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Exploring the subjective effects of a simulated psychedelic experience on creativity

Seminary work

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Simuleeritud psühhedeelse kogemuse subjektiivsed mõjud loovusele

Kokkuvõte

Leidub tõendeid, et psühhedeelsed ühedid võivad soodustada loovust. Seejuures pole veel kindel, kas mõjud loovusele on tingitud subjektiivsetest elamustest või neurokeemilistest mõjutustest psühhedeelse kogemuse ajal. Meie eesmärk oli eraldada psühhedeelikumide subjektiivsed ja neurokeemilised mõjud kasutades virtuaalreaalsuskogemust (VR), mis simuleerib psühhedeelse kogemuse subjektiivset fenomenoloogiat, ja uurida selle mõjusid loovusele. Avatud teostatavusuuringus osales üheksa inimest, kes olid oma teatava loovprobleemi lahendamisega tupikusse sattunud. Enamus osalejaid hindas VR kogemust oma probleemi lahendamise osas küll kasulikuks, ent mitte otsustavaks faktoriks. Lisaks, suur osa osalejatest omistas VR kogemusele positiivseid mõjusid, näiteks afektiivsed muutused, kõrgendatud vabameelsus, äkktaipamiste kogemine ja perspektiivimuutused. Need tulemused on paljutõotavad, aga katseplaani piirangute tõttu ei saa me põhjuslikke järeldusi teha. Niisiis on uuring inspiratsiooniks ja kinnituseks tulevastele kontrollitud uuringutele, et psühhedeelsete ainete vahendavaid subjektiivseid mõjusid psühhedeelset virtuaalreaalsust rakendades edasi uurida.

Märksõnad: psühhedeelikumid, virtuaalreaalsus, loovus, mõttevälgatus

Exploring the subjective effects of a simulated psychedelic experience on creativity

Abstract

Evidence suggests that psychedelic compounds might facilitate creativity. However, it is still not certain whether the effects on creativity result from subjective experiences or neurochemical manipulations during the psychedelic experience. Our goal was to separate the subjective and neurochemical effects of psychedelics by using a virtual reality (VR) experience that simulates the subjective phenomenology of a psychedelic experience and exploring its subjective effects on creativity. Nine subjects who were experiencing a creative impasse went through the psychedelic simulation in an open-label feasibility study. Most participants reported the VR experience as useful, but not decisive for their solving the problem. In addition, most participants attributed to the experience positive effects such as affective changes, elevated insightfulness, experiencing insights and shifts in perspectives. These results are encouraging, but due to limitations concerning the study design, we cannot make causal conclusions. Thus, this study serves as inspiration and validation for controlled future studies to implement psychedelic VR and investigate the mediating subjective effects of psychedelic substances further.

Keywords: psychedelics, virtual reality, creativity, insight

The term „psychedelic“ was coined by Humphry Osmond in a letter to Aldous Huxley in the year 1956 (Osmond, 1957). Psychedelic means „mind-manifesting,“ referring to something that enriches the mind and enlarges the vision via heightened awareness and feeling. This state of altered consciousness emerges as a result of consuming a psychedelic substance – such as LSD or psilocybin – and it is known as the psychedelic experience. Commonly associated with the psychedelic experience is enhanced creativity; however, as discussed in more detail below, scientific evidence of this remains contradictory and even the existence of this link has not been decisively established. The aim of this study was to investigate the question of psychedelics and creativity from a novel perspective – by simulating the psychedelic experience in a virtual reality environment and exploring its potential to facilitate creative insights.

Creativity

Weisberg (2006) defined creativity as a cluster of factors that enable a person to engage in the creative process. The creative process was defined as a process of bringing about novel solutions and ideas – innovations. For something to reflect creativity, it must meet two criteria: first, it has to be novel for the author, or else, even if the author is certain that the idea is original, it would actually not reflect creation, but merely retrieval from memory, a phenomenon called *cryptomnesia* (Jung, 1905/1970). The second criteria of creativity is that the idea had to be generated intentionally, meaning the innovation was not an accident or a random outcome. For example, pressing piano keys in a random sequence would not reflect creativity – even if it sounds good.

The underlying mechanisms of creativity are not understood in full detail (Aru, 2022). Many diverse theories of creativity exist (Weisberg, 2006), but the framework of creativity for this study will be one argued for in further detail in Aru (2022). In his view, creativity begins with various semantic and experiential knowledge structures stored in one’s memory, as postulated by Endel Tulving (1972). The essence of creativity is forming novel connections between such knowledge structures through mental simulation operations (Aru, 2022). However, as of today, we do not have a proper understanding of such mental operations (Fan & Markram, 2019; Aru, 2022). Nevertheless, the operations can be visualized analogously to putting together a puzzle, piece after piece, rotating them and testing which combinations fit and which do not, striving to build something that is greater than just the sum of its individual parts – the bigger picture.

