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The benefit of external focus of attention preserved in the VR punching task regardless of haptic information

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Abstract

In punching a boxing bag, a salient source of information for the movement effect is the felt impact. Using virtual reality (VR), we manipulated the haptic information specifying the impact, to test if indeed the advantage of external focus relates to attention toward the movement effect. Twenty-four participants (18 males, 6 females) performed a punching task under both internal and external focus of attention instructions across two separate sessions. Participants wore a VR headset and punched a bag in two conditions: a virtual bag (without haptic information on the movement effect) and physical bag (with haptic information). Hand velocity at impact functioned as the performance measure. Linear mixed-effects model analysis revealed a significant main effect of attentional focus, with higher punching velocity under external compared to internal focus of attention. A significant main effect of bag was also observed, with higher velocity when striking the physical bag compared to the virtual bag. Critically, the interaction of attentional focus and bag condition was not significant, indicating that the advantage of external focus of attention was preserved regardless of the availability of haptic information related to movement effects. This finding challenges the explanation from common coding theory that the advantage of an external focus is due to its attention for movement effect. Rather, it is consistent with an ecological perspective that external focus is superior because it fosters attunement to task relevant information specifying the dynamic relation between the fist and the target.

Introduction

In striking-based combat sports, athletes use punches and kicks to breach an opponent's defenses. Achieving competitive success requires these strikes to be executed with both speed and power (Liu et al., 2021). While optimal performance depends on strength, coordination, and control of movement, verbal instruction particularly those directing focus of attention can significantly affect performance outcome (Halperin, Chapman, Martin & Abbiss, 2017). Extensive research across various tasks and sports, including punching and kicking in combat sports, has consistently demonstrated that adopting an external focus that directs attention to the effects of the movement on the environment (e.g., punch the target as hard as possible) enhances motor performance as well as learning more effectively than an internal focus that directs attention to the body movements themselves (e.g., move the arm as fast as possible) (Wulf, 2013; Halperin et al., 2017; Becker, Fairbrother, Couvillion, 2020; Chua et al., 2021; Asadi, Daneshfar, Maleki & Aiken, 2023; Sanjani, van der Kamp, Bahram & Savelsbergh, 2023; Noroozi et al., 2024).

Several theoretical perspectives have been proposed to explain why directing attention externally toward movement effects enhance performance and learning. The most widely cited is the constrained action hypothesis (McNevin, Shea & Wulf; 2003). It states that an internal focus of attention, which is associated with a higher degree of conscious control of movement, “constrains the motor system by interfering with automatic motor control processes that would ‘normally’ regulate the movement” (Wulf & Prinz, 2001, p. 1144). By contrast, an external focus of attention minimizes interference of conscious control, thus enabling the movement to self-organize more automatically and effectively (Wulf, 2013;

Wulf & Lewthwaite, 2016). The hypothesis has been supported by numerous studies, for example, studies show that compared to external focus of attention, an internal focus enhances cognitive load, reduces movement fluency, and increases muscle co-contractions (e.g., Becker et al; 2020; Kal et al; 2013; Lohse et al., 2010; Wulf & Prinz, 2001). However, the scope of constrained action hypothesis appears limited because it merely describes how an external focus of attention prevents performance disruptions through conscious control; it does not elaborate how directing attention to the effects of movement increases performance and learning. In other words, while the constrained action hypothesis can explain why instructions invoking an external focus of attention leads to superior performance and learning compared to internal focus of attention instructions (or conversely, why internal focus instructions are less effective), it provides less ground for the common observation that external focus instructions are also advantageous relative to performance and learning without attentional instructions. This suggests that alternative or additional explanations are needed to understand why an external focus is beneficial than other foci in various conditions.

Originally, the benefits for an external focus of attention on the movement effects were also explained within the common coding theory (Prinz, 1997; Wulf, Höß, & Prinz, 1998; Wulf & Prinz, 2001). Basically, the common coding theory postulates that actions are planned and controlled in terms of the anticipated perceived effects of the movement. This follows from the idea that perception and action share a common representational domain, thereby circumventing the problem of representational theories that sensory and motor codes have different content, and consequently, that coordinating perception and action requires transformation or translation. In common coding, this incommensurability problem is solved by assuming that actions are planned and controlled in terms of their distal effects, because it is on this abstract level that perception and action converge (Prinz, 1997; Wulf et al, 1998). An external focus of attention toward the movement effects is hypothesized to be advantageous because it perfectly aligns with how actions are planned, controlled, and represented (Wulf et al., 1998; Wulf & Prinz, 2001).

It follows from common coding theory that the benefits of an external focus of attention would relate to the availability of information specifying the anticipated perceived effects the movement. In striking tasks, such as punching, the effects of the movement correspond to the perceived impact of the punch on the target. The impact is not only specified optically but also haptic information is particularly salient. Accordingly, the haptically felt impact potentially is a task-relevant source of information for the planning and control of punching movements. In punching, therefore, the hypothesis that an external focus of attention benefits performance and learning because it aligns with how actions are planned and controlled, can be tested by manipulating the haptic information generated during impact. The current study achieves this by having participants perform in a virtual reality (VR) environment.

