

Understanding crowd responses to emergencies using virtual reality and social psychological methods

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Abstract

Our project brings together research from crowd psychology and evacuation research to design and build virtual reality experiments that explore crowd responses to perceived threats. This summary outlines some of the main advantages and considerations that we have found when combining our research areas. We discuss novel ways to overcome practical and ethical limitations when researching responses to emergencies and behaviour in large groups, methodological advances that address common issues such as interdependence of data and experimental control, the ability to integrate and test theory into study design, and the benefits of triangulating diverse data collection methods to understand how and why crowd reactions occur in emergencies in real-time.

Introduction

There is a recurring trend of terrorist attacks targeting crowded spaces to cause maximum disruption. Incidents such as at the Manchester Arena on 22nd May 2017 and London Bridge on 3rd June 2017 show how the attacks can create confusion and fear. Crucially, however, they also show how crowd members can pull together to coordinate their response, help one another and save lives.

Researchers in both crowd psychology and evacuation research have addressed human responses to emergencies but with different primary focuses. Research from crowd psychology has explored the reasons underpinning collective response (e.g., Drury et al., 2009; Drury, 2018), whereas research on evacuations has used virtual reality research to examine decision-making (e.g., Kinateder & Warren, 2016; Arias et al., 2020). As part of the ESRC funded project ‘Perceived threats and ‘stampedes’’, we bring together these research avenues to design and build a virtual reality experiment that tests the role of key variables impacting perceptions of threat and sudden flight behaviour.

We have had extensive exciting discussions about how to incorporate conventional methodologies from each discipline, including what benefits the disciplines can offer one another, the new research possibilities afforded to us by collaboration, and the practical considerations when combining conventional methods from separate disciplines. Here, we outline some of the main advantages and considerations that we have found when combining our research areas.

Ability to create virtual scenarios

Crowd psychologists face numerous challenges when designing crowd experiments. Replicating a crowd scenario can require a large number of participants to participate at the same time and substantial funds to pay them. If we are successful in recruiting enough people for the crowd scenario then we would need to consider the effect of interdependence of data, and face difficulties maintaining controlled conditions. Creating an emergency environment poses particularly important ethical considerations such as how to ensure participant safety during evacuation (although there have been successful examples of controlled emergency field experiments, e.g., see Carter et al, 2016).

Using virtual reality allows us to overcome these challenges. We can recruit and test participants individually in pre-defined controlled environments. We are able to create

scenarios where we can manipulate particular variables and keep important factors constant, such as how other crowd members behave, what information the crowd members are given, and when the information is presented. Particularly important for our project, it has allowed us to create a virtual emergency scenario that avoids risk to participants and overcomes ethical and practical challenges such as having to manage multiple people in a controlled evacuation. It has opened up the possibility to explore crowd behaviour in immersive and non-immersive virtual environments under different conditions, thus increasing our understanding of *what* behaviour may occur in different conditions, and *why* the behaviour occurs.

Use standard methodologies in new ways

In psychological research, we often use stimuli at the beginning of studies to manipulate participants' perception and/or decision-making. Through vignettes or imagined scenarios we may, for instance, increase participants' social identification with a particular group (e.g., Templeton et al., 2018) or prime participants' perceptions of groups and individuals. However, the stimuli may not be sufficiently realistic or engaging to be effective primes, and its effects may diminish throughout the experiment. Virtual reality can provide a solution since it allows researchers to seamlessly integrate stimuli into the environment with close experimental control. Methodologies akin to priming stimuli are sometimes used in virtual reality experiments measuring social influence, such as by testing how a participant reacts when virtual agents are either absent, run towards a correct exit, or stand still (see Kinader et al., 2014). However, they do not manipulate a key variable affecting social influence: social identification.

In our project, we combine priming methodologies from both disciplines to create engaging primes with close experimental control. We use traditional stimuli from social psychology (e.g., vignettes to manipulate threat level) before the participants enter the virtual scenario, and then use methods from virtual reality to complement the information within the virtual scenario (e.g., a newspaper stall discussing the threat level). Thus, we have been able to use conventional psychological stimuli to prime social identification at the start of the studies before participants enter the virtual environment, and then complement these with stimuli that serve as reminders about the primes within the environment. This increases continuity through the study and allows us to establish new ways to present psychological primes and

keep those primes salient for the participants, particularly at key times when the prime should be most relevant.

Integrating and testing psychological theory

Our project uses aspects of the social identity approach (Tajfel & Turner, 1979; Turner et al., 1987), social appraisal (Manstead & Fischer, 2001), and signal detection (Johnson & Tversky, 1983). These concepts are core to our research question of how people in crowds respond in the immediate aftermath of emergencies. For example, the social identity approach suggests that people are most influenced by those they perceive to be members of their group. According to the social appraisal literature, in novel situations such as emergencies people look to others' emotions for information about how to act. Meanwhile, research from signal detection suggests that experience of previous attacks or 'false positives' (i.e., false alarms) may predict hypervigilance.

One way to research who participants look to in emergencies is by using eye-tracking methodologies. This can then be correlated with behavioural data (such as route-choice decisions) to infer why behaviour occurs. However, it is a substantial operational challenge to create an emergency situation, manipulate perceptions of group membership, and perform eye-tracking on a crowd of participants. Using virtual reality enables researchers to both integrate theory in the study design and test the effects of theory in their outcome measures. For example, researchers can integrate self-categorisation theory by manipulating who participants perceive to be ingroup and outgroup, and they can measure the effects by how the participants respond to information presented in the virtual scenario. Using virtual reality also provides the ability to repeatedly test the same scenario to gain confidence in the results, as well as comparing between conditions (e.g., others in the scenario being ingroup or outgroup members) to evaluate whether the outcomes are consonant with the theoretical predictions. More broadly, using virtual reality can assist with replicability to test the experiments across diverse populations.

Understanding *what* happens and *why* it happens in real-time

One major advantage of combining traditional methodologies from psychology and virtual reality is that we can combine behavioural and self-report data to understand what behaviour occurs in different conditions and why it occurs. Previous influential research on behaviour on crowd flight is mostly based on retrospective survivor accounts of behaviour and choices

(e.g., Cocking, 2013; Drury et al., 2009). Although retrospective data is important, the research on real-time behavioural decision-making is limited. Drury et al. (2009) paved the way for how to combine real-time behavioural data in virtual evacuation supplemented by self-report information about levels of social identification with others in the scenario, and level of help the participants wanted to provide others in the virtual scenario.

Our research builds on the methodologies of Drury et al. (2009) and researchers in the field of Human Behaviour in Fire (Arias et al., 2019; Arias et al. 2020) by testing psychological phenomena such as perceived risk and decision-making in real time. For example, we use data from eye-tracking to ascertain what information participants attend to, and movement decisions such as whether or not to follow others in the environment. Immediately following the virtual scenario, we use a survey to gain self-report data about the reasons for the behaviour. Thus, we triangulate conventional data collection methods from both disciplines to gain a fuller understanding of what crowd reactions can occur and why they occur. Moreover, we are able to repeatedly test how different participants respond to the same conditions to increase our confidence in what is causing their reactions.

Concluding remarks

There are clear benefits of using our interdisciplinary methodologies and collaborative approach. Throughout our project activities, we have learned new ways to measure core questions (e.g., how crowd responses develop in real-time under different conditions) and improved our methodological abilities (e.g., manipulating key independent variables in both immersive and non-immersive virtual environments). Our collaboration has enhanced our understanding of crowd members' decision-making in emergencies. However, the approach will allow us to continue to build our theoretical knowledge of group processes and develop interdisciplinary methodologies to address joint questions far into the future.

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