Physical Demand of Mid-air Hand Gestures in VR

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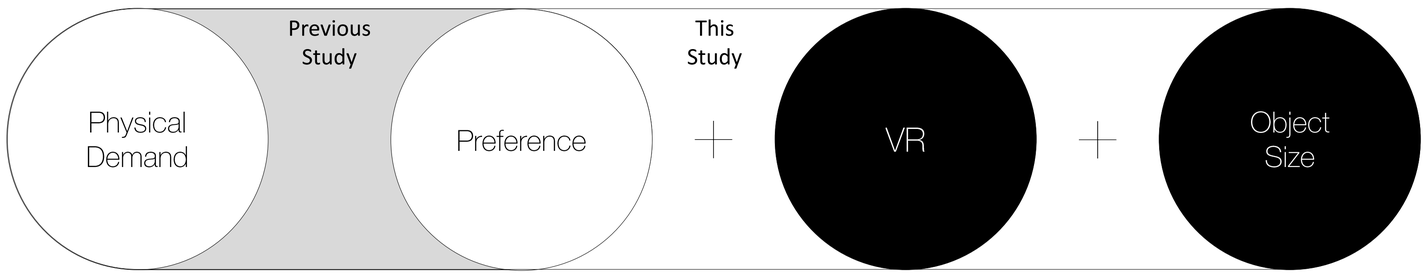
MOTIVATION & QUESTIONS



Negative correlation between perceived physical demand and preference for gestures.

Verify the result of previous study in VR environment with an additional variable (size of objects).

"How can designers design mid-air hand gesture interface with less physical effort?"

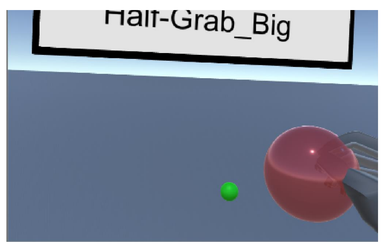
Assumption: Priorities of gestures for both of physical demand and preference are different depending on size of objects.

Independent Variables			
Gesture	*Pinch*	*Half-Grab*	*Fist*
Size	*Small*	*Medium*	*Big*

Dependent Variables	
Physical Demand	*Preference*

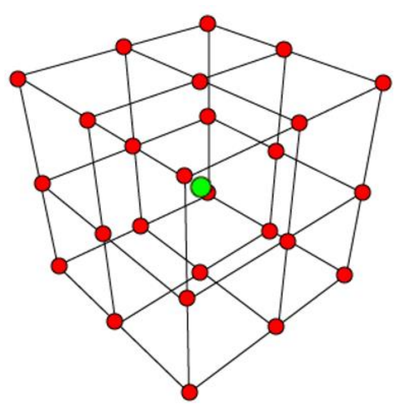
EXPERIMENT

Task



- A task is to catch a red ball and touch it with a green ball.
- Since there were three gestures and three sizes each, there were a total of nine experimental conditions.
- In one condition, a red ball appeared randomly in 26 positions for each trial.
- Therefore, participants performed 26 tasks per condition.
- After finishing 1 condition, they responded the perceived physical demand and preference for the gesture with a 1-10 scale.
- They performed each condition in a random order, two times in total. And first trial was practice session.

Experimental Design



3*3*3 Cube. Center of cube is green ball.

2(Repeat) * 9(Conditions) * 26(Positions)
= 468 trials for 1 participant

Procedure

Practice Session → Main Experiment → Exit Interview

Total 10 participants (5M/5F)
Mean Age: 24.3 (SD 2.11)

All had less experience for VR and gesture interface.

The experiment was conducted sitting in a lab environment. Participants carried out the experiment with the Leap Motion Controller & VR device (SAMSUNG HMD Odyssey) on.

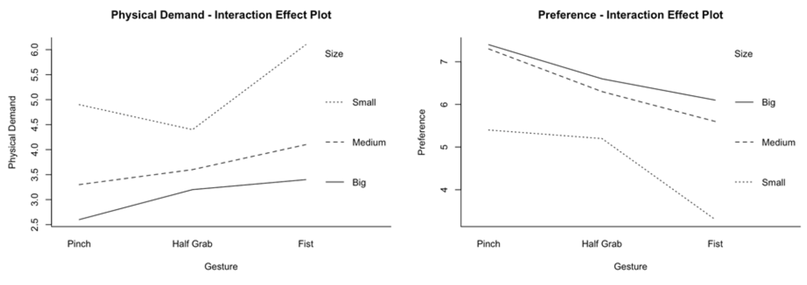
RESULT

- Regardless of the type of gesture (Physical Demand: *p=0.20*, Preference: *p=0.09*), subjects felt the least physical demand (*p<0.001*) when they caught the largest object and preferred it most (*p<0.001*).
- Regardless of the size of the object (*p=0.09*), subjects preferred to use the pinch to grab the object (*p=0.002*).
- There was a significant negative correlation between physical demand and preference felt by subjects (r_s=*-0.55, p<0.001*).