In VR performers are immersed within an interactive computer-generated environment. This allows the researcher to systematically control information that specifies interactions with the environment, including information about movement effects. Only a limited number of studies have examined attentional focus in VR, while most of them did not carefully associate an external focus with the movement effect or outcome. Cochran et al. (2021) had participants perform a single leg jump as far

and as close as possible to a cone (at 5m). Indeed, the participants jumped larger distances with this external focus of attention. Further, Yamada et al. (2021) had participants move a virtual cube between two virtual targets. Performance accuracy was higher when participants were instructed to focus on moving the cube compared to when they were told to focus on moving the arm accurately, showing that external attention is also more effective in VR environments. Finally, in a rehabilitation setting, Kragting et al. (2024) documented that asking participants to search for hidden birds in the virtual environmental increased the head range of motion compared to asking them to maximally rotate their head. The authors interpreted this as showing advantage for external focus, but their instructions did not, strictly speaking, refer to the effects of movement in the environment. These studies provide evidence that the benefits of external focus of attention hold in VR environments, but crucially for our purposes, they did not systematically manipulate haptic information specifying the effect of movement.

In fact, because in aiming tasks the location of the anticipated movement effect coincides with the target location there is yet another plausible explanation for the benefits of an external focus of attention, also in the absence of haptic movement outcome information. Ecological psychology holds that actions emerge from a continuous coupling between information and movement (Warren, 2006). Performance accuracy is achieved when a performer attunes or directs attention to task relevant specifying information (van der Kamp & Renshaw, 2015). Accordingly, any benefit of an external focus of attention could arise from directing attention to information that specifies the dynamic relation between performer and target (Herrebroden, 2023; Peh, Chow, & Davids, 2011; van der Kamp, Oudejans, & Savelsbergh, 2003). In moving a cube to a target (Yamada et al., 2021) or in punching (Sanjani et al., 2023), this would relate to information that specifies the closing distance and speed between cube or fist and the target, as these ensures aiming accuracy as well as a controlled impact (i.e., minimizing or maximizing impact depending on the task constraints (Marchant et al., 2009). This information is by and large optically available, also in VR environments.

In this study, we compare punching performance in an immersive VR environment with an external focus instruction that directs attention to movement effects (i.e., hit the bag as hard as possible) to performance with an internal focus instruction directing attention to movement execution (i.e., move the arm as fast as possible). We manipulate the availability of haptic information related to impact by creating two conditions: a VR environment with a virtual boxing bag only and no physical boxing bag (i.e., VB-condition), which forecloses haptic impact information; and a VR environment with a physical boxing bag at the same location as the virtual bag (i.e., PB-condition), which does provide haptic information at impact. The visual environments and optical information are identical in the two conditions. According to common coding theory, taken away information about the anticipated movement effect will disrupt planning and control of the action. Hence, it can be hypothesized that in the PB-condition, where haptic impact information about movement effect is available, an external focus of attention instruction would enhance performance relative to internal focus of attention instruction, while in the VB-condition, where haptic impact information is absent, this performance advantage for an external-focus instruction would be reduced or disappears. By contrast, based on ecological psychology, the implicated prospective information that optically specifies the unfolding relation between performer and target is continuously

available in both conditions, and thus an external focus of attention instruction would be predicted to enhance performance in both conditions.

Method

Participants

An a priori power analysis was conducted using G*power3.1 to determine the required sample size for 2 within factors (focus instruction: internal, external) and (bag condition: virtual bag (VB), physical bag (PB)). The analysis was based on effect size (f = .25), alpha level of .05, and a statistical power of (1 − β = 0.80). The results indicated that a minimum of 24 participants would be required to reject the null hypothesis. A total of 24 healthy adults (18 males, 6 females) were recruited through social media advertisements, contact with coaches, and direct communication with athletes at local gyms. Participants were required to be at least 18 years old, healthy, free from any upper or lower-body injuries, and to have a minimum of one month of experience in boxing, kickboxing, or training using a punching bag. All participants were naïve to the purpose of the experiment. Participants, on average, had 3.5 years of boxing experience (SD = 4.5 yrs; range 1 month to 16 years). Participants practiced boxing on average 2.0 hours per week (SD = 2.5 hours). Among 24 participants, 21 participants reported right hand dominance, while the remaining participants were left hand dominant. The study protocol was approved by the local ethical review committee (VCWE-2025-071) and all participants signed informed consent before the start of the experiment.

Equipment

Punching bag

A portable, free-standing punching bag (height = 157 cm, diameter = 60 cm) was used in the experiment. The bag had a synthetic leather surface, and it was securely fixed against the wall to minimize movement during impact and maintain spatial alignment with the location of the virtual bag across trials and conditions. The punching bag height was adjustable, such that the middle of bag could be aligned with the participants' chest level.

Virtual reality

HTC Vive virtual reality headset (HTC Corporation, Taiwan) was used to present the custom-made experimental environment. The VR scenario was developed and programmed using Unity software (Unity Technologies, USA). The virtual environment consisted of a punching bag and a designated area that indicated the distance of the participant from the bag. The system used two HTC Vive tracker 2.0, standard HTC Vive handheld controllers, and two base stations for motion tracking. One tracker was attached to the wrist of the dominant hand, while the second tracker was placed on the floor and linked to the spatial location of the virtual punching bag. The sampling frequency of the trackers was 80 Hz.

