

# The Effect of Lip and Arm Synchronization on Embodiment: A Pilot Study

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## ABSTRACT

We are interested the effect of lip and arm synchronization on body ownership in VR (the illusion that the users own a virtual body). Participants were invited to give a presentation in an HMD, while seeing in a virtual mirror a gender-matched avatar who copied their arm and lip movements in sync and a-sync conditions. We measure participants' reaction with questionnaires administrated verbally after their presentation while immersed in VR. The result suggested an interaction effect of arm and lip, showing reports of higher level of embodiment with the congruent as compared to the incongruent conditions. Further study is needed to confirm if the same interaction effect can be captured with objective measurements.

**Keywords:** body ownership; embodiment; virtual characters; user studies.

**Index Terms:** H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, Augmented, and Virtual Realities; J.4 [Computer Applications]: Social and Behavioral Sciences—Psychology

## 1 INTRODUCTION

In recent years, the popularity of HMD devices and real-time optical motion tracking devices (i.e., Kinect, Leapmotion) has enabled a novel way in which users can control their avatars: they can be placed in the body of their avatar, whose movements is synced to the user's.

Various methods could be used in the technical implementation of embodiment. In most cases, due to restrictions of resources only a subset of body expressions will be captured to animate the avatar. The question we ask and investigate in this experiment is whether these technical restrictions will harbour the illusion of body ownership or if there is flexibility in which the mind will accept its mobility in Virtual Reality as has been proven with body image [1].

## 2 BACKGROUND

It has long been established in research that synchronized movements between the user and their avatar have a positive effect on both the users cognitive ability and feeling of agency over the virtual avatar [2]. Existing literature suggested that it is possible to have the sense of ownership over a body part that isn't your own [3]. As mentioned above, HMD devices and real-time optical motion tracking devices in recent years has enabled users to be placed *in the body* of their avatar, whose movements is synced to

theirs in virtual reality [4]. Indeed, several studies suggested that the ownership of another person's body, or the "embodiment illusion", can be induced via multisensory correlation [5] and could have a direct impact on users' behaviour [6]. Body ownership illusion, or responses to this illusion, can be measured subjectively through questionnaires or objectively through physiological data [7].

With the introduction of these sensory controllers it's important to investigate such anatomical control systems in more depth, particularly the potential link between their functionalities and embodiment, in this case, in first person. In a previous setup where the participant faced a reflection of their avatar representation, where they were head tracked by Fakespace Labs Wide5 HMD and gesture tracked by a 12 camera Optitrack [8]. It was found that participants' upper body movement being mirrored alone was a strong tool to provoke the illusion of both agency and body ownership towards the virtual body even without full body tracking. This pilot study explores the extent to which lip synchronization (lip sync) and arm synchronization (arm sync) influence embodiment, and the relationship between these two features. Our hypothesis was that there would be a stronger effect on embodiment when both lip and arm are synchronised due to more access to control over the body, and that the level of embodiment would reduce when only one or none were synchronised.

## 3 EXPERIMENTAL DESIGN

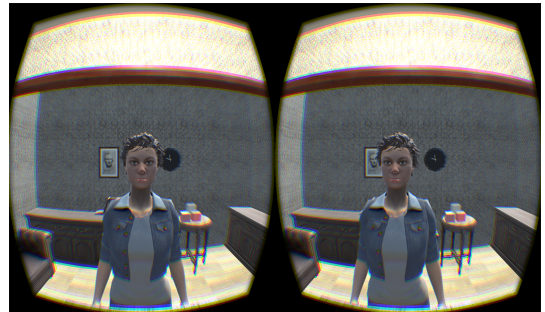


Figure 1 shows the virtual room and female avatar used in the experiment.

The Virtual Environment (VE) was created using Unity3D 5.3.4p1 patch as at the time of development it was the most compatible version with the current VR Headsets. The VE consisted of minimal furniture and a mirror which reflected the top half of the avatar. It was viewed via Oculus Rift 1.3 Consumer Version 1. The virtual characters were purchased from the Unity Asset Store; both the male and female avatar were Caucasian and chosen to look very generic and simply dressed. Lipsync was integrated utilizing the OculusLipsync plugin for Unity. The inverse kinematics was implemented using the position data from infrared tracking collected by the Kinect Version 1, and the head position using the position and rotation data collected from the Oculus rift. A standard plugin microphone was used to capture the participants' voice.

