

# An Immersive Virtual Reality: The Effect of Haptics on Agency in a Virtual Environment

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## Abstract

With an increasing number of virtual reality applications, more research must be conducted regarding human interaction with virtual environments. Various studies have researched agency over a virtual avatar and others have researched haptics in virtual reality (VR). This experiment combines these two sects of VR studies to determine if haptics in a virtual environment alters the perception of agency a user feels over their virtual hands. UnrealEngine and an Oculus Rift with an attached Leap Motion sensor were used to create an immersive virtual environment with hand tracking capability. Human subjects were individually tested in 2 tasks. First, they were to touch and lift a block with their virtual hands, then they did the same with an identical block in front of them so they would be interacting with a real and virtual block simultaneously. A questionnaire was given afterwards to measure the user's agency over the virtual hands during each task. The results show that haptic feedback decreases one's agency over virtual hands. This suggests that the proprioceptive response related to feeling an object with a person's actual hands decreases the effectiveness of the illusion that the hands on the screen actually belong to the user, meaning a more immersive virtual environment could be created with less haptic feedback. More research should be conducted verifying the impact tangible virtual objects have on a user's virtual experience, but overall this research could have far-reaching implications. Instead of augmenting virtual environments with real ones, an environment with less interaction with reality could allow for better VR applications.

## Background Research

### Agency in Virtual Reality

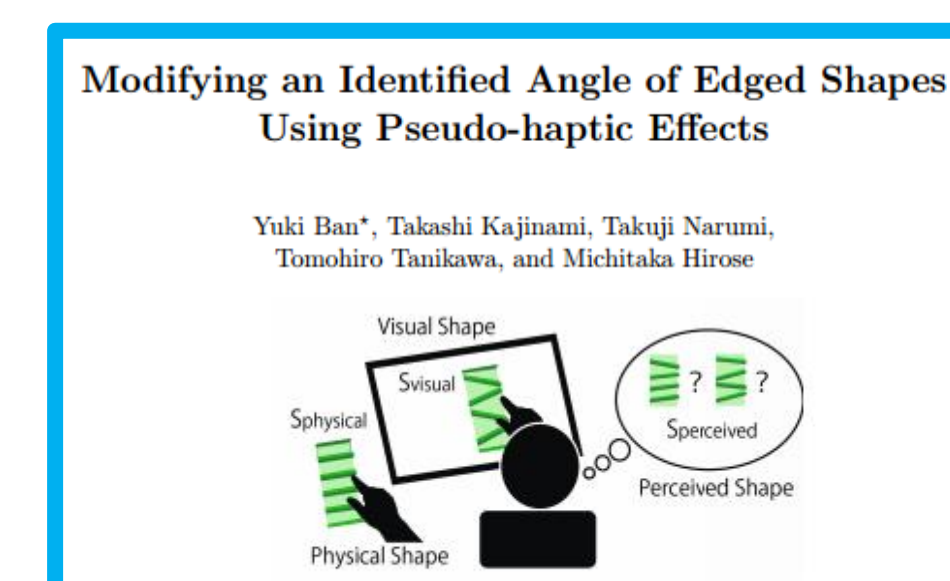
- The feeling of being in control of a virtual avatar
- Often studied as dependent variable in relation to other factors: skin color, realism, action of avatar
- Can be of any body part but hand or leg is often used