A wide variety of methods have been employed to study and measure creativity, ranging from subjective reports and biographical studies of high-level creators to case studies of significant advances and *in vivo*, real-time studies of scientists working in their laboratories (Weisberg, 2006). While the strength of such methods is that the object of study is certainly real – or "big" – creativity, they are also accompanied by several shortcomings: for instance, subjective reports provide unverifiable information, biographical and case studies only support qualitative analysis and real-time studies lack both a control condition as well as a manipulation of any variables of interest. Such methods, therefore, prevent researchers from drawing causal conclusions. Consequently, controlled laboratory experiments are often favoured (Weisberg, 2006).

In contemporary research, creativity is most commonly studied via creative thinking tests (Aru, 2022). Among the most popular of such tests is the Alternate Uses Task (AUT); yet, a number of analogous tests exist (Acar & Runco, 2012; Kaufman, 2016). Characteristically, these are divergent thinking tests – in AUT, for example, the responder has three minutes to come up with as many different and unusual ways as possible in which a menial item such as a chair or a brick can be used (Guilford, 1967). The score depends on the quantity of answers – or rather associations made – as well as their relevance, diversity and uniqueness, compared to a wider pool of responders (Kaufman, 2016). One major issue with divergent thinking tests is their validity in terms of creativity – just as divergent thinking is not equal to creativity (Guilford, 1957; Silvia et al., 2008; Runco & Acar, 2012), it is evident that divergent thinking tests do not capture the full scope of creativity. They do, however, capture the ability to create numerous connections between existing knowledge structures (Aru, 2022). Therefore, due to the absence of a universally accepted and applicable research method of creativity, the selection of the method depends on the question one wishes to investigate and one should choose the means best fit for answering that question, keeping in mind its potential limitations (Weisberg, 2006).

One of the reasons why creativity has been difficult to study is that people reach novel, creative solutions and ideas in various ways. On the one hand, there is the analytical approach: this is the gradual, step-by-step process in which a person works purposefully and actively on solving their problem. In this top-down manner, one progression leads to another, until finally, they find the answer (Aru, 2022). On the other hand, there is another way where the solution appears in a bottom-up manner: suddenly and unannounced, oftentimes while the

person is not even engaged with the problem, they are struck with a realization and, in the flash of a moment, the solution feels obvious (Aru, 2022). In this case, the person would have experienced a moment of insight.

Insight

Insight is a ubiquitous phenomenon in which one suddenly achieves a novel understanding of something: in contrast to more analytical approaches, an insight produces the solution – some new idea, thought or perspective – seemingly instantly (Kounios & Beemann, 2014). Insight is the result of unconsciously making significant novel connections between existing knowledge structures or restructuring one's knowledge structures in a new way (Tulver et al., 2021). Once a meaningful combination between knowledge structures has formed, the result surfaces in the individual's awareness and triggers a moment of insight (Tulver et al., 2021). Insight is often perceived as sudden or unpredictable, which is why it feels surprising to the individual; because of this, insight is at times referred to as the Aha! moment or eureka effect (Kounios & Beeman, 2015; Laukkonen et al., 2021a). Besides experiencing intellectual understanding and a feeling of clarity (Sips, 2019), insight is accompanied by positive affect, a feeling of relief (Webb et al., 2016) and a belief that the epiphany is undoubtedly true (Laukkonen et al., 2018). Insight can be observed across tasks and contexts: for example, Tulver et al. (2021) examined insight in the contexts of problem solving, meditation, psychotherapy, psychotic episodes, and psychedelic experiences. Additionally, like the conceptualization of creativity in Aru (2022), the potential for insights is present in every person and the fundamental mechanisms of insight are uniform.

Insight could be very closely related to creativity because: (1) the processes constituting insight likely coincide with those of creativity; and (2) creative solutions are often produced by insights (Aru, 2022). Creative solutions are not always „insightful" in the sense that they were brought about by insight (Weisberg, 2006); however, every insight is creative because the ideas and perspectives that insight has delivered to the author match the two criteria of creativity: they are novel for the individual and they were created intentionally. Admittedly, the extent to which insights are intentional is debatable, but it is important to emphasize that insight is unlikely to occur unless the individual has spent a sufficient amount of time and effort on the problem first (Aru, 2022). In order for a novel combination to emerge through unconscious operations, there needs to be some sort of mental tension as insights are hypothesized to be produced as a direct response to counter that

tension (Tulver et al., 2021). In creative problem solving, the source of this tension is often impasse – a frustrating feeling of having arrived at a dead end or being stuck and unable to progress any further (Ohlsson, 2011) – which occurs as a result of deliberate conscious effort (Tulver et al., 2021). This illustrates that while a moment of insight itself does not arise intentionally, the individual is responsible for putting themselves in a position where insights can occur. For this reason, insights are intentional, which means that the insightful idea or solution is indeed creative. Therefore, in accordance with Aru (2022), insight is considered an inseparable aspect of creativity in the present theoretical framework.

