The Impact of Time Pressure on Spatial Ability in Virtual Reality

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Abstract. The aim of this study is to explore the influence of time pressure on the spatial distance perceived by participants in the virtual reality. The results show that there is no significant difference while participants estimates the distance whether with or without time pressure. But while participants estimating short distance and long distance in the virtual environments there is significant difference. And under horizontal or vertical direction there are also significant differences while participants estimate long distance has more errors than short distance.

Keywords: Time pressure · Under horizontal · Vertical direction

1 Introduction

Psychometric studies of spatial ability [1–3] report evidence for several major spatial abilities factors. Two of them, spatial orientation and spatial relations, require the ability to imagine spatial forms from a perspective. When time-pressured, research shows that in general people become more anxious and may adopt a number of different strategies to complete tasks. However, for spatial ability very few studies indicate that time pressure has some effect on it [4–7].

The aim of this study is to explore the influence of time pressure on the spatial distance perceived in the virtual reality. To verify the impacts from the time pressure, experiments are designed. The experiment is to examine if there is significant difference while persons perceiving static distances between with limited time and without time limited.

2 Methodology

This experiment was conducted under the 3D scene and every participant must be experimented in two scenes. In the first scenario experiment participants should judge between the two groups of block (the black ones, the red ones)in a virtual tunnel. When they cross the tunnel, there is a distance of 10 meters two blue balls as a reference. Participants need to through the tunnel and judge the distance between the other two groups of block. In the second scenario experiment, participants sit in the Tower crane

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control room and observe three stacking (the blue one, the red one, the black one) under the tower crane. The height of the blue one is 10 meters as the reference. Participants need to judge the height of the other stacking.

2.1 Participants

Twenty persons (10 males and 10 females) from Beijing, aged 20 to 25 were recruited for the experiment. These participants were asked to do the space perception test, and with which used to measure their ability of space perception. In order to test the spatial visualization ability of subjects, this test has used folding questions. The result shown in Table 1 as follows. In the analysis between the groups in mean square value is 0.450, the within groups in mean square value is 4.517. The test statistic $F = 1.0$. $p = 0.756 > 0.05$. So there is no significant differences in the spatial perception between the two groups of experimental personnel.

Table 1. One-way ANOVA

	Sum of squares	df	Mean square	F	Sig
Between Groups	.450	1	.450	.100	.756
Within Groups	81.300	18	4.517		
sum	81.750	19			

2.2 Apparatus

The trials were completed by using two tasks. Firstly, the tunnel experiment, the subjects need to pass through the tunnel and judge the distance between the two groups of block, a set of 10 meters block (The blue one) as a reference. The scenario of the tunnel experiment is presented on Fig. 1. In the second picture, you can see the scene after the experimenter entering the tunnel. After the experimenter through a distance of 10 meters of blue reference, and then he will be through two black cube object and two red sphere object, the object distance between the two groups were 5 meters,10 meters. The experiment requires that the experimenter judge the distance of the two groups object after they through the tunnel. Secondly, the tower crane experiment, this scenario is simulated as a construction site, on the Fig. 3 there are three stacking under the tower crane on the construction site. This is presented in the first view of the experimenter. The participants in the tower crane operating room must observe the height of three stacking. Among them, the blue stacking's height of 10 meters as a reference. Figure 4 is the observation of three stacking with the third view point. Because of their location exists the difference between front and back, although the black stacking's height is 6 meters, the red stacking is 5 meters, the black object seems to be much higher than the red one in the first perspective. Therefore, the scene investigates that the experimenter's ability to judge the height of the stacking in the location exists the difference between front and back (Fig. 2).