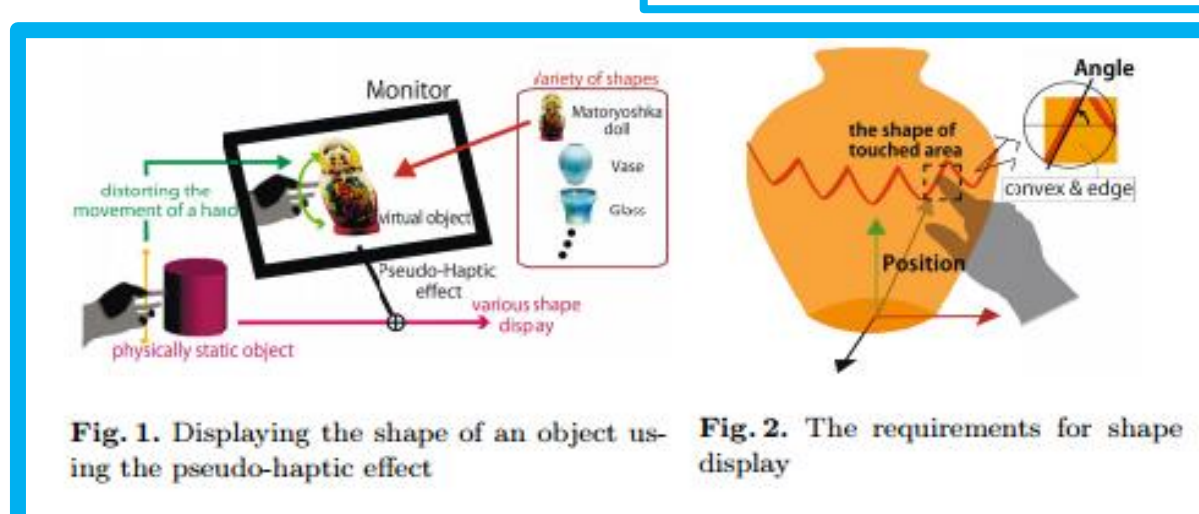
Argelaguet, F., Hoyet, L., Trico, M., & Lécuyer, A. (2015, March). The role of interaction in virtual embodiment: Effects of the virtual hand representation. In *Virtual Reality (VR)*, 2015 IEEE (pp. 3-10). IEEE.

### Haptics in Virtual Reality

- Proprioception (the sense of touch) being active while in virtual reality
- Pseudo-haptics deals with manipulating that sense of touch
- Most VR studies research pseudo-haptics and its potential applications



Yuki Ban\*, Takahiko Kajinami, Takaji Narumi, Tomotake Tanikawa, and Michitaka Hirose. Modifying an identified angle of edged shapes using pseudo-haptic effects. In *International Conference on Human Haptic Sensing and Touch Enabled Computer Applications* (pp. 25-36). Springer Berlin Heidelberg.



## Purpose

This study combines these two sects of virtual reality studies to determine if haptics in virtual reality alters the perception of agency a user feels over their hands.

