Distinct task-independent visual thresholds for egocentric and allocentric information pick up

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Abstract

The dominant view of the ventral and dorsal visual systems is that they subserve perception and action. De Wit, Van der Kamp, and Masters (2011) suggested that a more fundamental distinction might exist between the nature of information exploited by the systems. The present study distinguished between these accounts by asking participants to perform delayed matching (perception), pointing (action) and perceptual judgment responses to masked Müller–Lyer stimuli of varying length. Matching and pointing responses of participants who could not perceptually judge stimulus length at brief durations remained sensitive to veridical stimulus length (egocentric information), but not the illusion (allocentric, context-dependent information), which was effective at long durations. Distinct thresholds for egocentric and allocentric information pick up were thus evident irrespective of whether perception (matching) or action (pointing) responses were required. It was concluded that the dorsal and ventral systems may be delineated fundamentally by fast egocentric- and slower allocentric information pick up, respectively.

1. Introduction

The perception–action model (Milner & Goodale, 1995) proposes a task-based dissociation between the ventral and dorsal pathways of the primate visual brain in which the two systems subserve perception (i.e., identification of objects) and action (i.e., visual control of movement directed at objects), respectively.1 The model argues that the dorsal system operates through fast pickup of egocentric information about the absolute size, orientation and position of objects relative to the effector that performs the action directed at the object. The dorsal system is thought to function only in real time, and not when there is a delay between stimulus offset and movement initiation. By contrast, the ventral system mediates perception through slower pickup of allocentric information, specifying the size, orientation and position of objects relative to their surroundings. Allocentric information is thus context-dependent, and any effects of the contextual elements of geometrical illusions, such as the wings of the Müller–Lyer illusion, indicate pick up of allocentric information, whereas immunity to the illusion points to pick up of context-independent egocentric information (see Bridgeman, 1992; Bruno & Bernardis, 2003; Van Doorn, Van der Kamp, De Wit, & Savelbergh, 2009). Information picked up by the ventral system is thought to remain available for longer periods after stimulus...
offset, allowing for recognition of objects and scenes over time (Goodale & Haffenden, 1998; see Milner & Goodale, 2008 for a recent explication of the perception–action model’s assumptions).²

De Wit, Van der Kamp, and Masters (2011; De Wit, Masters, & Van der Kamp, 2012) asked whether, as a consequence of the differences in the speed with which the dorsal system and the ventral system each pick up information, the two systems may have dissociated temporal visual thresholds. Participants performed immediate and delayed (2000 ms) pointing movements in response to brief (12 ms) and long (1500 ms) exposed masked stimuli consisting of Müller–Lyer figures of three different lengths. Based on work by Binsted, Heath and colleagues (Binsted, Brownell, Vorontsova, Heath, & Saucier, 2007; Heath, Maraj, Godbolt, & Binsted, 2008; Heath, Neely, Yakimishyn, & Binsted, 2008), who showed that Fitts’ law is preserved for actions directed at completely masked (e.g., unreportable) briefly exposed (13 ms) stimuli, it was hypothesized that at the brief exposure duration, stimuli would be presented below the perception threshold but above the purported action threshold. At the long exposure duration, stimuli were expected to exceed both the perception and the action threshold. To assess whether briefly exposed stimuli indeed did not exceed the perception threshold, participants performed a perception task in which they had to report the length of the briefly exposed stimuli. Participants who were able to perform the perception task above chance levels were excluded from the action analysis. Intriguingly, both immediate and delayed pointing movements to briefly exposed stimuli by the participants who could not perform the perception task above chance levels were a function of stimulus length, but not of the illusion. Conversely, at long stimulus durations movements were a function of both stimulus length and the illusion, confirming that long exposed stimuli exceeded both the action and the perception threshold.