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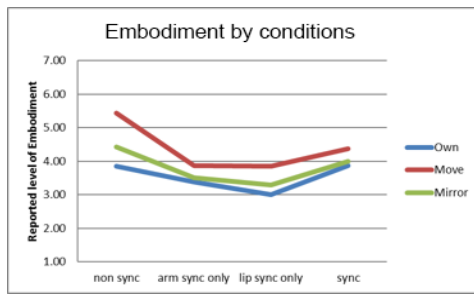


Figure 2 means of questionnaire results arranged by conditions

30 participants took part in this experiment (12 females) with a mean age of 29 (range 20-65). There was a mix of racial backgrounds. Each participant was paid 5 pound for their involvement. The participants were recruited from Goldsmiths University, through both word of mouth and on social media.

It was a 2x2 factorial design, between-group experiment where each participant experienced only one of the four conditions; both sync (8 participants), lip sync only (7), arm sync only (8), and non-sync (7). Arm sync only had no lip movements, lip sync only had no arm movements, and for non-sync there were no movements (on both arm and lips). The head movement provided by the Oculus CV1 was constantly present in all four conditions.

The participant put on Oculus CV1 and had a test run for 30 seconds, the participant was then asked to deliver an interview speech (teaching job in Ghana) to their "self-reflection" in the mirror for 2 minutes. After this period, the participant was asked to close their eyes and answer a verbal questionnaire assessing their level of embodiment, read out to them by the experimenter.

Upon completing the questionnaire, participants then took part in an exploratory secondary study which is outside the scope of this study. The experiment had been approved by the university Research Ethics Committee.

#### 4 MEASUREMENT

The independent variables of this experiment were: *Lip-Sync* (the avatar's mouth moved to the speech of the participant, based on audio from a microphone) and *Gesturing* (the avatar's arm movements imitated those of the participant, as tracked by a Kinect). We measured the effect of each condition with verbal questionnaires. The embodiment questions asked were to find out; (1) How much the user felt the avatar body was their own (*OWN*); (2) How much control they felt over the body (*MOVE*); and (3) How much they felt that the reflection was their own reflection (*MIRROR*). These questions were based on the 'Body Ownership and Agency Questionnaire' with a 1-7 Likert scale where 1 indicates completely disagree and 7 completely agree [9].

#### 5 RESULTS

We performed a two-way ANOVA test with SPSS, setting *lip* (sync, a-sync) and *arm* (sync, a-sync) as the two dependent variables and questionnaire results (*MOVE*, *ANOTHER*, *OWN*) the dependent variables. There was a significance interaction effect ( $p = 0.048$ ) between the arm and lip on *MOVE*, as shown in Figure 2. Figure 3 shows the mean of the average score of all participants for the three questionnaire measurements, arranged by congruency - the congruent conditions are when both the lip and arm were synced or a-synced, and the incongruent conditions are when only one of them was synced. Although this result was not statistically significant, the same pattern was presented in all three measurements. This indicates that maintaining congruency between arm and lip sync could be important in the level of embodiment.

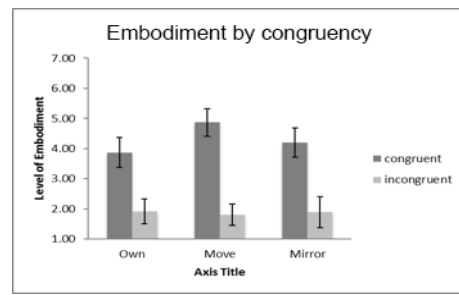


Figure 3 means arranged by congruency

#### 6 DISCUSSION

Our hypothesis was supported by the subjective results gathered from the verbal questionnaire, but also pointed out the effect of congruency over synchronicity. It is also interesting to see that participants felt higher levels of control in the congruent non-sync condition, where they had very little actual control over the avatar (only head movement) than they did when they controlled lips or arms (but not both). This is important as using virtual reality with embodiment can lead to a deeper understand of human behaviour and social interactions [10]. In future research, we hope to explore further this effect with a wider participant pool and full body motion capture.

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