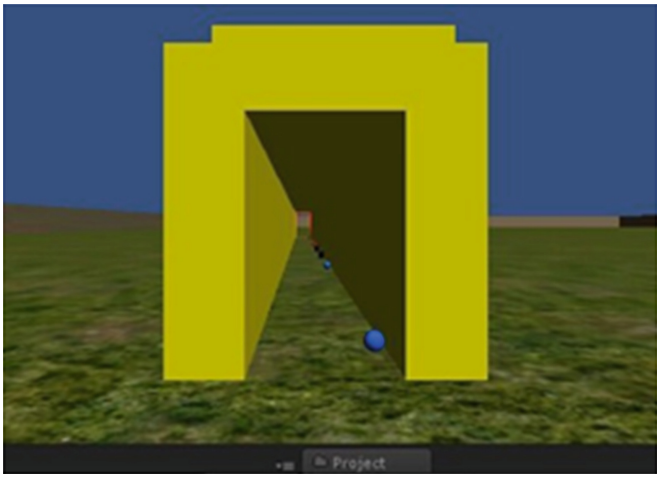

Fig. 1. Tunnel for experiments

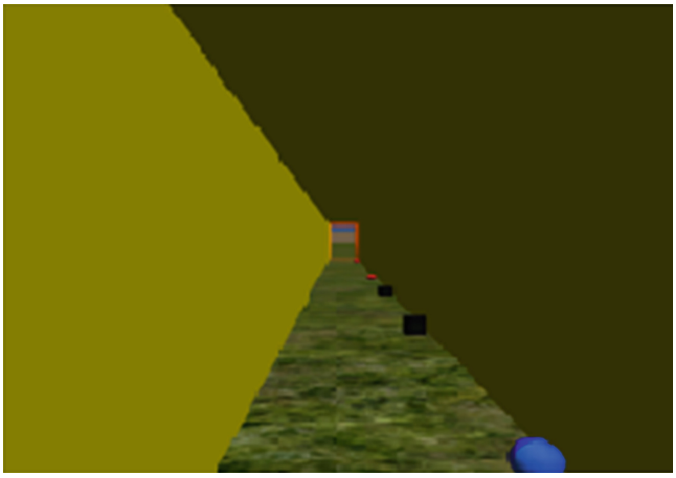

Fig. 2. Inside of the tunnel for experiments

2.3 Procedures

In this experiment, two groups of participants should complete two experiments. The first group of participants must estimate the horizontal distance between the objects and judge the vertical height of the object in 5 s. The second group of participants should complete the two experiments in the infinite time.

Each participant must fill in the informed consent and basic information questionnaire and then they can do the spatial ability experiments. Before doing the experiments, they must be familiar with the environment in the virtual space. Each one completed two formal experiments that judging the distance between two objects in a horizontal direction and determining the height of the object on the longitudinal. There