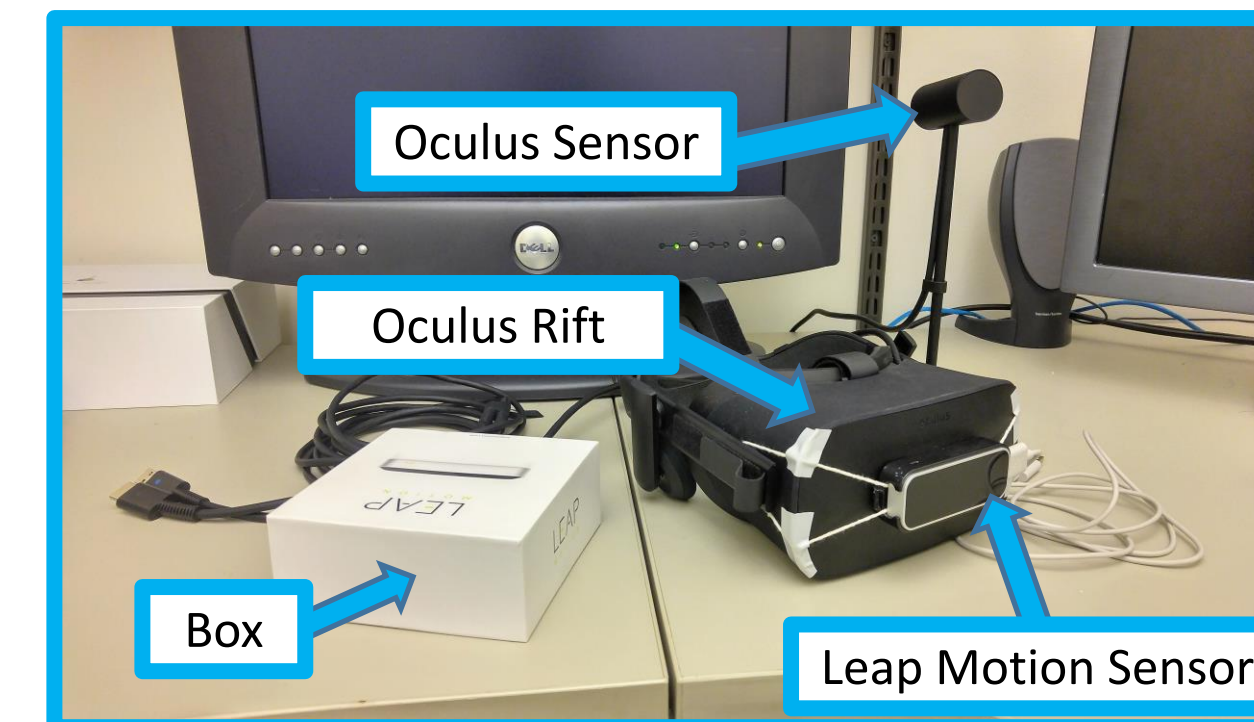
## Hypothesis

If a user receives haptic feedback in a virtual environment, then the agency they feel over their hands would decrease, since they would attribute the proprioception to reality and not the virtual representation of their hands.

## Materials and Methods

### Virtual Environment Design

- In order to test the user's agency over their hands, a virtual environment was created in Unreal Engine 4.
- Three boxes were in front of the user on a large slab
- Users were isolated in the environment from any other object, so there were no other distractions
- The user's hands appeared as the plain white LeapFloatingHandsCharacter.



### Experimental Set Up

1. Leap Motion sensor was secured to the HMD using string and electric tape.
2. All devices were plugged in the computer and their functionality was checked via their respective softwares.
3. Calibration with leap motion sensor was done through leap motion control panel to assure highest quality hand tracking.
4. Paper was taped to the desk and the oculus sensor was taped to the desk.
5. The size of the box was adjusted in the virtual environment to be the same as the real box.
6. The position of the box was adjusted to be the same in the virtual environment as in real life, and the position was traced on the paper taped to the desk, so that boxes could return to their initial setup after each test subject.

### Materials

Software	Hardware	Materials
• UnrealEngine 4	• Computer	• String
• Leap Motion Service and Control Panel	• Leap Motion Sensor	• Electric tape
	• Oculus Rift	• Leap Motion Sensor holder
	• Head Mount Display (HMD)	• 3 Boxes
	• Oculus Rift Sensor	• Measuring tape
		• Paper
		• Pencil
		• Questionnaire

