Does Perception Asymmetrically Influence Motor Production in Upper and Lower Visual Fields?

K. Brownell, T. Rolheiser, M. Heath, and G. Binsted

The authors examined if previously reported anatomical asymmetries between the upper (uVF) and lower visual fields (lVF) influence the preparation and control of visually and memory-guided reaching movements. To manipulate visual field, participants maintained their visual gaze on a cue position presented above or below the location of a target object, thus resulting in reaches completed in respective uVF and lVF of peripersonal. In Experiment 1, participants performed reaches to four targets with indices of difficulty ranging from 3.1 to 5.1 bits under five visual-memory conditions: full vision and memory-guided conditions entailing 0, 2, 5, and 10 s of delay. In Experiment 2, participants reached to the vertex of Müller-Lyer figures in 3 visual-memory conditions: full vision, and memory-guided conditions entailing 0, and 2 s of delay. In accord with duplex theories of vision (e.g., Milner & Goodale, 1992), it was hypothesized that the introduction of a visual delay and/or the introduction of context-dependent illusory structure would differentially bias the efficiency and effectiveness of uVF and lVF reaches. Although data displayed mixed supported for the existence of an lVF advantage for movement execution, neither the introduction of delay nor contextual illusions succeeded in differentiating visual fields. Thus, performance advantages for movements made in the lower visual field do not appear associated with preferential connections to parietal (i.e., dorsal-action) and temporal (i.e., ventral-perception) architectures.

While various dichotomous accounts of action production have circulated for over a century (e.g., Woodwoorth 1899; Beggs & Howarth 1972; Keele, 1968; Meyer et al. 1988; see Elliott et al. 2001 for a review), the suggestion of two autonomously functioning visual streams is much more recent (in macaque: “what” versus “where”, Ungerleider & Mishkin 1979; Mishkin & Ungerleider 1982; “form” versus “motion”, Hubel & Livingstone, 1987). Goodale and Milner (1992) proposed the existence of two streams of visual processing extending through the extrastriate cortex and diverging into two distinct streams: dorsally via the posterior parietal cortex (PPC) and ventrally via the inferior temporal lobe (IT). Contrary
to earlier accounts, this binary system had specializations for the recognition of visual objects and for the preparation and execution movement—the dorsal and ventral streams respectively.

The dual-systems hypothesis of Goodale and Milner (1992), however, is not the only account addressing dissociative visual processing systems in visuomotor control. Indeed, and in a manner akin to Woodworth’s (1899) initial model of limb control, Glover (2004) has proposed a planning/control model asserting that anatomically and functionally distinct regions within the human parietal lobe support the respective planning and online control of action. Consistent with both of these views, recent evidence suggests that dedicated circuits within the posterior parietal cortex (PPC) mediate online adjustments. For example, both artificial (via TMS) and natural (via stroke) lesions of PPC interrupt the “automatic” adjustments normally observed during goal-directed action (Desmurget et al. 1999; Grea et al. 2002; Pisella et al. 2000). However, anatomical evidence suggests that this capacity for rapid adjustment may not be equally distributed across the retina; the lower visual field (LVF) in particular shows preferential associations with the constituent regions of PPC for online control (e.g., area V6a, Maunsell & van Essen 1987; area MT, Gelletti et al. 1999). Further, it has been proposed that the disproportionate number of projections to the dorsal regions induce a processing benefit for online visual feedback control in the LVF (Danckert & Goodale, 2001; see also Previc 1990, 1996 for a review)—consistent with the improved ability to manipulate tools in near-peripersonal space. Behaviorally, however, this anisotropy has received equivocal support as some studies report greater speed and accuracy in the IVF. Danckert and Goodale (2001; see also Khan & Lawrence 2005) whereas others report a null advantage for online processing in the IVF (Binsted & Heath 2005; Krigolson & Heath 2006).

