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ORIGINAL ARTICLE

An exploratory study on manifesting decision-inertia in a 360-degree extended reality terrorist incident

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Abstract
Emergency response decision making is crucial in managing critical incidents; however, several studies have demonstrated the negative effects of decision inertia. Understanding the manifestation and impact of decision inertia, as well as utilising extended reality (XR) technology with 360-degree immersion, should enhance decision making in high-stress environments and improve emergency response efforts. This study investigated decision inertia, using 109 participants, in an XR 360-degree environment and its impact on decision-making outcomes. The findings revealed that participants often opted for a sub-optimal outcome, and decision inertia scores varied across these outcomes. Linear regression analysis demonstrated that decision inertia scores significantly predicted decision outcomes, with higher decision inertia scores associated with sub-optimal decision-making. Participants prior moral decision-making did influence subsequent immersive reality decision outcomes and demonstrated a Bayesian updating effect. The Structured Tabular Thematic Analysis highlighted the importance of information validity, decision confidence, and scenario fidelity in decision-making within the immersive environment. The study provides insights into decision inertia in immersive virtual reality critical incidents and offers practical solutions for improving decision-making processes in emergency response contexts.

Keywords Decision-making · Extended reality · Immersive environments · Emergency response

1 Introduction

Emergency response decision making is a complex and critical process that plays a pivotal role in effectively managing and mitigating the impact of critical incidents (Alison et al. 2013; Shortland et al. 2020a, b, c; Turoff et al. 2011) – this encompasses a wide range of scenarios, including natural disasters, terrorist attacks, industrial accidents, and public health emergencies (e.g., Craigie et al. 2020; Ghaemmaghami et al. 2021). Responding to such events requires emergency personnel to make swift, informed decisions under high-stress conditions (Alison et al. 2013, 2022; Eyre and Alison 2007; May et al. 2023; Power and Alison 2018; Shortland et al. 2020a, b, c), often with limited time and resources (Thunholm 2003; van den Heuvel et al. 2014). The ability to navigate these situations and make optimal choices (e.g., minimising casualties) is crucial for collaborative interoperable decision-making (e.g., multi-system response to a critical incident event; Davidson et al. 2023; Kapucu and Garayev 2011) and optimal outcomes (Shortland et al. 2020a, b, c).

The impact of exogenous (i.e., outside of the boundaries of the emergency response operation, such as decision models) and endogenous factors (i.e., within the boundaries of the emergency response) can have severe consequences on critical incident decision-making. In this context, exogeneity arises from the lack of clarity surrounding the operational system tasked with addressing the decision problem. For instance, Bearman et al. (2017), suggest that uncertainties can stem from confusion regarding the expected behaviours of oneself and others, significantly impairing the effectiveness of team planning and decision execution. When applied to a critical incident command team - often interdisciplinary and cross-functional – they face particular challenges due to their diverse compositions and varying levels of operational experience (Nohrstedt 2000). The

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ad hoc and hierarchical nature of these teams can obstruct their ability to function interoperably (House et al. 2014). Confusion over roles and responsibilities not only generates uncertainty but also diminishes confidence and self-efficacy, affecting dynamic decision-making (Shanteau 1992; Bandura 1997; Olson et al. 1996). Effective decision-making, therefore, relies on clear communication and shared understanding of roles and responsibilities, which can mitigate the adverse effects of exogenous factors (Salas et al. 1995; Espinosa and Clark 2014). This is particularly relevant when emergency responders face experiencing decision inertia, as these challenges can contribute significantly to decision-making paralysis within critical incident response personnel and teams. Decision inertia, in this context, refers to the delay or failure to make decisions due to uncertainty, fear of making the wrong choice, or lack of clear direction. Exogenous factors, such as confusion over roles, expectations, and the operational system, exacerbate this inertia by creating an environment where decision-makers are unable to move forward confidently.

Endogenously, critical incidents can negatively impact responder's cognitive processes. Klein (1993) characterises endogeneity as stemming directly from the complexities of the problem at hand. This form of indecision is driven by specific environmental factors encountered during decision-making scenarios, such as the presence of unclear information, the pressures of limited time, and the inherent risks involved (Oransanu and Connolly 1993). These elements can significantly contribute to a state of doubt among decision-makers. The essence of endogenous factors lies in the immediate assessment and understanding of the current situation, and extends to forward-looking considerations, including predictions and expectations about future developments (Klein and Snowden, 2007). Situations ubiquitously associated with endogeneity are often marked by the scarcity, overload, contradiction, or novelty of available information (Oransanu and Connolly 1993). As such, the inability to effectively interpret and understand a situation can lead to cognitive dissonance (Koppenjan and Klijn, 2004). In scenarios characteristic of critical incident – for example, fraught with rapid changes, instability, and emotional intensity- may hinder the decision-maker's capacity to grasp the situation adequately (Nohrstedt 2000). This perceived lack of control over the outcomes of one's decisions can heighten emotionality and amplify the likely uncertainty experienced (Klein, 1993). The challenge of mitigating situational uncertainty is particularly pronounced in dynamic contexts, where information can be inherently complex, contradictory, or simply not forthcoming (Fiore et al., 2010). Consequently, efforts to alleviate endogenous uncertainty through the pursuit of additional information can be ineffective.

In response to these challenges, strategic decision-makers often resort to alternative coping strategies. These include reliance on assumption-based reasoning, where decisions are informed by parallels drawn from past experiences, even at the risk of making incorrect assumptions about the present situation, and forestalling, which involves postponing decision-making as a temporary measure (van den Heuvel et al. 2014). Thus, endogenous uncertainty emerges from the problematic aspects of the decision-making environment and poses significant management difficulties due to its inherent complexity and the ambiguity of the information involved. For instance, individuals exposed to stress may encounter fragmented or distorted memories (Hope 2016), in part due to intentional rehearsal that inadvertently introduces misleading details (Crombag et al. 1996). This is an important process of preparing for, and responding to, a critical incident event. Prior experience and lessons learnt from previous incidents may not translate effective in the response to a critical incident event, as the recognition primed memory may be distorted (Klein, 1993). Stressed individuals may therefore find it challenging to effective respond to an event, and post-event provide accurate and reliable information during incident debriefings or investigations (Smith and Milne, 2018). These findings emphasise the importance of managing acute stress and minimising memory distortions in critical incident contexts to enhance the accuracy and reliability of information obtained for effective decision-making and resource allocation (see Verhage et al. 2018; for an overview on how stress can impair decision-making in high-stakes scenarios). More specifically, the ability to weigh risks and benefits, consider multiple options, and think critically are important considerations, as they may be compromised, especially under dynamic, uncertain, high-risk circumstances (Alison et al. 2022). As such it is important that research seeks to understand these cognitive-level processes within critical incident events (Eyre et al. 2012; May et al. 2023; Murata et al. 2015; Penney et al. 2022).