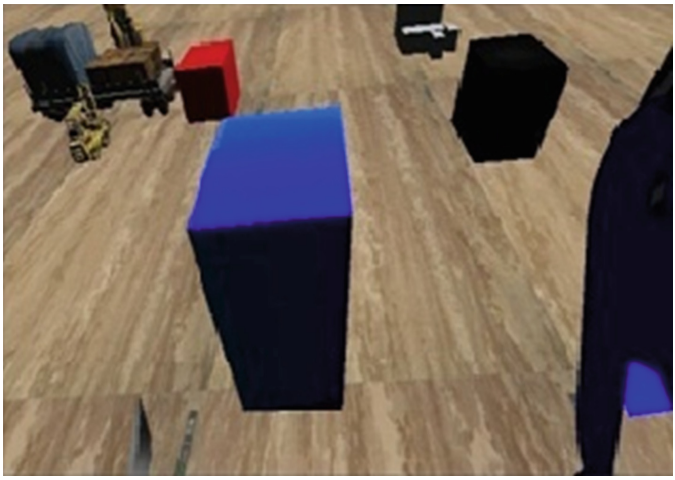

Fig. 3. Tower crane in the first perspective

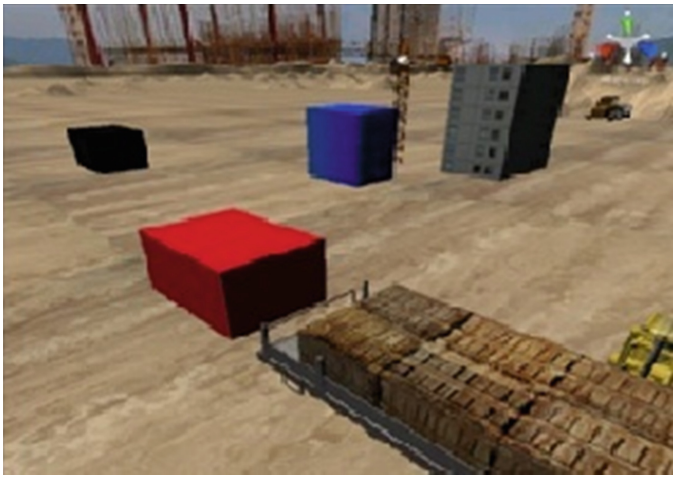

Fig. 4. Tower crane in the third perspective

is a reference for the participant to judge. Experiments are conducted in a random order and the researchers recorded the time and the number of errors in the experiment after the participants completed it.

3 Results and Discussion

Table 2 showed the descriptive statistics of average errors, which are difference between correct and estimated values. Without time pressure while participants estimating horizontal distance, the mean are 2.10 and with time pressure the mean are 2.30.

Without time pressure while participants estimating vertical distance, the mean are 1.65 and with time pressure the mean are 2.30.

Table 3 showed the results of analysis of variance. For time pressure or direction, there was no significant difference between with pressure and without pressure while participants estimating distance in the virtual environments. For distance, the results showed that the significant was 0.000 less than 0.05 while participants estimating short distance and long distance in the virtual environments, which indicated there was significant difference while participants estimate long distance have more errors than short distance in the virtual environments. As for interaction effects, on the condition different direction there was significant difference between short and long distance. And the significant was also 0.005 less than 0.05. The results indicated that under horizontal or vertical direction there were significant differences while participants estimate long distance has more errors than short distance in the virtual environments.

Table 2. Descriptive statistics of errors

Direction	Time pressure	Distance	Mean (meters)	Std. Deviation	N
Horizontal	Without pressure	Short	1.15	1.15590	10
		Long	3.05	1.97836	10
		Total	2.10	1.85387	20
	With Pressure	Short	.60	1.07497	10
		Long	4.00	2.30940	10
		Total	2.30	2.47301	20
	Total	Short	.88	1.12244	20
		Long	3.53	2.14890	20
		Total	2.20	2.15965	40
vertical	Without pressure	Short	1.30	1.81353	10
		Long	2.00	1.05409	10
		Total	1.65	1.48767	20
	With Pressure	Short	2.20	2.14994	10
		Long	2.40	1.57762	10
		Total	2.30	1.83819	20
	Total	Short	1.75	1.99011	20
		Long	2.20	1.32188	20
		Total	1.98	1.68306	40
Total	Without pressure	Short	1.23	1.48213	20
		Long	2.53	1.63413	20
		Total	1.88	1.67466	40
	With Pressure	Short	1.40	1.84676	20
		Long	3.20	2.09259	20
		Total	2.30	2.15073	40
	Total	Short	1.31	1.65517	40
		Long	2.86	1.88444	40
		Total	2.09	1.92711	80

Table 3. Tests of between-subjects effects

Source	Type III Sum of squares	df	Mean square	F	Sig.
Corrected Model	84.138(a)	7	12.020	4.136	.001
Intercept	348.613	1	348.613	119.953	.000
Direction	1.013	1	1.013	.348	.557
Time pressure	3.613	1	3.613	1.243	.269
Distance	48.050	1	48.050	16.533	**.000**
Direction * Time pressure	1.013	1	1.013	.348	.557
Direction * Distance	24.200	1	24.200	8.327	**.005**
Time pressure * Distance	1.250	1	1.250	.430	.514
Direction * Time pressure* Distance	5.000	1	5.000	1.720	.194
Error	209.250	72	2.906		
Total	642.000	80			
Corrected Total	293.388	79			

4 Conclusion

The results show that there is no significant difference while participants estimates the distance whether with or without time pressure. But while participants estimating short distance and long distance in the virtual environments there is significant difference. And under horizontal or vertical direction there are also significant differences while participants estimate long distance has more errors than short distance. The results of the analysis could be as the foundation for the future.

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