There is evidence of the conditions that facilitate insight: Tulver et al. (2021) argued that the specific prerequisites for an insight to occur can be split into two broader factors. The first is tension within one's knowledge structures, which refers to some conflict between their mental representations, aversive arousal or some other form of cognitive dissonance, which is stressful for the person and which they feel compelled to resolve (Festinger, 1957; Tulver et al., 2021). Solving the problem in order to defuse the tension is the motivation behind unconscious activity of which insights emerge. The intensity of this tension depends on the weight of the problem (Tulver et al., 2021). The subjective value of the solution, therefore, correlates positively with the intensity of experienced tension. Furthermore, diffusion of this tension is the reason why insights are accompanied by relief and positive affect (Tulver et al., 2021). The second factor essential for insight is the state of plasticity or, in other words, insightfulness. This is a state of mind which enables the existing knowledge structures to be transformed (Tulver et al., 2021). Insightfulness is characterized by broadened and diffused attention, higher openness, enhanced metacognitive awareness, reduced cognitive control and increased plasticity (Tulver et al., 2021). In a state of insightfulness, the mind is liberated of the various constraining influences imposed by prior beliefs, and this paves the way for insights (Ohlsson, 2011). In combination, these two interdependent processes – mental tension and insightfulness – create a psychological environment that facilitates the emergence of insights (Tulver et al., 2021).

As mentioned, a state of insightfulness enables insight because it helps to relax the constraints imposed by the individual's prior knowledge (Tulver et al., 2021). Aru (2022) explained how people are sometimes inhibited by dominant patterns of thought, implicit assumptions or some other kinds of self-imposed restrictions on their thinking. These are obstacles which keep the person stuck in a loop, unable to view the problem from a fresh

perspective. Such constraints are often evident in the 9-dot problem (Loyd, 1914), in which nine dots placed in a 3x3 square formation must be connected by drawing at most four straight lines. Importantly, the lines may not be retraced and the pen must not be lifted from the paper at any time. People are unable to solve this problem until they literally start thinking outside the box, meaning they realize that drawing outside of the boundaries of the square formation is permitted. Such metal restrictions are cancelled in a state of insightfulness and for some period of time, new perspectives become available that, guided by mental tension, can lead to breakthrough insights (Tulver et al., 2021).

Based on prior discussions, it would be reasonable to presume that if a person is faced with a problem that requires a creative solution, and they have been unsuccessful in making progress, then they likely possess some inhibiting mental constraints. In order to overcome this impasse, insightfulness should aid them in breaking through the plateau via lifting these restrictions and promoting insight (Tulver et al., 2021). It is possible to induce the state of insightfulness for instance with sleep (Tononi & Cirelli, 2014), meditation (Colzato et al., 2017), and psychedelic compounds (Carhart-Harris & Friston, 2019), of which the latter is most relevant for the present work.

Psychedelics

Psychedelics are psychoactive substances that cause alterations in perception, emotions and numerous cognitive processes through the agonism of the serotonin 5-HT_{2A} receptors (Nichols, 2016). The effects of psychedelics include visual and auditory illusions, synaesthesias, distorted sense of time, ecstasy, mystical experiences, and hyper-associative loosened irrational thinking (Feldman, Meyer, & Quenzer, 1997). Although many psychedelic compounds exist, the most important of them are the „classic“ psychedelics – lysergic acid diethylamide (LSD), psilocybin (the psychoactive component of the group of fungi commonly known as magic mushrooms), dimethyltryptamine (DMT) and mescaline (Johnson, Hendricks, Barrett, & Griffiths, 2019). Historically, psychedelic flora and fungi have been used by indigenous communities likely for thousands of years for purposes such as healing rituals, religious ceremonies, and shamanic practices (Carod-Artal, 2015). However, western civilizations were introduced to psychedelics mostly after the Second World War, when LSD was ingested for the first time by its discoverer Albert Hofmann in 1945 (Hofmann, 1979).