Decision making in critical incidents, therefore, is not without its challenges (Brown et al. 2020; House et al. 2014; May et al. 2023; Wilkinson et al. 2019), and deficits at the cognitive level has received limited attention in the literature (May et al. 2023). Studies that have investigated cognitive deficits have demonstrated that one specific phenomenon that hinders effective decision making is decision inertia (Alison et al. 2022; Power and Alison 2017, 2018; Shortland et al. 2018). Decision inertia refers to the tendency to maintain current courses of action despite changing circumstances or the availability of potentially better alternatives (Alison et al. 2015). It arises from various cognitive biases (e.g., Kahneman 2011) and psychological factors, such as the desire for stability, fear of making mistakes,

or the reluctance to deviate from established routines or protocols (e.g., Joint.

Joint Emergency Service Interoperability Programme (JESIP[1]); see, Waring et al. 2020). In the context of emergency response, decision inertia can have significant consequences, leading to delays in response, suboptimal resource allocation, and increased risks to responders and affected populations (Alison et al. 2015). Despite this, decision inertia in emergency response decision making remains relatively underexplored in the literature (May et al. 2023; Shortland et al. 2020a, b, c). In addition, little attention has been given to its specific manifestation and implications in the context of emergency response in critical incidents (Alison et al. 2022; Shortland et al. 2020a, c).

To gain a more nuanced understanding of decision inertia in critical incidents and its underlying cognitive processes, research has turned to the use of immersive technology (e.g., Alison et al. 2013; Brown et al. 2020; Wilkerson et al. 2008). Such technologies can provide a computer-generated simulation that immerses individuals in a three-dimensional, interactive environment, allowing them to navigate through realistic scenarios. For instance, the immersive nature of virtual reality (VR) replicates the complexity and stress of real-world contexts (Ruben 2023; Servotte et al. 2020), thereby enhancing the ecological validity of decision-making research. By creating a sense of presence within the virtual environment, VR and similar technologies (e.g., extended realities (XR) enable researchers to capture nuanced behaviours, responses, and cognitive biases (e.g., Feng et al. 2018) that may influence decision inertia. VR can elicit more authentic and reliable decision-making outcomes compared to traditional methods such as paper-based scenarios or computer-based simulations, by creating dynamic and interactive simulations of critical incidents (Brown et al. 2020; May et al. 2023). In this context, emergency responders can make decisions in a controlled, yet realistic, environment (House et al. 2014). This approach provides an opportunity to examine how decision inertia manifests within a virtual environment and its impact on decision-making outcomes. However, it is important to distinguish the characteristics from Virtual Reality (VR), which immerses users in entirely synthetic environments, to 360-degree XR content, which captures real-world perspectives for exploration.

1.1 Bayesian updating and decision inertia

Bayesian updating, a key concept in economic theory and decision-making under uncertainty, provides a foundation for dynamic decision-making strategies. This method, rooted in Bayes' rule, offers a structured way to revise initial beliefs in light of new evidence. Its relevance extends from theoretical economics to practical decision-making in emergency response, where it can guide the continuous adjustment of decision-making as new information arises. However, the gap between ideal Bayesian behaviour and actual human decision-making is relatively unknown in high-stakes environments. Studies indicate that individuals often deviate from Bayesian analysis, favouring heuristic evaluations (Kahneman & Tversky 1973; Ouwersloot et al. 1998; Zizzo et al. 2000). This deviation presents a challenge in emergency decision-making and can be associated to decision inertia. Alós-Ferrer et al. (2016) have shown that a preference for convergency and consistency can lead to repetitive decisions, even when those decision may lead to potential suboptimal outcomes.

As such, this study considers the process of Bayesian decision-making as a factor of decision inertia, where multiple options of uncertain outcomes might lead to repetitive decision-making, regardless of the presentation of new information. In this instance, the use of deontological tasks – commonly referred to as the 'Trolley Problem', can serve as an initial *prior*, which should be refined with new data to improve decision outcomes (i.e., least-worst decision making; Alison et al. 2015).

1.2 Immersive technologies: the use of 360 degree extended reality (360-XR)

Virtual reality (VR) emerges as a cutting-edge instrument in experimental research, particularly for its application in enhancing ecological validity of socio-cognitive evaluations. Traditional methodologies have relied on pre-established stimuli in controlled environments, utilising analogue tools like paper-and-pencil, or digital means such as computerised systems (Wilson et al. 1989; Negut et al., 2016). However, these methods typically offer only moderate ecological validity in terms of their ability to predict real-world outcomes (Alvarez and Emory 2006; Parsons 2015). To address these limitations, VR has been increasingly adopted for creating scenarios that reproduce real-life situations with heightened fidelity (Parsons and Rizzo 2008; Parsons 2015; Gamito et al. 2017; Parsons and Barnett 2017). VR interventions are capable of immersing participants in authentic, high-stakes environments, thus enabling the simulation of a diverse range of scenarios with exceptional internal validity and experimental control (van Gelder et al. 2014). Researchers can observe behaviours as they unfold in real-time, from the scouting patterns of burglars in virtual neighbourhoods (van Gelder et al. 2014; Gelder et al. 2019) to the nuanced decision-making processes of jurors (Reichherzer et al.2021). The transition towards VR-based applications

[1] See, https://www.jesip.org.uk/.

reflects a deliberate move to improve the ecological validity of assessments, seeking to more accurately encapsulate the complexities and subtleties of real-world settings. This shift in research methodology opens up a unique avenue for data collection and the study of decision-making phenomena that are otherwise challenging to examine due to ethical, logistical, or financial constraints (Abu-Safieh 2011; Conges et al. 2023; Zhang et al. 2023). The controlled yet highly realistic virtual contexts created by VR (Mania and Chalmers 2001; van Gelder et al. 2017), combined with its rigorous experimental governance (Blascovich et al. 2002; Fox et al. 2009), make it an unparalleled tool in experimental research.

