Research article

Motor affordance for grasping a safety handle

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ABSTRACT

Mere observation of objects in our surroundings can potentiate movement, a fact reflected by visually-primed activation of motor cortical networks. This mechanism holds potential value for reactive balance control where recovery actions of the arms or legs must be targeted to a new support base to avoid a fall. The present study was conducted to test if viewing a wall-mounted safety handle – the type of handle commonly used to regain balance – results in activation of motor cortical networks. We hypothesized that the hand area of the primary motor cortex would be facilitated shortly after visual access to a safety handle versus when no handle was visible. Here, we used transcranial magnetic stimulation (TMS) to measure corticospinal excitability in hand muscles directly following access to vision while participants performed a seated reach-grasp task. Vision was controlled using liquid crystal lenses and TMS pulses were time-locked to occur shortly after the goggles opened but prior to any cue for movement. Between trials the response environment was unpredictably altered to present either a handle or no handle (i.e. covered). Our results demonstrated a rapid motor facilitation in muscles of the right hand when participants viewed a handle versus trials where this handle was covered. This effect was selective both in terms of the muscles activated and the timing at which it emerged. The First Dorsal Interosseus and Opponens Pollicis muscles (synergists in closing the hand) were facilitated 120ms after viewing the handle. Interestingly, this effect was absent at earlier (80ms) and later (160ms) points. Conversely, Abductor Digiti Minimi, which moves the little finger out from the rest of the hand, tended to diminish when viewing the handle. These findings suggest a rapid engagement of muscles suitable for grasping a handle based on vision. This is consistent with the concept of affordances where vision automatically translates viewed objects into appropriate motor terms. The fact that this affordance effect was present for a wall-mounted safety handle commonly used to regain balance has implications for automatically priming recovery actions with upper limbs suited to our surroundings, even before postural perturbation is detected.

1. Introduction

Considerable evidence from animal [1–4] and human research [5–12] has shown that viewing objects can potentiate specific actions, suggesting that we put our surroundings into motor terms automatically. This concept referred to as ‘affordances’ [13] has been demonstrated in humans using a variety of imaging techniques including functional Magnetic Resonance Imaging (fMRI) [8,9]. Transcranial Magnetic Stimulation (TMS) [5–7,10,14] as well as behavioural outcomes such as increased reaction speed when afforded actions are subconsciously primed [11]. The ability to automatically translate the visual world into potential actions, such as reaching to grasp a nearby object, offers

a big advantage to smoothly interact with our environment. Indeed, the predictive nature of action priming based on vision is especially relevant given processing delays inherent in a complex nervous system. Consequently, behaviours that must be quick, yet simultaneously goal-directed, stand to become more effective.

Over the last few years a great deal has been learned regarding the neural circuits involved in reaching and grasping behaviour [15–18]. TMS has been particularly informative in human studies to reveal the dynamics of cortical motor output relative to visual cues and to investigate functional connectivity across distributed cortical networks during reaching and grasping. Using a combination of single, and paired-pulse TMS techniques, evidence supports that several brain regions modulate motor cortical output based on object parameters and task require-

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ments. While action planning relies on networks upstream of primary motor cortex (e.g. parietal-premotor circuits) [15], motor cortical excitability shows a transient increase immediately after a graspable object is viewed [19] even without the requirement to move [7]. Overall, past findings support how vision can impact motor output in a rapid and object-specific way, and highlights the utility of TMS to explore the dynamics of motor priming.

Among the class of human behaviours that could benefit profoundly from a rapid visual priming of action is the control of balance, particularly in situations where a compensatory reach-to-grasp is necessary to establish a new support base and avoid a fall. While the basic notion that affordances could impact compensatory arm reactions seems logical, there is presently no direct evidence that objects associated with maintaining balance (such as a supportive handrail) engage relevant limb actions through observation. Indeed, past studies investigating affordances have relied upon methods that do not necessarily translate into a postural context for a variety of reasons. For example, the types of affordance cues that have been employed in research typically consist of items such as coffee mugs, screwdrivers, erasers, pencils, and various objects commonly used in daily life, but never anything expressly useful for recovering balance. Moreover, the visual stimuli used in these past studies have often been presented via computer screen or two-dimensional pictures versus real-life objects. In fact, the motor responses (if any) are often decoupled from directly interacting with the presented objects (e.g. pressing a button when viewing handle orientation of an object presented as a picture [11]). In terms of measurement techniques, past studies have sometimes used methods such as fMRI that are insensitive to revealing temporal dynamics of an affordance effect [8,9]. Notably, some investigators have used TMS to obtain a more temporally precise estimate, however time of TMS pulse delivery has varied considerably across studies [5–7,10,20]. For example, Cattaneo and colleagues observed no change in motor cortical excitability of the hand muscles when participants simply viewed graspable objects using TMS pulses delivered 1200ms after presenting visual stimuli [20]. By contrast, Franca and colleagues revealed increased excitability in hand muscles but only immediately (i.e. 120ms) after viewing graspable objects and not at later time points [7]. This suggests that the object-driven increase in motor facilitation may diminish quickly, at least when an ensuing movement is not immediately required.

