating his or her movements, but also is more adept at inhibiting erroneous movements, such as swinging at balls out of the strike zone. Such inhibitory control does not fit easily into the planning–control framework articulated by Glover and, therefore, we question the sufficiency of the current model to account for much of naturalistic behavior.

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Evidence from optic ataxia does not support a distinction between planning and control mechanisms in human motor control

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Abstract: Evidence from optic ataxic patients with bilateral lesions to the superior parietal lobes does not support the view that there are separate planning and control mechanisms located in the IPL and SPL respectively. The aberrant reaches of patients with bilateral SPL damage towards extrafoveal targets seem to suggest a deficit in the selection of appropriate motor programmes rather than a deficit restricted to on-line control.

Glover is to be commended for his extensive review of this largely unresolved current issue in motor control. His planning–control model, however, is not as parsimonious as many existing models and is unconvincing for several reasons. Furthermore, the distinction between planning and control processes appears rather arbitrary and unnecessary when a single continuous mechanism for both would be far more practical and elegant. Glover's distinction between planning and control mechanisms is an expansion of traditional models based upon the observation that on-line adjustments are usually seen only towards the latter stages of fast aiming movements. The lateness of such adjustments, however, probably has as much to do with the inertial properties of the limb as they have with a putative switch between planning and control mechanisms. Although the model might successfully explain experimental data more accurately than the perception and action model (Milner & Goodale 1995), a more succinct and parsimonious model is the inverse-forward model (Wolpert & Ghahramani 2000). The latter not only allows for a single continuous recursive process active from before movement onset until movement endpoint but can also be applied to eye movements, whereas the planning–control model cannot. Overall, the planning–control model does not advance our understanding of motor control above and beyond existing models; although we believe the model has numerous flaws, this commentary will focus specifically on optic ataxia and deficits of on-line control.

According to the planning–control model, a patient suffering from optic ataxia has deficits that are limited to on-line control but has *unimpaired* movement planning. The "planning" stage has access to all of the necessary spatial characteristics relating to the actor, effector, and target in order to plan a goal-directed reach and specify the velocity and timing of the reach. The "control" phase of the movement determines the fine-tuning of certain elements of the reach, such as grip aperture, hand configuration, and target acquisition. We could therefore expect the reaches of optic ataxic patients to head generally in the right direction, under the influence of an efficient motor plan, but expect their final endpoint or grip formation to be inaccurate. This is not the typical observation with many optic ataxic patients, however, for whom the initial reach direction is also often grossly inaccurate. For example, nonfoveal patients (see Buxbaum & Coslett [1997] for this distinction) typically misreach towards fixation when reaching to extrafoveal targets. It is important to note that, contrary to what Glover's model suggests, it is *not* the case that (a) their initial reach direction is accurate, and (b) their subsequent aberrant on-line control makes the reach inaccurate.

This is particularly apparent in patients with bilateral damage to the superior parietal lobes. Patients Mrs. D. (Carey et al. 1997), D.P. (Buxbaum & Coslett 1997), J.J., and M.U. (Jackson et al. 2004) all present with bilateral superior parietal damage and all show a type of "magnetic misreaching" akin to nonfoveal optic ataxia. For example, Mrs. D., with asymmetric slowly progressive

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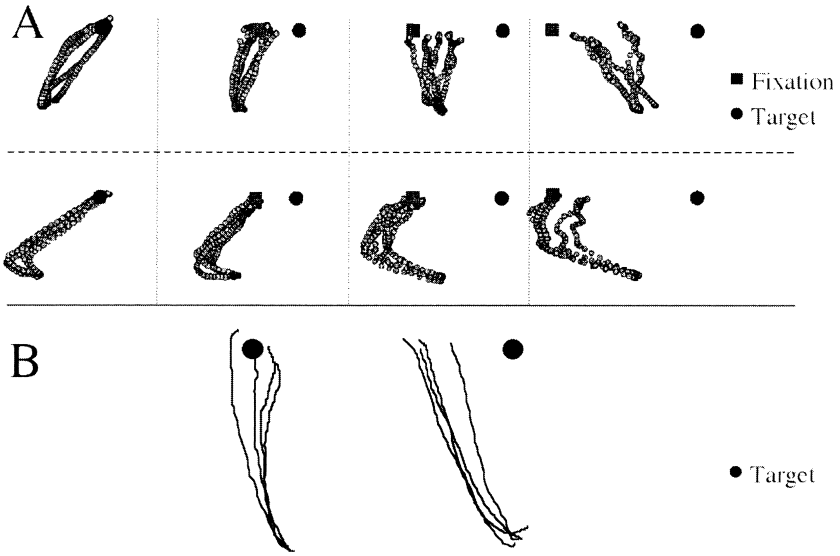