In the present examination we chose to examine a corollary prediction arising from the reported vertical visual field asymmetry and their distinct and preferential connections to visuo-perceptual and visuo-motor systems. In particular, we sought to determine if the uVF projections—which are purportedly associated with structures of the visuo-perceptual systems of the ventral pathway—elicit increased sensitivity to perceptually and memory mediated processes. In Experiment 1, this prediction was addressed by utilizing memory delay conditions within a pointing task. This manipulation is often reported to induce ventral functioning (e.g., Westwood et al., 2001) and thus should be optimized for reaches performed in the uVF. Similarly, in Experiment 2, we exploit a Müller-Lyer pointing paradigm; along similar lines, reaching movements made in the uVF should show increased susceptibility to pictorial illusions, presumably due to the increased efficacy of ventral inputs. As an extension to Experiment 1, a memory manipulation was retained in Experiment 2. Thus when illusory stimuli are acted upon in a memory dependent fashion (see Westwood, Heath & Roy 2001), induced bias, and presumably ventral pathway utilization is increased. Moreover, if IVF and uVF connect preferentially to PPC and IT respectively, any observed illusion effect asymmetry should be accentuated in under memory conditions—illusory bias being present (or perhaps inflated) during memory guided reaching in uVF and minimized (or perhaps absent) with full vision in IVF.
Experiment 1: Vertical Visual Field Asymmetries in Memory-Guided Reaches

Recent work by our group has suggested that the visuomotor system is able to maintain a temporally robust, albeit spatially variable, representation of target location to support the planning and control of memory-guided reaches for up to 5000 ms of delay (e.g., Heath 2005; Heath & Binsted 2007; Heath et al. 2004). Moreover, our group has proposed that target information supporting memory-guided actions is laid down and maintained by the temporally durable perceptual networks of the ventral visual pathway (e.g., Westwood et al., 2000; Rolheiser, Binsted & Brownell 2006). As such, and based on the proposed asymmetry between uVF and lVF, one would predict that memory-guided actions performed in the uVF should elicit salient benefits over lFV counterparts because the latter situation affords more direct access to temporally stable target information retain in the ventral visual pathway.

In the current study, participants performed discrete aiming movements—completed in the uVF and lVF—under five visual conditions: full vision and delays of 0, 2, 5, and 10 s (see Figure 1a). Presumably, the dorsally directed connections associated with the lVF should have limited access to ventrally located (memorial) target representations whereas direct access of uVF connections to the ventral pathway should facilitate retrieval of spatial location of the target thereby resulting in reaches that are faster, more accurate and less variable. Conversely, and consistent with previous investigations (Danckert & Goodale 2001, Khan & Lawrence 2005; but see Binsted & Heath 2005) participants should demonstrate superior aiming performance in the lVF when concurrent feedback is available to mediate online control processes.

Materials and Methods

Participants

Eleven university students (six female, five male; mean age = 22.1 years; S.D. = 3.0) participated in this experiment. All participants were right handed and had normal or corrected to normal visual acuity. Informed consent was obtained from each participant before commencing the task and the protocol was approved by the University of Saskatchewan's ethics committee and in accordance with ethical standards put forth by the American Psychological Association (2002).

Task

Participants completed six pointing trials at each of 4 indices of difficulty1 [(3.1, 3.8, 4.3 and 5.1 bits; composed of two amplitudes (15, 25 cm) and two target sizes (1.5, 3.5 cm)], five visual conditions (i.e., full vision; FV, zero second delay; 0D, two second delay; 2D, five second delay; 5D, and ten second delay; 10D) and two visual fields (UfV or LVF), for a total of 240 trials. Participants were asked to reach “as quickly and as accurately as possible” the center position of the target. Before the target being presented participants were to focus on a cross located
Figure 1 — Depiction of stimulus display for (A) Experiment 1, and (B) Experiment 2. Dark lines depict an example condition.
8 cm above or below the target. This fixation was to be maintained through the movement execution, failure to do so resulted in the trial being eliminated. The experimental stimuli (home position, fixation cross, target) were projected on a rear projection screen (1m x 1.2 m) at a height of 1m and oriented at 30° to vertical. Stimuli were projected using an LCD projector (NEC VT470) projector located on the ground and projecting perpendicular to the 30° incline movement surface.

