The influence of environmental context in interpersonal observation-execution

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Abstract

Cyclical upper-limb movements involuntarily deviate from a primary movement direction when the actor concurrently observes incongruent biological motion. We examined whether environmental context influences such motor interference during interpersonal observation-execution. Participants executed continuous horizontal arm movements while observing congruent horizontal or incongruent curvilinear biological movements with or without the presence of an object positioned as an obstacle or distractor. When observing a curvilinear movement, an object located within the movement space became an obstacle, and thus, the curvilinear trajectory was essential to reach into horizontal space. When acting as a distractor, or with no object, the curvilinear trajectory was no longer essential. For observing horizontal movements, objects were located at the same relative locations as in the curvilinear movement condition. We found greater involuntary movement deviation when observing curvilinear compared to the horizontal movements. Also, there was an influence of context only when observing horizontal movements, with greater deviation exhibited in the presence of a large obstacle. These findings suggest the influence of environmental context is underpinned by the (mis-)matching of observed and executed actions as incongruent biological motion is primarily coded via bottom-up sensorimotor processes, whilst the congruent condition incorporates surrounding environmental features to modulate the bottom-up sensorimotor processes.

Keywords:

top-down modulation; motor contagion; environmental context; proximity-to-hand effect

Introduction

There is a direct link between perception and action with internal representations subserving both observation and execution of common motor behaviours (Hommel et al., 2001; Prinz, 1997). The interaction between observation and execution is thought to underpin the imitation of other people's actions (Wild, Poliakoff, Jerrison, & Gowen, 2010; Bisio, Stucchi, Jacono, Fadiga, & Pozzo, 2010) and the learning of novel motor skills through observation (Hayes, Roberts, Elliott, & Bennett, 2014; Mattar & Gribble, 2005). This observation-execution interaction is frequently examined by measuring the simultaneous execution of motor responses that are congruent or incongruent to an observed human stimulus (Heyes, 2011). For example, when continuously moving an arm in one direction (e.g., horizontal), the observation of an arm movement stimulus in an incongruent direction (e.g., vertical) elicits involuntary movement deviation (i.e., motor interference) toward the direction of the observed stimulus (Kilner, Paulignan, & Blakemore, 2003). This effect is referred to as *motor contagion* (see Blakemore & Frith, 2005). Thus, it is generally held that these involuntary deviations in the incongruent/observed direction are a result of a motor "resonance" process in which the response codes associated with the observed movement become active in the motor system of the observer and subsequently interfere with movement execution.

Using a similar interpersonal observation-execution task as Kilner et al. (2003),[1] we have shown that while executing horizontal arm movements, there was greater involuntary movement deviation exhibited during the observation of a curvilinear stimulus trajectory featuring the same horizontal end-points but different trajectory, compared to a congruent horizontal stimulus (Roberts, Hayes, Uji, & Bennett, 2015). In addition, the pattern of deviation was specific to the stimulus-motion properties of the unfolding curvilinear stimulus (i.e., performers moved with a similar trajectory as the observed stimulus). This finding indicated that the observed movement kinematics were mapped onto a representation for execution in addition to, and independently of the spatial end-points. This conclusion is consistent with action-observation involving bottom-up sensorimotor processes (Rizzolatti, Fogassi, & Gallese, 2001), and may enable the observer to understand people's action intentions through the simulation of observed goal-directed behaviour (Becchio, Manera, Sartori, Cavallo, & Castiello, 2012; Oberman & Ramachandran, 2007).

In our study, and others like it (e.g., Hardwick & Edwards, 2011; Hayes et al., 2014), movement trajectories were presented within open space and may have been deemed irrational when considering the location of the movement end-points and the absence of any environmental context. That is, the observed curvilinear movement stimulus had a longer resultant displacement and thus less efficient movement trajectory to achieve the same spatial end-points as a horizontal movement stimulus. Thus, we may ask, in addition to the bottom-up sensorimotor process, what influence does the context of a movement have on the interpretation of rationality, and subsequent motor contagion? To date, it has been shown that perceived intention of an observed action can modulate imitation by manipulating the environmental context (e.g., a mechanical constraint imposed upon the moving limb) (Liepelt, Cramon, & Brass, 2008). Intention in this context influences top-down processes, which modulate (i.e., up-regulation; down-regulation) the bottom-up sensorimotor processes responsible for coding biological stimuli (Heyes & Bird, 2007; Spengler, Brass, Kühn, & Schültz-Bosbach, 2010).