The advent of 360-degree video technology marks a significant stride in the evolution of VR, enhancing the pace at which VR content can be developed. The emergence of 360° technology (Huang et al. 2017) can mimic the natural human capacity to gaze in every direction. This innovative camera-based technology is not only user-friendly but also accessible in terms of cost, negating the need for advanced technical *know-how* for everyday usage (Parsons 2015; Serino et al. 2017). Its adaptability has seen it find applications across areas, including but not limited to, educational settings (McKenzie et al. 2019), immersive journalism (Schutte and Stilinović 2017), and marketing (Habig 2016). This technology, therefore, introduces novel features that revolutionise how content is communicated and experienced, notably through user-directed control over viewing angles and an immersive quality that amplifies the sense of presence. Importantly, the consumption of 360-degree videos does not mandatorily require Head-Mounted Displays (HMDs); they can be viewed through web-based video players, which support interactive navigation by allowing users to drag and zoom within the video panorama. While applications of 360-degree have been explored and validated for their effectiveness, the broader adoption and application of this technology necessitate a more streamlined process for content creation and delivery.

As such, the focus of this study was on exploring the practicality of using 360-degree technology as an alternative method for generating virtual reality (VR) content aimed at assessing decision inertia. In particular, this approach involved capturing real-world environments with 360-degree cameras and then presenting these recordings to subjects via web-based video players, as opposed to the conventional method of designing VR scenarios through computer graphics (Slater and Sanchez-Vives 2016). This was an important factor in this study, as the experience of 360-degree video content can vary significantly depending on whether it is consumed through immersive or non-immersive mediums (Negro-Cousa et al., 2019). The distinction between these two types of media primarily hinges on the viewer's perspective and the level of engagement elicited during the experience. Immersive experiences facilitated by 360-degree technology can stimulate a great sense of presence and immersion, effectively transporting users inside the virtual environment. These experiences allow users to interact with 360-degree content on conventional devices like PCs, smartphones, or tablets by manipulating the device's orientation to navigate through the video, positioning users as mere spectators rather than active participants in the environment.

1.3 Deontological decision-making

Deontological principles assert that the morality of an action is inherently determined by adherence to rules or duties, providing a framework for evaluating high-stakes decision-making processes. A classic example of this, is *the trolley problem* - a well-known ethical thought experiment that presents individuals with a difficult decision involving a runaway trolley headed towards multiple individuals. The moral dilemma is whether to take action to divert the trolley to a different track, potentially saving some lives but sacrificing others (Foot 1967). In the context of critical incidents, the importance of integrating moral values and ethical considerations cannot be overstated (Penney et al. 2022). These complex situations require decision-makers to navigate not only the immediate practicalities of a crisis but also the profound moral dimensions inherent in their operational choices (Cuthbertson and Penney 2023). Understanding how moral reasoning interacts with the cognitive processes of decision inertia is crucial for gaining a comprehensive grasp of decision-making in such high-stress environments.

However, despite the role of affective empathy in shaping these judgments, caution has been urged by some regarding the assertion that Trolley Problem adequately evaluates morality and utilitarian reasoning (Bauman et al. 2014; Kahane 2015). These problems, lack immersion and realism (Bauman et al. 2014), often eliciting amusement rather than genuine ethical concern from participants. Consequently, they fall short of mimicking real-life ethical dilemmas, and the psychological mechanisms they engage may not reflect those activated in real-world contexts. To address these limitations, attempts have been made to present the trolley problems within virtual reality environments (Navarrete et al. 2012). However, Bostyn et al. (2018) have highlighted the limited predictive value of these hypothetical dilemmas for actual behaviour, indicating a disconnect between expressed utilitarian preferences and real-life decision-making. This finding suggests there is a need for more realistic and immersive materials in studying high-stakes *moral* decision-making (FeldmanHall et al. 2012), to better capture the complexity of genuine ethical judgments. As such, this study sought to explore the high-stakes

moral decision-making. Given that the emergency services often rely on a demonological position (e.g., to preserve life), rather than a utilitarian position (e.g., least-worst outcomesShortland et al. 2020a, b, c), it is important to address how these principles interact with high-stakes outcomes, where least-worst utilitarian decision making is often optimal (Alison et al. 2015).

1.4 The present study

The present study therefore aimed to examine how decision inertia manifests within an immersive 360-degree XR environment and explored its impact on decision-making outcomes in a critical incident. Given the exploratory nature of this study, no a-priori hypotheses were developed; however, this study did seek to answer whether decision inertia could be manifested in a high-stakes 360-degree extended reality environment. To achieve this, a terrorist incident was created, given that terrorist incidents are complex, high-stakes decision-making environments that demand immediate and effective responses to prevent loss of life, property damage, and widespread panic (Power and Alison 2018; Skryabina et al. 2020). Utilising Extended Reality (XR) technologies, particularly immersive 360-degree environments, in this study is not a superficial embrace of technology; rather, it is grounded by a need to investigate decision inertia within the context of high-stress critical incidents (Alison et al. 2013; May et al. 2023). XR, for instance, facilitates the creation of highly realistic and controlled simulations, enabling an authentic exploration of decision inertia in emergency response, going beyond technology's mere application to genuinely comprehend real-world challenges. Such methods allow a focus on Bayesian updating effects (i.e., the process of revising beliefs or estimates in light of new evidence), providing opportunity to examine the cognitive processes during high-stress decision-making, adding substantial depth to research (Brown et al. 2020). By incorporating a moral reasoning, the current study also establishes a baseline of participants' moral decision-making processes. This baseline is essential for assessing Bayesian updating effects accurately, as it provides insight into participants' initial moral inclinations and the moral context they bring to the decision-making process. In addition, it sets the stage for evaluating how, and to what extent, these moral considerations evolve or remain static when confronted with the immersive critical incident scenario.

By examining the dynamics of decision inertia on applied emergency response, this research aimed to contribute to the broader understanding of decision making in high-stress environments. It hoped to shed light on the specific challenges that may be faced by emergency responders and provide insight into the cognitive and psychological processes that influence their decision-making behaviours. Ultimately, this study aimed to pave the way for evidence-based strategies that optimise decision making in critical incidents, leading to more effective emergency response efforts and improved outcomes for both responders and affected populations.