**Procedure**

The participants were seated with their head stabilized in a chin rest for the duration of the study (~1 hr). All manual aiming movements were performed with limb visible and were initiated from a home position located 15 or 25 cm from the target (Figure 1a). All trials entailed completing a reaching movement from the left home position to a right target location. Participants were asked to perform the movement quickly and accurately in both full vision and no-vision (D0 s; D2 s; D5 s; D10 s delay) conditions in response to an imperative start tone. For the FV trials, the target was continuously available throughout participants reaching response, whereas the target was extinguished either concurrent with the imperative start-tone (i.e., D0) or 2 (i.e., D2), 5 (i.e., D5) or 10 (i.e., D10) seconds in advance of response cuing.

When the fixation (i.e., cross) was presented in the upper part of the screen (i.e., 8 cm above the target), the target was located in the individual’s uVF. Conversely, when the cross was presented in the lower part of the screen the target was located in the individual’s uVF. To ensure identical biomechanical requirements in both visual fields only the fixation points changed position, thus the movement occurred on the same plane for each of the 240 trials. Eye movements were monitored on all trials using an EyeLink2 eye-tracking system to ensure participants maintained fixation in the appropriate visual field. In the event that eye-movement was detected the trial was discarded, the participant was reminded to maintain their fixation, and the condition was rerandomized for future recollection. A random block presentation was used for visual conditions, and all other experimental variables (i.e., target amplitude, target width, and visual field) were randomized within visual block.

**Data Collection and Reduction**

The Visualeyez 3000 motion tracker gathered kinematic data in real-time (200Hz) in reference to an infra-red light-emitting diode (IRED) attached to the end of the participant’s right index finger. The IRED was sampled for 3 s following the imperative tone to permit reaction time sampling as well as sufficient time for all participants to compete the designated task. IRED position data were filtered off-line using a second-order dual pass Butterworth filter (low-pass:15 Hz). Instantaneous velocities and accelerations were calculated by differentiating data using a five-point central finite difference algorithm. The initiation of each pointing movement was identified interactively by determining the first sample after which index finger velocity attained and maintained a value of 50 mm/s for ten consecutive frames (i.e., 50 ms). Movement offset was the point at which index finger velocity fell below 50 mm/s and remained below this criterion for ten consecutive frames (i.e., 50 ms).
Dependent measures included: reaction time (RT); movement time (MT); peak velocity (PV) and time after peak velocity; and the movement displacement error in the primary direction (x; constant and variable error). Further, correlations were also calculated between the position of the limb at peak acceleration/velocity/deceleration and the final limb position; the accounted variance (i.e., $R^2$) has been demonstrated to be sensitive to online control by determining the degree to which early landmarks predict ultimate position (see Heath et al. 2004).

For most dependent variables results were examined via 2 (visual field) × 2 (amplitude) × 2 (target size) × 5 (visual condition) repeated-measures ANOVA. For movement time however, we employed 2 (visual field) × 4 (index of difficulty) × 5 visual conditions repeated-measures ANOVA to permit the determination of a Fitts’ Law relation. While movement time data could have been examined using the common ANOVA model, the inclusion of index of difficulty instead of the composite amplitude and size permits more direct commentary on previous claims regarding the efficacy of Fitts’ Law in the lower visual field. The spatial correlation between limb position at PA, PV and PD relative to ultimate movement endpoint was examined using 2 (visual field) × 5 (visual-memory) × 2 (amplitude) × 3 (kinematic landmark) repeated measures analysis of variance. Note that to increase the stability of correlation estimates target size was removed as a factor; increase the contributing trials to 12 per correlation. Simple effects analyses using a Bonferroni correction for multiple comparisons or power polynomial trend analyses were used to specify the nature of any significant effects.