The interaction between top-down and bottom-up processes can result in qualitatively different behavioural outcomes based on the nature of the environmental context. For example, imitation in infants can be influenced by the constraints imposed on a model when performing movements (Gergely, Bekkering, & Kiraly, 2002). When an infant observes a model turning on a light-switch using their forehead, there was a greater frequency of imitating the head action when the model's hands were free (irrational), compared to when the hands were occupied by holding a blanket (rational). It was suggested that imitation was underpinned by selective and inferential processes that evaluate the rationality of the observed movement. When irrational, the observed movement is perceived as an essential feature of the to-be-copied action, whereas the most efficient course of movement with respect to the observed context is usually adopted (Gergely, 2007; Csibra & Gergely, 2007). Thus, when observing rational actions, the observer may down-regulate the coding of stimulus-motion properties. Alternatively, it was suggested the hands-free condition of the study was better imitated because it more closely resonated with the observer (Paulus, Hunnius, Vissers, & Bekkering, 2011a; b). That is, the infant observers imitated the head action following the observation of the hands being used to support the body at either side of the light-switch. Once more, it has also been suggested the imitation of the hands-free model was related to the fewer distractions away from the observed movement (Beisert et al., 2012). Therefore, the hands-free condition may have also accommodated greater attentional resources to allow the infants to code for the observed head action.

Another way that top-down factors modulate imitation, and the associated bottom-up sensorimotor processes, is through the environmental context becoming embedded within the observers' movement. That is, observers may use the environmental context not only to infer the intention of observed actions, but also to directly map onto a motor representation. For example, a movement executed toward a target presented simultaneously alongside a distractor object tends to take longer than when the target is presented alone (*distractor interference*; Tipper, Lortie, & Bayliss, 1992; Welsh & Elliott, 2004). Moreover, the slowest responses are typically found when a distractor is located in close proximity to the limb generating the movement (*proximity-to-hand effect*; see Welsh & Weeks, 2010 for a review). These findings indicate that distractors activate a competing motor response in conjunction with the target-directed response. With respect to interpersonal observation-execution, Frischen and colleagues examined how distracting objects were coded by the observer when having pairs of participants take turns to move to a target presented alone or simultaneously with a distractor located in the near (i.e., close to the execution) or far (i.e., close to the observer) side of space (Frischen, Loach, & Tipper, 2009; see also Welsh & McDougall, 2012). The results showed an increase in response times (an indicator of interference) following the observation of movements featuring a distractor. In addition, the distractor located near execution, and far from the observer, generated the slowest responses, and thus reversed the typical proximity-to-hand effect. Therefore, the spatial objects pertaining to the environmental context were coded by the observer, similar to if the observer themselves had executed the movement.

We aimed to investigate the role of environmental context toward the coding of continuous biological motion kinematics during interpersonal observation-execution. More specifically, we examined whether the involuntary movement deviation during observation could be influenced by the observed environmental context aside from the stimulus-motion itself. Observers performed continuous horizontal arm movements whilst simultaneously observing a horizontal or curvilinear movement stimulus. In each stimulus, the environmental context was manipulated so that a large, small or no object was present. Also, the objects became obstacles when located within the vicinity of the observed movement, or distractors when located outside of the observed movement. When an object acts as an obstacle in the path of a straight movement, the curvilinear nature of the observed movement stimuli is rational and essential for avoiding the object to reach the other side of horizontal space. In contrast, when an object is located outside the path of the movement (i.e., as a distractor), the curvilinear stimuli should be considered an irrational movement because the trajectory is no longer essential to reach the other side of horizontal space. Instead, movement between the endpoints could be completed using a more efficient horizontal trajectory. The distractor enabled us to control for any potential effect of visual attention imposed by the mere presence of an object independent of rationality (Beisert et al., 2012). In addition to manipulating the location of the object, the size of the object was also varied. That is, the same amplitude of the curvilinear movement was used in the presence of either a large or small obstacle. For the large-sized obstacle, the magnitude of the curvilinear movement was rational because it was necessary in order to avoid the obstacle. For the small-sized obstacle, the magnitude of the curvilinear movement was irrational because a lower amplitude trajectory could have been adopted.

