British Journal of Psychology (2018), 109, 427–430

The British Psychological Society

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Commentary

Virtual reality: A new track in psychological research

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One major challenge of social interaction research is to achieve high experimental control over social interactions to allow for rigorous scientific reasoning. Virtual reality (VR) promises this level of control. Pan and Hamilton guide us with a detailed review on existing and future possibilities and challenges of using VR for social interaction research. Here, we extend the discussion to methodological and practical implications when using VR.

A central goal of psychological research is to understand real-life human behaviour. Yet, scientific reasoning requires psychologists to examine behaviour under highly controlled conditions, ideally with only a few manipulations at a time to allow rigorous scientific inferences. Hence, researchers find themselves in a dilemma: Experimenters often need to choose between experimental control and ecological validity. How can psychologists overcome this impasse?

In their review paper, Pan and Hamilton (2018) outline how this challenge can be tackled using virtual reality (VR) in social interaction research. VR allows to create complex and realistic social environments that are under full experimental control and enable participants to behave naturally. Hence, VR offers the best of both worlds: full experimental control required for scientific reasoning and natural behaviour and realistic environments to boost ecological validity of the results. Pan and Hamilton provide a very nice summary of the advantages and future challenges that occur on several levels of experimentation when using VR for social interaction research.

Here, we would like to highlight three main advantages of VR. First, VR allows to make the impossible possible (e.g., participants can take on the role of superman; see Rosenberg, Baughman, & Bailenson, 2013). This is useful for the exploration of novel research questions (e.g., Banakou, Hanumanthu, & Slater, 2016), creation of control stimuli (e.g., Ferstl, Bülthoff, & de la Rosa, 2017), or dissociation of otherwise 'inseparable'

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DOI:10.1111/bjop.12302

psychological mechanisms (e.g., Lenggenhager, Tadi, Metzinger, & Blanke, 2007). VR therefore opens the window to new research questions.

Second, as discussed by Pan and Hamilton (2018), VR enhances the ability to replicate social psychological experiments. Programming a VR experiment forces researchers to exactly define the experimental situation in programming code. With this, it is now possible to share these software projects, and allow other researchers to precisely replicate the experiment. VR therefore contributes positively to the recent reproducibility debate in psychology (Aarts *et al.*, 2015).

Third, VR offers the possibility to change our thinking about social interaction by allowing to examine a defining aspect of social interactions: the reciprocal exchange of information between interaction partners. So far, the social interaction behaviour is often understood in terms of a Shannon–Weaver communication model (Shannon & Weaver, 1963): One person encodes a signal and sends it via a communication channel to another person, who decodes the signal. This thinking nicely aligns with the current statistical approaches (e.g., general linear models, GLM). For a two person interaction, GLM would consider the behaviour of one person as the dependent variable and the other person's behaviour as the independent variable. This kind of exchange does not always warrant a proper social interaction as the following dialogue between Peter and Sandra intends to demonstrate:

> *Peter:* 'How are you?'
> *Sandra:* 'I've got three green balls. How about you?'
> *Peter:* 'I am fine. Where are you going?'
> *Sandra:* 'I've got no red ball'.

Although Peter and Sandra exchange information in Shannon-like style, their conversation is missing a defining feature of social interactions, namely relating the answer to the other persons' question, that is, the reciprocity (e.g., Luhmann, 1995). The interactive nature of VR offers the opportunity to examine the psychological processes involved in establishing these reciprocal relationships between humans and their (social) environment. Yet, psychologist needs to use appropriate analytical tools tailored to capture these reciprocal relationships (e.g., feedback control theory) which have been used only sparsely so far (e.g., Dumas, de Guzman, Tognoli, & Kelso, 2014). By enabling researchers full experimental control over a social interaction, VR offers the opportunity to take a new methodological and theoretical look at social interactions.

With many years of VR experience in our laboratory, we also would like to comment on the challenges of VR. Like many powerful tools, VR can also introduce undesired artefacts if not done carefully: mismatches in limb locations, delays in movements, limited field of view, or incongruent cues are just some examples. All these can lead to distorted measurements or even to VR sickness of the participants. In addition, consumer-level VR systems are optimized for price, convenience, and end-user experience by employing proprietary tricks and approximations. For example, all current head-mounted displays will induce an unnatural combination of eye vergence and accommodation due to their optical design of the stereo display. Researchers should be aware that these might influence experimental results. With these limitations and black box algorithms in place, calibration and verification of consumer-level VR systems can be challenging (e.g., Niehorster, Li, & Lappe, 2017).

Turnkey VR systems might not always suffice and additional equipment such as eye trackers, EEG, or GSR devices might be required for a specific scientific question.

Integration of such devices is likely to require a deeper dive into the underlying technical layers. As this can be very time consuming, many have to rely on experienced VR technicians to take care of the interplay of the low-level components, adding to the total cost of ownership.

The VR software is the central component that integrates all the elements and allows the design of an experiment. Akin to the hardware, VR software has also become widely available and turned into easy-to-learn products. But as it is also targeting the mass (entertainment) market, researchers might find it challenging to implement the required fine grained control over the stimulus presentation needed for scientific experimentation. Hence, a good amount of programming skills and knowledge of graphics pipelines is still required for anything but the simplest VR environments.

Finally, psychologists entering the field of VR development also need to consider the aspect of 'content creation', that is, the design and production of the images and 3D models to be shown in the virtual environment. Particularly careful crafting is necessary in the creation of human avatars as humans are very sensitive to even small deviations from normal social information (e.g., incorrect eye gaze). Moreover, it holds that 'one cannot not communicate' (Watzlawick, Bavelas, & Jackson, 1967): Even small artefacts in the appearance or behaviour of virtual humans might trigger psychological processes that are different from those relevant to the experiment (Crookes *et al.*, 2015), thereby potentially lowering the experiment's internal validity. Hence, the effort (and talent) required for creating human avatars should not be underestimated.

Considering all the benefits and challenges of VR for psychological research is it still valuable going down the VR road? Some parts of the road are still bumpy and need patching efforts. Yet, we firmly believe that the destination makes the trip worthwhile: the understanding of real-life human behaviour. Pan and Hamilton provide an excellent survey map for this trip through the social interaction research landscape.

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Received 8 March 2018; revised version received 14 March 2018