The Influence of Visual Appearance of User's Avatar on the Manipulation of Objects in Virtual Environments

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Abstract

This paper describes an experiment conducted to study the influence of visual appearance of user's avatar (or 3D cursor) on the manipulation of virtual objects in Virtual Environments (VE). Participants were asked to pick up a virtual cube and place it at a random location in a VE. We found that one visual property of the avatar (the presence or absence of a directional cue) could influence the way participants picked up the cube in the VE. When using an avatar or a 3D cursor with a strong directional cue (e.g., arrows pointing to the left or right), participants generally picked up the cube by a specific side (e.g., right or left side). When using 3D cursors with no main directional cue, participants more frequently picked up the virtual cube by its front or top.

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Keywords: avatar, 3D cursor, visual appearance, directional cue, manipulation

1 Introduction

The avatars (or 3D cursors) used to display the user during manipulation tasks can look very different in Virtual Environments (VE) [1]. However, we do not know today the potential impact of the avatar's visual appearance on the behaviour of users when manipulating virtual objects [2] [3]. Therefore, we have conducted an experiment to study the influence of the visual directional cue of avatars on the selection and manipulation of a virtual object in 3D.

2 Experiment

2.1.1 Participants

Twenty-four participants aged from 19 to 25 (mean=20.5, standard deviation: sd=1.4) took part in this experiment. There were 2 women and 22 men. All the participants were right-handed and naïve to the purpose of the experiment.

2.1.2 Experimental Apparatus

We used a haptic device (PHANToM Omni of Sensable Technologies [4]) in passive mode (i.e., without any force feedback) to track the user's position precisely. The participants could manipulate the extremity of the interaction device like a pen, using their dominant hand (Figure 1).

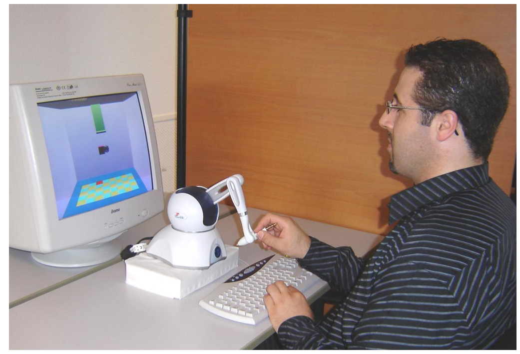

Figure 1: Experimental Apparatus

The virtual scene (see Figure 2) was made of a chessboard, a pink cube, a green platform, and a blue avatar (3D cursor of the user). The visual feedback was displayed on a 19" computer screen in monoscopic conditions, with a frame rate of 85Hz (see Figure 1). When manipulating the PHANToM device, the participants could move accordingly the virtual avatar. However, the orientation of the avatar was kept constant, as the rotations of the device and of the user's hand were not applied to the 3D cursor.

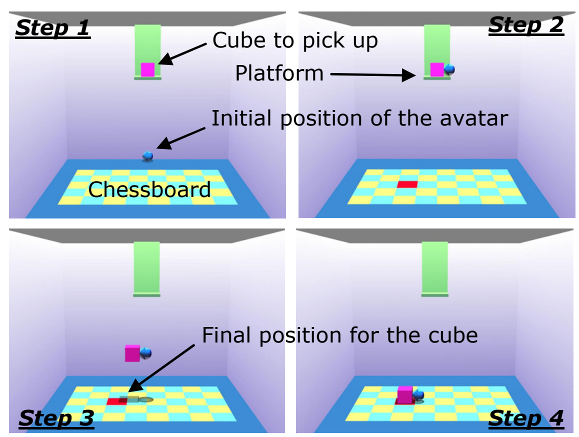

Figure 2: Virtual scene and task procedure

2.1.3 Procedure

The participants were seated in front of the screen, with the PHANToM device being placed in front of them (see Figure 1). The participants could use their non-dominant hand for the keyboard. Every trial consisted in two phases: one phase for the selection of the cube and one phase for the displacement of the cube. At the beginning of every trial, the virtual cube was automatically positioned on a virtual platform located at the top of the screen (see Figure 2).

- <u>Selection:</u> The participants had first to press one start key on the keyboard. Then, the avatar automatically appeared at its initial position, i.e. at the bottom of the screen (see Figure 2).

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The participants had to grasp the extremity of the PHANToM and remove it from its neutral position. Then the user had to pick up the virtual cube located on the upper platform. To do so, they had to put the spherical envelope of the avatar (see Figure 3-Right) in contact with the cube and press the space bar.