Over the last decades of psychedelic research, both beneficial and disagreeable effects have been observed; the differences can be attributed to varying degrees of consideration for the set and setting of the experience (Hartogsohn, 2017; Carhart-Harris et al., 2018). The terms „set“ and „setting“ were coined by Harvard University professor Timothy Leary – set is understood as the psychological factors one brings to the experience such as intention, personality, expectations, spirit and all other internal states, while setting is the environmental context – physical, social and cultural – in which the experience occurs (Leary, 1961; Hartogsohn, 2017). Although these terms only emerged in the 1960s, the concepts themselves are far older: historically, shamanic rituals and indigenous ceremonies have manipulated psychedelic effects through extra-drug factors such as drumming, chanting, dancing, incense and dramatic ritual enactments in sacred temples and other sites of religious significance (Winkelman, 2021).

Paying attention to the set and setting of the psychedelic experience is paramount, because 5-HT_{2A} receptor agonists promote plasticity and thus increase one’s affinity for contextual elements both psychological as well as environmental; these are among the foremost determinants of the content and outcomes of psychedelic experiences (Carhart-Harris et al., 2018). As discussed by Carhart-Harris et al. (2018), all trials demonstrating promising positive results of psychedelic administration have paid special attention to context, while disregard of set and setting has led to significantly less positive or even psychologically harmful outcomes after administration of psychedelics. On the contrary, exaggerated attention to context can be harmful: as noted the journalist Hunter S. Thompson, solemn preparations and senselessly strict procedures of controlled psychedelic experiments can render the subjects so rigidly indoctrinated by what they have been told that by the time they finally enter the experience, their reactions have already been articulated in their own minds; should the experience deviate from their preconceived notions – or shatter them altogether – panic will likely ensue (Thompson, 1967). Therefore, to minimize the risks associated with psychedelic experiences and enable one to safely capitalize off of the emergent state of insightfulness, the factors of set and setting must not be neglected, and an optimal level of protective measures must be implemented.

Some anecdotal evidence suggests that psychedelics may enhance scientific creativity (Gandy, Bonnelle, Jacobs, & Luke, 2022). Additionally, psychedelics are known to have been used as creative tools by many renowned and influential artists such as Aldous Huxley

(Huxley, 1954), the Beatles (Gilmore, 2016), and Jimi Hendrix (Boyd, Head, & Weis, 1973) and many others. Moreover, Steve Jobs has openly stated that he considered the psychedelic experience as one of the most impactful experiences in his life as it inspired a shift in his creative focus (Gandy et al., 2022). While this is obviously not conclusive evidence, it does suggest that a link between psychedelics and creativity may be possible. This hypothesis is backed by theoretical support: the psychedelic state of mind has been associated with impaired attention, enhanced cognitive flexibility, increased meta-cognitive awareness, dreamlike effects (Kraehenmann et al., 2017; Bălăeț, 2022) – the facets of insightfulness. Ample evidence exists of psychedelics inducing profound, belief-shifting insights of personal importance (Gasser, Kirchner, & Passie, 2014; Noorani et al., 2018; Davis, Barrett, & Griffiths, 2020; Timmermann et al., 2021); however, it has been noted that sometimes psychedelics just enhance the „feeling“ of creativity and insight, so that even trivial, ordinary thoughts can seem like significant revelations (Hartogsohn, 2018; Preller et al., 2017). Regardless, a high enough dose of psychedelics will increase insightfulness (Carhart-Harris et al., 2014; Millière et al., 2018).

Empirical studies on this topic have mostly focused on microdosing – the practice of regularly using sub-perceptual doses of psychedelics to enhance performance and productivity – and the results in terms of creative performance have been contradictory (Prochazkova et al., 2018; Anderson et al., 2019; Polito & Stevenson, 2019; Mason et al., 2021). Newer, blinded and controlled studies have led to the understanding that the anecdotal benefits of microdosing, including positive effects on creativity, can be explained by the placebo effect (Szigeti et al., 2021; Cavanna et al., 2021). However, higher doses of psychedelics have been employed in psychedelic assisted therapy and the ability of psychedelics to facilitate insightfulness and relax existing psychological constraints has been shown in patients suffering from treatment resistant depression (Carhart-Harris et al., 2017; Roseman et al., 2018; Watts et al., 2017), alcoholism (Nielson et al., 2018; Garcia-Romeu et al., 2019), and nicotine addiction (Noorani et al., 2018). These patients often demonstrate such rigid mental constraints which hinder change and which need to be relaxed for symptoms to subside (Ratcliffe, 2014; Westin, 2020).