2 Method

2.1 Participants

To investigate the potential manifestation of decision inertia within a proof-of-concept 360-degree environment, this study did not specifically seek out a purposive sample of emergency responders. This decision was informed by several factors: (1) it was important to ensure the study retained high external validity. In this context, external validity refers to the degree to which the outcomes or conclusions of the study can be extended or applied to other contexts, including different XR tasks, environments, populations, and times. It is an important aspect of research because it underpins the ability to draw broad conclusions from exploratory research and ensures that practical applications or interventions developed from applied research are efficacious across various settings, demographics, and temporal spans; (2) by using an opportunistic sampling method, it ensured that participants represented a heterogenous sample, and enabled the generalisation of manifestation of decision inertia as a holistic construct; and (3) it was felt that the use of emergency responders was unethical in a proof-of-concept study. More specifically, it was important to demonstrate the efficacy and utility of 360-degree XR, as a tools for manifesting decision-inertia before seeking to recruit a purposeful sample. Data for this study was collected from 160 participants recruited randomly across social media, and undergraduate and postgraduate student channels. However, 51 participants were excluded from the study because they did not participate in the immersive simulation phase, and consequently, they did not complete the post-immersion questionnaire. Of the 109 participants included for full analysis (M_{age}=40.55, SD_{age}=14.76; N_{Female}=83, N_{Male}=12, N_{Other}=3, $N_{Not\ Indicated}$=11), 20 (18.3%) completed an additional qualitative questionnaire that asked open questions about their decision-making and experiences of the immersive environment and use of virtual reality.

Table 1 An example of the Social Moral Dilemma Task, with a binary decision outcome

Social Moral Dilemma Example	Outcome
Alice is a doctor in a hospital's emergency room when six accident victims are brought in. All six are in danger of dying but one is much worse off than the others. Alice can just barely save that person if she devotes all of her resources to him and lets the others die. Alternatively, Alice can save the other five if she is willing to ignore the patient who is most seriously injured. Is it permissible for Alice to save the most seriously injured patient?	1) Save 5 patients 2) Save 1 patient

2.2 Materials

2.2.1 Social moral dilemma task

Drawing on the original Trolley problems (Foot 1967), five moral dilemmas were developed, each representing a fictitious scenario ranging from the traditional trolley problem to an emergency doctor performing lifesaving care (see Table 1). Each scenario was represented by a binary outcome: to choose whether to save a majority of the potential victims, or to save a minority of the potential victims. It is important to note, that each decision outcome is not without its consequences. Both represent an outcome that is harmful and morally challenging. After each scenario, participants were asked to rate their confidence on a scale from 1 (not at all confident) to 5 (completely confident) on their decision, and whether they would consider changing their decision (anchored on a 1 (not at all) to 5 (definitely). This measure was used to calculate participants overall morality orientation (deontological versus consequentialist).

2.2.2 360-Degree immersion event

A 360-degree camera (3D vista) was used to capture a mock terrorist scenario, where a hostile individual wearing a suicide vest was holding 4 individuals' hostage (see Fig. 1). The scenario was captured at the University of Portsmouth, where a 360-degree camera was able to capture several locations within the environment. Each still 360-degree shot, was then stitched using adobe photoshop, to create the full environment. Individual nodes were placed throughout the environment to enable participants to walkthrough the scenario – this included the separated room, where a single victim was placed. Auditory cues were later embedded (police sirens) and hosted via a web-based video player through an embedded HTML code on the questionnaire platform, Qualtrics.

A vignette was also created, to provide participants we a utilitarian perspective: participants were told, contrary to their social dilemma tasks, that they were likely not able to save the hostages:

> *You are a senior decision-maker, responding to a terrorist incident. When you arrive on scene you are made aware of an active suicide bomber, holding a triggered suicide vest. The terrorist has stated that he will detonate the suicide vest if there are any attempts to rescue the four hostages. The intelligence suggests that an attempt to rescue the hostages may result in the suicide vest exploding, killing everyone. You also notice a seriously injured female lying on the floor. You are confident that you are able to save her; however, as your resources are limited you may not have the time to save the hostages.*

Participants were also presented with five possible outcomes: saving the hostages, saving the injured person, deferring their choice, refusing to make a decision, or I don't know. Participants were asked to rank each decision outcome, from most preferable (1) to least preferable (5).

2.2.3 Decision inertia questionnaire

Participants were asked to complete a questionnaire (adapted from Power et al., 2018) to rate their agreement with statement concerning the decision they were asked to make. Participants were asked to rate their response on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). See Table 2 for a breakdown of each question.

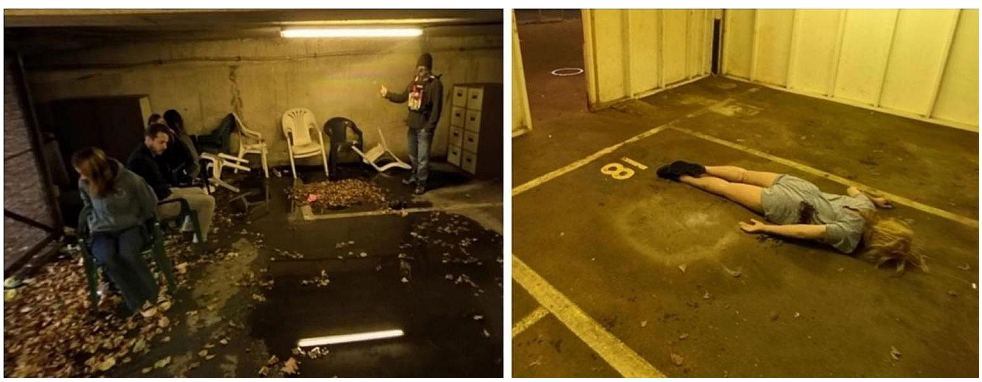

Fig. 1 An example of the immersive environment, depicting the suicide bomber, hostages, and the individual victim

Table 2 A breakdown of the decision inertia questionnaire, with the relevant descriptive statistics

Statement	M	SE	SD
There was an optimal decision	***3.01***	***0.12***	***1.09***
I relied on my previous experiences to help me make a decision	***2.85***	***0.15***	***1.32***
I needed more information before I could make a decision	***4.09***	***0.10***	***0.95***
I would defer my decision to a more senior colleague	***3.41***	***0.13***	***1.14***
I would defer my decision to someone else	***2.56***	***0.13***	***1.16***
I would need more time to consider my options before I made a decision	***3.61***	***0.12***	***1.12***
I would focus my efforts on saving the most amount of people possible	***4.00***	***0.10***	***0.92***
I would focus my efforts on helping those that need it most	***3.67***	***0.11***	***0.97***
I would follow my 'gut instinct' to help me make a decision	***3.93***	***0.12***	***0.97***
I would rely on my training to help me make a decision	***4.32***	***0.08***	***0.74***
After I had made a decision, I was eager to consider a different option	***2.96***	***0.13***	***0.14***
I was trying to find an optimal solution to the event	***4.23***	***0.10***	***0.86***
Decision-making was high-risk	***4.38***	***0.10***	***0.87***
I wanted to wait and see what happened	***2.60***	***0.13***	***1.13***
I felt that I missed an opportunity to make a better decision	***2.74***	***0.10***	***0.94***
There were too many options to pick between	***2.60***	***0.11***	***1.02***
I am confident that the decisions I made were right	***3.28***	***0.10***	***0.93***
I felt that my understanding of the situation throughout the incident was accurate	***3.55***	***0.11***	***0.98***
I found decision making to be complex	***3.94***	***0.11***	***1.00***
I was uncertain about my potential options	***3.01***	***0.13***	***1.20***
I felt time pressured	***3.90***	***0.13***	***1.14***
I was confused by my responsibilities	***2.77***	***0.13***	***1.18***
I would be worried that my decision would be held to account	***3.39***	***0.14***	***1.28***
I would be worried about being blamed for the wrong decision	***3.44***	***0.14***	***1.30***
I would be worried that I would regret my decision in the future	***3.88***	***0.12***	***1.08***