The lack of an illusion effect despite an effect of stimulus length on the immediate and delayed pointing movements to briefly exposed stimuli shows that these actions were predicated on egocentric information rather than allocentric information, suggesting that egocentric information was retained over a longer than expected time scale (e.g., minimally two seconds). The relatively preserved motor behavior in the face of disrupted perception may imply that distinct thresholds exist for action and perception, with the threshold for action being lower than the threshold for perception. As such, the findings can be interpreted in support of Milner and Goodale’s (1995) task-based characterization of the dorsal and ventral visual systems. However, this would require an extension of the model to include the possibility that the dorsal system is also involved in the control of actions that are performed after a delay, which runs counter to received wisdom that the dorsal system can guide actions only in real time. Alternatively, the ventral system may have been responsible for guiding the delayed actions, but this runs counter to the model’s central assumption that the ventral system relies on allocentric information to perform its function (e.g., Goodale, Westwood, & Milner, 2004; Milner & Goodale, 2008).

In this paper, we address a more parsimonious explanation in which the findings reported by De Wit et al. (2011) reflect a differentiation between visual thresholds as a function of information pick up (e.g., fast egocentric information pick up and slower allocentric information pick up) rather than task (e.g., action and perception). The perceptual judgments of size in the perception task necessarily required comparison of stimulus length to the length of previously presented stimuli, and thus depended on allocentric information (e.g., to judge that a stimulus is of medium length, participants have to, implicitly or explicitly, perceive its length relative to the length of long and short stimuli). The chance level performance shows that this information was not available at the brief exposure duration. In the immediate and delayed action tasks, participants could potentially exploit both egocentric information about the stimulus shaft relative to their effector and allocentric information about the stimulus shaft relative to its illusory context. The fact that pointing movements were a function of stimulus length but not of the illusion shows that only the egocentric information, and not the allocentric information, exceeded the visual threshold.

It is thus unclear whether the dissociated visual thresholds described by De Wit et al. (2011) are a function of task irrespective of response delay, or of information pick up irrespective of task (and response delay). Here, we describe an experiment that was designed to distinguish between these possibilities. In three tasks, participants were presented with brief (12 ms) and long (1500 ms) exposed masked ‘wings in’, ‘wings out’ and ‘no wings’ Müller–Lyer stimuli of three different lengths. In one task, participants performed a version of De Wit et al.’s action task, making 1500 ms delayed pointing movements along the shaft of the stimuli. In another task, participants performed De Wit et al.’s perception task, requiring judgments of stimulus length. A crucial addition in the present study was a third task in which participants were required to manually match the size of the presented stimulus, following a 1500 ms delay. This type of matching task is commonly used as an indicator of perception, i.e., participants report the size of an object by adjusting finger aperture such that it corresponds to object size (e.g., Bruno & Franz, 2009; Dewar & Carey, 2006; Ganel & Goodale, 2003). Accordingly, research almost without exception shows that the matching response is affected by contextual illusory information (i.e., allocentric information), but obviously also involves the use of context-independent information about length (i.e., egocentric information). Hence, if the threshold distinction reported by De Wit et al. is related to perception, we would expect a disruption of size matching (as in De Wit et al.’s perceptual judgment task) for briefly exposed stimuli. However, if the distinction relates

² Taking an ecological perspective on perception and action (e.g., Gibson, 1966, 1986), we refer to ‘allocentric and egocentric information pick up’ (see Michaels, 2000; Van der Kamp, Oudejans, & Savelbergh, 2003), where Milner and Goodale (1995)—taking a constructivist or information processing perspective (e.g., Helmholtz, 1924; Neisser, 1967)—refer to ‘processing visual input within an allocentric or egocentric frame of reference’ (see, for example, Milner & Goodale, 2008, p. 778). Although the ecological and constructivist approaches differ profoundly in their central theoretical assumptions, for the purpose of the present paper, the reader may substitute ‘pick up’ with ‘processing’, should she be so inclined.
to information pick up, we would expect size matching to be robust against masking (as in De Wit et al.’s pointing task), but an illusion effect to be absent.

2. Methods

2.1. Participants

Eighteen right-handed participants (8 females) aged 22–41 years participated in the experiment after having provided informed consent. They were treated in accordance with the ethical guidelines of the local institution. All except one (author J.V.d.K.) were naive regarding the design and purpose of the experiment.