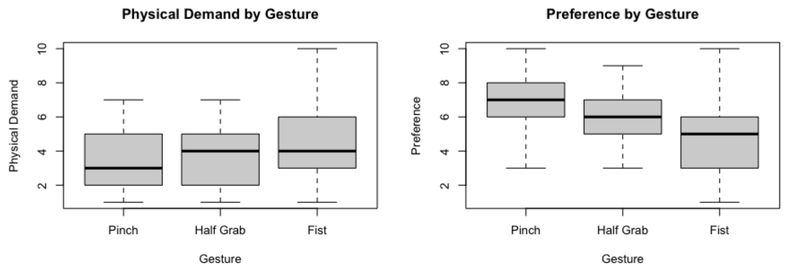
**** Because the obtained data do not follow the normal distribution, the non-parametric method confirmed that it was a statistically significant result.***

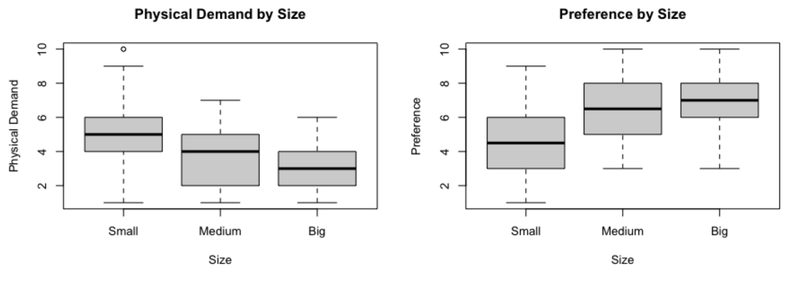
	Physical Demand			*Preference*		
Variables	*Gesture*	*Size*	*Interaction*	*Gesture*	*Size*	*Interaction*
F-Value	2.083	16.87	1.591	9.339	13.95	2.19
DoF	2	2	4	2	2	4
p	0.15	<0.001	0.20	0.002	<0.001	0.09

Result of RM 2-way ANOVA



Interaction Effect Plots

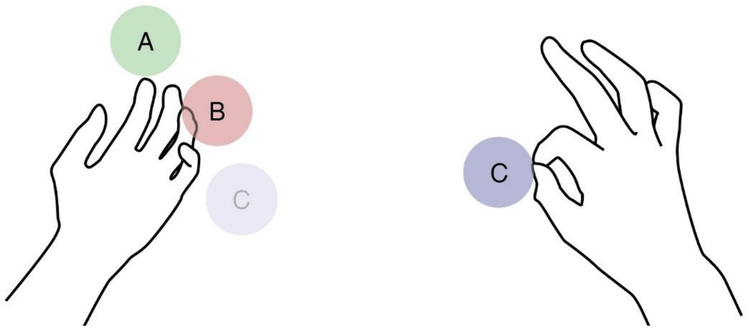




Perceived Physical Demand and Preference for Gestures and Size of Objects

IMPLICATIONS

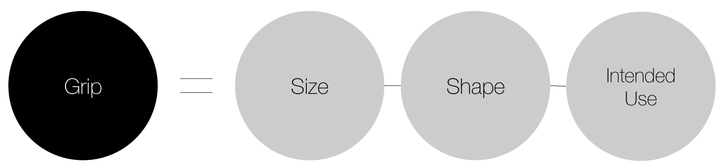
- This study is meaningful in that existing research results were confirmed in various contexts (the size of objects) in VR environment.
- For drag-and-drop interaction, larger objects are better, and the pinch gesture is appropriate in VR.
- When users use gestures in VR, the size of objects and type of gesture tend to be independent of each other for the physical demand or preference they feel.



Mid-air Hand Gesture Interface Example

LIMITAIONS & FUTURE WORKS

Limitations



Grips should be considered not only the size of objects, but also the shape and intend of use.

Future Works

Research on resolution suitable for VR environments

We can compare with experts to provide design guidelines.

[1]Kayne Barclay, Danny Wei, Christof Lutteroth, and Robert Sheehan. 2011. A quantitative quality model for gesture based user interfaces. In *Proceedings of the 23rd Australian Computer-Human Interaction Conference*, 31–39.
[2]Marcio C. Cabral, Carlos H. Morimoto, and Marcelo K. Zuffo. 2005. On the usability of gesture interfaces in virtual reality environments. In *Proceedings of the 2005 Latin American conference on Human-computer interaction*, 100–108.
[3]April H. Crusco and Christopher G. Wetzel. 1984. The Midas touch: The effects of interpersonal touch on restaurant tipping. *Personality and Social Psychology Bulletin* 10, 4: 512–517.
[4]Abraham Georgiadis and Shahrouz Yousefi. 2017. Analysis of the user experience in a 3D gesture-based supported mobile VR game. In *Proceedings of the 23rd ACM Symposium on Virtual Reality Software and Technology*, 1–2.
[5]Xiaoxing Liu and Geb W. Thomas. 2017. Gesture interfaces: minor change in effort, major impact on appeal. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 4278–4283. https://doi.org/10.1145/3025453.3025513
[6]Michael Nielsen, Moritz Störring, Thomas B. Moeslund, and Erik Granum. 2003. A procedure for developing intuitive and ergonomic gesture interfaces for HCI. In *International gesture workshop*, 409–420.
[7]Dennis A. Nowak and Joachim Hermsdörfer. 2009. *Sensorimotor control of grasping: physiology and pathophysiology*. Cambridge University Press.
[8]Brigitte Vollmer and Hans Forssberg. 2009. Development of grasping and object manipulation. *Sensorimotor control of grasping: Physiology and Pathophysiology* 100: 178–192.
[9]Yukang Yan, Chun Yu, Xiaojuan Ma, Xin Yi, Ke Sun, and Yuanchun Shi. 2018. VirtualGrasp: Leveraging experience of interacting with physical objects to facilitate digital object retrieval. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–13. https://doi.org/10.1145/3173574.3173652
[10]C. Spearman. 1904. The Proof and Measurement of Association between Two Things.The American Journalof Psychology15, 1 (1904), 72–101.https://doi.org/10.2307/1412159

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