To ensure the internal consistency of these scale items, Cronbach's alpha, a measure of internal consistency, was calculated. The Cronbach's alpha coefficient indicated a good level of agreement among the scale items, with a value of 0.806. This suggested that the items within the decision inertia characteristics scale were measuring a consistent construct and were reliable for assessing participants' tendencies towards decision inertia.

2.2.4 Qualitative questionnaire

Qualitative data was collected through an additional questionnaire, that sought to capture the experience of using the 360-degree immersive platform. Each question represented an open response (e.g., How did the virtual environment make you feel?).

2.3 Procedure

Participants were invited to take part in an online study, that sought to examine decision inertia in a 360-degree XR environment. To access the study, participants were provided with a Qualtrics link. All participants were required to provide their full consent before proceeding to the main study.

2.3.1 Pre-immersion

Pre-immersion refers to the initial phase before users are immersed in a VR environment. In the current study, all participants were asked to complete a moral dilemma task that included the traditional trolley problem (Foot 1967) and four adapted versions of the trolley problem. This phase was crucial for introducing participants to the process of moral dilemma decision-making. It allowed participants to align their virtual decision-making processes with real-world values and decisions, particularly those relevant to principles of emergency response services (i.e., deontological) where 'saving life' is the primary objective.

2.3.2 Immersion

The participants were then presented with a scenario vignette, where they assumed the role of a senior decision-maker responding to the terrorist incident. The vignette outlined the presence of an active suicide bomber with a triggered suicide vest, who had threatened to detonate the vest and therefore kill the hostages if any rescue attempts were made. Within the vignette participants were also informed of the injured female who was placed in a different room to the suicide attacker. Participants were led to believe that this female could be saved, but that limited resources meant that if the female was saved, there might not be enough time to save the four hostages as well. Next all participants were immersed in an XR 360-degree virtual environment. Whilst participants were unable to engage in a comprehensive interaction with the environment. they could move around within the scenario through strategically placed nodes, zoom in on specific elements, and swivel on a static node, thereby enabling them to achieve a comprehensive 360-degree view of the environment. They were also able to navigate through various static points within the virtual environment

and visually observe a simulated suicide terrorist incident where four hostages were at risk. Additionally, participants had the opportunity to navigate to a different room where they encountered an injured female, who was separate from the suicide attacker in a safe environment. The immersion experience was heightened through auditory cues (e.g., participants could hear police sirens), which further enhanced the realism of the scenario.

Within the virtual environment, participants had a clear visual view of all four hostages as well as the suicide attacker and the hand-triggered suicide vest. They were able to examine their surroundings within the virtual environment and assess the potential risks and consequences associated with different courses of action.

2.3.3 Post-immersion

In the post-immersion phase of the study, participants were presented with five outcomes: saving the hostages, saving the injured person, deferring their choice, refusing to make a decision, or selecting I don't know. Each participant was asked to rank each decision outcome, based on their preferable outcome. This allowed for the examination of participants' initial choices and the distribution of decisions within the sample. In addition, participants were presented with a series of 25 statements that reflected decision inertia, such as "I would defer my decision to someone else," on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Likert scale allowed participants to indicate the extent to which they agreed or disagreed with each of the 25 items. Following this, all participants were provided with an opportunity to participate in a subsequent qualitative study, where their decision-making and experience of the 360 degree XR environment was further explored.

2.4 Structured tabular thematic analysis (ST-TA)

This study used the analytical approach of Structured Tabular Thematic Analysis (ST-TA; see, Robinson 2022), a technique designed for working with concise qualitative data in a structured manner. The field of qualitative research in psychology and social sciences has long emphasised the collection of in-depth data as a counterbalance to the reductionist tendencies of quantitative psychology. Early work, like Flanagan's (1954) Critical Incident Technique, focused on gathering extensive texts containing thousands of words per person or conversation. This emphasis on lengthy texts has persisted in qualitative methods over the years, with approaches like Grounded Theory, the Comparative Method, Conversation Analysis, and Interpretative Phenomenological Analysis being developed to analyse these rich texts. However, Structured Tabular Thematic Analysis (ST-TA) offers a flexible technique specifically designed for working with concise qualitative data in a more structured manner. ST-TA fills a gap between existing approaches to thematic analysis and those analysing brief texts like narrative analysis. ST-TA also provides a hybridised process that incorporates elements from Braun and Clarke's (2006) thematic analysis process and Boyatzis's (1998) thematic analysis phases. This allows for a systematic and staged approach to analysing brief qualitative data, offering researchers a structured framework to work with.

3 Results

3.1 Manifesting decision-inertia in an immersive environment

First, participants were asked to rank each outcome variable on a 1–5 scale (1 denoting their priority decision and 5 denoting least likely priority). Given the low sample for outcomes 3 to 5, the data was re-categorised into to two outcomes variables – these are hereinafter referred to as the optimal outcome (saving the injured person) and sub-optimal outcome (saving the hostages, deferring their decision, not making a decision, or I don't know). Only 32 (44.4%) prioritised (e.g., ranked this as 1) the optimal outcome, as their primary choice, compared to 40 (55.6%) prioritising a sub-optimal outcome as their primary choice (e.g., ranked this as 1).

Next, to assess the manifestation of decision inertia between each decision outcome, participants decision inertia scores were calculated based on mean total score of then 25-items in the decision inertia questionnaire. For reference, a score of 25 would indicate low decision inertia; a score of 125 would indicate high decision inertia. Overall, decision inertia scores ranged from 54 to 125 ($M = 86.57$, $SD = 11.26$). Of those that opted to prioritise and selected to save the injured individual ($N = 32$; 44.4%), their decision inertia score ranges from 54 to 125 ($M = 84.66$, $SD = 12.44$). For those that prioritised a sub-optimal outcome, their decision inertia scores ranged from 61 to 106 ($M = 93.70$, $SD = 8.41$).