The present study investigated if a wall-mounted safety handle results in facilitation of grasp relevant hand muscles. Here we attempt to bridge observations from past affordance research and determine if this concept applies when viewing a safety handle commonly used to avoid a fall. Presumably, in the same way that cup handles, tools or other objects engage specific motor representations – likely learned early in development [21] – a well-established link may similarly exist between a standard safety handle and grasping behaviour. To address this, TMS was used to capture the time-course for changes in corticospinal excitability (CSE) of hand muscles in response to viewing a safety handle located within a graspable range. We hypothesized that viewing the handle would result in greater CSE in the intrinsic hand muscles across all time points compared with trials where the handle was not visible.

To help us address our specific aim, several factors that have been established in past studies were used to inform a very focused research design. Previous affordance work provides a consensus view that objects affording a particular type of grasp produce rapid excitability changes in muscles that are involved in grasping the viewed object, but only when the object lies in close proximity to the individual. Based upon this foundation we streamlined our approach to address a specific set of questions. Namely, does viewing a wall-mounted safety handle produce an affordance effect measurable with single-pulse TMS, and when is this effect most prominent following access to vision? Such findings provide an important basis from which to later test the poten-

tial impact of affordances in the domain of reactive balance control using objects that afford a secure hand-hold.

2. Material and methods

2.1. Participants

A total of 25 young, healthy participants (13 Male, 12 Female) between 18 and 29 years of age (mean = 22.8 ± 2.9 years) were recruited from the student population at Utah State University. All participants provided written informed consent to the procedures prior to testing. All procedures received approval from the Institutional Review Board at Utah State University and were conducted in accordance with the Declaration of Helsinki. Participants with neurological illness were excluded from the study. Furthermore, participants were screened prior to testing to assess the suitability for TMS using guidelines developed by a consortium of experts [22].

2.2. Data acquisition

Electromyography (EMG) was recorded using Delsys DE-2.1 differential surface electrodes, which contain preamplifiers potted in polycarbonate enclosures (Delsys Inc., Boston, MA, USA). The electrode configuration includes 2 silver bars each 10mm long by 1 mm in width. EMG signals were amplified (gain = 1000) using a Delsys Bagnoli-4 amplifier (Delsys Inc., Boston, MA, USA). EMG data was sampled at 5000 Hz and bandpass filtered (10–1000 Hz) using Signal Software and a Cambridge Electronic device (Power 1401, Cambridge Electronic Design, Cambridge, UK).

EMG was collected from three intrinsic hand muscles and a forearm muscle. The intrinsic hand muscles measured were the First Dorsal Interosseus (FDI), Opponens Pollicis (OP), and Abductor Digiti Minimi (ADM) given the important role of these muscles in gripping objects and past TMS-based studies exploring hand affordance on intrinsic hand muscles [5–7,10]. In addition to grasp-related hand muscles, a wrist extensor (Extensor Carpi Radialis, ECR) was measured given the role of this muscle when initiating the reach to support handle from a resting arm position on the lap (observed during pilot testing).

2.3. TMS protocol

Single-pulse TMS was delivered over the hand motor cortical representation while participants completed the experiment. These TMS pulses were time-locked to the opening of liquid crystal goggles (described below) for all experimental conditions. The purpose was to investigate the influence on motor preparation immediately upon receiving visual access to the environment. Notably, TMS was delivered soon after visual access, but prior to any movement (in trials where movement was required). Recall that the essential feature of this study was the preparatory state of the motor system related to perception of the environment, which means that TMS pulses were not delivered at any time when the body was in motion.