If environmental context influences action rationality, and perceived rational actions down-regulate the sensorimotor processes underpinning motor contagion, we would expect the observation of a curvilinear movement over a large obstacle to elicit the least amount of deviation in the performer's horizontal arm movement compared to other contexts (none, small obstacle, small distractor, large distractor) (Gergely et al., 2002). However, if environmental context has little or no influence, and motor contagion is independently driven by bottom-up sensorimotor processes, then we expect higher levels of deviation to be present across all curvilinear stimulus conditions (Paulus et al., 2011b). If contagion is a consequence of directed attention whereby there is distraction from the observed incongruent movement trajectory, we would expect lower levels of deviation for the object conditions (obstacle and distractor) compared to the no object condition (Beisert et al., 2012).

In addition to, or independent of, motor contagion that is underpinned by incongruent curvilinear movement observation, the mapping of observed objects (Frischen et al., 2009) may also influence movement deviation. That is, if the object in close proximity to the observed movements is mapped onto an observer's motor system, much like in execution, then we expect increased deviation for the large obstacle in horizontal movement observation by way of simulating the avoidance of the observed object.

Method

Participants

Data were recorded from fifteen participants (age range 18-21 years). All had normal or corrected-to-normal vision and gave written informed consent prior to participation. The study was approved by the local ethics committee and was conducted in accordance with the Declaration of Helsinki.

Stimuli and Procedure

The visual stimuli were pre-recorded video clips of a human (adult male) model executing cyclical movements. The videos were displayed on a flat white screen (2.0 x 1.7 m) at a viewing distance of 2.0 m using a CRT projector (Barco Graphics 908) with a spatial resolution of 1024 x 768 pixels and temporal resolution of 85 Hz. The stimuli were edited using Adobe Premier CS5 software, and presented using COGENT toolbox controlled by MATLAB (Mathworks Inc.). The to-be-observed movement cycles were executed at a frequency of 2 Hz with the aid of an auditory metronome for duration of 30 s. The model movements included two sets of horizontal and curvilinear movement cycles. The horizontal movements aimed for a 400 mm horizontal amplitude with minimal movement in the vertical axis. The curvilinear movement aimed for a 400 mm horizontal amplitude (left and right endpoints), and a 300 mm movement within the vertical axis at the central upper vertex of the trajectory. The movement deviation and peak position details are featured in Table 1 and Table 2 respectively. In addition, there was a control stimulus featuring the same model at rest with a single red dot located over the upper torso.

Each model movement was executed with either no object, a large object (25 cm height) or a small object (10 cm height) present (Figure 1). Both the object sizes (large/small) and the location determined the perceived context of the movement. The objects were located at centre and presented either as an obstacle preventing the limb from moving left to right, or a distractor that had no direct influence on the model movement. For the obstacle conditions, the large and small objects were held at the same ground height, and thus the large object appeared closer to the moving limb than the small object. More specifically, the top of the large object was located within 10 cm of the moving limb, whilst the small object was located within 25 cm from the moving limb. For the distractor conditions, the large and small objects were held at different ground heights so to appear within the same proximity of the moving limb. That is, both the top of the small and large objects was located 40 cm from the moving limb. The location of the objects was secured via an adjustable stand. Notably, the absolute location of the objects was different between the horizontal and curvilinear condition, though their relative location remained the same. When present, the objects were displayed 3 s prior to stimulus movement onset and remained visible throughout the duration of the trial. This preparatory period enabled participants to fully process the task constraints imposed on the model before, as well as during, observation-execution.