To assess whether decision inertia could therefore predict preference for the optimal outcome (i.e., save the injured individual), a linear regression analysis was undertaken. All assumption checks were conducted, and no violations were found. Decision inertia did predict participants preference for the optimal decision outcome, explaining 7.3% of the overall variance, $F(1,67) = 5.29$, $p = .03$, adjusted $R^2 = .06$. Decision inertia was a significant positive predictor for the optimal decision outcome ($B = 0.02$, $\beta = 0.27$), suggesting that as decision inertia scores increased, preference for the

optimal outcome decreased (i.e., a higher score indicated that the decision outcome became less of a priority). Decision inertia also predicted sub-optimal outcomes, explaining 7.3% of the variance, $F(1,67) = 5.29$, $p = .03$, adjusted $R^2 = .06$. Decision inertia was a significant negative predictor for sub-optimal outcomes ($B = -0.01$ $\beta = -0.27$), suggesting that as decision inertia scores increased, preference for the sub-optimal outcomes increased (i.e., a low score indicated that the decision outcome became more a priority).

3.2 Decision inertia and effect of bayesian updating

To assess the effect of Bayesian updating, and whether prior deontological principles had an effect on decision inertia in the XR environment, each participant completed a pre-immersion morality task. 86 (79%) of participants aligned their decision-making with the expected deontological response (i.e., toward minimising harm; Foot 1967). In order to assess this, a morality measure was calculated, based on,

$$MoralityScore = T1\,(C) + T2\,(C) + T3\,(C) + T4\,(C)$$

where *T* represented the trolley problem, and *C* represented the participants level of confidence in their decision. The morality score allowed the interpretation of whether an individual was more deontological positioned (lower scores), or consequentially positioned (i.e., higher scores). Note, the lowest achievable score was 7 (deontological) and the highest achievable score was 40 (consequentialist). Participants scores ranged from 7 to 40 ($M = 25.94$, $SD = 8.27$). In order to demonstrate a Bayesian effect, participants with deontological positions would be more likely to update their beliefs and select a more consequentialist decision outcome (e.g., saving the single individual).

Pearson's correlation revealed a significant positive relationship with suboptimal decision outcomes, $r(71) = .264$, $p = .026$. Pearson's correlation also revealed a significant negative relationship with optimal decision outcome $r(71) = -.264$, $p = .026$. When morality scores were assessed to examined the association with decision inertia, Pearsons correlation revealed a significant negative relationship, $r(71) = -.418$, $p < .001$.

3.3 Structured tabular thematic analysis (ST-TA)

Three themes were identified: (i) Information Validity and Presence, (ii) Decision Confidence, and (iii) Scenario Fidelity. Relevant exemplars are provided as examples for each theme.

3.3.1 Information validity and presence

Information validity is considered as the participants decision-making response and how they used the informational presence to infer action and realism. For example, whether a participant was able to utilise the available information presented within the virtual environment to consider their response options (i.e., save the hostages, or save the individual victim), whilst also considering the realism of the scenario (i.e., they could not achieve all outcomes). Participants highlighted informational realism, leading to a strong suggestion of immersion '*Yes, seeing people's faces makes it harder than in written scenarios'.* When participants were probed further to consider the immersive environment and the informational presence, many considered that the lack of information offered a sense of realism that forced decision-inertia effects *' ... I felt I had insufficient information and I was being asked to choose between lives when I didn't have the information I needed*' and as such, *'...it felt like a lose-lose situation no matter what decision was picked.*' However, the static nature of the immersive environment did appear to limit the informational validity for some. For example, some participants were enthused to take a course of action that was not realistically achievable in this scenario, such as *'...[negotiate] with the terrorist- could we come to a compromise*'. However, not unsurprisingly participants continued to posit that '*If [they] had more information, more options may have come to [them*]'.

3.3.2 Decision confidence

Decision confidence refers to a participant's decision-making response and whether they were confident in their original decision, or whether they would consider alternative decisions. The immersive environment appeared to elevate a lack of confidence amongst participants, as the decision outcomes were considered challenging because '*no one wants to live with regret'* as the *'... the role of an [emergency responder] is to preserve life and limb without favouritism. Everyone deserves to live'.* The immersive environment also appeared to re-create indecision, as it was suggested that the scenario was '*costing time that people may not have. Do [they] act quickly and rashly or think but risk running out of time*.' Further, when decisions were considered holistically, users queried their response outcomes '*Both decisions could have dire outcomes, that [they] would regret for the rest of life…what were the chances of success of each decision? Who were the hostages and the woman? I'd better try to save 4 strangers than one; if there's one great individual and 4 war criminals, I may reconsider my decision…*'. Participants also explicitly stated that because of the lack of information they '*didn't feel at all confident*

with [their] decision so [they were not] able to commit' and that they *'felt a responsibility to make a decision so [they] wanted to make a decision, but [they] didn't particularly like or feel confident with any of the options presented.*' However, some participants did intuitively consider their options more holistically, increasing their decision confidence. For instance, participants stated they '*could hear in the background that clearly there was police nearby, that meant that there would also be marked officers'* and that their previous response '*…training would kick in, [and they] would probably pledge my moral values to myself and do what has to be done'*.

3.3.3 Scenario fidelity

Users highlighted high-fidelity and immersion. For example, users were '*…impressed by this, the senses of the brain did feel stressed, the noise and you felt trapped. With no outside understanding of what happened*.'. Further the pictorial immersion created a depth of realism as users suggested that they *'…felt cold watching it!!'*, *'…stressed, tense, fight or flight response was activated*' and '*scared and on edge. the dingy light and the people felt very real*'. However, whilst there was a strong response toward immersive fidelity, there were several complaints. For instance, '*hearing voices would have made it more realistic and would bring more information*', and the scenario set-up was not set-up to represent a true terrorist incident, '*The actors all looked a bit too clean' and 'Surely a terrorist would seek to enter a more valuable building like a government building or something or at least have more hostages. So, it didn't feel that realistic based on those thoughts*'. Of particular importance, was the indication that the scenario '*assisted in visually setting the scene'*, as it appeared to assist users in remembering past events, such as remembering '(…) a few incidents from years ago, (….) *but nothing bad, most issues like this people suffer from trauma and PTSD* (…)'.