**Results**

Average RT for this experiment was 253 ms ($SD$ 18), no manipulation-related effects for this variable observed. While no effects were evident for RT, MTs (grand mean = 358 ms, $SD$ 25) were found to increase as a function of increasing ID [$F(3, 30) = 8.52, p < .001$]; that is, a reliable speed-accuracy trade-off was observed with increasing target ID (see Figure 2; only significant linear effect: [$F(1,10) = 10.93, p < .01, R^2 = 0.83$]). Further, the position of the limb at movement completion (i.e., endpoint in the x-axis) was consistently influenced by the target amplitude [$F(1,10) = 17.47, p < .005$], that is, when target eccentricity increased reaching amplitude scaled accordingly. Endpoint variability in the primary axis (i.e., standard deviation in the x-axis) demonstrated a significant effects of visual condition [$F(4,40) = 12.92, p < .001$; full vision (11mm) < 0 s delay (14mm) <2, 5, 10 s delay (17mm)], visual field [$F(1,10) = 8.16, p < .05$, lVF (14mm) < uVF (18mm)], and target size [$F(1,10) = 4.94, p < .05$, small (11mm) < large (19mm)].

Inspection of peak velocity produced main effects for field [$F (1, 10) = 5.52, p < .05$] and target amplitude [$F (1, 10) = 13.71, p < .01$]: PVs were greater in the lVF (1765 mm/s, $SD$ 139) than uVF (1726 mm/s, $SD$ 143) and increased as a function of increasing target eccentricity (15cm = 1692mm/s, $SD$ 140; 25 cm = 1799 mm/s, $SD$ 153). Analysis of the time spent after peak velocity, showed that the movement deceleration interval increased only with increasing target eccentricity ($F (1, 10) = 8.90, p < .05$; 15 cm = 178 ms, $SD$ 14; 25 cm = 200 ms, $SD$ 17).

Finally, we examined the correlation between the spatial position of kinematic landmarks (i.e., PA, PV, PD) and final endpoint as an index of the degree of online
Figure 2 — Relation between movement time and index of difficulty for reaching movements in Experiment 1.

Figure 3 — Degree of explained spatial variance as a function of visual field and kinematic landmark in Experiment 1 (error bars depict between subjects standard error of the mean).
control (see Heath et al., 2004). This analysis yielded a main effect of landmark (see Figure 3; $F(2,20) = 59.75, p < .001$). $R^2$ values demonstrated a monotonic increase from PA to PD, and at PV and PD. Importantly however, no main effect or interaction involving visual field was evident ($F$’s < 2, p’s > 0.3 and 0.2 respectively).

**Discussion**

We examined the hypothesis that the upper and lower visual fields have preferential connections with the dorsal and ventral pathways respectively. As such, one would predict that the uVF should have demonstrated performance benefits under memory demanding conditions and the lVF would be predicted to show optimization for conditions where vision for movement execution was available. Although the results did indeed replicate previous reports of both increased endpoint consistency and speed in the IVF (e.g., Binsted & Heath 2005; Khan & Lawrence 2005; Krigolson and Heath 2006) as well as a monotonic reduction in endpoint error with increasing memory delay (e.g., Westwood & Goodale 2003; Heath 2005), however these factors did not interact in a manner consistent with preferential associations between dorsal regions and lVF. Specifically, uVF movements should have been relatively insensitive to memory delay, while those produced IVF should have shown a marked deficit with increasing delay. Moreover, and counter to the findings of Danckert and Goodale (2001; but see Binsted & Heath 2005) a speed-accuracy relation consistent with the seminal work of Fitts (1954) was observed for both lVF and uVF reaches and across the different visual conditions used here. Further, there was no indication of improved feedback control (i.e., time after peak velocity or predictive value of kinematic landmarks) in IVF, counter indicating a preferential association with dorsal regions.

Given the relative paucity of positive findings involving visual field, one might contend that the design used in this investigation lacked sufficient power to detect predicted effects. However, while one must always be cautious interpreting null findings, the current investigation did indeed replicate the bulk of previous results involving memory, target, and field. Moreover, although we used relatively few trials per condition, similar trial numbers have been used previously to detect field effects; indeed we confirmed a reliable field effect, only failing to show its mediation by memory.