2.2. Materials

Stimuli were presented on a 19 inch CRT-monitor (Philips Brilliance 109P4) with a refresh rate of 85 Hz and a resolution of 1024 × 768 pixels using E-Prime stimulus presentation software (Psychology Software Tools, Pittsburgh, PA). An Optotrak 3020 motion analysis system (Northern Digital, Waterloo, Ontario) was used to measure the extent of the pointing movements in the pointing task and the hand aperture in the matching task. To this end, the positions of infrared light emitting diodes attached to the finger tips were recorded with a frequency of 200 Hz. Participants viewed the stimuli from a distance of approximately 60 cm, with the center of the stimulus display aligned with the participants’ mid-sagittal axis, at approximately 20 cm below eye height.

Stimuli consisted of wings out and wings in Müller–Lyer figures and neutral figures (i.e., without wings) of three lengths (short: 115 mm, 10.9°, medium: 145 mm, 13.8°, and long: 175 mm, 16.7°). The lines that made up the figures (shaft and wings) were 5 mm wide. Each of the two lines that made up a single wing had a length of 30 mm (2.9°) and an angle of 45° relative to the shaft. Stimuli were presented randomly in one of six locations (top-left, center-left, bottom-left, top-right, center-right, bottom-right) but appeared equally often on the left and right side and top, center and bottom of the display.

2.3. Procedure and design

In all tasks, participants self-initiated the trial by pressing the spacebar of a keyboard in front of them, after which they placed the tip of their right index finger on a fixation dot that was positioned at one end of the to-be-presented stimulus shaft, and fixated their gaze on the tip of their finger (see Fig. 1). The dot was present for 3000 ms, after which the target stimulus was presented. Stimulus duration was either brief (12 ms) or long (1500 ms) and responses were always made after a delay of 1500 ms following stimulus offset, prompted by an auditory start signal. Participants were instructed to maintain gaze fixation upon the tip of their finger until they heard the start signal, after which they were allowed to direct their gaze as they wished. Brief and long stimulus duration trials were performed in separate blocks. Stimulus presentation was always followed by a mask that was presented for 200 ms and consisted of an array of scrambled target stimuli.

In the matching task, the start signal prompted participants to take their index finger off the screen and, together with the left index finger, match the length of the horizontal line as accurately as possible by adjusting the aperture between their fingers.

![Fig. 1. Schematic representation of stimulus presentation. In this example the target stimulus is presented at the top-left position and consists of a wings out figure of medium length.](image-url)
fingers (see Van Doorn, Van der Kamp, & Savelsbergh, 2007; Van Doorn et al., 2009 for similar procedures). Participants were instructed to place their fingers at the bottom and center of the screen. It was stressed that they were to attempt to indicate the stimulus’ size, but not by aligning the two fingers beneath the left and right endpoint of the stimulus. The possible use of this strategy was further prevented by instructing the participants to bring their index fingers together before making the size estimation. In the pointing task, the start signal prompted participants to take their index finger off the screen and point as accurately as possible to the other end of the horizontal line. If the dot and stimulus appeared at the left side of the screen a movement from the left end of the stimulus shaft to the right end of the shaft was required, and vice versa. Participants also performed a perceptual judgment task. In this task, the start signal prompted participants to take their index finger off the screen and indicate whether the length of the stimulus’ horizontal line was short, medium or long by pressing a corresponding key on the keyboard in front of them. In this task, stimulus duration was always brief (i.e., 12 ms). Participants were encouraged to respond fairly quickly, within 1500–3000 ms after stimulus offset.

