Embodiment in a Strong Virtual Body Influences Weight Lifting Endurance

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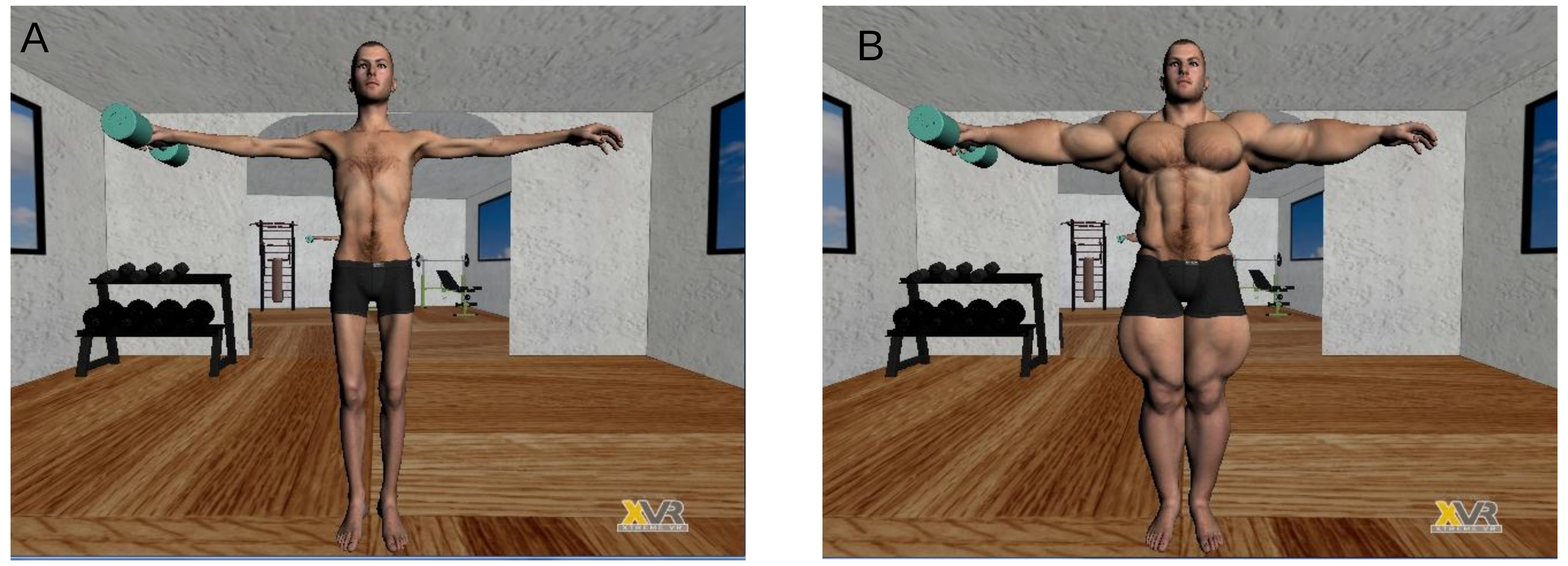
Recent research has shown that appropriate multisensory stimulation can quickly generate the illusion in people that their body has changed in some significant way, for example as shown in the rubber hand illusion (1). Similar multisensory techniques have also been applied to illusory body ownership of a manikin seen from third (2) or first person perspective (3) using video streamed through head-mounted displays, and also of a virtual body experienced in immersive virtual reality (4). However, although the evidence is strong that illusory body ownership occurs, no attention has been paid to the psychological and behavioural consequences of illusory ownership over a body that is quite different from the real body. When someone is immersed in a virtual environment with a body form that is substantially different from their own, do they exhibit concomitant attitudinal or behavioural changes? We addressed this issue by considering the consequences of virtual body ownership on weight lifting endurance time. The virtual body was either very weak or very strong looking. Our aim was to investigate whether body ownership over a very strong or very weak looking virtual body would influence weight lifting endurance time.

METHODS

Thirty four men were recruited for an experiment carried out in two phases several days apart. In both they entered a virtual reality through a wide field-of-view high-resolution stereo and head-tracked head-mounted display with full body tracking. In phase 1 they raised a weight of 1.5Kg in their right hand for as long as possible, and the time (*t0*) was recorded, but they saw only a virtual representation of the weight, without a virtual body. They were then split into two (*BodyType*) groups of n=17: Weak VB (WVB) and Strong VB (SVB). In phase 2 they saw themselves from first person perspective and in a virtual mirror with the SVB or WVB. After several minutes of adaption to the body, they were asked to hold up a virtual weight that was registered with the same real object, and their endurance time (*t1*) was recorded (Figure 1). A questionnaire recorded the strength of their body ownership illusion.