To explain this, Carhart-Harris and Friston (2019) proposed the model of relaxed beliefs under psychedelics (REBUS). The model is built on the entropic brain hypothesis, according to which psychedelic drugs increase the entropy of spontaneous brain activity and

this is mirrored at the subjective level by both an increase in diversity and vividness of conscious experience as well as unpredictable and disordered thinking (Carhart-Harris, 2018). The model also incorporates a theory of global brain functioning known as hierarchical predictive coding, which postulates that the primary function of the brain is to minimize prediction errors between the anticipated input and the input actually received; this predicting is based on our internal generative models of the world (Millidge, Seth, & Buckley, 2022). These models are encoded in a hierarchy of brain regions, with sensory regions located in the lower end of the hierarchy and higher abstract conceptual beliefs at the top. The REBUS model states that increased brain entropy reduces the stability and rigidity of existing beliefs, models and assumptions about ourselves and the world, known as high-level priors, rendering them malleable so that they could be revised and novel understandings could be considered (Carhart-Harris & Friston, 2019). Psychedelics do this largely by reducing the activity and connectivity of the default mode network (DMN) – a high-level brain network considered an „intrinsic“ system and associated with daydreaming, reminiscing, future planning, and theory of mind among other cognitive and social processes (Carhart-Harris & Friston, 2019; Yeshurun, Nguyen, & Hasson, 2021). DMN is also associated with the sense of narrative self or ego, which refers to cognitive functions such as self-related attitudes, beliefs, autobiographical memories and introspection (Millière, 2017), which might explain the phenomenon of ego dissolution – disturbance of self-consciousness; in other words, losing one's sense of self completely, often described as a dramatic breakdown – in psychedelic experiences (Carhart-Harris & Friston, 2010; Millière, 2017; Deane, 2020). Conclusively, the REBUS model proposes that psychedelics inhibit and quiet the DMN, which relaxes the high-level priors and consequently liberates bottom-up information flow such as sensory input via its entropic effect. This can ultimately lead to the emergence of insights.

Although such is the popular opinion, a different point of view has also been discussed (Kaup et al., 2022; Aru, 2022). It challenges the explanation that the chemical effects of psychedelics in the brain decrease the activity of the DMN and, consequently, increase the activity of sensory regions. Instead, maybe the bizarre, enigmatic experiences – such as the psychedelic experience – increase the activity in sensory regions, which in turn decreases activity in the DMN. It might be so because, as the brain is attempting to predict the input it receives (Millidge et al., 2022), it cannot do that under extraordinary conditions due to the lack of appropriate models, making the extraordinary conditions unpredictable and stimulating neuron populations that typically do not get stimulated (Aru, 2022). Therefore,

supernatural sensory input and profound changes in the state of consciousness could be catalysts for the deactivation of the DMN and restrictions imposed by high-level priors, which enables insights to occur, especially when mental tension is present (Tulver et al., 2021).

A similar idea was examined in thorough detail by Wiseman and Watt (2022) in their recent review article of impossible experiences and creativity. They defined an impossible experience as one in which people encounter an event that they believe cannot occur. For illustration, such experiences would include illusions and magic tricks, science fiction and fantasy narratives, surreal virtual reality environments and bizarre dreams. When an impossible experience occurs, it is expected to enhance creative thinking (Wiseman & Watt, 2022). To explain this potential connection between impossible experiences and creativity, the authors incorporated the schema disruption theory, according to which an impossible experience by definition violates people's fundamental assumptions and beliefs of themselves and the world and consequently disrupts their schemata by modifying existing models and generating new categories, thus resulting in more creative thinking. Moreover, such experiences can be awe-inspiring as people experience awe when they encounter something that is both vast and challenging to their understandings of the world (Wiseman & Watt, 2022). This is significant, because there are both correlational (Silvia et al., 2015; Zhang et al., 2021) and experimental (Chirico et al., 2018; Shiota, Keltner, & Mossman, 2007) studies suggesting that awe-inspiring experiences enhance creativity. For certain, psychedelic experiences are also impossible experiences, and awe-inspiring effects of psychedelics are well documented (Hendricks, 2018; Johnson et al., 2018; Monroy & Keltner, 2022). Therefore, although experimental findings remain insufficient to confirm causality, this is another reason to believe that the effects of psychedelics do enhance creativity and are not – or at least not entirely – the result of chemical manipulations.

If this hypothesis was correct and supernatural, extraordinary, seemingly impossible sensory input was indeed the main facilitator of unconstrained thinking in psychedelic experiences, then this would imply that chemical manipulation is not necessarily required (Aru, 2022; Kaup et al., 2022). Consequently, the externally presented surreal sensory stimuli – equivalent to the internally generated visual alterations in a psychedelic experience – may induce insightfulness and thus promote creativity as well.