The perceptual judgment task was performed before and after the brief and long stimulus duration blocks of the matching and pointing tasks, the order of which was counterbalanced across participants. In all tasks, each stimulus type (wings out, wings in, no wings) in combination with each stimulus length (short, medium, long) was randomly presented three times leading to a total of 27 experimental trials per task. To maintain active engagement in the experiment despite the high task difficulty in the brief stimulus duration blocks, experimental trials were randomly interspersed with trials in which stimulus duration was 36 ms instead of 12 ms. In these trials, each stimulus type in combination with each stimulus length was presented once (total 9 trials). These blocks thus consisted of 27 + 9 = 36 trials of which only the 27 experimental trials were analyzed. To familiarize participants with the different stimulus lengths and types and with the task requirements, the experimental blocks were preceded by a practice block of 18 trials in which all stimuli were presented twice for 3000 ms and stimulus length was verbally indicated for each stimulus by the experimenter. Participants performed a total of seven separate blocks; one practice block, two perceptual judgment blocks (12 ms stimulus duration), two matching blocks (12 ms, 1500 ms stimulus duration) and two pointing blocks (12 ms, 1500 ms stimulus duration), amounting to a total of 198 trials. There was a 5 min break between the third and the fourth block and the experiment was completed in approximately 1 h.

2.4. Data analysis

For the perceptual judgment task, a proportions test (see Eq. (1), where c is the number of correctly identified stimuli, 54 stands for the total number of responses, and 0.33 for chance level judgment performance) was used to identify individual participants for whom the stimuli exceeded the perception (or allocentric information pick up) threshold. A Z-score greater than 1.65 was interpreted as an indication that the participant was performing above chance levels (z = 0.05).

$$Z = \frac{(c/54 - 0.33)}{\sqrt{(0.33 \cdot 0.66/54)}}$$

As an additional test of participants’ sensitivity to stimulus properties in this task, we also performed analyses that incorporated all responses, regardless of whether they were correct or incorrect. To this end, we summed the numeric values (i.e., 115, 145 or 175) and computed the average judged length for each stimulus length and type. To test for sensitivity of judgments to stimulus length, mean judged lengths for short, medium and long stimuli were submitted to a one-factor analysis of variance with repeated measures. The difference between the mean judged length of wings out and wings in stimuli was computed as a measure of illusion magnitude and submitted to two-tailed one sample t-tests (with test value = 0) to test for sensitivity to the illusion.

Length perception in the matching task was determined by subtracting the difference in mm between the position of the left and right index finger for each trial. Similarly, pointing extent in the pointing task was determined by subtracting the difference in mm between the start and end position of the pointing movement for each trial. To examine whether matching and pointing responses were sensitive to veridical target length, mean responses to each stimulus length were submitted to a 3 (length: short, medium, long) × 2 (task: matching, pointing) × 2 (stimulus duration: brief, long) analysis of variance with repeated measures. To test for an effect of illusion, the mean difference between responses to wings out and wings in stimuli was submitted to a 2 (task: matching, pointing) × 2 (stimulus duration: brief, long) analysis of variance with repeated measures. For all analyses of variance, Huynh–Feldt corrections to the degrees of freedom were applied in case of violations of sphericity and partial eta-squared (⁴) values were computed to assess the proportion of total variability attributable to each factor or combination of factors. Post hoc comparisons for length effects were performed using paired t-tests. Illusion effects were followed up by two-tailed one sample t-tests (with test value = 0).

3 It has been argued that matching depends on information about size (which is affected by the Müller–Lyer illusion), while pointing can depend on information about endpoint position (which is not affected by the illusion; e.g., Mack, Heuer, Villardi, & Chambers, 1985). However, De Grave, Brenner, and Smeets (2004) have shown that while pointing movements perpendicular to the Müller–Lyer illusion are indeed primarily based on position information, pointing movements along the shaft of the stimulus depend on size information. Bruno, Bernardis, and Gentilucci (2008) provide further evidence for this in a meta-analysis that compared pointing movements made from outside the illusion with pointing movements made from one of the shaft’s endpoints (see their Fig. 5). Pointing was selected as an action measure over grasping (which may require size information by default, but see Smeets & Brenner, 1999) because it allowed for the presentation of 2-D stimuli on a CRT-monitor, and thereby for brief exposure and masking of the stimuli.
3. Results

Following data collection, one male participant self-reported severely reduced uncorrected vision in one eye. This participant was removed from the analysis. Analyses were performed on the remaining 17 participants, who all reported normal or corrected-to-normal vision.