This set up ensured that in both the PB-condition (i.e., with a physical bag spatially aligned to the location of the virtual bag) and the VB-condition (i.e., with only the virtual bag present and the physical bag being removed) participants had identical optical information about target and fist locations. There were no visual effects related to impact such as bag displacement (i.e., it was for this reason the physical bag was fixed against a wall), and the VR headset produced white noise to cancel auditory information about impact. Critically, in the PB-condition, the participant got haptic information during impact with the bag (i.e., tactile deformation upon contact and encountering resistance against the motion of the hand and arm), whereas in the VB-condition this haptic information was removed. Thus, the two conditions differed only in the availability of haptic information about impact.

To calibrate the locations of the physical and virtual bags, we first used the HTC Vive controller. Seven points on the surface of the real bag (i.e., four on the top circular surface, two on the upper and lower edges, and one at the top centre) were sampled. These points were used to fit a 3D geometric model of the bag (i.e., estimating its center, radius, and height) in tracking-space coordinates. The same model was then represented at the corresponding location in the VR environment, so that the virtual bag's position and orientation exactly aligned with the position and orientation of the physical bag.

We also recorded the 3D position of the middle knuckle and shoulder acromion of the dominant arm and used the distance between these markers as an estimate of arm length. This arm-length estimate was used to place a small virtual sphere at a fixed distance in front of shoulder (set at 87% of the arm length to the centre of the bag), which defined the required starting position for each punch.

Instruction Compliance and Feeling presence questionnaires

To assess instruction compliance, participants were asked to answer two questions after completing each condition. 1) Were you able to focus your attention on the given instruction? 'Yes' or 'No'; 2) How much of time were you able to adhere your attention to the given instruction? For this question, participants rated adherence on a visual analog scale (VAS) ranging from 0 to 100, where 0 indicated not at all successful and 100 indicated very successful. This compliance measure was adopted from previous studies (Beker et al., 2019; Sanjani et al., 2023).

To compare participants' sense of presence in the PB-condition and the VB-condition, participants were asked to rate their feeling of presence immediately after completing both experimental sessions. To this end we adopted on item from the Presence Questionnaire (Slater, Usoh & Steed, 1994): "To what extent were there times during the experience when the virtual environment was the reality for you?". Responses were recorded on a seven-point Likert scale, ranging from 1 (not at all) to 7 (very much so).

Procedure

The experiment was conducted across two separate sessions within one week, with at least one day between sessions. Each session was dedicated to one attentional focus condition (i.e., internal, or

external) with the order of attentional focus conditions counterbalanced across participants. At the beginning of the first session, participants received general information about the study procedures and safety guidelines and provided written informed consent; no attentional focus instructions were mentioned at this stage to avoid biasing any condition. They then completed a demographic questionnaire.

Participants performed a five-minute warm-up, which included upper body stretching and light aerobic exercises. After calibrating the Virtual reality set up, participants were asked to punch two to three times in both the PB- and VB-scenario's to get familiar with the set-up and to ensure accurate calibration of the distance of the participant and the bag and the alignment of the virtual and physical bags. The PB-condition was defined as the condition in which the virtual bag was spatially aligned with the physical bag, enabling the participants to make physical contact with the bag (Fig. 1B). The VB-condition was defined as the situation in which only a virtual bag was present, and the physical bag was removed (Fig. 1C). In the VB-condition, participants struck the virtual bag displayed in the VR environment, effectively punching into an empty physical space in front of them. The participants wore HTC Vive head mounted display during the entire session. The standing location of the participant was indicated by a green square in the virtual environment, and the participant was instructed to stand on the square with their feet parallel to constraint the amount of force imposed on the bag. The starting position of the hand for each punch was in front of the shoulder and was marked by a transparent virtual sphere to ensure consistency across all conditions.

Participants performed two sessions, one with an internal focus of attention instruction and one with an external focus of attention instruction. In both sessions, the participant performed in both the PB-condition and the VB-condition with five minutes rest period between conditions to minimize fatigue effect. The order of conditions was counterbalanced among participants for each session, but the same across sessions for individual participants. Focus of attention instructions were pre-recorded and played by the VR headset speaker. After the instruction participants delivered a straight punch toward the bag. The attentional focus instructions were provided in Dutch or English, depending on the participant's native language. These instructions were the same as the validated instructions in the study of Sanjani et al. (2023). For the external focus of attention participants were instructed to 'focus on hitting the target as hard as possible' and in the internal focus of attention, participants were told to 'focus on moving the arm as fast as possible'. Immediately after completing each condition, participants filled the Instruction Compliance questionnaire to assess adherence to the attentional focus instructions. At the end of both experimental sessions, participants completed the Presence Questionnaire to assess their sense of presence for both the PB-condition and the VB-condition.

Data analysis

Instruction compliance and presence questionnaire

The mean of instruction compliance scores was calculated. This score represents the percentage of time that participants reported to successfully adhere to the instructed focus, in each of four conditions. For assessing presence, in the PB-condition and the VB-condition the mean score on the seven-point Likert scale was calculated.