Present study

The goal of this study is to investigate the potential of supernatural sensory inputs to foster creativity, particularly in people who are currently experiencing mental tension due to some unresolved creative problem. To produce these supernatural stimuli, I will be using a virtual reality (VR) environment designed to reduce egocentric thinking by exposing users to diverse surreal psychedelic stimuli (Kaup et al., 2022), an idea suggested in Aru (2022). The benefits of utilizing a VR environment are plentiful: for one, as the experimenter has full control over every aspect of the VR experience and it is possible to manipulate just one variable at a time, VR offers endless opportunities to develop novel experimental contexts unparalleled by any other means in regards to its ability to immerse the user in the experience. Thanks to this, VR is the ideal tool to use to simulate the psychedelic experience. Moreover, VR can provide high ecological validity and it enables direct reproducibility as VR environments are easy to share and implement (Pan & Hamilton, 2018). Importantly, especially in comparison to psychedelic substances, VR is very safe: while it can induce cybersickness – an umbrella term for symptoms such as nausea, headache, and vertigo (Rebenitsch & Owen, 2016) – this is progressively less common as technology advances. Furthermore, in case of adversities, the user can disconnect from the experience at any moment. However, as discussed by Vasser and Aru (2020), there are some difficulties associated with immersive VR experiences, such as ensuring reliability due to the absence of adequate methods for measuring the immersion induced by a sense of presence – the illusion of being in the virtual world (Slater, 2018) – or validity pitfalls resulting in questionable generalisability to the real world. Nevertheless, for the purposes of simulating a psychedelic experience, no equivalent alternatives to VR exist at this time.

There is evidence of VR's potential to influence perception (Laak et al., 2017; Vasser et al., 2019), enhance cognitive flexibility (Rastelli et al., 2022), help reduce symptoms of depression (Kaup et al., 2022) and possibly catalyze some aspects of the psychedelic experience like detachment from familiar reality, changes in self-experience and mystical experiences (Sekula, Downey, & Puspanathan, 2022). Additionally, virtual reality has been discussed as a promising method for induction of impossible experiences (Wiseman & Watt, 2022). It is, however, yet unknown whether mimicking the effects of psychedelics in a VR environment can also affect creativity. This is important to find out considering the practical and ethical advantages VR has over psychedelic drugs (Aru, 2022). To elaborate, psychedelic drugs can bring about adverse, negative and challenging experiences known as "bad trips", psychedelics are difficult to get in possession of as they are still illegal in most places and the

utilization of psychedelics cannot be publicly encouraged yet. VR experiences, however, do not suffer from these limitations, by virtue of which everyone could benefit from them, should they produce sought-after beneficial effects. Hence, this open-label feasibility study strives to provide first evidence either for or against the pursuit of more controlled experimental designs to study the potential of a simulated psychedelic experience to induce a state of insightfulness and, furthermore, the potential of it functioning as a trigger or catalyst for creative insights.

Method

Participants

Nine people (4 men and 5 women) participated in this study. Their ages ranged from 20 to 33 (M = 25.3, SD = 5.3). Convenience sampling was used as six of the nine participants were my acquaintances. The rest were referred to me by third persons. All participants were Estonian creatives who regularly engaged in something creative; they were two programmers, a blogger, a corporate director of marketing, a tattoo artist, a singer-songwriter, and students of literature, philosophy, and media design. In addition, every participant had one or more creative problems which they needed to solve, but had so far been unable to solve. In other words, all participants were experiencing impasse at the time of the experiment. On the one hand, the qualifications of a creative problem were not specified, but on the other hand, the criteria of inclusion were strict: (1) they can distil their problem down to a single question; (2) they possess all of the necessary resources (knowledge, skills, opportunities) for solving their problem; (3) they have attempted to solve the problem and depleted their initial ideas; (4) they have the time and tools to engage in problem solving after the experiment. Every participant had normal or corrected to normal vision. Conditions for exclusion were a history of epileptic seizures, a diagnosis of psychotic disorders, a family history of schizophrenia and hypersensitivity to motion sickness.

Apparatus

During the experiment, participants were equipped with an Oculus Quest 2 VR headset, a state-of-the-art device with a resolution of 1832x1920 px per eye (3664x1920 px in total), a refresh rate of 90 Hz and a field of view of 100°. Using an USB-C cable, the VR headset was connected to an Asus ROG Strix laptop computer (Intel Core i7 CPU, NVIDIA GTX 1060 graphics, 8GB of RAM), from which the psychedelic simulation was run. It was

important to use a laptop computer as I wanted the entire set-up to be conveniently portable so that the experiment could take place in a variety of locations. Moreover, using a powerful computer was crucial for the simulation to run steadily and not lag or crash during the experiment. Lastly, participants wore a Redragon Garuda H120 gaming headset to suppress surrounding environmental noises and ensure a comfortable experience with supreme audio quality. The headset was connected to the laptop by a TRS cable.