Thus, despite the increased perceptual demands associated with memory guided reaching, no uVF advantage was garnered in any measure as would be expected if a transition toward ventral processing were occurring. Similarly, no IVF deficit was observed when movement was required to rely on memory. However, one might argue that the reported memory-decay paradigm was insufficient to induce significant ventral stream processing and thus failed to detect the associated field asymmetries. In Experiment 2 we incorporate a more overt perceptual perturbation—the Müller-Lyer illusion—to elucidate any visual field/stream association.

**Experiment 2: Vertical Visual Field Asymmetries in Reaching to Pictorial Illusion**

Pictorial illusions have been used to indirectly examine the functional significance of the proposed dissociation between dorsal and ventral visual pathways (e.g., Aglioti et al., 1995; Haffenden & Goodale, 1995; Heath et al. 2006; Mendoza et al. 2006;
see Goodale & Westwood 2004 for a review). The basic tenet of this method is to preferentially bias the conscious percept of an object/picture such that it becomes incongruent with the veridical physical properties (e.g., location bias associate with the Induced Roeloff’s effect illusion, Heath et al. 2006; Ebbinghaus size illusion, Aglioti et al., 1995). While the extent to which illusions influence visually guided actions is contentious, it is almost universally accepted that illusions elicit a salient impact on action under memory-guided conditions. (Gentilucci et al. 1996; Westwood et al. 2000). This nonveridical behavior is often considered evidence of a transition between modes of control or underlying visual representation—dorsal to ventral—as the environment demands a move away from normal “real-time” visual operation (see Westwood & Goodale, 2003).

The purpose of this second study was use the Müller-Lyer (ML) illusion to examine the association between uVF and lVF to the ventral and dorsal pathways respectively. Once again, if a preferential association exists between the action (dorsal) system with the IVF, one would predict decreased susceptibility of action to contextual illusions in this region of peripersonal space. In contrast, if, actions performed in the uVF have preferential access ventral visual pathway than actions performed in this context should show increased sensitivity to context-dependent illusory bias. Further, like Experiment 1, we introduced three visual conditions (full vision, zero second delay, 2-s delay; see Figure 1b). Thus IVF movements should show maximum context-resistance in the presence of concurrent vision, and perhaps retain veridical operation in memory conditions, due to a bias toward dorsally mediated functioning. Conversely, movements performed in the uVF should remain biased under all visual-memory conditions (including full vision), perhaps even demonstrating increased perceptual influence, under delay conditions.

Materials and Methods

Participants

Eight students (five female, three male; mean age = 20.2 years; SD 2.0) participated in this experiment. All participants were right handed and had normal or corrected-to-normal vision. Informed consent was obtained from each participant before commencing the task and the protocol was approved by the University of Saskatchewan’s ethics committee and in accordance with ethical standards put forth by the American Psychological Association (2002).

Stimuli

Variations of the commonly used Müller-Lyer figures were implemented as a contextual illusion. The figure consisted of a horizontal line with either a curved-in fin, curved-out fin, or perpendicular lines (see Figure 1b). The curved-in figure was used induce the perception of the line being shorter (relative to the curve-out configuration) while the curved-out figure was used to create the perception of a longer line (see Figure 1b). All remaining physical and technical specifications were identical to Experiment 1.
Task and Procedure

Participants completed five pointing trials across three amplitudes (20, 25, and 30 cm) to three target configurations (i.e., curved-in, curved-out, and neutral) in three visual conditions (i.e., full vision; FV, zero second delay and 2 s delay) and for reaches in uVF and lVF for a total of 270 trials. All remaining aspects of task, instructional set, visual-memory memory manipulation and specification of visual field occurred in a manner identical to Experiment 1.