Hand velocity at impact

Hand velocity at impact was computed from the positional data of digital marker at knuckle. For each trial hand velocity at impact was defined as the velocity at the final sample of the movement window, which was bounded by punch onset and impact. Movement impact corresponded to the moment when the knuckle marker first crossed the surface of the virtual bag (i.e., making contact with the bag). The same calculations were used in both conditions. An analysis of a subsample of the data showed that the resulting hand velocity correlated very highly with the hand peak velocity, which is sometimes also used as an index for impact (see e.g., Sanjani et al., 2023).

Statistical analysis

Statistical analyses were performed using Python (statsmodel package). The data of one participant in internal focus condition were missing due to the data collection error. The assumption of normality was checked using Shapiro-Wilk test. For instruction compliance and hand velocity at impact linear mixed model analysis was applied. This model includes all available data without excluding the participant with missing data points. In each analysis, focus instruction and bag condition and the focus instruction by bag condition interaction were included as a fix effect. Participant was included as a random effect. As participants' level of experience varied between subjects, the experience in years was included as a covariate to control for interindividual differences in baseline performance. The statistical significance was assessed using Wald z-tests and the models were estimated using restricted maximum likelihood (REML) estimation. For the sense of presence, which involved a comparison between PB-condition and VB-condition a paired-sample t-test was performed. Significant interactions were followed up by t-tests with Bonferroni adjustments.

Results

Instruction compliance

All participants answered, 'Yes' in response to the question of 'Were you able to focus your attention on the given instruction?' A linear mixed model analysis for the instruction compliance ratings revealed no significant main effect of focus instruction, b = 1.87, SE = 3.77, Z = 0.49, p = 0.62, 95% CI [– 5.53, 9.28], bag condition, b = 1.25, SE = 3.77, Z = 0.33, p = 0.74, 95% CI [-6.15, 8.65] and the interaction of focus instruction and bag condition, b = 4.58, SE = 5.34, Z = 0.85, p = 0.39, 95% CI [-5.88, 15.05].

Sense of presence

A paired-samples *t*-test showed that the sense of presence was significantly higher in the PB- condition (M = 5.04, SD = 1.70) than in the VB-condition (M = 3.37, SD = 1.40), t(23) = − 3.53, p = .002, d = 0.72.

Hand velocity at impact

A linear mixed-effects model analysis for velocity at impact revealed a significant main effect of focus of attention b = − 0.68, SE = 0.13, z = − 5.08, p < .001, 95% CI [− 0.94, − 0.41], indicating that participant punched with higher velocity in external focus of attention compared to internal focus. There was also a significant main effect of bag condition, *b* = 0.89, *SE* = 0.13, *z* = 6.79, *p* < .001, 95% CI [0.63, 1.15], showing that participant punch with higher velocity in the condition with the physical bag present compared to when the physical bag was removed (i.e., when punching in empty space). The interaction between focus of attention and bag condition was not significant, *b* = 0.05, *SE* = 0.18, *z* = 0.30, *p* = .75, 95% CI [− 0.31, 0.42], which means that the advantage of external focus of attention over internal focus was similar in the physical bag and virtual bag conditions.

Discussion

In this study, we examined whether the advantage of an external focus of attention depends on the availability of movement-effect information, as predicted by common coding theory (Prinz, 1997; Wulf et al, 1998; Wulf & Prinz, 2001). To test this, we manipulated the presence of haptic information about the movement effects in a virtual reality punching task by removing or adding a physical boxing bag. Based on common coding theory, we hypothesized that the performance benefit of an external focus of attention would manifest itself when haptic information specifying the effect of the movement was available. Specifically, in the condition where a physical bag was present, directing attention externally toward the movement effect—primarily supported by salient haptic information about impact—was expected to enhance punching velocity relative to an internal focus on body movements (Halperin et al., 2017). In contrast, in the condition where only a virtual bag was present, this advantage was expected to be reduced or eliminated.

The results did not support this hypothesis. Instead, and contrary to predictions that we derived from common coding theory, findings showed that an external focus of attention enhanced punching performance in both conditions, and that the advantage of external focus was not contingent on the availability of haptic information related to the movement effect. Although removing a salient source of movement-effect information in the virtual bag condition reduced punching speed and perceived presence, it did not attenuate the relative benefit of external focus. These findings raise questions about the hypothesis that the performance advantage of external focus is driven by information on the anticipated effect or outcome of the movement.

From an ecological psychology perspective, skilled action is guided by the perception of prospective task-relevant information that specifies opportunities for action in the environment (Gibson, 1979; Michaels & Carello, 1981). Importantly, even in the absence of haptic information related to movement

effects, optical information specifying the performer–environment relationship—possibly related to the changing distance and time to contact with the intended target on the bag—remained continuously available in the virtual bag condition and was similarly available in the physical bag. Visually directing attention externally toward the target may therefore have facilitated attunement to these informational variables to guide the punching action compared to focus on the limb movements (Herrebroden, 2023; Peh, Chow, & Davids, 2011; van der Kamp, Oudejans, & Savelsbergh, 2003. As a result, the advantage of an external focus of attention was not disrupted even when haptic movement-effect information was unavailable.