Insert Table 1 and Table 2 about here

Insert Figure 1 about here

Upon entering the lab participants received two practice trials. Participants were instructed to execute continuous horizontal arm movements across the mid-line of the body between two computer-generated targets displayed on the flat white screen with the aid of an auditory metronome (presenting tones at 1 Hz; one movement segment per auditory tone) for duration of 30 s. Once participants were familiarized with the criterion movement both the targets and auditory metronome were removed from the model presented in the experimental phase. During this phase, participants always executed horizontal movements when either fixating on a static dot or in-time with horizontal or curvilinear model movements. Therefore, the observed horizontal stimuli were congruent, and the observed curvilinear stimuli were incongruent, to the movement being executed by the participant. Furthermore, objects were only presented embedded within the model stimuli, and not in the movement space of the participant.

There were a total of twenty-two trials for each session. There were two trials for each observed stimulus condition, which were presented in random order with the caveat that no single combination of movement stimulus and context could be presented on two consecutive trials. To assess the potential muscular fatigue and inattention imposed by the task procedure, the first and second control trials were implemented at the start and end of the testing session respectively. Limited differences in the participants' movements for the control trials would demonstrate little or no fatigue and/or inattention.

Data Collection and Analysis

Movements were detected from an infrared marker secured to the index finger of the right hand recording at 200 Hz using a 3D Investigator Motion Capture System (Northern Digital Inc., Ontario, Canada). The first and last 5 s from each 30 s recording were removed to minimize any potential muscular fatigue or inattention effects within trials. The position data were low-pass filtered with a cut-off of 10 Hz using an autoregressive filter implemented in MATLAB. The movement segments were then determined by identifying the reversals within the primary axis of movement (i.e., x-axis; horizontal). As a measure of contagion, we adopted a procedure from original work (e.g., Kilner et al., 2003; Kilner, Hamilton, & Blakemore, 2007; Stanley, Gowen, & Miall, 2007), which involved calculating the standard deviation of the orthogonal axis of movement (i.e., y-axis; vertical) for each individual movement segment and then averaging. To quantify the direction of movement deviation, we calculated the mean peak position of the limb within the orthogonal axis of movement. This involved identifying the single most extreme orthogonal position of the limb (positive/negative) for each individual segment (Roberts et al., 2015; Welsh, Elliott, & Weeks, 1999). Hence, orthogonal movement performed in the upward direction would demonstrate a positive peak. Lastly, the within-participant standard deviation of segment-to-segment peak position was calculated as a measure of the variability of the performers' movement direction.

Mean deviation data for the control trials were compared using a paired-samples t-test. The experimental trials were submitted to a 2 movement stimulus (horizontal, curvilinear) x 5 context (none, large obstacle, small obstacle, large distractor, small distractor) repeated-measures ANOVA. Significant two-way interactions were decomposed via a simple main effect ANOVA at levels of the movement stimulus factor. In the event of a violation of Sphericity (as indicated by Mauchly's test of Sphericity; $p < .05$), the Huynh-Feldt correction was used when ε was greater than or equal to .75, whereas the Greenhouse-Geisser correction was used when ε was less than .75. Significant main effects featuring more than two means were further decomposed using the Tukey HSD post hoc procedure ($p < .05$).

Results

Movement deviation

There was no significant difference between the first ($M = 5.31$, $SE = .54$ mm) and last ($M = 5.39$, $SE = .47$ mm) control trials, $t(9) = -.12$, $p > .05$.[2] Therefore, there was no significant muscular fatigue or loss of attention caused by the task trial procedure. For the experimental trials, there was a significant main effect of movement stimulus, $F(1, 14) =$

22.50, $p < .001$, *partial* $\eta^2 = .62$, indicating increased deviation for the curvilinear stimulus compared to the horizontal stimulus. There was no significant main effect of context, $F(4, 56) = 1.35$, $p > .05$, *partial* $\eta^2 = .09$, although there was a significant movement stimulus x context interaction, $F(4, 56) = 2.78$, $p < .05$, *partial* $\eta^2 = .17$ (Figure 2). Simple effects analyses revealed a significant effect of context for the horizontal stimulus, $F(4, 56) = 6.13$, $p < .001$, *partial* $\eta^2 = .31$, but no significant effect of context for the curvilinear stimulus, $F(4, 56) < 1$, $p > .05$, *partial* $\eta^2 = .04$. Post hoc comparisons on the horizontal condition revealed significantly greater deviation for the large obstacle compared to no object ($p < .05$, $d = .15$), large distractor ($p < .05$, $d = .16$) and small distractor ($p < .05$, $d = .19$) conditions.