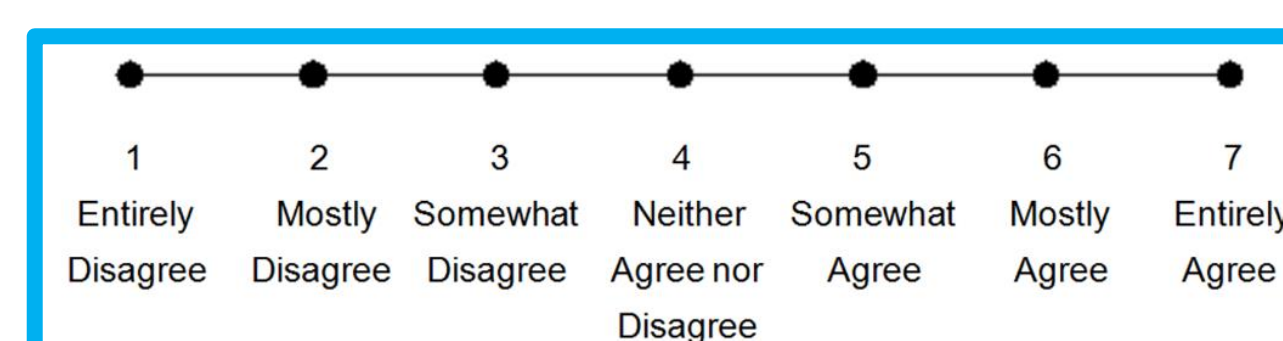
## Experimentation

### Procedure:

1. Each participant's age, contact information and previous experience in virtual reality was recorded, and their consent was taken.
2. They were given the HMD to adjust it to their head size and comfort.
3. When in the virtual environment each subject was told to raise their hands and find their hands in the virtual environment and perform the following two tasks.
4. Task 1: To feel the virtual box and attempt to lift it, while there was nothing actually in front of them.
5. Task 2: To feel the virtual box and attempt to lift it, while there was actually a box in front of them as well, so they would be seeing themselves feel a virtual block while feeling a real one.
6. After the tasks, each participant filled out the questionnaire.

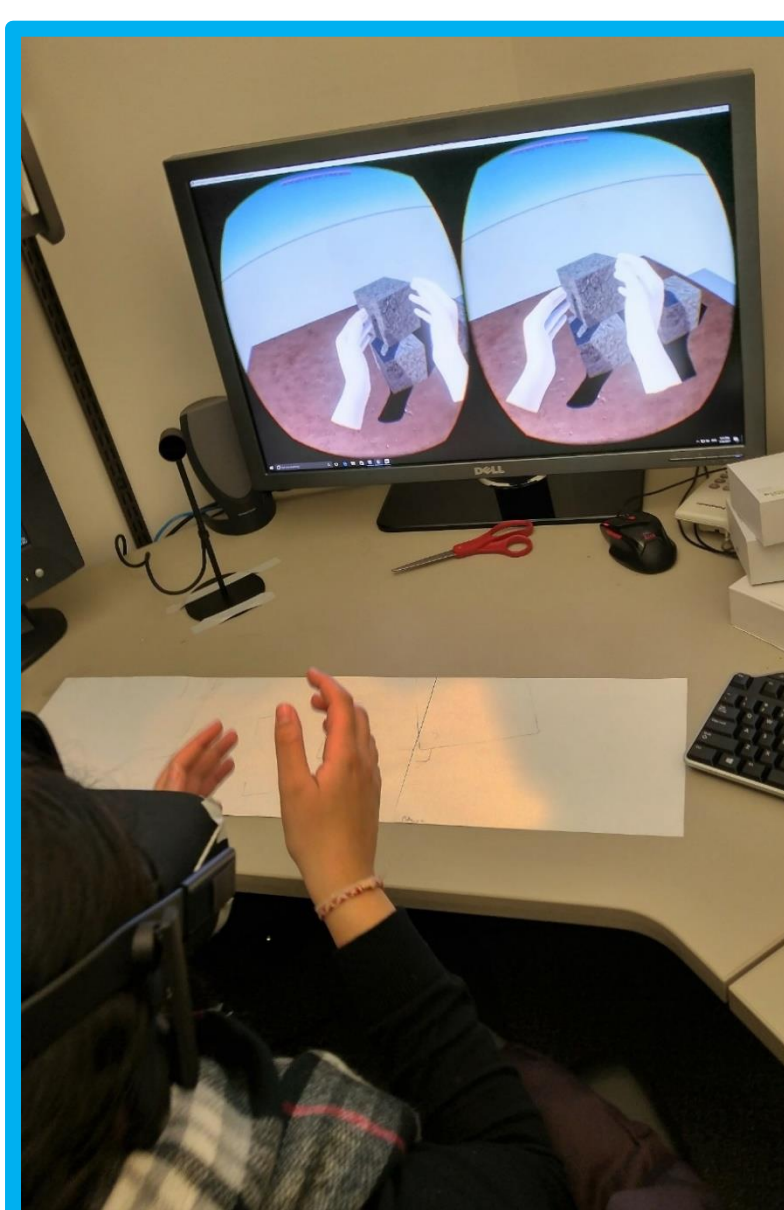
### Questionnaire—Rated statements on a 7 point Likert Scale.