Nonetheless, one may argue that participants may have shifted their attention inward when the physical punching bag was removed. Although such an interpretation may appear inconsistent with the reported adherence to both attentional instructions in virtual bag condition, the substantial reduction in performance observed in the virtual bag condition suggests that attention may have been unintentionally or unknowingly directed toward movement execution. This inward attentional shift may have increased conscious control over movement processes and disrupted movement automaticity, consistent with Wulf's constrained action hypothesis. Such a mechanism may also account for the overall performance decrement observed in virtual bag condition relative to the physical bag condition. Accordingly, within the framework of the constrained action hypothesis, an emerging internal focus may have impaired performance during punching in virtual bag condition. Confirmation of this alternative hypothesis requires future kinematic and electromyographic (EMG) investigations to objectively assess changes in movement automaticity associated with different attentional focus conditions.

The presence of a physical boxing bag significantly enhanced overall punching performance, likely also due to factors beyond information pickup for movement planning. When striking the physical target, participants could fully commit to the movement, confident that impact would be safely absorbed by the bag (Li et al, 2025; Berger et al, 2018; Zhang et al, 2018). In the virtual-only condition, the absence of a physical target may have induced protective movement regulation, with participants subconsciously limiting punch velocity to avoid joint overextension or potential injury. Thus, while external focus supported effective performance in both conditions, haptic information may have enhanced absolute performance by increasing task representativeness and allowing performers to exploit their action capabilities more fully and safely (Pinder et al, 2011).

For VR-based training, this suggests that training environments designed to improve punch speed and power should incorporate a strategy to appropriately direct attention as well as make available haptic information or feedback to preserve representative affordances and support maximal performance expression. In this respect, ecological psychology contends that early stages of motor learning are primarily, but not exclusively, driven by the discovery and differentiation of task-relevant perceptual information, rather than by maximal force production or impact feedback (Jacobs & Michaels, 2007). Accordingly, for individuals in the initial phases of skill learning, VR environments without haptic information may support exploration and stabilization of basic movement patterns. However, as learners progress, haptic information likely becomes increasingly important to optimize performance, such as

calibrating movement to information to achieve maximum force at impact. To examine this more precisely, future studies should incorporate kinematic measures of movement coordination, and ground reaction forces and investigate how these interact with different skill levels and focus of attention.

Several methodological considerations should be highlighted when interpreting and generalizing the present findings. First, the study focused on immediate performance outcomes rather than motor learning. Although haptic information from a physical bag may facilitate adaptation and calibration processes during extended practice, these learning-related effects were not examined here and should be addressed in future research. The same is true with respect to the advantage of external focus of attention. The present study cannot rule out that on the longer time scale for learning the advantage of external focus does implicate haptic information. Second, while individual variability related to skill level and boxing experience was statistically controlled in the performance outcomes, these factors were not systematically manipulated or examined. Given that skill level may influence how performers direct attention and use information, future studies should more explicitly control and stratify participants based on expertise. Finally, performance assessment was limited to impact punch velocity, without accompanying measures of movement coordination or force production. Incorporating detailed kinematic and kinetic analyses would allow for a more precise understanding of how attentional focus drives motor performance and learning. An additional limitation is that effect-related information was not completely eliminated in either the virtual or physical bag conditions. Although haptic impact information, which we presumed to be the primary and most salient information source for impact, was absent in the condition without bag, participants still had access to optic information specifying the movement target, and consequently, about the position of the hand relative to the target at impact. As such, the findings cannot conclusively demonstrate that information about movement-effect is not involved at all in mediating the advantage of an external focus of attention. In fact, an alternative explanation for the present findings, upholding predictions of common coding, is that haptic information does not represent the dominant information source for impact. This can be tested by independently manipulating both haptic and optic impact information.

In conclusion, the current findings challenge the prediction that external focus of attention benefits access to information about the effect of the movement as is predicted by common coding theory. Rather, we suggest that in line with ecological psychology, an external focus direct attention to specifying information. In addition, the results provide practical recommendation for conditions under which coaches can incorporate VR to enhance athletes' performances.

Declarations

Author Contribution

Faezeh Mohammadi Sanjani and John van der Kamp conceptualized and designed the study, with John van der Kamp supervising the project. Faezeh Mohammadi Sanjani conducted the experiments, collected the data, and performed the statistical analyses. Dominic Orth assisted with designing the

virtual reality environment and provided support with data analysis. Faezeh Mohammadi Sanjani and Moslem Bahmani jointly drafted the introduction and discussion sections. John van der Kamp and Dominic Orth then edited and revised the drafted manuscript. All authors reviewed and approved the final version.