4 Discussion

This study sought to investigate whether decision inertia could be manifested in a 360-degree immersive environment as a proof of concept. Decision inertia was assessed through two distinct approaches. Initially, the analysis focused on determining if the scores of decision inertia predicted the nature of the decision outcome, classifying these outcomes as either optimal or suboptimal (Alison et al. 2015). Subsequently, the study examined the influence of Bayesian updating on decision outcomes. This part of the analysis specifically explored how the process of refining initial assumptions or 'priors' (in this context, utilising tasks similar to the trolley problem) with new information could impact decision-making, aiming to discern a link between the effectiveness of Bayesian updating practices and the achievement of more optimal decision outcome.

The study found that participants had a preference toward sub-optimal and deontological outcomes (i.e., saving the hostages), compared to the least-worst outcome: saving the injured individual. This might be due to the varying emotional responses or psychological processes required for each decision outcome. For example, saving hostages might have involved a sense of urgency or responsibility while suboptimal outcomes (e.g., deferring the decision) could be related to a lack of confidence or a desire to avoid accountability (Alison et al. 2015; Power and Alison 2017). Further, participants moral values and ethical principles have been shown to influence decision-making processes (e.g., Crawford and Finn 2015; Larkin and Arnold 2003; Leider et al. 2017).Thus, saving an injured individual or a group of hostages may involve different moral dilemmas or conflicting priorities, leading to differences in decision inertia. When decision outcomes are considered from a deontological standpoint, it might be that the participants actions are aligned with established moral rules. In this regard, deontological principles served as a limiting factor, as they prohibited certain acts even if those decisions could potentially lead to a more favourable outcome (Bartels 2008). In other word, participants may have felt hesitant to make a different decision because intentionally causing harm to someone, regardless of the possible benefits, is strictly prohibited (Waldmann and Dieterich 2007).

It is important to note, however, that this study suggested that when participants were presented with new information, they were successful able to update their decision-making processes towards a more consequentialist perspective (i.e., participants were able to demonstrate a Bayesian effect). This finding highlights the potential of utilising 360-degree XR technologies as a methodological tool to empirically demonstrate the phenomenon of decision inertia within a controlled environment. By immersing participants in scenarios that require constant evaluation and re-evaluation of decision-making outcomes, this technology provides a unique platform to manifest and subsequently measure decision inertia. Furthermore, the study's finding that participants could adapt their decision-making strategies in light of new information - indicative of a Bayesian updating process - suggests that 360-degree XR environments can effectively facilitate the observation and analysis of how decision inertia is overcome or exacerbated by the introduction of novel data.

In this study different decision outcomes might have required distinct cognitive processes, and higher cognitive flexibility, which effectively aligned to the specific type of

cognitive processing with the nature of the problem being addressed (e.g., the ability to switch between fast, intuitive thinking and slow, analytical thinking). In this context, decision-makers may have gained the capability to greatly enhance their decision-making performance, ultimately leading to more optimal outcomes (e.g., Laureiro-Martínez and Brusoni 2018). Lastly, the cognitive demands imposed by each decision outcome could have influenced the decision inertia scores observed among participants. Certain choices may demand varying degrees of cognitive effort or thoughtful consideration, which can result in different levels of decision inertia compared to other options. For instance, participants might have exhibited a tendency to delay their decision-making process until the opportunity had passed, particularly when faced with options that required more deliberation (e.g., Power and Alison 2018). However, it is important to note that this aspect was not explicitly measured or captured in the post-immersion questionnaire.

Linear regression analysis found that decision inertia scores did significantly predict decision outcome, as participants with higher decision inertia scores predicted participants preference toward (1) not making an optimal decision outcome, and (2) having a preferencing toward a sub-optimal outcome (e.g., saving the hostages, or deferring their decision). Lower decision inertia scores also suggested that individuals may be more receptive to new information and be more willing to update their beliefs or preferences based on the new information (i.e., Bayesian updating effects). For instance, previous research has found that decision making accuracy may be associated with suboptimal Bayesian updating; but it is not linked to decision inertia specifically (Jung et al. 2018, 2019). Openness to changing information may have allowed participants to consider a broader range of alternatives and make decisions that are better suited to their current circumstances. However, as decision inertia often stems from various cognitive biases (e.g., status quo bias, characterised by a tendency to replicate the choices of others; anchoring bias, where individuals rely too heavily on the initial information or reference point (anchor) when making subsequent decisions; and omission bias, which involves a preference for inaction; Power and Alison 2018), decision inertia may have hindered objective decision making which may have led to suboptimal choices being made. As decision inertia reduced, participants may have demonstrated an increased awareness of cognitive biases, which in turn may have enhanced their ability to overcome them. However, as this was not directly measured, future research may wish to consider various cognitive biases as potential latent factors toward optimising decision outcomes in high-stakes incidents. By achieving this, a heightened awareness of cognitive bias can lead to improved decision quality, particularly in situations characterised by uncertainty (e.g., Kinsey et al. 2019). In the specific context of immersive simulation and emergency response decision-making, recognising and addressing cognitive biases can present an opportunity to cultivate awareness of suboptimal decision-making behaviours. By actively acknowledging and mitigating these biases, individuals can reduce the likelihood of overly optimistic assessments of potential outcomes. Consequently, decision-making in emergency scenarios can align more closely with a rational approach, taking into account the limitations imposed by the available information (Kinsey et al. 2019).

To consider whether moral decision-making had any effect, another aspect of the study focused on moral decision-making and Bayesian updating effects (see, Brown et al. 2020; May et al. 2023). The study found significant associations between prior moral decision-making and subsequent choices when confronted with new information in the immersion phase of the study, indicating that pre-immersive moral decision-making did minimise decision-inertia in this context and resulted in a preference toward more optimal outcomes (e.g., ranking sub-optimal outcomes as least preferable). This is supportive of prior research (e.g., Wilkinson 2020), suggesting that individuals do consider new information, and update their beliefs. As note above, this also dmoenstrtaes the effectiveness of 360-degree XR as a methodological tool to measure decision inertia and its associated factors. However, it is important to highlight the limitations of these scenarios. In the moral dilemma scenarios, participants were asked to complete philosophically trivial dilemmas, where they were not tasked with making dynamic, complex and high-risk decisions where a least-worst outcome was the optimal choice (Alison et al. 2015; Shortland et al. 2020a, b, c). The unambiguous nature of life-and-death decisions, typical of trolley problems, is fortunately not reflective of daily moral dilemmas. Research suggests that the trolley problems may predispose individuals to more utilitarian choices than those encountered in everyday life (Vyas et al. 2017). Adapting these problems to more relatable scenarios has led to findings with broader applicability to real-life situations (Lotto et al., 2014; Vyas et al, 2017; Pletti et al. 2017; Takamatsu, 2019), highlighting the importance of developing ecologically valid moral dilemmas. Such efforts are particularly relevant given the growing interest in understanding moral decision-making across various psychological conditions, thereby providing insights into how factors like empathy influence ethical judgments in diverse clinical populations.

