Popular Science Summary

Virtual reality (VR) here refers to the simulations of a virtual space experienced through a head-mounted display. It has become a popular method for experiments due to its high degree of freedom in scenario design and relatively low dangers and risks compared with real laboratory experiments. However, VR's nature, game like simulation, simplified interactable modes compared to real-world, and the lack of consequence due to the absence of real dangers, can reduce the reliability and validity of experimental results obtained in VR. To enhance the reliability and validity of the result in VR fire scenarios, additional sensory perceptions are often adopted, such as temperature changes and smoke smell to improve the fire threat perception in VR.

However, due to the nature of using VR to avoid actual risks associated with real fire and smoke, simulated temperature changes are significantly weaker than those experienced in real-life scenarios. Ethical guidelines generally suggest that the maximum heat radiation should not be more than $2kW/m^2$, the intensity is mostly like standing under sunlight at a summer noon. Since the intensity is way weaker than the actual fire, and the use in experiment still requiring ethical approval from authority, then why not let people imagine a heat in their mind instead? Therefore, rather than using a real simulated heat radiation, the subject-expectancy effect, also known as placebo effect, is adopted in this thesis. Placebo effect is commonly observed in medical for drug testing. In this study, participants were shown a heat radiation device which were not activated during the VR experiment, allowing them to be tricked by their expectations of receiving heat radiation.

The study examines whether the placebo effect could achieve similar results to using simulated heat radiation in terms of enhancing the fire threat perception in VR. The experiment used between-subject comparison (Treatment group and Control group) and three different sizes of virtual fires (Large, Medium, and Small) as setup. All participants were instructed to approach those fires individually until they believed they reached appropriate safe distances, which help evaluate their fire threat perception in VR. The treatment group was clearly informed about the presence of heat radiation in the experiment to create the placebo effect, while the control group was not.

The results, based on statistical analysis of the distance from the virtual fires and questionnaire responses, involved a total of 33 participants, with 17 in the treatment group and 16 in the control group. Though the analyse on safe distances does not show significant statistical differences between the two groups, the difference on heat sensation was confirmed statistically. In the treatment group, half of the participants reported feeling weak heat radiation. The study discovered that placebo effect on heat influenced half of participants in the treatment group, and a few individuals in the control group was affected significantly, they reported feeling heat explicitly even though they were told the heat radiation was not involved. One thing worth mentioning, placebo effect may be broken down as the scale of fire decreasing. Unlike the large and medium fires cases, for the small virtual fire, the treatment group shows a closer averaged distance contribution, possibly derived from the participants' desire to confirm the presence of heat sensation at close distances.

In conclusion, the use of the placebo effect with heat radiation showed a slight benefit in the realism and immersion of fire scenarios in VR. But it still cannot be determined whether the use of the placebo effect or simulated heat radiation is superior, the lack of comparative research with actual fire scenes and the potential influence of the size of the virtual fire source require further research to explore the relationship and impact among these variables.