- Displacement: Once the cube was selected, the final position where the cube was to be released was randomly selected and indicated to the participants by a change in colour on the chessboard (see Figure 2). The participants had to move the virtual cube to its final position. The motion (positions) of the participants was directly applied to both the avatar and the cube (apart from the rotation) via the PHANToM device. To release the cube, the participants had to release the space bar. When the participants estimated that the cube was well positioned, they could end the trial by pressing one key of the keyboard. The avatar disappeared and the participants had to replace the PHANToM at its neutral position, i.e. to clutch it on its base. The next trial was launched by pressing a key of the keyboard.

2.1.4 Conditions

We used three different avatars: a "star" avatar and two "arrow" avatars (see Figure 3-Right). Contrary to the star, the two arrows had a main directional cue. These three avatars looked different, but they had exactly the same contact area with the cube via the same surrounding semi-transparent sphere (see Figure 3-Right).

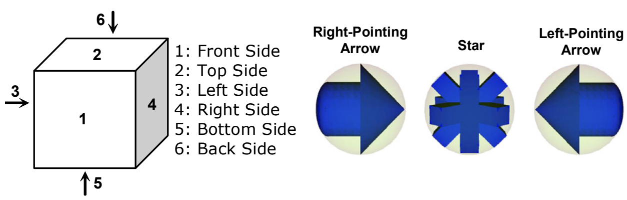

Figure 3 - Left: Sides of the virtual cube. Right: Avatars used.

The 24 participants were divided into 3 groups of 8 persons. The participants of each group used only one avatar, e.g., the participants of the first group used only the star-like avatar during the full experiment. Every participant had then to perform 55 trials. At the beginning of the experiment, the participants had a learning phase including 5 trials. The experiment lasted about 40 minutes, including the learning phase and breaks.

2.1.5 Collected data

For every trial, we collected the side by which the participant picked up the cube: front, back, bottom, top, left, right (see Figure 3-Left).

2.1.6 Results

The average percentages of selection for each side of the virtual cube are provided in Table 1 as function of the three avatars. Globally, the participants preferred to pick up the cube by its front side (45% of the trials for all participants, whatever the experimental condition). Then, the participants chose the right side (25%), the top side (15%), the left side (11%) and the back side (4%). The bottom side was very difficult to reach (4/1320, i.e. 0,3% of the trials), since the cube was posed on the platform. Thus, this condition is not reported in Table 1.

Statistically, there was a strong association between the avatars and the side chosen to pick up the cube (Cramer's V^2=0.45). To further analyse this association, we computed the associated Relative Deviations (RD). The results (displayed in Table 1) show that in the case of the star, the participants favoured the front and top sides. The left-pointing arrow was more associated with the choice of the right side. The right-pointing arrow was more correlated to the left side. The test was highly significant (Khi 2 = 1056.9, DoF= 10, $p < .0001$). This confirms that the avatar condition strongly influenced the participants and their picking strategy.

Table 1: Choices of the participants concerning the side to pick-up the virtual cube as function of the avatars (% values indicated in bold and underlined correspond to positive RD >.20)

Avatar	Front Side	Top Side	Left Side	Right Side	Back Side
Star	***67.05%***	***27.50%***	0.23%	0.45%	4.77%
Left-Pointing arrow	26.59%	0.91%	0.45%	***70.68%***	1.36%
Right-Pointing arrow	***41.59%***	16.59%	***32.73%***	2.95%	***6.14%***

2.1.7 Discussion

A predominance of the front side was globally noticed. This is probably due to the fact that the front side was the most visible and the easiest to access. The orientation-neutral avatar, i.e., the star avatar, was found highly correlated with the front side. Then, the participants picked up the cube preferentially by its right side when they were exposed to the left-pointing arrow and, conversely, they favoured more oftenly the left side in the case of the arrow pointing to the right.

Taken together, these results suggest first that if the avatar gave a directional cue, the user tended to pick up the virtual object by "pointing" the avatar toward the centre of the virtual object. Second, when no directional cue was suggested by the avatar the participants tended to use the front of the target as the selection area.

The strategy of selecting the front side remained highly chosen in the case of the right-pointing arrow. This could be explained by the fact that all participants were right-handed and that they all manipulated the device with their right hand. Thus, it was probably more difficult for them to rotate their wrist and point to the right, and it was thus probably less "natural" for them to reach and pick up the cube by its left side.

3 Conclusion

The results of our experiment showed that the visual directional cue of an avatar could change the way participants selected and picked up a virtual cube. Orientation-neutral cursors could make the participants pick up the cube by its front or top. The visual directional cue of virtual arrows could make the participants pick up the virtual cube more preferentially by its right or left sides.

The choice of the graphical display of the user's avatar seems thus to be very important in virtual manipulation tasks. Indeed, the visual directional cue of an avatar could partially determine the manipulation strategy in the VE.

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