Insert Figure 2 about here

Peak position

There was a significant main effect of movement stimulus, $F(1, 14) = 19.65$, $p < .005$, *partial* $\eta^2 = .58$, indicating increased positive extent for the curvilinear stimulus, but no significant main effect of context, $F(4, 56) = 1.53$, $p > .05$, *partial* $\eta^2 = .10$. Moreover, there was a significant movement stimulus x context interaction, $F(4, 56) = 4.33$, $p < .005$, *partial* $\eta^2 = .24$ (Figure 3). Simple effects analyses revealed a significant context effect for the horizontal stimuli, $F(4, 56) = 8.14$, $p < .005$, *partial* $\eta^2 = .37$, but not for the curvilinear stimuli, $F(4, 56) = 1.02$, $p > .05$, *partial* $\eta^2 = .07$. Post hoc comparisons on the horizontal condition revealed increased positive extent for the large obstacle compared to no object ($p < .05$, $d = .28$) and small distractor ($p < .05$, $d = .29$) conditions.

For the within-participant standard deviation of peak position there was a significant main effect of movement stimulus, $F(1, 14) = 20.23$, $p < .005$, *partial* $\eta^2 = .59$, with greater dispersion for the curvilinear stimuli ($M = 23.9$, $SE = 1.9$ mm) compared to the horizontal stimuli (*M* = 17.2, *SE* = 1.2 mm). There was no significant main effect of context, $F(4, 56) = 1.60$, $p > .05$, $partial\ \eta^2 = .10$, nor a significant movement stimulus x context interaction, $F(4, 56) < 1$.

Insert Figure 3 about here

Discussion

The role of environmental context on involuntary movement deviation was examined during interpersonal observation-execution by introducing an object within the observed movement space. We manipulated the rationality of observed curvilinear movement, which was incongruent to the executed horizontal movement, by manipulating the location and size of the object, which in turn changed the proximity of the object with respect to the observed movement. The interaction between movement stimulus and context revealed two important findings. First, there were equally high levels of movement deviation during the observation of the curvilinear movement conditions with the magnitude not affected by context. Second, deviation increased during the observation of horizontal movement in the presence of a large obstacle. Thus, there appears to be modulation during interpersonal observation-execution that is consistent with the environmental context, but this was dependent upon the congruency of observed and executed actions.

The differential role of environmental context indicates a role for the relationship between the observed actions of the model stimulus and the instructed actions of the observer. That is, the congruent horizontal condition provides a close match between the observed and executed actions, which seems to facilitate an influence of spatial objects as obstacles compared to the incongruent curvilinear condition where there was a mismatch between observed and executed actions. These differences in the effect of environmental context are consistent with the interaction between the observed action and movement intentions proposed by Ondobaka and colleagues (Ondobaka, de Lange, Newman-Norlund, Wiemens, & Bekkering, 2012; Ondobaka, Newman-Norlund, de Lange, & Bekkering, 2013). For example, following a prime to fulfil congruent action intentions (e.g., observe high card selection, execute high card selection) there was increased interference (delayed response times) following the observation of incongruent movement intentions (e.g., observe selection right, execute selection left). When the observed and to-be-executed action intentions were incongruent, however, there was less interference caused by the observed movement.