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Figures

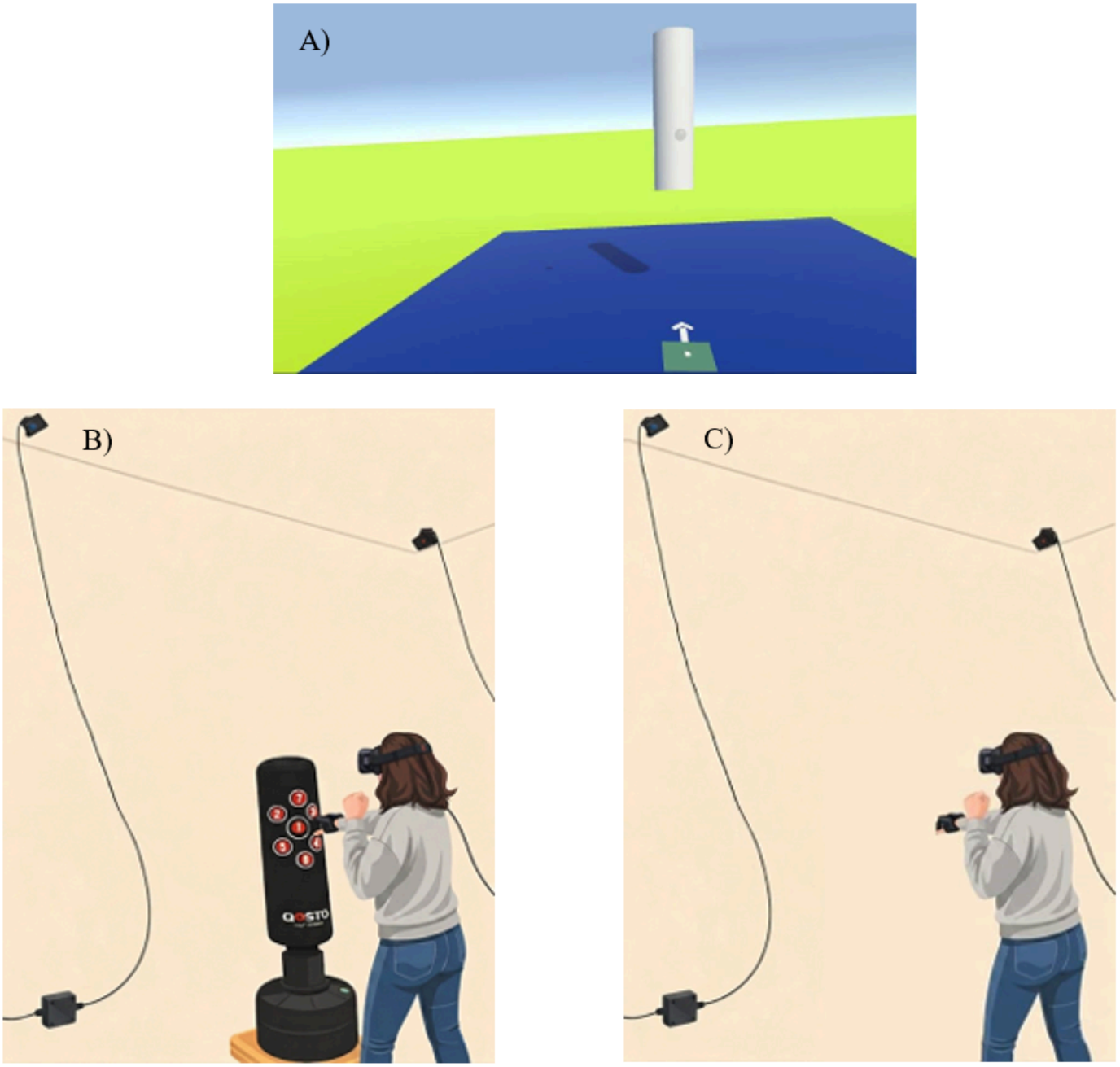


Figure 1

A) The VR environment displayed in virtual reality headset and as seen by the participant. B) Virtual reality condition and C) physical bag condition.