Q1	It felt like I was actually holding something when I was holding the virtual block.
Q2	I felt that I was able to manipulate the blocks in the way I wanted to
Q3	Manipulating the blocks (ie moving, touching, lifting, grabbing...) was (1 difficult, 7 easy)
Q4	Using the virtual hands to move the block felt no different from using my real hands
Q5	I felt like I had control of my virtual hands as if they were my own hands.
Q6	Manipulating the block felt realistic (ie similar to manipulating a block in real life of similar size and shape)

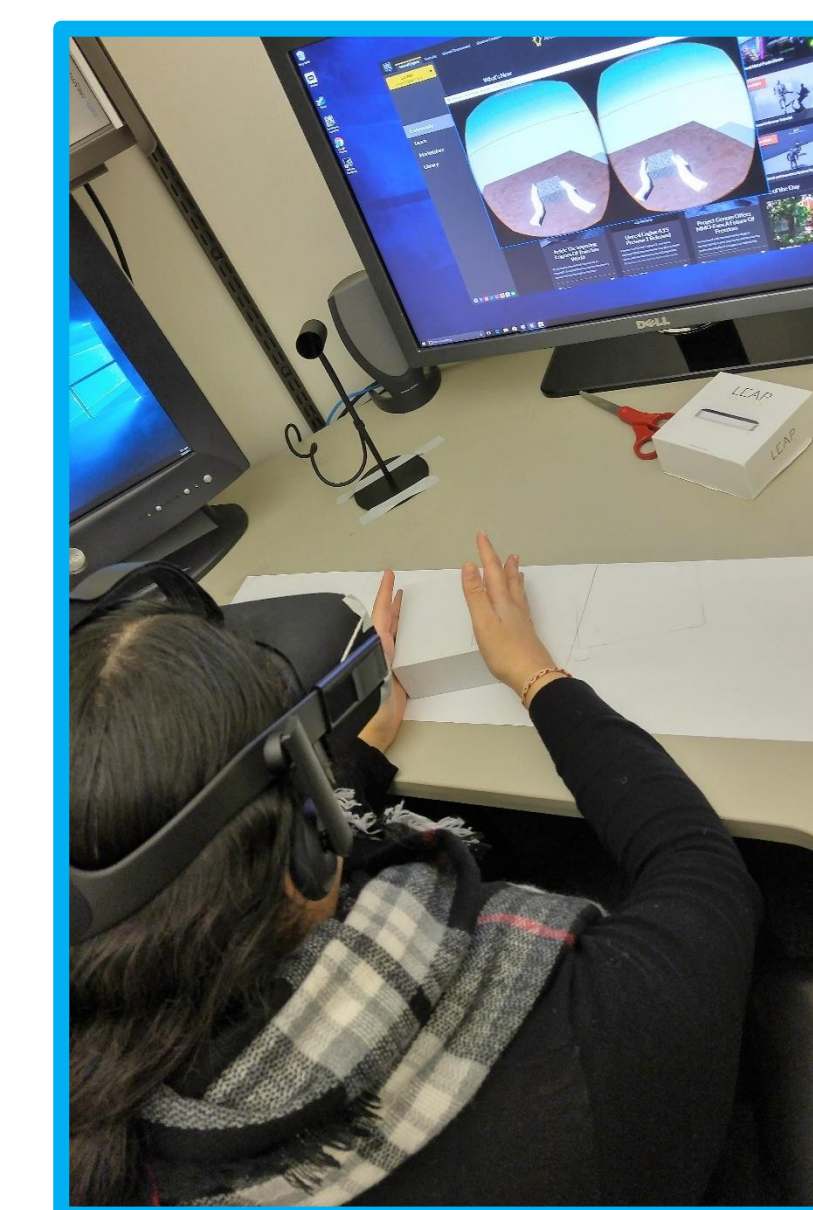


### 7 Point Likert Scale

- A common method to measure one's attitude or opinion from one's cognitive or affective components of attitude.



