Lecture 10: Essentials of Experimental Design for Interface Evaluation

Part 04

Examples

Typical Experimental Description for a User Study

Participants
Ethics
Experimental design and Conditions
Materials (Apparatus and Equipment)
Method
Procedure
Results (descriptive and inferential statistics)

Bergström, J., Mottelson, A., Muresan, A. and Hornbæk, K., 2019, May. Tool extension in human-computer interaction. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-11).

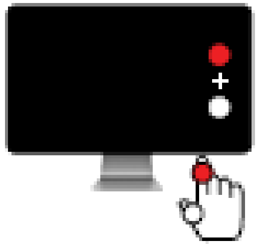
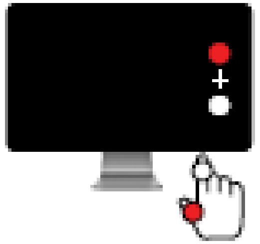
	Vibrotactile stimulus	*Visual distractor*	*Correct responses*
	**Congruent conditions**		
	On the index finger	Above the cursor	Lift the toes
	On the thumb	Below the cursor	Lift the heel
	**Incongruent conditions**		
	On the index finger	Below the cursor	Lift the toes
	On the thumb	Above the cursor	Lift the heel
CCE - Mean RT in Incongruent Conditions - Mean RT in Congruent Conditions			

Figure 2: The stimuli and responses for incongruent and congruent tactile and visual stimuli, and the calculation of the CCEs based on response times (RTs).

Bergström, J., Mottelson, A., Muresan, A. and Hornbæk, K., 2019, May. Tool extension in human-computer interaction. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-11).

Participants

Data were collected from 12 right-handed participants (7 identified themselves as females and 5 as males, with an mean age of 25.92 ± SD of 3.85 years). Six of them used a mouse and ten of them a touchpad daily.

Design

The experiment followed a two-by-three within-subjects design with the congruency between the tactile stimuli and the visual distractor as the first factor and input condition as the second.

Bergström, J., Mottelson, A., Muresan, A. and Hornbæk, K., 2019, May. Tool extension in human-computer interaction. In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-11).

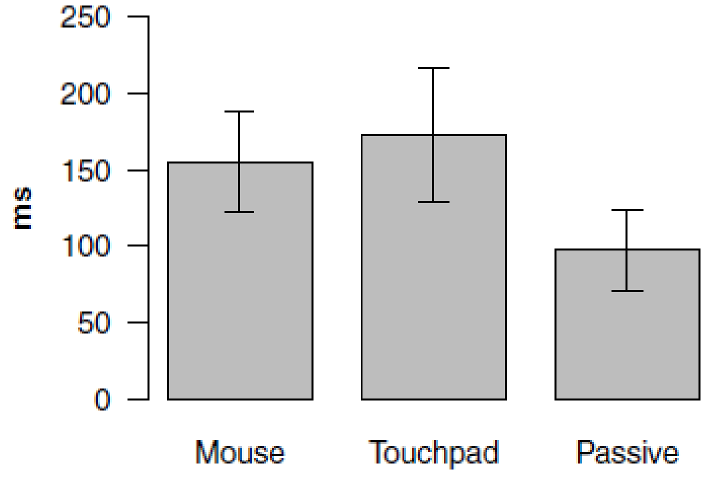


Figure 4: The average CCEs for the input conditions in Experiment 1. The error bars denote .95 confidence intervals.

We used Bonferroni corrected paired sample t-test to analyse differences between each input condition and the passive condition by using the mean values per condition for each participant. The t-tests show a significant difference between the two input condition pairs: mouse and passive ($t(11)=3.66$, $p = .004$), and touchpad and passive ($t(11)=4.72$, $p < .001$).

Bergström, J., Mottelson, A. and Knibbe, J., 2019, October. Resized grasping in vr: Estimating thresholds for object discrimination. In Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology (pp. 1175-1183).