Stimuli

The psychedelic VR experience (Psyrreal) was designed and constructed by researchers of the Institute of Computer Science of the University of Tartu. The experience incorporates many phenomenological elements of the psychedelic states such as colour enhancement, drifting of objects, after-images, closed eye visuals, visions and mystical experiences (Kaup et al., 2022). The awe-inspiring elements and concepts were selected based on anecdotal evidence, scientific literature and descriptions of the psychedelic, meditative and mystical experiences as well as visual replications and written reports of such experiences (Kaup et al., 2022). Like a cherry on top, the visuals are supported by a custom psychedelic instrumental soundtrack composed specifically for this experience, meaning the visuals and music are in sync, which amplifies the psychedelic quality of the experience by emulating audio-visual synaesthesia (Kaup et al., 2022).

The simulation begins with a guided meditation in a tranquil ancient temple. After 10 minutes, the meditative introduction is finished and the increasingly escalating bizarre and surreal “trip” begins. It follows the course of a psychedelic experience induced by drugs such as psilocybin or LSD, except in an accelerated fashion. At first, slight visual distortions occur, intensifying gradually. Then, abstract 2D patterns emerge, progressively evolving into three-dimensional virtual spaces. At that point, the participant enters a sequence of surroundings consisting of geometric patterns, kaleidoscopic tunnels, mandalas, metaphorical objects, dreamlike images, and conceptual shapes, which have no obvious meaning in themselves, but allow the participant to project their own meaning to the experience. The scenes are constantly in motion, changing in size and colour, stretching and morphing to emulate the experience of observing things from a different perspective. The experience peaks with a celestial view of the planet Earth. There, the particles of the universe converge inside of the participant, followed by an explosion and fading away of the particles, seeking to facilitate a feeling of connectedness, self-disintegration and merging with the universe –

known also as ego-dissolution (Millière, 2017). After that, the comedown begins as surreal elements slowly vanish and ultimately disappear. The simulation ends where it began – at the ethereal temple without any alterations. The psychedelic segment of this experience lasts for 50 minutes, making the entire experience an hour long. Illustrative visual examples of the simulation are presented in appendix A.

Measures

Two custom-made questionnaires were administered to the participants: one verbally before the experiment in the form of a semi-structured interview, and one digitally some time after the experiment. The reason for composing the questionnaires ourselves was that, to our knowledge at the time of planning the study, no other studies akin to this had ever been conducted before and so any standardized, reliable and valid questionnaires that would fill our needs did simply not exist. Therefore, there was no other option but to compose our own measures. Both questionnaires were administered in Estonian.

Questions of the pre-experiment interview are presented in appendix B. What made it a semi-structured interview was that, while I had prepared the questions, it was not my priority to methodically follow the questions. Instead, they served as guidelines for the general course of the interview and marked the objectives of what I needed to learn from our conversation. I did so to avoid building any artificial walls between myself and the participant, and rather let the conversation flow casually. Operating in such a manner allowed me to collect the necessary information while establishing rapport with the participant, paying respect to the importance of set and setting as discussed above. The interviews ranged in length from 20 to 30 minutes.

Conducting the interview served four primary purposes: first, the goal was to determine if the participant meets all of the inclusion criteria. The second goal of the interview was to gauge the problem – in brief, questions such as what the problem is about, how long have they had this problem for, how much progress have they already made. Third, the function of the interview was to level the participants prior to the experiment. To rephrase, I wanted to ensure that all of the participants had reached certain milestones – the inclusion criteria – regarding their problem before the psychedelic VR experience in order to reduce the theoretical variance in the distances between their current situations (looking for the solutions) and their desired situations (having solved the problem). Furthermore, during the interview I primed the participants with justifications and explanations of why I believed

the simulation would be beneficial for them. The rationale behind priming the participants was to motivate them to take the experiment seriously and „play along," and secondly to balance their expectations of its potential effects. Additionally, this being a feasibility study, we figured that it would be a scientifically stronger result if despite all of our influencing, we were to still not observe an effect, as compared to a potential result that there was no effect under conditions of minimal interference and most experimental control. Finally, the interview was an opportunity to establish a time and place for the experiment to occur.

The post-experiment questionnaire is shown in appendix C. In it, I operationalized the impact of the psychedelic simulation as the participant's estimation of whether and to what extent the VR experience aided them in solving their problem. In other words, I asked them to rate how much they believed and felt that the VR experience played a role in them coming up with a solution to their creative problem. Furthermore, various other aspects of the solution and the participant's journey to the solution were inquired in the questionnaire.