There was no significant difference between the groups with respect to age, weight or height, or the extent to which they played video games, and all were right-handed. They had no prior experience of virtual reality.

A critical question in the post-experience questionnaire was "*Even though the virtual body I saw did not look like me I had the sensation that the virtual body I saw was my body.*" This was scored on a 1-7 Likert scale where 1 = "Strongly Disagree" and 7 = "Strongly Agree". There was no significant difference between the WVB and SVB groups on this question (P > 0.40).



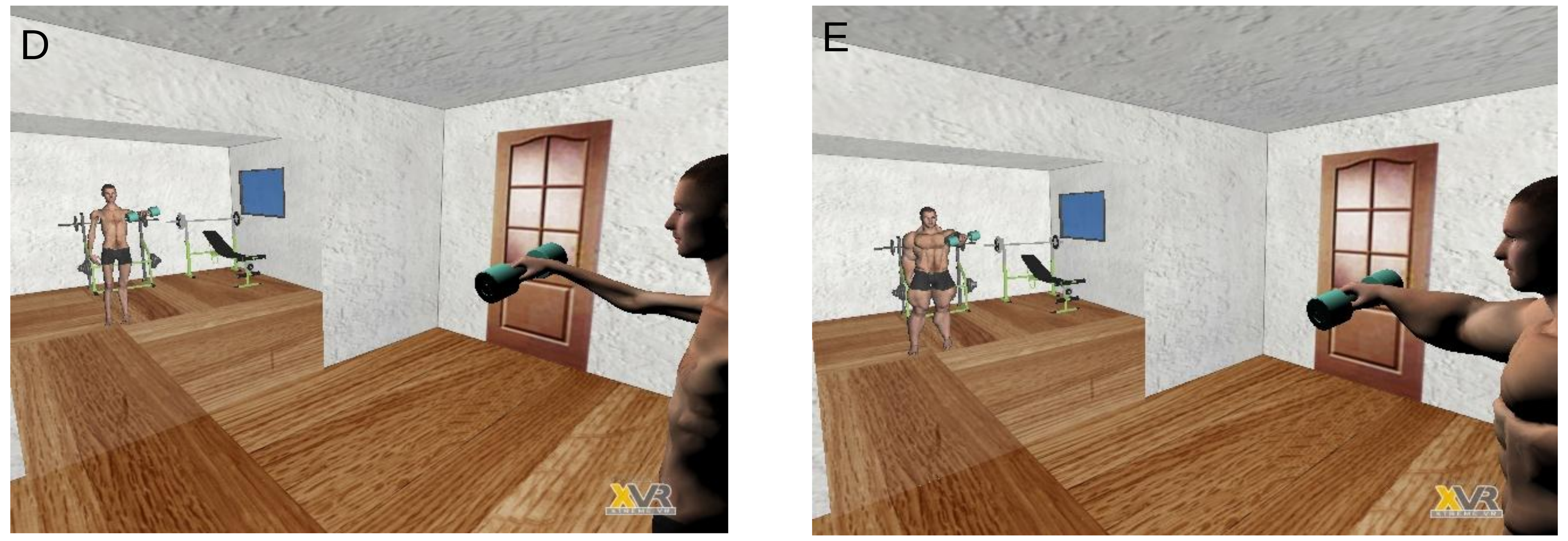
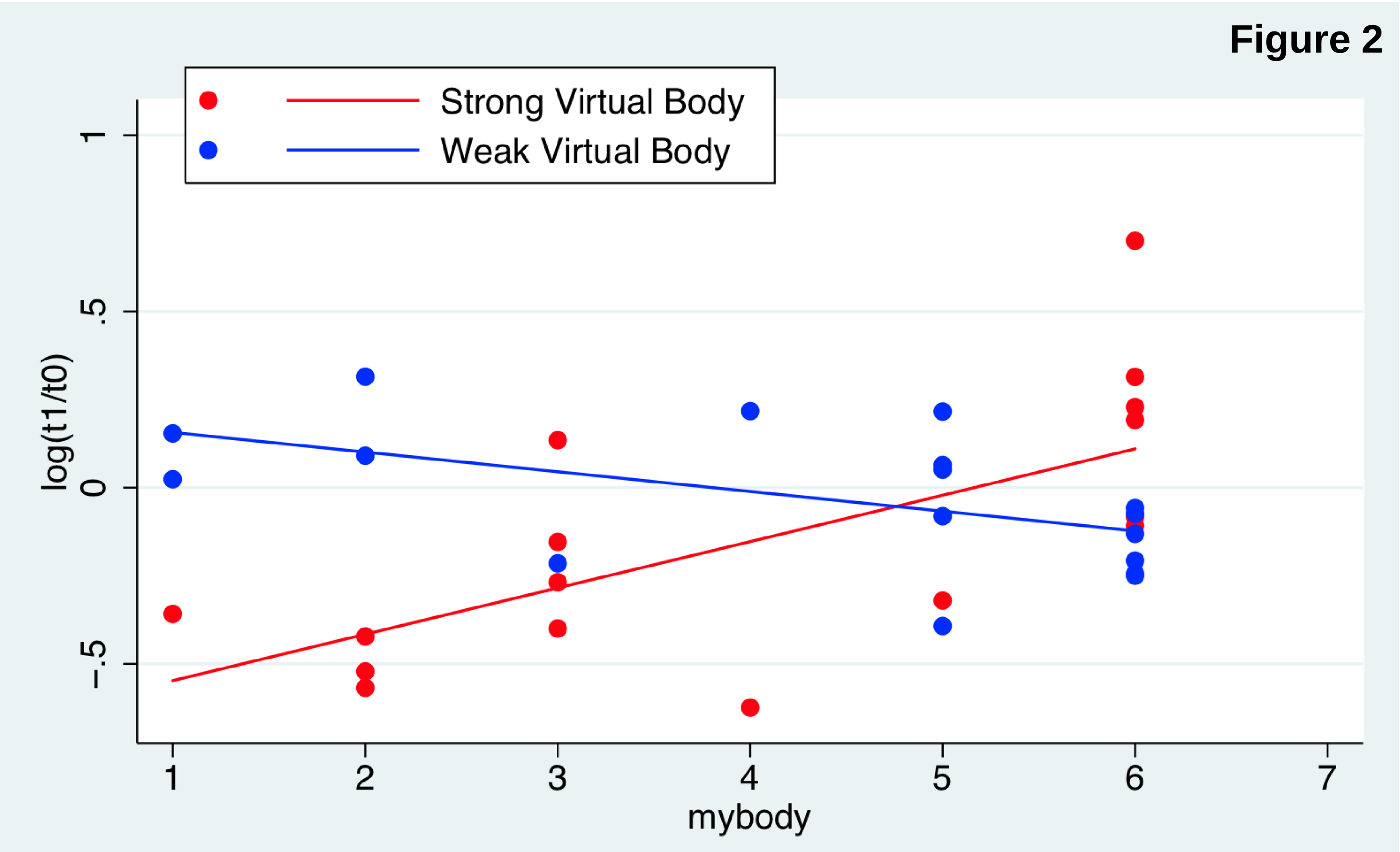