Data Collection and Reduction

Data collection and reduction procedures were performed in an identical fashion to Experiment 1. A 2 (visual-field) × 3 (amplitude) × 3 (ML configuration) × 3 (visual condition) repeated-measures ANOVA was used to examine all dependent measures. In a manner analogous to Experiment 1, analysis of the spatial correlations between kinematic landmarks was accomplished with the addition of kinematic landmark (peak acceleration, peak velocity, peak deceleration) as a factor and the removal of ML configuration (thus the number of contributing trials per correlation was 15).

Results

Overall participants responded with RT of 282 ms (SD 21) and MT of 378 ms (SD 16). No main effects were observed in mean RT, however movement time revealed a predictable main effect of amplitude \( F(2,14) = 13.70, p < .001 \): movement durations increased linearly as a function of target eccentricity (only linear effect significant: \( F(1,7) = 14.43, p < .01 \)). Further, a main effect was also present for visual field \( F(1,7) = 4.68, p < .05 \), thus replicating previous investigations (see Experiment 1) demonstrating an execution advantage in the lVF (uVF = 385 ms, SD 13; IVF = 370 ms, SD 11). Correspondingly, at movement completion, endpoint position showed reliable effects of amplitude \( F(2,14) = 13.65, p < .001 \), ML-configuration \( F(2,14) = 6.37, p < .05 \) as well as a ML-configuration by vision condition interaction \( F(4,28) = 4.27, p < .01 \). Post hoc analysis here demonstrated that while participants were influenced by the illusory context of the ML figure across conditions, the magnitude of this influence failed to reach conventional levels of significance when participants retained vision of the target \( F(2,14) = 1.12, p > .3 \); D0, \( F(2,14) = 7.36, p < .01 \); D2000, \( F(2, 14) = 7.68, p < .01 \); see Figure 4). Note, however, no mediating effects of visual field were observed. Finally, examination of the variability of end position (i.e., SD of x-position at movement completion) demonstrated only an effect of visual field \( F(1,7) = 4.12, p < .05 \). Thus, as expected, participants were more consistent in the execution of their aiming movements in the lower visual field (uVF = 23 mm, lVF = 16mm).

Upon consideration of peak velocity, analyses yielded significant effects of amplitude \( F(2,14) = 9.64, p < .005 \), vision \( F(2,14) = 3.7, p < .05 \), and field \( F(1,7) = 4.31, p < .05 \). These effects directly reflect the previous findings for MT, such that participants reached higher speeds when pointing over larger amplitudes (i.e., amplitude; linear polynomial \( F(1,7) = 9.77, p < .05 \). Participants move more
Figure 4 — Influence of illusion and visual-memory conditions on endpoint accuracy in Experiment 2 (error bars depict between subjects standard error of the mean).

rapidly in the absence of vision ($FV = 1567 \text{ mm/s, } SD_{154} > D0 = 1846 \text{ mm/s, } SD_{138}, D2 = 1842 \text{ mm/s, } SD_{167}$) and when acting in the lVF ($lVF = 1785, SD_{139}; uVF = 1716, SD_{143}$). Examination of the time spent after peak velocity yielded only an effect of amplitude [$F(2,14) = 7.30, p < .01$]; participants spent more time engaged in online control with increasing target amplitude [linear polynomial $F(1,7) = 9.61, p < .05$]. Finally, we examined the correlation between midtrajectory limb positions and final endpoint (see Heath et al., 2004). This analysis yielded a main effect of landmark [$F(2,14) = 30.31, p < .001$] such that the closer participants were to their terminal position the more predicted the current location of the limb (and therefore less intervening online control processes). Importantly, and consistent with Experiment 1, no evidence of increased online control was present for the lVF (i.e., time after peak velocity and trajectory correlation, $F's < 2, p's > 0.3$).