With respect to the matching of observed and executed action in the congruent horizontal condition, the increased deviation for the large obstacle indicates that spatial objects are represented when in close proximity to the observed movement (see Figure 1). In this instance, it would appear deviation relates to the competing motor responses elicited by the observation of spatial objects (Welsh & Elliott, 2004). To be precise, the observer appears to deviate from a straight-line horizontal movement trajectory by way of inhibiting any unintended motor responses geared toward the observed object. These findings are consistent with behavioural evidence of close proximity distractor objects influencing the observation (Frischen et al., 2009; Welsh & McDougall, 2012) and execution of actions (Keulen, Adam, Fischer, Kupers, & Jolles, 2002; Tipper et al., 1992; Welsh et al., 1999). In addition, they fit with recent neurophysiological evidence of modulating corticospinal excitability through the presence of distractor objects during observation (Sartori, Xompero, Bucchioni, & Castiello, 2012). The increased deviation of the current study was underpinned by similar increases in orthogonal peak position for the large obstacle condition, which may indicate observers attempted to move over the observed obstacle by simulating the avoidance of a potential collision. That is, the mapping of observed spatial objects onto a motor representation corresponds with the avoidance behaviours typically engaged in execution (Howard &

Tipper, 1997; Tresilian, 1999; Welsh & Elliott, 2004). This behavioural response occurred even though no physical objects were present in the environment during the execution of horizontal movements. Therefore, when initially matching observed and executed actions there is mapping of the observed spatial objects onto a motor representation for execution in a corresponding environmental context.

For the mismatch of observed and executed actions for the incongruent curvilinear condition, the increased deviation across all contexts suggests the bottom-up sensorimotor processes underlying motor contagion were predominantly driven by the unfolding stimulus-motion properties. This conclusion is consistent with evidence of observers closely copying the inefficient movement trajectories (e.g., curvilinear instead of horizontal movement; Griffiths & Tipper, 2009; Hardwick & Edwards, 2011) and kinematics (e.g., asymmetric movement velocity profiles; Hayes et al., 2014) of model stimuli. These findings support the suggestions from Paulus and colleagues (Paulus et al., 2011a, b; Paulus, Hunnius, & Bekkering, 2013) that imitation of incongruent motor behaviours is determined by observed actions resonating in the motor repertoire of an observer. Thus, when there is a mismatch between the observed and executed actions the observed movement is mapped onto a motor representation for execution of a corresponding movement (Rizzolatti et al., 2001; see also, Becchio et al., 2012).

This is not to say that the environmental context fails to influence the mapping of incongruent biological stimuli in motor contagion effects (e.g., Liepelt et al., 2008). Though we can only speculate, it may be that during close interpersonal synchrony the mismatching of observed and executed actions leads to a greater influence of observed incongruent movements toward execution. In other words, the environmental context may have lesser influence when the observed and executed actions are mismatched during interpersonal settings. This suggestion is indirectly supported by evidence that dyadic pairs moving in synchrony (compared to asynchrony) can subsequently alter their social dynamics and associated attitudes (Miles et al., 2010; Roberts et al., 2015).

Conclusion

We have shown that there is a role of environmental context during interpersonal observation-execution, which is modulated by the matching (or mismatching) of observed and executed actions. Matching of observed and executed actions up-regulates the mapping of observed spatial objects onto a motor representation, whereas mismatching isolates the mapping process to the observed movement, thus rendering the context less important.

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Table 1. Mean movement deviation (mm) (± SD) of each model.

	Context				
		Obstacle		Distractor	
Movement	None	Large	Small	Large	Small
Horizontal	13.03 (2.26)	13.99 (3.13)	12.97 (3.14)	10.86 (2.90)	13.61 (2.26)
Curvilinear	134.02 (9.89)	106.39 (8.03)	108.08 (10.19)	107.31 (8.60)	114.03 (8.13)

Table 2. Mean peak position (mm) (± SD) of each model.