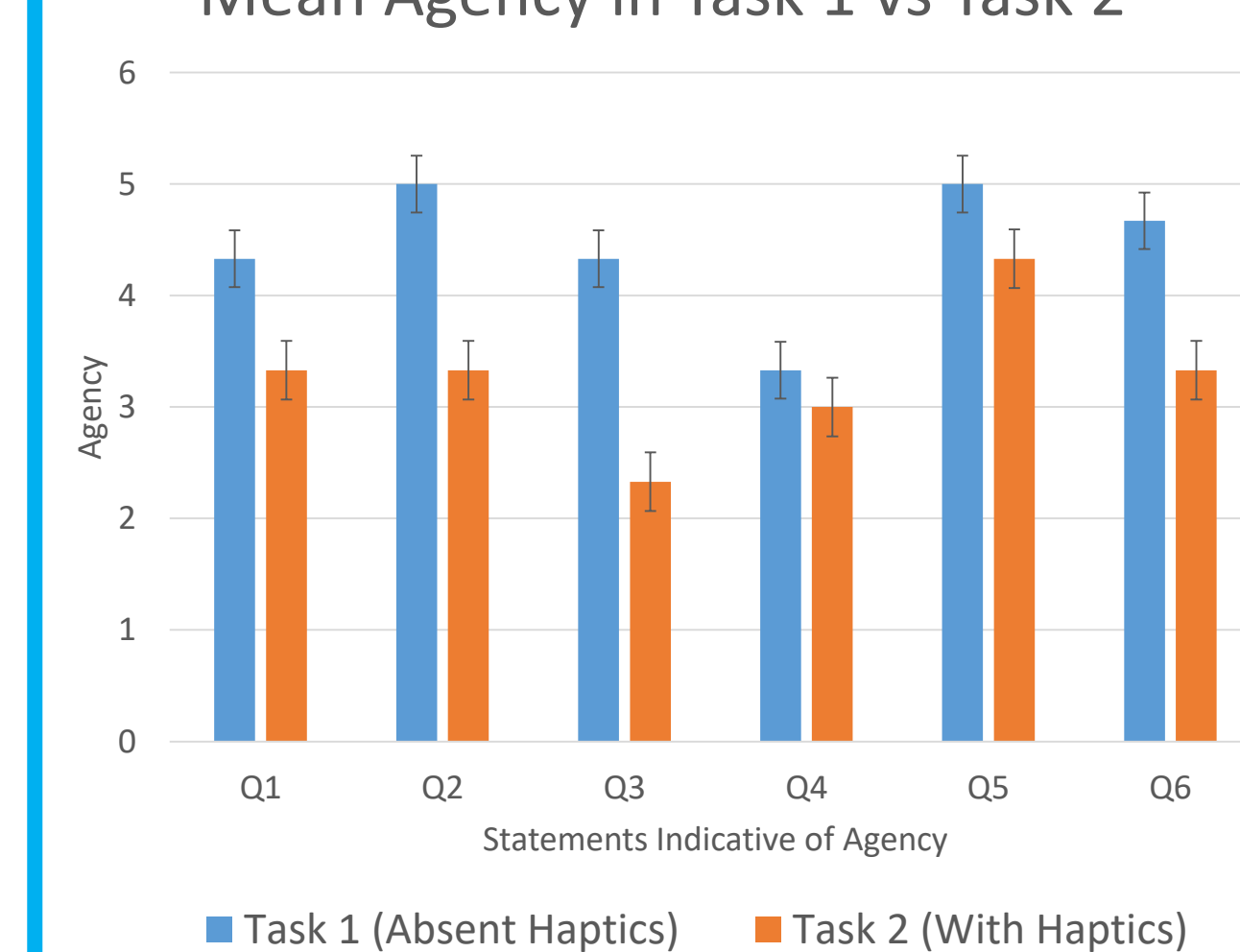
Task 1: Absent Haptic Feedback



Task 2: With Haptic Feedback

## Results

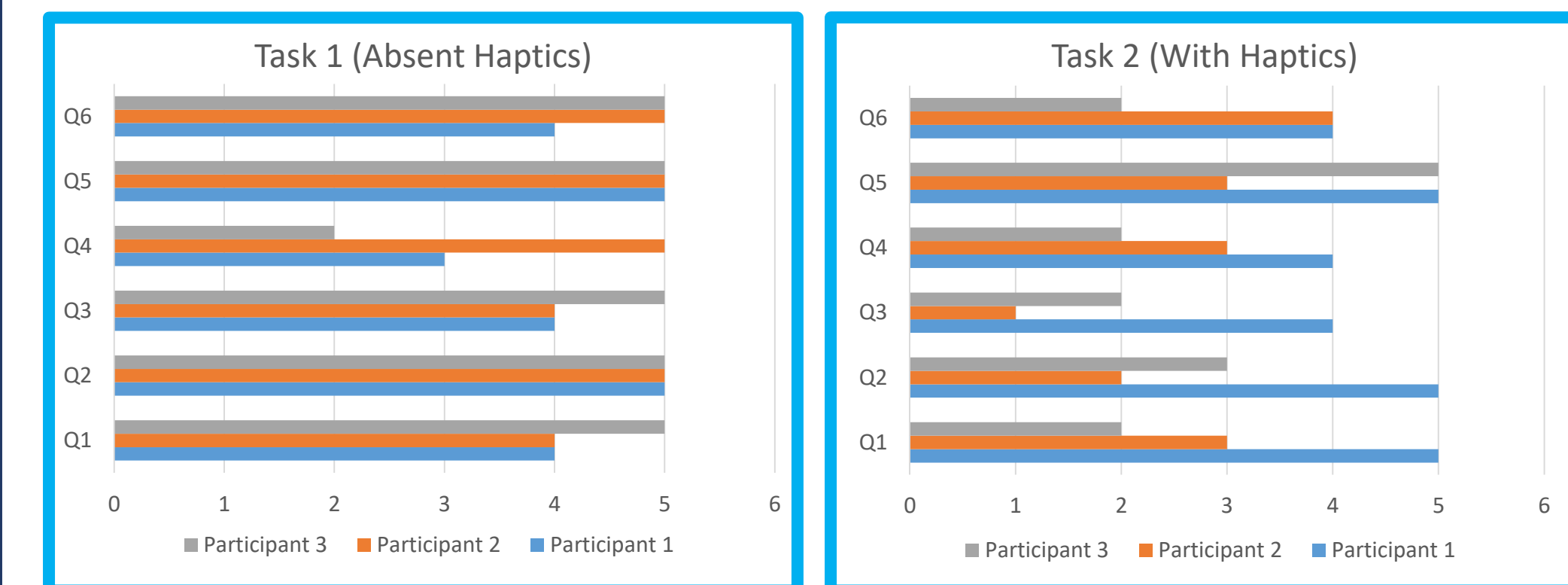
### Mean Agency in Task 1 vs Task 2



	Task 1				
Question:	Participant 1	Participant 2	Participant 3	Mean	Std. Dev.
Q1	4	4	5	4.33	0.58
Q2	5	5	5	5.00	0.00
Q3	4	4	5	4.33	0.58
Q4	3	5	2	3.33	1.53
Q5	5	5	5	5.00	0.00
Q6	4	5	5	4.67	0.58

	Task 2				
Question:	Participant 1	Participant 2	Participant 3	Mean	Std. Dev.
Q1	5	3	2	3.33	1.53
Q2	5	2	3	3.33	1.53
Q3	4	1	2	2.33	1.53
Q4	4	3	2	3.00	1.00
Q5	5	3	5	4.33	1.15
Q6	4	4	2	3.33	1.15

## Data Analysis



- Individual comparison of cluster bar charts qualitatively shows less agency in Task 2.
- Mean comparison of bar charts shows quantitatively every question in Task 2 indicated less agency than in task 1.