3.1. Perceptual judgment task

First, the percentages of correct responses in the first and second perceptual judgment block were compared. Because of a lack of difference between the two blocks ($p = .387$) we collapsed the perceptual judgment data, as larger trial numbers give more accurate proportions tests results. Out of the seventeen participants, ten performed above chance levels (mean percentage correct responses: 54.1%), and seven performed at chance levels (mean percentage: 36.5%; see Fig. 2).

The fact that there were both chance and above chance performers gave us an additional opportunity to test our hypothesis because it generates opposite predictions with regards to the behavior of participants for whom the brief stimuli were presented below the perception (or allocentric information pick up) threshold, and the behavior of participants for whom the brief stimuli were presented above the perception (or allocentric information pick up) threshold. Unlike the participants in the chance group, those in the above chance group were expected to display sensitivity to stimulus length and possibly type in the perceptual judgment task and both stimulus length and type in the matching and pointing tasks at both stimulus durations.

In line with the proportions tests results, the analysis for the above chance group revealed a main effect of length ($F(2,18) = 65.50, p < .001, \eta^2_p = 0.88$). Post hoc comparison showed that mean judged lengths of short, medium and long stimuli could all be distinguished from each other ($p's < .01$). In addition, there was an effect of illusion ($t(9) = 2.80, p < .05$; mean difference: 4.83 mm).

For the chance group, there was no main effect of length ($p = .153$). Because no sensitivity to length was observed, the effect of the illusion on length perception was not assessed (see Fig. 3).

3.2. Matching and pointing tasks

First, a box plot analysis was performed over each individual’s matching and pointing responses at each stimulus length and duration. This identified a total of 45 outliers (2.5%), which were removed from the data set. For the above chance group, the analysis revealed main effects for length ($F(2,18) = 110.84, p < .001, \eta^2_p = 0.93$), task ($F(1,9) = 15.18, p < .01, \eta^2_p = 0.63$) and stimulus duration ($F(1,9) = 144.57, p < .001, \eta^2_p = 0.94$), and an interaction for length and stimulus duration ($F(2,18) = 66.69, p < .001, \eta^2_p = 0.88$). There were no interactions with task. Post hoc analysis indicated that for long stimulus durations, responses to all stimulus lengths could be distinguished from each other ($p's < .001$) while for brief durations, responses to short and medium and short and long stimuli could be distinguished from each other ($p's < .01$; see Fig. 4, right panel).

Fig. 2. Percentage of correct perceptual judgments for each participant. The position of the grey dashed line is based on the critical Z-score value for chance level performance. The black dashed line indicates the 33% level.
The *chance* group displayed a similar pattern, with the length analysis revealing main effects of length ($F(2,12) = 132.12$, $p < .001$, $\eta^2_p = 0.96$), task ($F(1,6) = 7.76$, $p < .05$, $\eta^2_p = 0.56$) and stimulus duration ($F(1,6) = 9.52$, $p < .05$, $\eta^2_p = 0.61$), an interaction between length and stimulus duration ($F(2,12) = 40.13$, $p < .001$, $\eta^2_p = 0.87$) and no interactions with task. Post hoc analysis again indicated that for long stimulus durations, responses to all stimulus lengths could be distinguished from each other ($p$'s < .001), while for brief durations responses to short and medium and short and long stimuli could be distinguished from each other ($p$'s < .05; see Fig. 4, left panel).

The illusion analyses revealed a different pattern. For the *above chance* group results there was a main effect of time ($F(1,9) = 6.34$, $p < .05$, $\eta^2_p = 0.41$) and no main effect of- or interaction with task. Post hoc analysis showed that illusion effects could be distinguished from zero at both long ($p < .001$) and brief durations ($p < .01$).