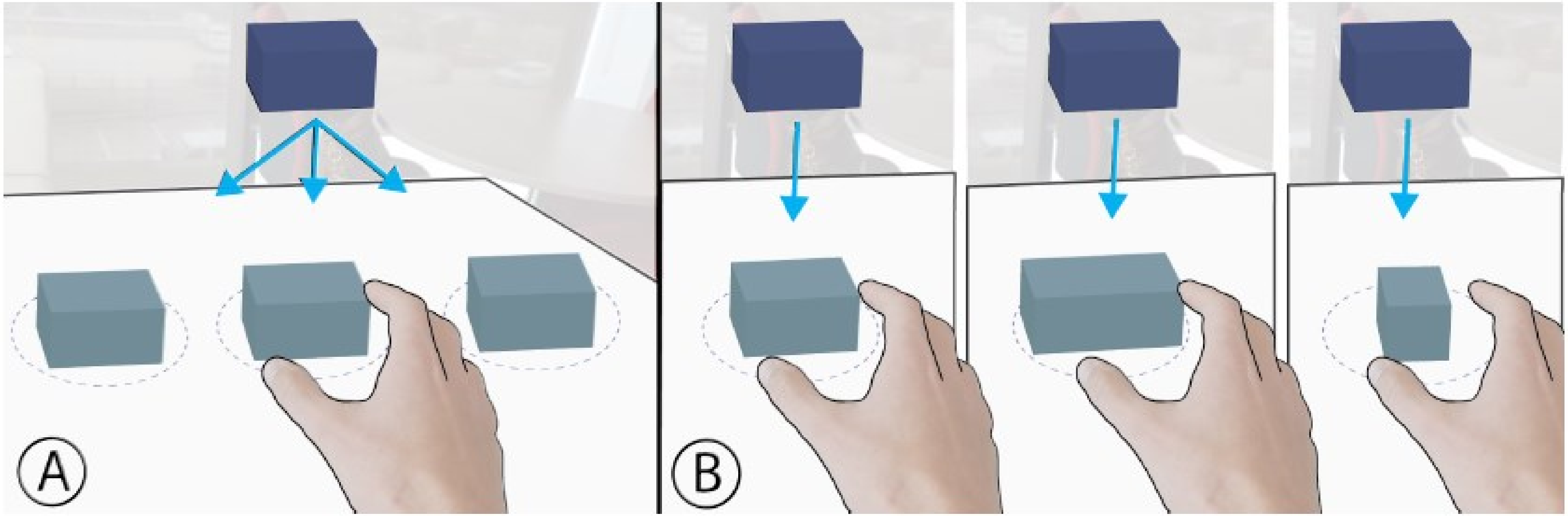


Figure 1. With arm redirection (A) a single physical object (dark blue) can represent virtual objects (light blue) at different locations. With Resized Grasping (B), we demonstrate how a single physical object can represent virtual objects of different sizes.

Bergström, J., Mottelson, A. and Knibbe, J., 2019, October. Resized grasping in vr: Estimating thresholds for object discrimination. In Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology (pp. 1175-1183).

Participants

We recruited 14 right-handed participants (7 identified themselves as females and 7 as males) for the experiment, with ages ranging from 22–47 ($SD = 9.3$). Their average thumb-index finger span was 17.7cm ($SD = 2.5$), which fits within the standard deviation range of the anthropometric mean of adult human hand [10].

Design

The experiment followed a within-subjects design with two independent variables: (i) the size of the physical cuboid, and (ii) the size of the virtual cuboid. In addition, samples were collected at three reach distances. The dependent variable was the subjective discrimination, administered per trial with the button prompts.

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Together with exploring the limits of the resized grasping illusion, we also explored the rate at which the illusion can be applied. Across our three distances (near, mid, and far),

we did not find an effect on the participants' perception of the illusion as an ANOVA showed insignificance for PSE on button distance: $F(2,6) = 0.4, p = .4$.

Bruder, G., Wieland, P., Bolte, B., Lappe, M. and Steinicke, F., 2013, October. Going with the flow: Modifying self-motion perception with computer-mediated optic flow. In 2013 IEEE International Symposium on Mixed and Augmented Reality (ISMAR) (pp. 67-74). IEEE.

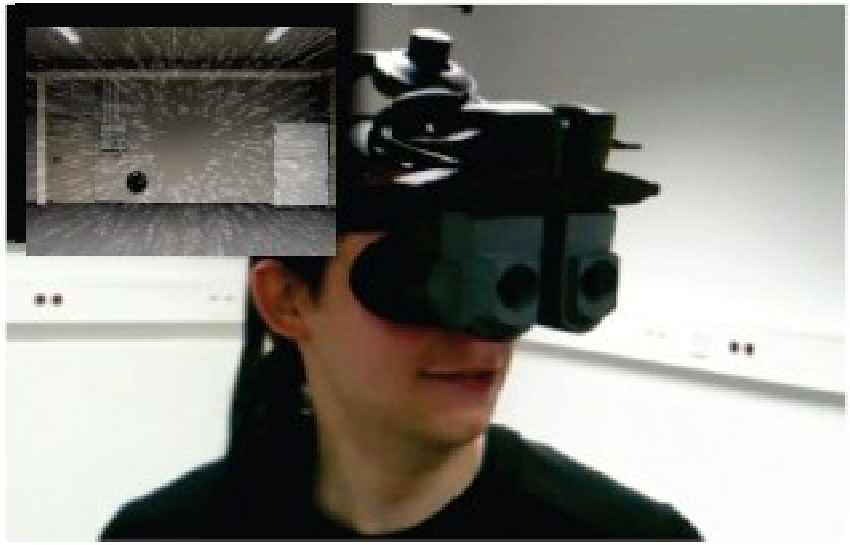

Figure 1: Photo of a user wearing a tracked NVIS nVisor MH-60V video see-through HMD. The inset shows an illustration of the resulting expansional optic flow field during forward movements.