## Discussion

### Possible explanation of results

- Proprioception triggered a cognitive response that ascribed the action of lifting a box to the real world instead of virtual reality
- When exposed to different (real vs virtual) situations simultaneously, the fidelity of the virtual hand decreased; it was less likely to behave in accordance with the user's intention

### Comparisons Past Research:

- Often ignores haptic or motor conditions in VR
- Most findings compliment this project's findings
- Many contradictions come from research relating to the "ownership illusion" however there is a distinction between "ownership" and "agency"
- Agency describes motor control and awareness of one's actions whereas ownership describes the feeling that one's body is the source where sensations are being felt

### Future Applications:

- Globalization and communication: virtually travelling or meeting someone
- Entertainment: video games, movies
- Education: to train doctors, astronauts, and other professionals.
- Medical: therapy treatments

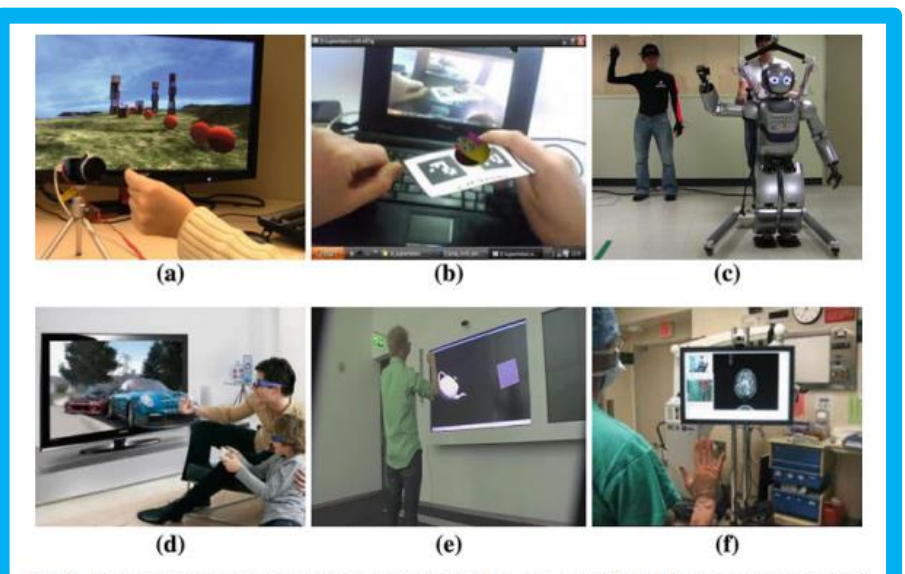


Fig. 8. Some key application domains for vision based hand gesture recognition. (a) Desktop-computing interaction using hand gestures (Gonzalez et al., 2002). (b) Augmented reality based interaction using hand gestures (Chaffard and Sillion, 2012). (c) A virtual learning using hand gestures (Gonzalez et al., 2002). (d) Virtual reality based training using hand gestures (Gonzalez et al., 2002). (e) Hand gestures for interaction with help centers (Gonzalez et al., 2002). (f) Hand gestures for interaction with help centers (Gonzalez et al., 2002). (g) Hand gestures for interaction with help centers (Gonzalez et al., 2002). (h) Hand gestures for interaction with help centers (Gonzalez et al., 2002). (i) Hand gestures for interaction with help centers (Gonzalez et al., 2002). (j) Hand gestures for interaction with help centers (Gonzalez et al., 2002). (k) Hand gestures for interaction with help centers (Gonzalez et al., 2002). 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