For the *chance* group, the main effect of time was near significant, with a substantial effect size ($F(1,6) = 5.92$, $p = .051$, $\eta^2_p = 0.50$); there was no main effect of- or interaction with task. Exploratory post hoc comparisons indicated that the illusion effect could be distinguished from zero at long durations ($p < .01$) but not at brief durations ($p = .144$; see Fig. 5).

Franz and colleagues (e.g., Bruno & Franz, 2009; Franz, Fahle, Bülthoff, & Gegenfurtner, 2001) have argued for a method that corrects illusion effects for differences in sensitivity to actual stimulus length between conditions. However, correction procedures are not always appropriate—the current experiment being a case in point. When we used Bruno and Franz’s (2009, p. 1425, Section 2.2.1) general scaling formula for responses with different slopes and intercepts, we arrived at mean percent corrected illusion effects for brief stimuli ranging from −45 to +91%. These effect sizes are clearly outside of the normal range of corrected illusion effects—meta analyses report median effect sizes of 3.8 for pointing and 11 (Bruno & Franz, 2009) to 23% (Bruno et al., 2008) for perceptual measures—and are highly unlikely to be the result of a genuine effect of stimulus type. They rather seem to result from the lack of a consistent pattern in the relationship between stimulus type and matching (pointing) extent at brief stimulus exposure durations (cf. De Wit et al., 2011, Fig. 4).
4. Discussion

Recently, De Wit et al. (2011) reported that delayed pointing movements to completely masked Müller–Lyer stimuli were a function of stimulus length, but not of stimulus type (i.e., the illusion). By contrast, movements directed at previously visible stimuli were a function of both stimulus length and stimulus type, replicating the common finding that delayed actions show effects of illusion comparable to effects on perceptual measures (e.g., Franz, Hesse, & Kollath, 2009; Gentilucci, Chieffi, Daprati, Saetti, & Toni, 1996; Hu & Goodale, 2000; Westwood & Goodale, 2003). The current results agree with these findings; delayed pointing and matching responses to previously visible Müller–Lyer stimuli were affected by stimulus length and the illusion to the same extent. Replicating the novel finding of De Wit et al. (2011), for those participants who were unable to perceptually judge the length of stimuli at brief stimulus durations (chance group), delayed pointing movements remained a function of stimulus length, but not of stimulus type. By contrast, movements to briefly exposed stimuli of participants that displayed sensitivity to stimulus length in their perceptual judgments (above chance group) were a function of both stimulus length and type.

The distinction in visual threshold between the dorsal and ventral systems that is implied by this finding may be modulated by task (i.e., action and perception), independent of delay, or by information pick up (i.e., allocentric information and egocentric information), independent of task and delay. To distinguish between these two possibilities, the current experiment also examined sensitivity to stimulus length and stimulus type in a delayed matching task directed at the same briefly exposed stimuli. Matching is widely considered a perception task; it indicates what knowledge about the object the observer has obtained (see for example, Bridgeman, Gemmer, Forsman, & Huemer, 2000; Bruno & Franz, 2009; Goodale & Haffenden, 1998). However, unlike the perceptual judgment task, which necessitated the pick up of allocentric information, the matching task crucially allowed for the pick up of both allocentric and egocentric information. Results showed that, like the delayed pointing responses, delayed matching responses to brief duration stimuli in the chance group remained a function of stimulus length, but not of stimulus type; those in the above chance group were a function of both stimulus length and type. Together with our current and previous findings from pointing movements to briefly exposed stimuli, this confirms that dissociated thresholds exist for the pick up of context-dependent allocentric and context-independent egocentric information, irrespective of whether a task requires a perception (i.e., matching) or action (i.e., pointing) response.