**Discussion**

In this second experiment we endeavored to highlight the association between dorsal/ventral stream and the upper/lower visual fields by using a pictorial illusion-aiming paradigm. The basic premise was that if the upper visual field is preferentially associated with the ventral stream, participants should show increased sensitivity to perceptual bias when aiming in this field whereas participants should be relatively resistant to illusions in lVF. Consistent with the extant literature (see
Bruno et al., 2008 for a review) a reliable influence of the Müller-Lyer figure was evident across conditions; modulation of this illusory bias was demonstrated as a function of the availability of vision. Specifically, pointing movements performed under memory dependent conditions (i.e., D0 and D2000) demonstrated a greater illusionary effect, presumably due to increased utilization of ventral inputs to the preparation of action (Figure 4; see Bruno et al. 2008 for a review). Notably, and despite a reliable performance advantage, no moderating influence of visual field was observed on either illusory or memory derived effects. Specifically, while field did moderate the rate and consistency of movements (i.e., LVF was reliably faster and less variable), the lower visual field showed no marked advantage for processes like online control (i.e., time after peak velocity) or movement preparation (i.e., reaction time).

Thus, although we successfully replicated the hallmark features of visual field, illusion, and memory on goal-directed action, these factors did not interact in a fashion consistent with a functional association between visual field and visual stream (i.e., perception versus action).

**General Discussion**

Throughout this investigation we sought to induce a task environment biased toward a perceptual mode of processing, presumably more reliant on processing within the inferior temporal (ventral) stream of the visual system. Based on previously reported asymmetries in the anatomical connections between visual fields and the parietal and temporal cortices it was hypothesized that these manipulations would yield an uVF advantage in memory guided aiming accuracy (Experiment 1) and an increased susceptibility to pictorial illusions (Experiment 2). However, despite replicating conventional findings for the independent and interactive effects of memory-delay and visual illusion, target size/amplitude, and visual field, we were unable to identify any mediating effects of visual field. That is, while LVF advantages were observed for performance features such as endpoint variability and movement time (Binsted & Heath 2005; Khan & Lawrence 2005), the location of visual events did not influence the relative efficacy of ventral and dorsal processes—as predicted by preferential field-stream associations.

Given the failure to produce the predicted field effects (i.e., those consistent with IVF-dorsal stream connections), we are compelled to consider alternate explanations that might account for the continued demonstration of IVF performance advantages. The most obvious candidate hypothesis is that despite a predisposition toward upper-ventral and lower-dorsal connections in cortex, there is no functional advantage apparent at a behavioral level. By corollary then, the regularly observed IVF advantages may simply arise due to targets in the IVF being more accurately encoded (i.e., localization, edge detection etc), thus permitting more precise planning of the reaching response. However, although PV findings are consistent with this view, one might have expected concomitant reaction time benefits. Conversely, the IVF superiority may simply reflect methodological limitations of the chosen task. Specifically, while task employed here (and elsewhere, see Binsted & Heath 2005; Danckert & Goodale 2001) provided biomechanical equity between uVF and IVF actions, it fails to provide comparable visual flow; the arm
disrupts uVF presentation during the final phases on control. This account cannot however address regularly reported early kinematic differences between reaching movements. Thus, while there can be little dispute as to a field-related practical advantage, and a number of potential accounts of its basis, this effect should not be attributed to preferential mapping between IVF and the putative dorsal visual systems housed in PPC. Upper visual field performance advantages also, while clearly present, should not be ascribed to the specialization of IT for perceptual (i.e., ventral) function per se.

Beyond rejecting the hypothesized functional relation between visual fields and cortical visual pathways, the current findings also provide insights into the efficacy of perception-action hypotheses more generally. Importantly, throughout this investigation the results ubiquitously replicate the seminal perception-action findings; action is relatively insensitive to perceptual input except in situations where real-time visual feedback is unavailable (see Bruno et al. 2008). However, the demonstration of field-related asymmetries in movement execution have recently been taken as further evidence of cortical specialization for action (e.g., Danckert & Goodale 2001; Khan & Lawrence 2005), this may be true however they do not appear to bare any relation to the dorsal-ventral pathways (and associated behavioral distinctions) forwarded by Goodale and others (see Milner & Goodale 2008 for a recent rereview).

Notes

1. According to Fitts’ Law, a person’s movement time (MT) will vary as a function of the amplitude of the movement (A) and the width of the target (W) such that: MT = a + log2(2A/W).

References