Figure 1 – The Experiment (A) Weak virtual body. **(B)** Strong virtual body. **(C)** In phase 1 participants saw the virtual weight while holding the true physical weight and their endurance time (*t0*) was recorded. In phase 2 participants were embodied from a first person perspective in either a **(D)** weak or **(E)** strong virtual body which moved synchronously with their real movements. They held up the weight for as long as possible and the time *t1* was recorded. They also saw a reflection of their body in a virtual mirror.

RESULTS

The main response variable was log(*t1*/*t0*). Analysis of Variance of this on *BodyType* showed no significant difference between the mean log ratio of endurance times of the two groups (P = 0.28, and the residual errors of the model satisfied normality). However, the subjective level of body ownership had a large influence. Figure 2 shows the plot of log(*t1*/*t0*) on the body ownership question, by *BodyType*. This suggests that there is a differential response depending on the type of body. Analysis of Covariance shows that the two slopes and intercepts are all significant (each P < 0.0005), and the residual errors satisfy normality. For those in the WVB the greater the degree of virtual body ownership the lower the change in the endurance time, with the opposite the case for those in the SVB.



Scatter diagram of log(t1/t0) by body ownership.

CONCLUSIONS

- Simply displaying a strong or weak virtual body, even from first person perspective, does not by itself cause a change in performance between the two groups.
- The critical factor is the level of the illusion of ownership over the virtual body – the highest levels of ownership over a strong body lead to enhancement of performance with respect to the baseline condition.
- The induction of a virtual body ownership illusion, in this case by visual-motor synchrony, may when successful, lead to temporary changes in behaviour, attitudes or in this case performance, concomitant with the form of the virtual body.

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