Our findings may have several implications for the characterization of the ventral and dorsal visual systems. First, they suggest that the dorsal system is able to guide responses that are performed after a delay. This agrees well with recent evidence of the involvement of the dorsal system in delayed conditions (Ball, Smith, Ellison, & Schenk 2009; Cohen, Cross, Tunik, Grafton, & Culham, 2009; Heath et al., 2008; Himmelbach et al., 2009; Thaler & Goodale, 2011). A second, more pressing, implication of our findings is that a distinction between the two visual systems on the basis of information pick up (i.e., slow pick up of allocentric information and fast pick up of egocentric information) is more fundamental than a distinction on the basis of task (i.e., perception and action). This runs counter to the currently dominant interpretation of the ventral and dorsal systems in which the systems are distinguished fundamentally by the tasks that they support (e.g. Milner & Goodale, 1995, 2008).

Fig. 5. Mean difference (and SE) of responses to wings out and wings in stimuli for the chance (left) and above chance (right) groups at 12 (brief) and 1500 ms (long) stimulus durations.
There is other evidence that supports an interpretation of the dorsal and ventral systems on the basis of information pick up rather than task. Schenk (2006) found that the performance of ventral pathway damaged patient D.F. was preserved in both an action and a perception task, as long as the task depended on the pick up of egocentric information. Similarly, Read, Phillipson, Serrano-Pedraza, Milner, and Parker (2010) showed that D.F. was very good at using absolute disparity to judge whether an isolated object appeared near or far (requiring egocentric information pick up) but was poor at using relative disparity between spatially separate locations (requiring allocentric information pick up). This implies that her ability to exploit allocentric information was disrupted (while her ability to exploit egocentric information was spared) rather than her perceptual ability per se. In line with this finding, Committeri et al. (2004) reported dorsal stream activation in neurologically intact observers that were required to perceptually determine which of two objects was closer to them. Finally, Vishton, Rea, Cutting, and Nuñez (1999; see also Wraga, Creem, & Proffitt, 2000), showed that both perception and action measures in response to the horizontal–vertical illusion could be rendered immune or susceptible to the illusion, depending, respectively, on whether tasks emphasized egocentric or allocentric information pick up. Notably, these findings led Bruno (2001) to hypothesize a functional interpretation of the dorsal and ventral systems not unlike ours. The current results and conceptualization extend these findings and suggestions by proposing an additional task-independent distinction between the dorsal and ventral systems on the basis of the speed of egocentric and allocentric information pick up.

Importantly, we do not wish to argue that our findings render the task-based interpretation of the ventral and dorsal systems obsolete. Due to the functional requirements of perception and action, a tight coupling is to be expected between perception and the ventral system and action and the dorsal system, particularly in temporally unrestricted viewing situations. In this light, it makes sense that the relation between participants’ responses and stimulus length was stronger for the long stimulus duration compared to the brief stimulus duration. That is, the dorsal system may be less well equipped for guiding responses after a delay (e.g., Bradshaw & Watt, 2002; Chen, Byrne, & Crawford, 2011; Goodale et al., 2004). Therefore, when the dorsal system is left alone to guide a delayed response, one would expect participants to perform sub-optimally (see also Goodale, Jakobson, & Keillor 1994, who showed disruption of patient D.F.’s action ability in conditions of delay).

We think that there are strong but not invariant mappings between the ventral and dorsal systems and perception and action (see also Madary, 2011; Van der Kamp, Savelsbergh, & Rosengren, 2001). While perception tasks generally rely more heavily on the ventral system, action tasks generally rely more heavily on the dorsal system—not because the systems are task-specific, but because they differ in terms of the type and speed of information pick up and the timeframe in which this information remains available. As a consequence, depending on specific task constraints (e.g., stimulus duration, response delay), action may sometimes involve slower allocentric information pick up over longer time scales (see for example, dorsal pathway damaged patient I.G. who can control movements only after a delay and only on the basis of allocentric information, Milner et al., 2001; see also Caljouw, Van der Kamp, Lijster, & Savelsbergh, 2011) and perception may sometimes involve fast egocentric information pick up (e.g., this experiment). Action and perception are thus understood in terms of softly assembled devices whose composition is variant and co-determined by the specific constraints of the task at hand and the operating characteristics of the dorsal and ventral visual systems (see also Pagano & Bingham, 1998; Van der Kamp, Rivas, Van Doorn, & Savelsbergh, 2008).

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References