In addition, when participants were presented with the new information provided by the immersive simulation, it may not have been compelling or influential enough to sway participants' initial moral judgments in order to see a stronger effect. The participants might have remained fixated in

their original decisions (Bartels 2008) regardless of the new information, due to factors such as strong personal beliefs or ethical principles. This is further supported by the fact that the majority of participants expressed moderate or higher confidence in their moral decision-making abilities. This high level of confidence might indicate that participants were confident in their initial moral judgments and were less susceptible to changing their decisions based on new information. Their confidence in their moral decision-making abilities could have acted as a cognitive bias, as previous research has indicated that various cognitive biases are prone to influencing moral intuitions and judgments (Caviola et al. 2014), reinforcing their adherence to their immersive decision choice.

Three themes emerged from the ST-TA: Information Validity and Presence, Decision Confidence, and Scenario Fidelity. Participants highlighted the importance of information validity in decision-making and how the lack of information in the immersive environment contributed to decision inertia. Decision confidence was influenced by the challenging nature of the decision outcomes and the perceived lack of information. Scenario fidelity was praised for its immersive and realistic qualities, although some participants suggested improvements such as incorporating more information or enhancing the scenario's realism.

Subjectively, information validity and presence suggested that participants' decision-making responses were influenced by the validity and realism of the information presented to them. Participants were observed to consider the available information within the virtual environment to assess their response options, such as choosing to save hostages or an individual victim. They also considered the realism of the scenario, recognising that they could not achieve all possible outcomes. The participants' responses highlighted the impact of informational realism on their decision-making. The presence of visual cues, such as seeing people's faces, made the decision-making process more challenging compared to written scenarios. This might suggest that realistic visual cues presented participants with a greater sense of immersion in the virtual environment (see, Wilkerson et al. 2008). However, the expense associated with immersive virtual reality (VR) may not be justified, as other presentation mediums (e.g., PowerPoint) supplemented with vivid film scenes may be just as effective (Leder et al. 2019).

Some participants demonstrated a more intuitive and holistic approach to decision-making, which might have increased their perception of decision confidence. For example, decision-makers may have experienced moments of insight where previously unrelated facts or components suddenly became connected. However, these intuitive breakthroughs can only occur after rational thought has laid the foundation by providing data, analysis, and the necessary groundwork for optimal decision detection (Sauter 1999). In other words, by considering contextual cues, such as hearing police nearby, and relying on previous experiences, external to the scenario training, may help guide participants choices. This highlights the intricate relationship between decision confidence and the immersive environment. While the immersive nature of the scenario contributed to a lack of confidence and increased decision pressure, participants demonstrated the capacity to consider multiple factors and draw on their expertise, leading to higher decision confidence in some cases.

Interestingly, the finding suggested that the scenario played a role in triggering participants' memories of past events and aided in the recall of incidents from years ago. Whilst this does raise some concern in maintaining cognitive resilience and emotional stability, participants indicated that it was not necessarily traumatic memories. This aspect highlights the potential impact of immersive environments on memory retrieval and the potential relevance of such scenarios in understanding and addressing trauma and post-traumatic stress disorder (PTSD).

4.1 Limitations and future research directions

There are several limitations to these findings. Firstly, decision inertia only explained a small portion of the variation in participants selected outcome. This suggests that other factors are likely to be at play that were not captured in this study, which could have influenced decision outcome. Secondly, the study found significant associations in decision inertia scores across different decision outcomes, such as saving hostages and deferring the decision. However, the underlying emotional responses or psychological processes that contribute to these differences were not fully explored or measured. The extent to which Cronbach's alpha measured the internal validity of the decision inertia scale is potentially problematic. Whilst the scale was an adaption from a previously published paper (Power et al., 2018), it is important to establish the internal validity of the decision inertia scale and its related factor loadings. As such, future research should consider demonstrating construct validity through other means, such as correlational studies with established measures, or exploratory factor analyses. Additionally, the present study highlighted the impact of cognitive biases on decision inertia, such as the status quo bias, anchoring bias, and omission bias. However, the study did not directly measure or assess the extent to which these biases influenced decision-making behaviours. Future research could benefit from incorporating more comprehensive measures of cognitive biases and their effects on decision inertia. It is also important to note that this study only examined one specific

scenario and may not capture the complexity of moral decision-making in real-life situations. Further research using a broader range of moral dilemmas and different types of new information could provide a more comprehensive understanding of the factors influencing moral decision-making and the impact of prior experiences on subsequent choices.

5 Conclusion

In immersive environments, such as virtual reality, augmented reality, or intense real-world scenarios, users' decision-making processes can be profoundly influenced, leading to decision inertia where they persist with a chosen course despite evidence suggesting better alternatives. This research indicates that decision inertia did sway participants outcome. This has important implications, because if someone believes a specific choice yields the best result in a virtual setting, they might remain steadfast in that choice, regardless of opposing evidence. Furthermore, emotional, and psychological factors, like risk aversion, can amplify this inertia, with some individuals gravitating towards familiar decisions over exploring new ones.

In emergency response settings, understanding decision inertia within immersive environments holds paramount significance. As first responders and emergency personnel increasingly utilise virtual and augmented reality for training and real-time decision-making, grasping how they perceive and act upon choices can be lifesaving. This insight can guide the development of training simulations that more effectively prepare responders for real-world scenarios, highlighting potential pitfalls in decision-making and teaching strategies to overcome them. Furthermore, it can inform the design of decision-support tools that assist emergency personnel in rapidly changing situations, ensuring that they don't remain anchored to suboptimal choices when seconds count. In essence, by comprehending the nuances of decision inertia in these immersive contexts, we can enhance the efficacy and safety of emergency response operations.

Building on this, it's essential to recognise that our current understanding, while promising, is still in its early stages. This research serves as a proof of concept, a preliminary point into the dynamics of decision-making within immersive environments tailored to emergency response. However, while the initial findings provide a foundation for future research, more comprehensive research is imperative to navigate the complexities of decision-making. By examining these constructs, we can hope to harness the full potential of immersive environments, ensuring that when emergencies arise, our responders are equipped not just with tools, but with the cognitive agility to use them most effectively.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.
The authors disclose that there are no financial or non-financial interests that are directly or indirectly related to the work submitted for publication.

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