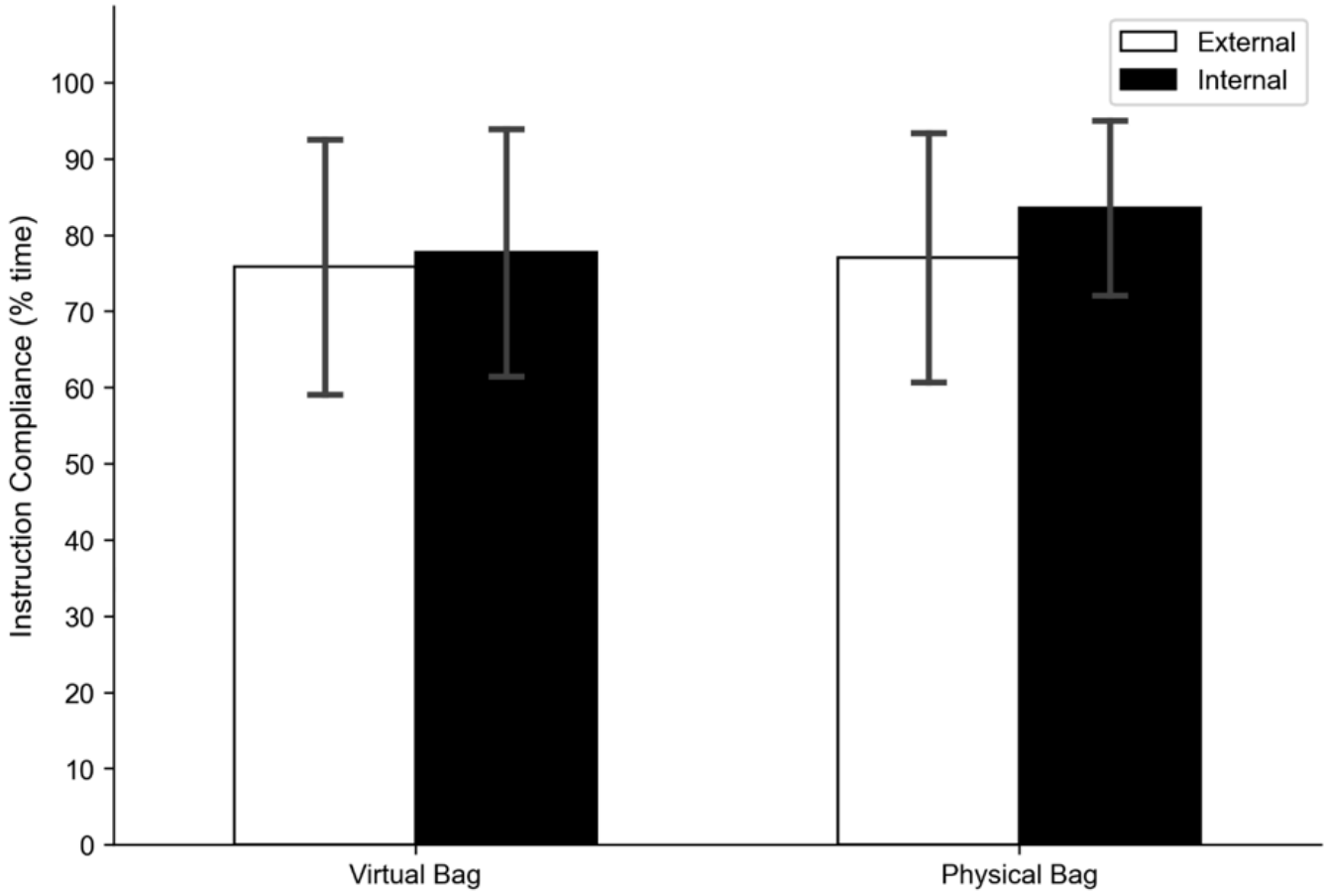


Figure 2

Means and SDs of instruction compliance as function of focus of instruction and bag condition. VB refers to virtual bag and PB refers to physical bag.