Magnetic stimuli were delivered to the left primary motor cortex (M1) by a Magstim 200 (monophasic waveform) stimulator (Magstim Company Ltd., Whitland, UK). Stimulation was applied using a figure of eight D70² Coil (Double 70mm² Coil – Magstim Company Ltd., Whitland, UK), located at the optimal position to obtain a motor evoked potential (MEP) in representative muscles of the contralateral hand. Specifically, TMS pulses were delivered over the optimal site to elicit an MEP for the right FDI. The stimulating coil was oriented at approximately 45° to the sagittal plane, thus inducing posterior to anterior current flow across the motor strip [23,24]. To allow hotspot localisation and consistent coil placement markings were made directly on the scalp. Once this hotspot was located, the resting motor threshold

(RMT) was determined, a stimulator intensity where 5/10 MEPs exceed 50 microvolts peak-to-peak [25]. The test stimuli used throughout the experiment was set at 1.2x RMT.

2.4. Control of vision

Access to vision was manipulated in this study by use of liquid crystal goggles (Translucent Technologies Inc. Toronto, ON, Canada). These goggles can be programmed to open or close at very distinct time points, allowing a means for controlling the onset of visual stimuli in the environment. While closed, these goggles allow an illuminated view without access to the visual scene therefore participants were unaware of the upcoming response setting. During this visual occlusion period, the handle was covered or uncovered by the experimenter on each trial in a random order. Participants needed to quickly perceive and select their action once the goggles opened for viewing. Because some small amount of auditory noise coincided with adjusting the environment in front of the participant's field of view, noise-reducing earplugs were worn throughout all test sessions.

2.5. Experimental procedure

All testing was conducted with participants seated directly in front of a safety handle mounted on a wall, within comfortable grasping range (Fig. 1). Throughout testing, participants were told to remain relaxed with their hands resting on their lap while looking at the handle. They were instructed to move only when: (a) the handle was visible (i.e. uncovered) AND (b) if an auditory tone cued a reach to grasp the handle. Participants were briefly familiarized with reaching to the handle from a seated position prior to testing. Once testing commenced, they were instructed to remain as relaxed as possible unless prompted to move by imperative stimuli (i.e. presence of a handle and tone). Participants were encouraged throughout testing to reach as fast as possible upon hearing the tone when the handle was visible. Each trial started with the occlusion goggles closing for 6 s after which point the goggles opened to offer a full view. The visual response environment included one of two possible configurations: (a) handle visible (Handle), or (b) handle covered (No-Handle). When the handle was present, participants were required to reach-to-grasp the support handle with

Fig. 1. Seated reach-to-grasp. Participants were seated directly in front of a wall-mounted safety handle within graspable range. Visual access was controlled using liquid crystal goggles and the handle was unpredictably covered or uncovered while goggles were closed. TMS pulses were delivered shortly after the goggles opened, but prior to any movement cues. Note: Participants remained relaxed throughout testing with their hands resting on their lap unless instructed to reach for the handle by an auditory tone. This figure depicts the completed reach position in order to demonstrate the proximity of the participant to the safety handle, which was customized for each individual.

their right arm as quickly as possible once they heard the tone. TMS pulses were delivered at three different time points (80 ms, 120 ms, 160 ms) in separate randomized test blocks. Each block consisted of 45 trials which lasted approximately 10 min per block (135 trials total for the experiment). Each trial was 10 s with short pauses before the next trial to allow participants a chance to reset as needed. Furthermore, participants were given a brief rest period in between each test block. TMS pulses were always delivered after opening the goggles but prior to any auditory cues (if present). This cue was presented after the goggles opened with an onset delay of either 200 ms or 1500 ms. For one third of these trials, no auditory cue was presented acting as a 'catch' trial to prevent anticipatory reactions. In addition to the two visual conditions listed above, 'no-vision' reference trials were randomly interspersed throughout collection blocks to deliver TMS without opening the goggles. The purpose of this condition was to provide a baseline reference to account for any task-related changes in motor activity (e.g. heightened arousal). These reference trials also offered a baseline for normalizing MEP amplitudes in this study.

2.6. Data processing

Only trials where an appropriate behavioural response occurred were included in the analysis. An appropriate response was defined as 'reaching for the handle following the tone AND when a handle is visible'. Consequently, any trials where the participant either (a) reached for the handle when it was covered, or (b) reached prior to the tone – even if the handle was visible – were excluded. Background EMG was determined from the root mean square of EMG activity in a time window of 100 ms immediately prior to TMS onset. If background EMG in this time window exceeded 10 μ V for a given muscle, the trial was discarded. Moreover, any trials where a muscle produced a very small MEP amplitude (i.e. <100 mV peak-to-peak) were excluded. Finally, outliers were identified as those values falling outside the threshold defined by 1.5 times the interquartile range, and these outliers were excluded from further analysis.