Figure 1 (Newport et al.). Evidence that optic ataxia involves a deficit of movement planning. **A.** Mrs. D., pointing with left (upper) and right (lower) hands towards foveal and extrafoveal (10°, 20°, and 30°) targets (from Carey et al. 1997). **B.** J. J. reaching bimanually while foveating left target.

bilateral lobe degeneration largely restricted to the SPL, could reach only towards the point of fixation with either hand. J.J., a right-handed male with asymmetrical bilateral posterior atrophy (damage to the left hemisphere involving the SPL and IPS, angular gyrus; damage to the right hemisphere involving the IPS and also over the posterior aspect of the angular gyrus), also tended to reach towards his point of fixation rather than towards the target. For example, when reaching bimanually for separate targets placed shoulder width apart while looking only at the left hand target, his right hand would err towards the fixated target for the left hand. As can be seen from Figure 1, reaching, for both patients, is inaccurate from the outset of the movement consistent with a deficit in both planning and on-line control, suggesting that a single mechanism might be responsible for both. It was *not* the case that the initial movement direction was correct and that aberrant on-line control then caused the hand to be directed towards the fixation; rather, the initial movement direction was incorrect and movement direction remained incorrect throughout the movement. This data is inconsistent with Glover's account of both optic ataxia and the role of the SPL. Glover also suggests that reaching errors in optic ataxia should be most evident in circumstances in which large corrections are required, including reaches towards extrafoveal targets. This implies the unlikely notion that the reaches of a neurologically intact individual towards an extrafoveal target would initially be as inaccurate as those of Mrs. D. and J.J. (because planning mechanisms are intact in both patients and controls), but that in normal subjects, unimpaired on-line control processes would correct for this error to make the final outcome accurate.

Furthermore, Glover cites the inability of patient I.G. to make in-flight adjustments to perturbed targets (Gréa et al. 2002) as evidence for the locus of on-line control within the SPL (I.G. presents with bilateral SPL damage). I.G., however, has preserved grip aperture formation, which according to Glover is also the preserve of on-line control. Patient J.J., on the other hand, does not adapt to prisms under terminal exposure conditions, which suggests a deficit of movement planning; terminal exposure does not allow time for on-line corrections. The erroneous hand position is seen only at the very end of the movement, and adaptation therefore requires that a reach be planned away from the direction of gaze (as gaze direction specifies the perceived rather than the actual target location). J.J. is unable to select the appropriate motor programme and as a consequence consistently reaches to the perceived target location (i.e., his point of gaze). According to Glover, however, such movement planning should be intact as J.J.'s IPL, the supposed locus of planning, is spared bilaterally. It is likely that the parietal lobes are responsible for comparing and maintaining current internal representations of the body, which are then communicated to the cerebellum, rather than having specific planning or control functions.

Planning and control of action as solutions to an independence of visual mechanisms

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Abstract: Glover proposes a planning–control model for the parietal lobe that contrasts with previous formulations that suggest independent mechanisms for perception and action. The planning–control model potentially solves practical functional problems with a proposed independence of perception and action, and offers some new directions for a study of human performance.

Glover proposes roles for the inferior and superior parietal lobes in the planning and control of action. He is somewhat at variance with the independent roles for the dorsal and ventral visual pathways previously hypothesized for the control of action and object identification (Goodale 2001; Milner & Goodale 1995). However, we agree that a reformulation of Milner and Goodale's position is required. Glover's planning–control model is laudable because it potentially solves a problem with a proposed independence of action and object identification, namely that of *independence* of mechanism within a context of functional and evolutionary *dependence.* By establishing the conditions under which these processing modes interact, Glover offers insights into coordinative

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