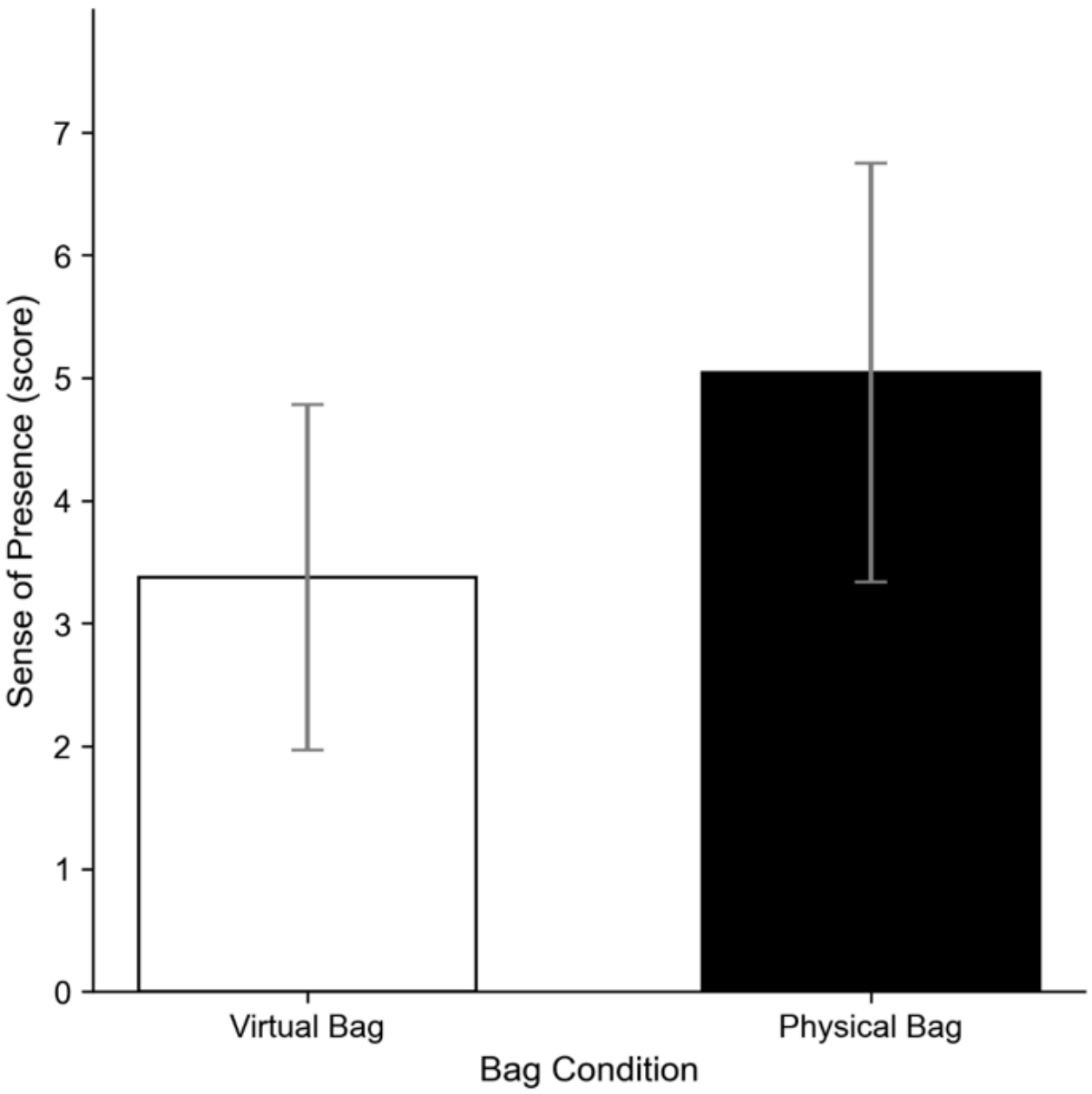


Figure 3

Means and SDs of sense of presence as a function of bag condition. VB refers to virtual bag and PB refers to physical bag.

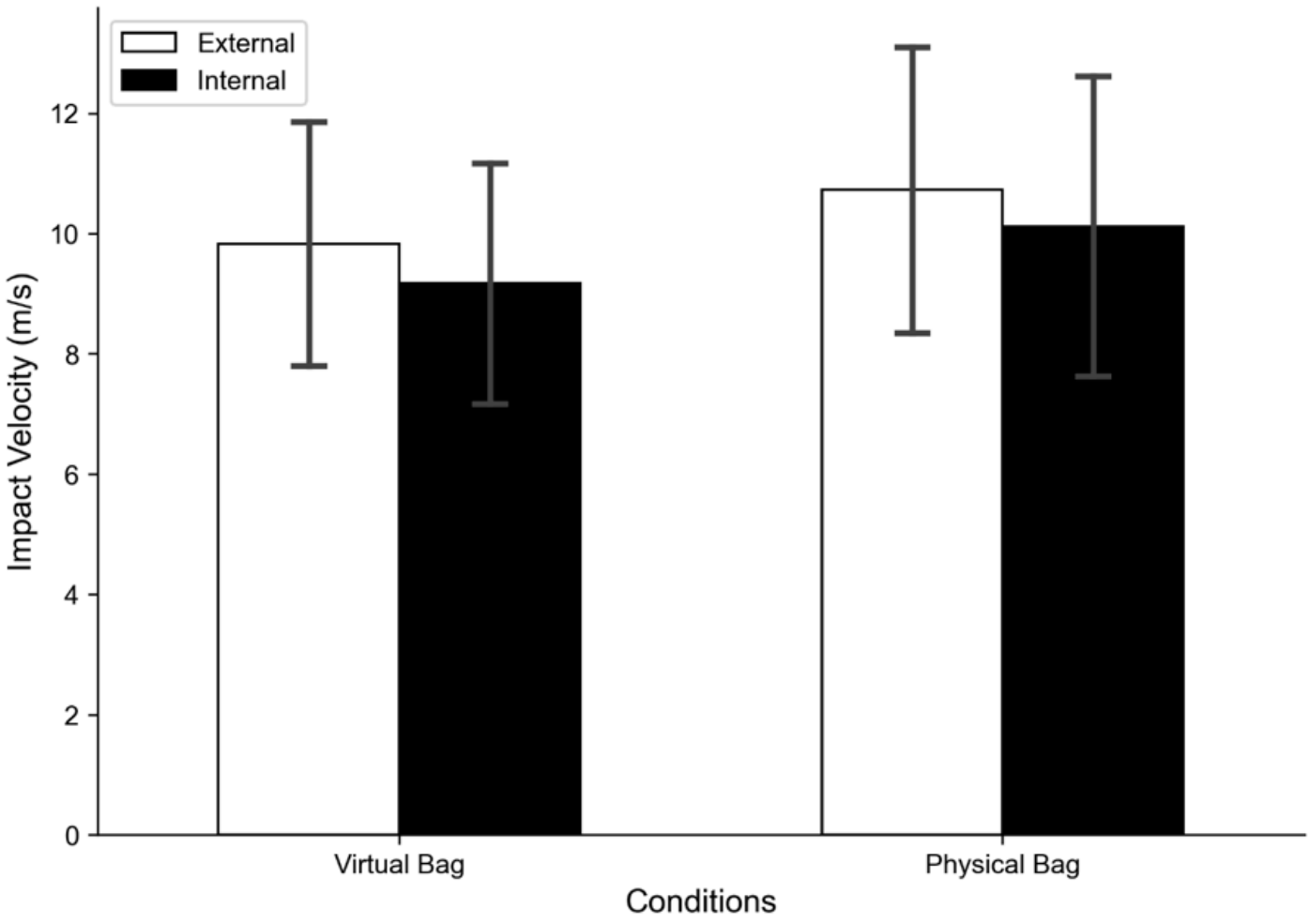


Figure 4

Mean (and SD) of impact velocity by focus of attention and bag condition. VB refers to virtual bag and PB refers to physical bag.