MEP amplitude was determined as the rectified EMG area beginning at the positive EMG signal deflection for each hand muscle, and ending 50 ms post TMS (~15 ms–50 ms). To help standardize data, MEP amplitudes were converted into z-scores to reduce potential variability between test blocks within an individual, and to reduce inter-subject variability [26,27]. The mean and standard deviations of the MEP amplitudes during 'no-vision' trials for each test block were used as a reference, for each participant separately. The individual MEP amplitudes observed in the other two 'vision' conditions (handle, no-handle) were converted into z-scores calculated from this reference. These normalized values were subsequently grouped for statistical analysis. Note that all MEP analyses were limited to the intrinsic hand muscles (FDI, OP and ADM) whereas ECR was only be used to monitor reaching behaviour following the imperative tone. Our data revealed that the TMS over the hand representation resulted in comparable FDI and OP responses. Given the synergistic nature of these muscles they were averaged together to assess grasping affordance. Conversely, the ADM was analyzed separately consistent with the distinct role of muscle when performing different grip types [20] and further consistent with the disparate influence of an affordance effect on FDI and OP versus ADM [7].

2.7. Statistical analysis

Two-way, repeated measures ANOVA tested for main effects and interactions between the factors 'Handle' (Handle, No-Handle) and 'Time' (80 ms, 120 ms, and 160 ms). Specifically, two separate 2 $\times$ 3 repeated measures ANOVAs were completed for (a) FDI-OP_{average} and (b) ADM respectively. Paired *t*-tests were used to test the hypothesis

that the presence of an available handle would facilitate CSE in the hand muscles relative to trials where the handle was covered, with significance levels set at $p < 0.05$. To aid interpretation of the inferential tests of significance, Cohen's d effect size statistics were also calculated. This is a dimensionless index, which describes the degree of departure from no effect, in other words, the degree to which the phenomenon is manifested. A small effect size is conventionally considered to be a d of 0.2–0.3, a medium effect size is a d in the region of 0.5, and a large effect size is indicated by a d of 0.8 or greater [28].

3. Results

Behavioral responses revealed that participants initiated their reach to handle (determined via ECR onset) on average 234 ms (± 50 ms) following the imperative tone, producing 1.6 response errors per participant. The average stimulator intensity for RMT was 40.9% ($\pm 7.1\%$) maximum stimulator output, and 49.2% ($\pm 8.5\%$) of maximum stimulator output for the test stimulus (1.2x RMT). Repeated measures ANOVA revealed a significant interaction between the factors 'Handle' and 'Time' for FDI-OP_{average} ($F_{2,48} = 3.654$, $p = 0.033$) but no main effects for 'Handle' ($F_{1,24} = 2.532$, $p = 0.125$) or 'Time' ($F_{2,48} = 1.680$, $p = 0.197$). Follow up one-tailed, paired t -tests were used to test the directional hypothesis that CSE would be greater in the presence of a handle versus no-handle at each time point. These comparisons revealed that CSE was larger for the FDI-OP_{average} when TMS was delivered 120ms following visual access to the handle ($t_{24} = 2.042$, $p = 0.026$, $d = 0.452$), but not at the other time points (80 ms $t_{24} = -1.157$, $p = 0.129$, $d = 0.255$; 160 ms $t_{24} = 1.057$, $p = 0.151$, $d = 0.091$) (See Figs. 2A and 3A). Surprisingly, ADM exhibited a very different relationship when the handle was viewed. For ADM, viewing the handle was associated with lower amplitude MEPs across all time points, reflected in the main effect test for "Handle" ($F_{1,22} = 4.306$, $p = 0.049$). There was no significant interaction ($F_{2,44} = 0.332$, $p = 0.719$) or main effect for 'Time' ($F_{2,44} = 0.809$, $p = 0.452$) (See Figs. 2B and 3B). The observed relationship for 'Handle' was opposite to the main hypothesis, which originally predicted that MEP amplitudes would be greater for all muscles (including ADM) when the handle was visible. Accordingly, follow up comparisons between the two levels of 'Handle' at each 'Time' were conducted using two-tailed paired t -tests. These comparisons failed to reach significance in the presence of the handle versus no-handle condition for ADM at any time point following access to vision (80 ms $t_{22} = -0.945$, $p = 0.129$, $d = 0.17$; 120 ms $t_{22} = -1.834$, $p = 0.08$, $d = 0.328$; 160 ms $t_{22} = -0.583$, $p = 0.566$, $d = 0.089$).