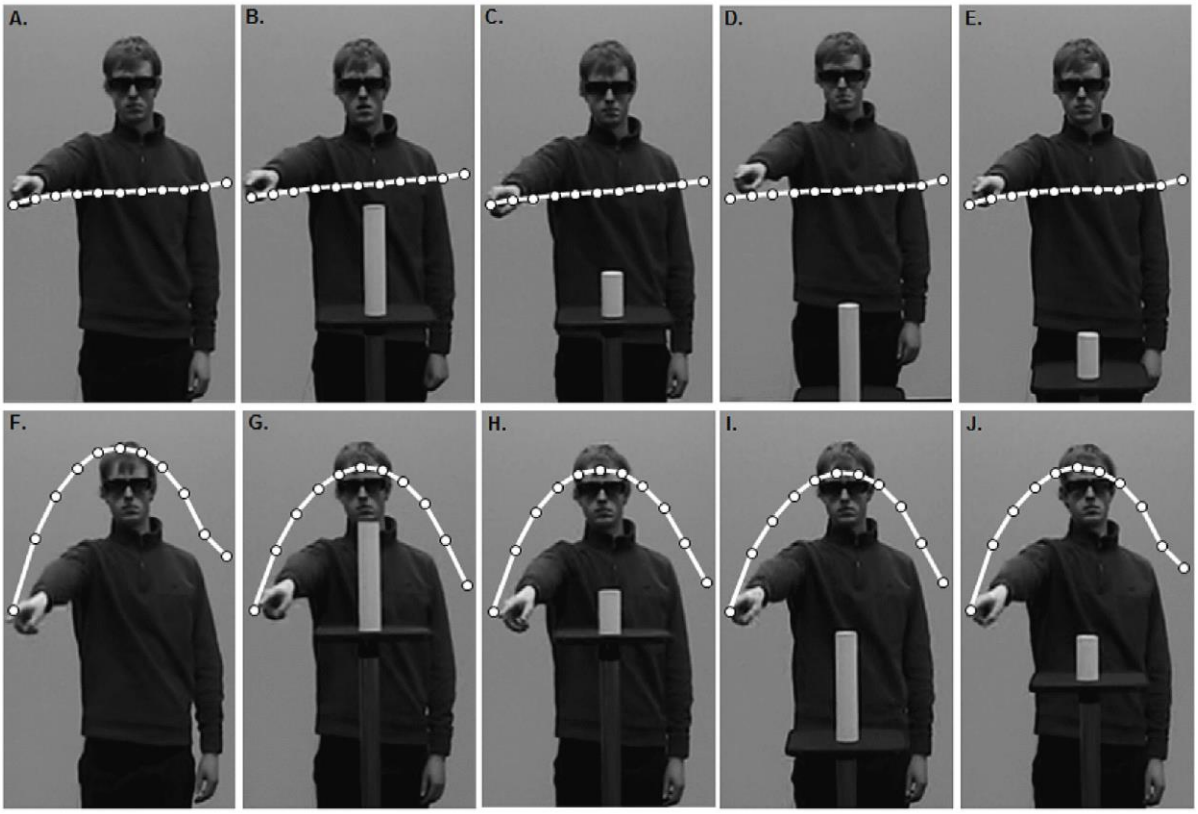
	Context				
		Obstacle		Distractor	
Movement	None	Large	Small	Large	Small
Horizontal	0.50 (35.60)	0.96 (40.43)	-1.60 (37.64)	-3.04 (31.69)	-3.26 (2.26)
Curvilinear	331.45 (77.33)	288.04 (30.90)	287.22 (37.44)	284.87 (33.03)	291.02 (47.05)