10 male and 10 female (age 20-44, avg: 27.7) subjects participated in the study. All subjects were students or members of the departments of computer science or psychology. All subjects had normal or corrected to normal vision; 6 wore glasses and 2 contact lenses

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The results of our experiments were normally distributed according to a Shapiro-Wilk test at the 5% level. The sphericity assumption was supported by Mauchly's test of sphericity at the 5% level, or degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. We analyzed the results with a repeated measure ANOVA and Tukey multiple comparisons at the 5% significance level (with Bonferonni correction).

We found a significant main effect of condition ($F(1, 19)=28.44$, $p<.001$, $\eta_p^2=.60$) on the walked distances. As expected, we found a significant main effect of target distance ($F(1.325, 25.173)=183.37$, $p<.001$, $\eta_p^2=.91$) on the walked distances. We found a significant interaction effect between condition and target distance ($F(1.496, 28.425)=4.33$, $p<.05$, $\eta_p^2=.19$). Post-hoc tests revealed that the walked distances were significantly shorter for the camera view condition for all target distances.

Duarte, N.F., Rakovic, M., Tasevski, J., Coco, M.I., Billard, A. and Santos-Victor, J., 2018. Action anticipation: Reading the intentions of humans and robots. IEEE Robotics and Automation Letters, 3(4), pp.4132-4139.

Fig. 1. Human-Human Interaction: an experiment involving one actor (top-right) *giving* and *placing* objects and three subjects reading the intentions of the actor (left); Human-Robot Interaction: a robot performing the human-like action and subjects try to anticipate the robots' intention (bottom-right).

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A. *Participants*

The study involved 55 participants (40 male, and 15 female), age 31.9 ± 13 (mean $\pm$ SD). There were 13 teenagers and 6 people over 50 years of age. Approximately 62% were students, 27% were professors, 7% were researchers, and 4% were staff members, 3 subjects were left-handed. All subjects were naive with respect to the purpose of the research.

The first conclusion is the most obvious and is shown in Fig. 2(a). The more temporal information is available to subjects, the better the decision is, the higher the success rate and the lower the variance. We validate this trend with a quantitative analysis, with a two-way ANOVA [27], that shows a very significant correlation between the amount of information and the success rate, $F(2\ 5560) = 1396.76$, $p < 0.0001$. Gaze alone is responsible for a 50% success rate of (about 3 times the chance level of 1/6 $= 16.7\%$).

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Han, D.T., Suhail, M. and Ragan, E.D., 2018. Evaluating remapped physical reach for hand interactions with passive haptics in virtual reality. IEEE transactions on visualization and computer graphics, 24(4), pp.1467-1476.

Fig. 1. Applications used in the research. *Right*: The immersive game designed in the case study uses remapped reaching techniques to interact with multiple virtual objects. *Left*: A representation of translational shift. The opaque hand and green cylinder show the virtual objects, and the partially transparent blue objects show where the hand and object are in the real world. This image demonstrates the simple environment used in Experiments 1 and 2, though the experiments did not include the blue representations of the real locations.

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Sixteen university students (8 male, 8 female) took part in Experiment 1. Participants' ages ranged from 20 to 29 with a median of 25 years. Participants were students in degree programs related to computing, engineering, and art. Nine participants reported spending at least one hour a week playing 3D video games, and 11 reported having prior experience with VR.

factors. For our analysis and presentation of results, we use repeated-measures ANOVA tests and graphical plots to represent differences due to experimental variables. For brevity, we only report test statistics for significant effects. We present results using box-and-whisker plots

Han, D.T., Suhail, M. and Ragan, E.D., 2018. Evaluating remapped physical reach for hand interactions with passive haptics in virtual reality. IEEE transactions on visualization and computer graphics, 24(4), pp.1467-1476.

tual object offset being *away* from user or *toward* the user). We ran three-way repeated-measures ANOVAs for reach time (the difference between the condition and average times for the position with baseline one-to-one reaching) and reach errors. The distribution of times are shown in Figure 4. Overall, the *interpolated reach* technique was significantly slower overall than the *translational shift* technique with a significant main effect yielding $F(1,15) = 4.83$ and $p = 0.048$, but this is better explained by interaction effects (to be explained in the following paragraph). The effect of offset direction was also significant $F(1,15) = 148.49$ and $p < 0.001$, showing that reach speeds were significantly faster when the virtual object was offset away from the body than when offset toward the body. Additionally, offset direction had a significant main effect with $F(3,45) = 27.83$ and $p < 0.001$, with posthoc Bonferonni-corrected pairwise comparisons showing offsets of size 30 were significantly slower than all other offset sizes. It is interest-

Resources

Essential:

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Bergström, J., Mottelson, A. and Knibbe, J., 2019, October. Resized grasping in vr: Estimating thresholds for object discrimination. In Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology (pp. 1175-1183).

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