4. Discussion

Rapid facilitation of intrinsic hand muscles emerged when participants viewed a wall-mounted safety handle relative to trials where the handle was covered. This visual priming was selective both in terms of the specific muscles activated and the timing at which it appeared. The FDI and OP muscles – synergists in bringing the thumb and fingers together for grasping – were facilitated 120ms after viewing the handle. Interestingly, this effect was absent at earlier (80ms) and later (160ms) points when TMS was delivered. Conversely, the ADM muscle – which abducts the little finger and is an antagonist to hand opposition – failed to show facilitation when viewing the handle, and was in fact diminished when the handle was present. These findings suggest a rapid and selective engagement of intrinsic hand muscles suitable for grasping a safety handle based on vision, and prior to any cue for movement. The fact that viewing graspable objects can lead to specific changes in cortical motor output has been demonstrated previously, however this is the first study to our knowledge that has directly as-

Fig. 2. Normalized MEP data. MEP amplitudes are depicted for the intrinsic hand muscles for all three time points (80 ms, 120 ms and 160 ms) for the FDI-OP_{average} (A) and ADM (B). The green circle represents trials where a handle is visible, and the red square represents when the handle is covered. Error bars show the standard error of the mean. * represents a significant difference ($p < 0.05$). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

sessed this affordance effect on a wall-mounted, safety handle commonly used to stabilize posture.

Cattaneo and colleagues observed unique preparatory patterns of motor cortical facilitation in ADM versus FDI related to different hand postures required to grasp either a disk or a handle [20]. In particular, FDI was facilitated relative to ADM when preparing to grasp a handle, but when grasping a disk this pattern reversed in a way which reflected distinct motor demands to manipulate each object (OP was not measured in their study). Remarkably, these opposing patterns of facilitation were absent when movements were not directed toward an object (i.e. when participants produced simple movements with the fingers, or when they mimicked the type of hand posture used to grasp a disk or handle). This suggested an important role for the viewed object parameters to inform the appropriate motor command. While these authors noted facilitation of FDI or ADM that related to object properties prior to movement, they failed to see any facilitation with observation alone. This would appear to conflict with present results. However, in their study, TMS was delivered 1200 ms after visual access, ten times later than when the effect was noted in the current study, suggesting that the affordance effect may quickly diminish or even be actively suppressed if irrelevant to the task. This is consistent with past findings by Prabhu et al. where the authors noted an object-driven modulation of CSE evident by 150 ms that was not sustained during a delay period, but emerged again shortly before the actual movement [19]. The previously discussed findings of Franca and colleagues [7] support the idea

Fig. 3. Difference in normalized MEPs based on viewing the handle for each subject. Positive values (green bars) represent cases where handle MEPs are greater than no-handle MEPs, whereas negative values (red bars) represent cases where the reverse is true. The figures are focused on comparisons where a significant difference was found in the group average data, namely for the FDI-OP_{average} at 120 ms (A) and the ADM collapsed across time (B). The dashed line in each figure represents the average difference across participants. (Note: participants 15 and 21 did not provide a reliable MEP for the ADM muscle and are therefore missing values in this graph). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

of a short-lived affordance effect which appears and then quickly dissipates when graspable objects are observed. In their study, participants viewed small objects that could be manipulated using a precision grip and TMS was delivered 120 ms, 150 ms or 180 ms following object presentation. They revealed vision-based activation of FDI and OP when stimuli were delivered at 120 ms (but not later) and not for ADM, both findings consistent with present results. Combined, these results may reflect a distinct role for FDI and OP in the grasping action with a very brief facilitation linked to vision, the duration of which is likely modified by task demands. Current data show that this affordance effect is not present by 80 ms, possibly reflecting a transmission limit in the visual influence on motor output.