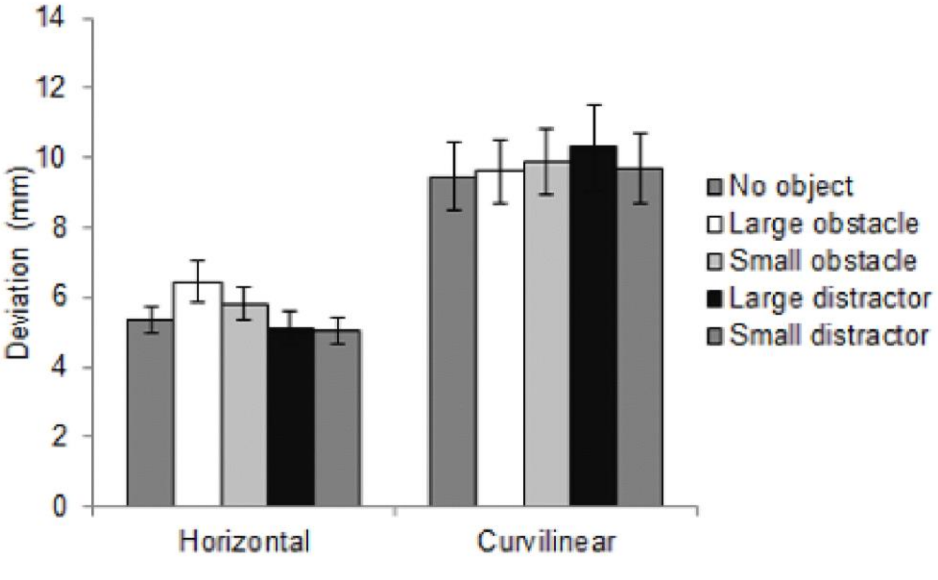
Figure captions

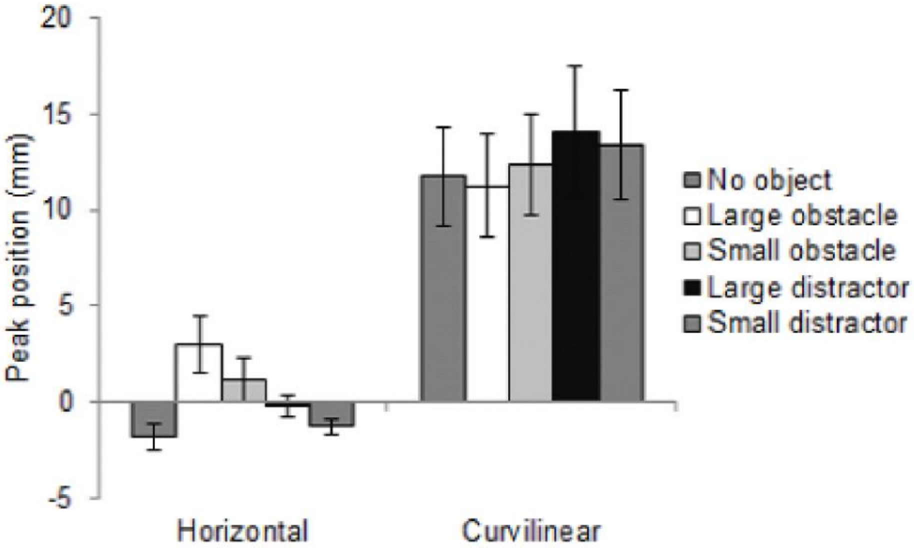
Figure 1. Illustration of stimulus displays. Average traces of the overall movement cycles are shown by *white lines*. Each *circle* represents 10% of the total horizontal amplitude. Top row: horizontal no object (A), horizontal large obstacle (B), horizontal small obstacle (C), horizontal large distractor (D), horizontal small distractor movements (E). Bottom row: curvilinear no object (F), curvilinear large obstacle (G), curvilinear small obstacle (H), curvilinear large distractor (I), curvilinear small distractor (J).

Figure 2. Mean standard deviation as a function of movement (horizontal, curvilinear) and context (no object, large obstacle, small obstacle, large distractor, small distractor).

Figure 3. Mean peak position as a function of movement (horizontal, curvilinear) and context (no object, large obstacle, small obstacle, large distractor, small distractor).


A.
B.
C.
D.
E.
F.
G.
H.
I.
J.


14
12
10
8
6
4
2
0
Deviation (mm)
Horizontal
Curvilinear
No object
Large obstacle
Small obstacle
Large distractor
Small distractor


20
15
10
5
0
-5
Peak position (mm)
Horizontal
Curvilinear
No object
Large obstacle
Small obstacle
Large distractor
Small distractor

Footnote

1. The term “interpersonal” has been adopted in this instance to describe the precise same source of sensory information projected by a real-life model (i.e., whole-body movement), but instead, via a pre-recorded video display. The term has been used to describe previous settings (Roberts et al., 2015).

2. Only 10 participants were featured in the control trial analysis due to some technical error during the first trial display