International Conference on Artificial Reality and Telexistence
Eurographics Symposium on Virtual Environments (2018)
T. Huang, M. Otsuki, M. Servières, D. Michael-Grigoriou (Editors)

Contribution to Ownership and Agency When Controlling a Mobile Robot

Junjie Hua [1], Masahiro Furukawa[1,2,3] and Taro Maeda[1,2]

[1]Graduate School of Information Science and Technology, Osaka University, Japan
[2]Center for Information and Neural Networks, Japan
[3]JST PRESTO, Japan

Abstract

Out-of-body experience shows that body ownership can be built through illusory visual-tactile correlation when man observes avatar from its back.On the other hand, ownership and agency are usually thought to be negative when observing avatar face to face. We aim to clarify whether person perspective plays an important role on ownership and agency when controlling a mobile robot, and if so, how does ownership and agency change when person perspective changes. In this article, we developed a mouse-robot control system to construct a visual-motor synchronous system. We found that agency over robot is independent from ownership; ownership over robot can be experienced when facing it under synchronous conditions.

CCS Concepts

• ***Computer system organization*** → *Robotic control;*

1. Introduction

Body ownership can be built through illusory visual-tactile correlation or visual-motor synchronous contingency. Early results suggest that body ownership over a body seen from behind in extra personal space is possible when the surrogate body is visually stroked and tapped on its back, while spatially and temporal synchronous tactile stimulation is applied to the back of the participants [LTMB07] [PS13]. In the research on ownership of an invisible body, illusory invisible body could be experienced in front of participants [KSM*18]. On the other hand, ownership and agency are usually thought to be negative when observing avatar face to face, we think in order to build ownership and agency, it is necessary to observe avatar from its back. In other previous research, contributions to reduce of ownership and agency are clarified. Some results suggest that the strength of illusion is reduced when posture of participant does not match the posture of avatar [BKS16]. These research make us curious: is person perspective one of contributions to ownership and agency? In this paper, we aim to clarify whether person perspective plays an important role on ownership and agency when controlling a mobile robot, and if so, how does ownership and agency change when person perspective changes.

2. Experiment

2.1. Stimulus and Conditions

We aim to clarify whether person perspective is one of contributions to ownership and agency by quantifying them when controlling a mobile robot under different perspective conditions. We hypothesized that: Ownership can be experienced in the bodily borders. Generally, ownership can be experienced at the location where the man is and count of body is one. When controlling the robot, with the link between robot and man is built, bodily borders prolong and cover the robot. When this process continues($t>t_0$), one body splits to two bodies–one covers man, the other one covers robot. Agency is dependent on ownership. A humanoid robot called Pepper (SoftBank Robotics) was used as the robot avatar because person perspective is dependent on relative direction of man and robot. We developed a mouse-robot control system to imitate a visual-motor synchronous system. In this system, participants control movement of robot by moving a mouse–like former research using HMD, when synchronous move between hand and robot is observed, ownership could possibly be experienced in real world. Two yellow barricades (point A and B in Figure1, the interval is one meter.) were used to describe track of robot. Participants sit and controlled robot one meter behind point A so the distance between man and robot is 1∼2 meters as Figure1 shows below.

As we want to clarify whether person perspective and movement of robot would have an influence on ownership and agency. We designed an experiment which include these factors. Here, because only robot changed its position and direction, when robot and participant face the same direction, we define that robot is observed on third-person perspective (3PP); when participant observes robot face to face, we define that robot is observed on second-person perspective (2PP).

DOI: 10.2312/egve.20181375

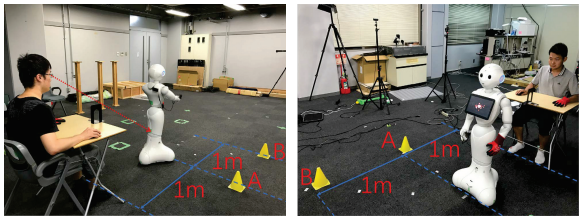

Figure 1: *Back view of the control system which shows collinearity (left); Front view which shows the same red glove (right)*