The time course for the emergence of neural activity serving visual-motor transformations has been clearly demonstrated in non-human primate models [1–4,29]. These studies show distinct activation patterns in premotor and motor cortical neurons during tasks that require either movement toward an object, selection among motor options, and/or simple observation of objects without movement. While the specific tuning characteristics of different cells may vary (e.g. movement specific versus object specific), many respond differentially within ~100 ms of an imperative cue, indicating that characteristics of the viewed object can impact the motor system by this stage, at least in non-human primates. Perhaps most informative is the research by Ledberg and colleagues where they measured local field potentials at sev-

eral cortical sites in monkeys during a visual Go/No-go task [29]. The authors revealed a clear progression of activity throughout the cerebral cortex time-locked to the visual stimulus. Onset of visual stimuli resulted in activity in early visual processing sites as early as 50 ms post-stimulus, followed by premotor activity ~30 ms later (i.e. ~80 ms post-stimulus) and finally, activation of more traditional supervisory (prefrontal) sites. These findings suggest that early cortical activity specifies a range of potential movement options whereas subsequent activity represents the selection process [30]. Overall, this demonstrates how visual cues can prime relevant motor regions even before the decision to act and demonstrates a neural mechanism for how vision of the world can potentiate actions prior to a decision to move.

The aim of the current study was to determine if viewing a safety handle within graspable range could evoke motor output relevant for grasping the handle. Past studies have demonstrated an important role for compensatory reach-to-grasp reactions to establish a new support base using a stable handle following postural perturbation [31–35]. These reactions quickly target the hand to a nearby handle even when vision is occluded at the moment of perturbation, revealing that online visual guidance is not compulsory [31]. In fact, a handle visible only in the peripheral field of view can be used to effectively guide a compensatory reach-to-grasp [31,34]. The spatial-temporal patterns that underlie a voluntary reach-to-grasp are preserved in perturbation-evoked, reach-to-grasp reactions, which suggests that a common cortical net-

work drives both voluntary and perturbation-evoked reactions, despite the fact that compensatory arm responses are twice as fast [33]. Subsequent work has provided additional evidence for a cortical role in the compensatory arm response by temporarily disrupting output from the motor cortex and observing reduced hand muscle activity during both voluntary and perturbation-cued reach-to-grasp reactions [32]. The fact that the cerebral cortex plays a role in generating the early hand reaction to grasp a support handle, suggests that the same affordance effect that shapes voluntary grasping behaviour could bias specific arm recovery actions suited to our surroundings, and this may occur even before the need for such action. If suitable responses could be established prior to a fall, this would offer a viable solution for producing fast, yet contextually-appropriate compensatory reactions.

There are some limitations when attempting to relate the affordance effect observed in the present study to reactive balance control. Most obvious is the fact that participants were seated, thus any affordance effects may differ in a standing context, particularly when postural threat is involved. That said, we anticipate that any affordance priming would actually be amplified in such instances instead of being abolished, but this awaits experimentation. Another issue with translating current results to reactive balance control is our use of direct vision where participants are focused on a handle to target a voluntary reach. In daily life, safety handles presumably would be encountered in peripheral vision, thus it is unclear how this may impact our results. However, Makris and colleagues demonstrated that even images presented in peripheral vision can evoke an affordance effect [14], which suggests that centrally fixed visual stimuli are unnecessary. Another possible limitation in the present study is that our cue to reach for the handle is an arbitrary tone, versus the more salient and arousing cue to reach for a supportive handle to avoid falling. However, for our purpose, the actual cue to move is a secondary matter as the speeded Go/No-go task was only meant to focus attention on the handle. Finally, it should be acknowledged that the classical ‘canonical’ neurons [4] – the neurons activated by vision alone – are located within premotor cortex, a fact which does not necessarily translate into immediate activation of the primary motor cortex. However, fast-acting facilitation has been observed between the premotor and primary motor cortex in humans using paired-pulse TMS techniques [36,37]. This appears to be context-specific, but it seems probable that the affordance effect itself may engage such a functional link. Despite these limitations, we feel this study represents an important first step in bridging past affordance research to the field of reactive balance control. A key extension here is the use of a ‘real-life’ safety handle associated with maintaining balance, and the use of temporally precise TMS probes to reveal the time course for changes in motor cortical activity immediately post-vision.

5. Conclusion

Present findings reveal a rapid and selective engagement of intrinsic hand muscles suitable for grasping a handle based on vision. Moreover, these results are consistent with the concept of motor affordances where vision automatically translates viewed objects into appropriate motor terms. The fact that this affordance effect was present for a wall-mounted safety handle commonly used to regain balance has implications for automatically priming compensatory arm reactions based upon our surroundings, even before postural perturbation is detected. Such priming would theoretically offer a big speed advantage when generating compensatory limb movements to avoid a fall. Future studies will need to determine if this affordance effect occurs in a standing balance context and for handles presented outside of central vision. Moreover, future work should test if this effect emerges with simple observation and whether it is amplified under postural threat.

Declarations of interest

None.

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