2.2. Procedures and Measures

Six volunteers (female=1, males=5) who had no experience in mouse-robot system took part in our experiment. They were native to the purpose of experiment. Through the whole experiment, participants wore the same red glove on their left hand as robot and robot kept raising hands since the experiment started–during the experiment, hands were always on the desk and kept in the sight of man. Before the experiment, participants were told that only slide with the mouse is allowed. Also, any causal move of body except right hand is abandoned. Sitting posture of the participants was adjusted to keep right eye, bookend and a marker on robot's leg collinear to ensure the same observation direction. During the experiment, participants were asked to keep controlling robot freely (omnidirectional) for two minutes while watching back of robot (3PP) and then asked to keep controlling robot freely (omnidirectional) for two minutes while watching face of robot (2PP) . Then participants were ordered to spend thirty seconds to operate robot in four synchronous conditions (robot moves as the mouse moves at the same time,approach or departure in 2PP or 3PP) and two asynchronous conditions (robot keeps stilled in 2PP and 3PP even participants moved the mouse) randomly. Right after each trial, participants were given two minutes to rest and when resting, questionnaire was asked. Each man performed 24 trials (6 conditions$\times$4) randomly. After every eight trials, participants were given extra two minutes for rest. We measured the embodiment with a questionnaire based on [KE12] and [KSM*18], adapting embodiment questionnaire from "Illusory body ownership of an invisible body interpolated between virtual hands and feet via visual-motor synchronicity" to measure quantity and location of body. The questionnaire consisted of 7 items and participants were ordered to evaluate on a 9-point scale ranging from -4 (not at all) to 4 (very strongly). Q1-Q4 evaluate ownership, Q5 (Pepper moved just like I wanted it to, as if it was obeying my will) evaluates agency, Q6 and Q7 (I felt as if Pepper was controlling my will/movement) work as agency control.

3. Results

The results show that all of them but participant 6 (written as P6) experienced high agency over the robot under synchronous conditions. One third of the participants (P1 and P4) reported positive experience on ownership (Group A). Two thirds of them answered negatively on ownership, scores are all almost -4 (Group B). In Group A, we found that P4 experienced strong ownership under synchronous conditions on Q1 (I felt as if Pepper was my body part) while P1 experienced weak but non-negative ownership, which means robot is covered in the bodily borders. However, both of them experienced weak ownership under synchronous conditions on Q2 (It felt as if Pepper became extended part of my body). As a result, we cannot confirm our hypothesis that bodily borders prolong to where robot is. However, the possibility that bodily borders get extended but do not yet cover robot still exists. So distance between robot and man may be a possible contribution. On Q3 (It seemed as if my body was drifting forward), both of them reported weak but not absolutely negative experience (near 0) which means participants could not confirm that his body was not drifted. On Q4 (It seemed as if I might have more than one body), P1 reported positive split experience while P4 reported negative split experience under synchronous conditions. Both Group A and Group B experienced rather positive agency, but only Group A experienced ownership, which shows agency and ownership over robot work on independent mechanism. We also found that for the same participant, answers in 2PP and 3PP (Q1-4,synchronous) were very close, which means ownership does not change when person perspective changes. In former research, 2PP was seldom considered, however, our results show ownership over avatar can be earned in 2PP. In conclusion, the results support that agency is independent from ownership and that ownership over robot can be experienced when facing it under synchronous conditions.

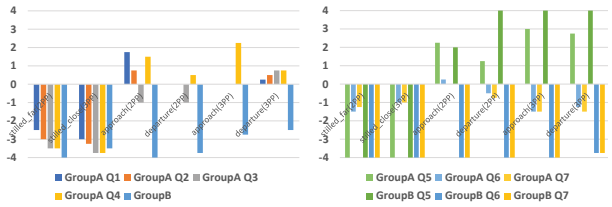

Figure 2: *Left: A simplified report on ownership; Right: A simplified report on agency and agency control*

Acknowledgments

This research was supported by JST, PRESTO Grant Number JPMJPR15D7, Japan and JSPS KAKENHI Grant-in-Aid for Scientific Research(A) Grant Number 15H01699.

References

[BKS16] BERGSTRÖM I., KILTENI K., SLATER M.: First-person perspective virtual body posture influences stress: A virtual reality body ownership study. *PloS one 11*, 2 (2016), e0148060. 1

[KE12] KALCKERT A., EHRSSON H. H.: Moving a rubber hand that feels like your own: a dissociation of ownership and agency. *Frontiers in human neuroscience 6* (2012), 40. 2

[KSM*18] KONDO R., SUGIMOTO M., MINAMIZAWA K., HOSHI T., INAMI M., KITAZAKI M.: Illusory body ownership of an invisible body interpolated between virtual hands and feet via visual-motor synchronicity. *Scientific reports 8*, 1 (2018), 7541. 1, 2

[LTMB07] LENGGENHAGER B., TADI T., METZINGER T., BLANKE O.: Video ergo sum: manipulating bodily self-consciousness. *Science 317*, 5841 (2007), 1096–1099. 1

[PS13] POMÉS A., SLATER M.: Drift and ownership toward a distant virtual body. *Frontiers in human neuroscience 7* (2013), 908. 1