Procedure

Before the experiment, I conducted a semi-structured interview with every participant to assess their current status in terms of the problem they were looking to solve. The interview occurred on the first possible instance following the signal of interest from the participant. All interviews were conducted in person. The experiments did not happen in any one standardized location. Instead, if possible, I wanted the experiment to occur in an environment where the participant typically engaged in their creative endeavours. In the case of an absence of a particular creative hub, the experiment took place at the participant's home. I opted for such an unorthodox approach with the purpose of enabling the participants to pursue solving their problem immediately after the simulation, while its potential effects were still fresh. Moreover, knowing the importance of set and setting, I wanted the participants to partake in environments where they felt comfortable and safe. Thus, the appropriate location of the experiment was agreed upon with every participant individually.

On the day of the experiment, at our prearranged location, I first prepared the experiment by booting up the simulation, advising the participant to use the restroom, dimming the lights and turning off all potential sources of unwanted sounds such as alarm clocks and app notifications. Next, I gave them a short overview of what was going to happen by introducing the course of the experience. Drawing from practices in psychedelic therapy, I suggested participants to turn their attention within, notice any feelings, thoughts or

sensations that may arise, and accept them as opposed to resisting them and pushing against (Johnson, Richards, & Griffiths, 2008; Wolff et al., 2020). Moreover, I reminded them of the possible adverse effects (overwhelming emotional reactions, cybersickness) which they had been informed of previously, emphasizing that they may discontinue the experiment whenever they feel like it. After these disclaimers I seated them someplace comfortable, set them up to the VR headset and initiated the simulation. Finally, when the simulation had ended, I collected my things and left so that I would not needlessly disturb them, unless they explicitly asked for me to stay for an integrative discussion of the experience.

Following the experiment, I waited for the participant to notify me, as we had previously agreed they would once they had solved their problem. Once either the participant announced to me that they had solved their problem or two weeks had passed since the experiment, I asked them to fill in the custom-made questionnaire, aiming to evaluate the subjective impact of the VR experience. The questionnaire was created using Google Forms and it was transmitted to the participants via their preferred channels of media.

Data analysis

Based on the data gathered from the interviews, most basic statistical analysis was conducted. In order to analyse the data provided to us in the questionnaire, I used thematic content analysis. Thematic analysis is a qualitative method for identifying, interpreting and reporting patterns or themes within a dataset (Braun & Clarke, 2006). Following the guidelines presented by Braun and Clarke (2006), and applying the instructions of Maguire and Delahunt (2017), the process began with me getting thoroughly acquainted with the data by reading and reflecting upon the answers, noting down initial impressions. Next, adopting a top-down approach, I highlighted and coded each segment of data that was somehow relevant or captured something of interest about our research question. The reason for deciding in favour of a theoretical as opposed to an inductive approach was that I aimed to explore the effects on creativity in particular, and not the overall impressions and general reactions to the simulated psychedelic experience. Then, from the coded data segments, I set out to search, identify and extract themes, mainly by testing combinations and examining for similarities across the generated codes. After reviewing these broader themes that seemed to say something about our research question, I modified them so that they would really be supported by the data and that they would be coherent, distinct and reasonable in the context of the entire data set, not just the single individual responses. Having refined the themes, I

finally defined and conceptualized them in a presentable manner in order to simply and clearly convey their essence and relations with the other themes.

Ethical considerations

One ethical hazard of the present study was the potential occurrence of cybersickness or strong unpleasant emotional reactions during the VR experience. However, all participants were made aware of the risks before the experiment and they had to sign a declaration of informed consent, which was available to them already before the interview. In addition, participation was entirely voluntary and everybody was encouraged to immediately notify me of their wish to withdraw from the experiment.

Another aspect of consideration was the potential invasion of the participants' private spaces and homes. Due to this, although I did make suggestions, ultimately the decision of the location was made by the participant. Furthermore, to minimize the effects of social pressure or their desire to behave in an assisting manner, I emphasized the paramount importance of their well-being and comfort for the success of the experiment and positively urged them to express their discomfort, should they feel like that, while assuring my non-judgemental attitude towards it.

Participants were informed that the data gathered would remain anonymous and stored securely in my personal desktop computer, inaccessible without the password which only I know. Also, participants were informed that the data would be used only for the purposes of this study and that it would be erased immediately once the study was done. The study was approved by the ethics committee of the University of Tartu.

Results

Descriptive findings

The descriptive findings of the pre-interviews are presented in table 1. Most notably, when the participants were asked to rate their subjective importance of trying to find a solution to the creative problem on a scale of 1-10, their answers ranged from 5 to 10, with a mean of M = 6.83; this hints at a strong motivation to solve the problem. In other words, participants experienced the state of impasse as at least somewhat stressful – some moderately, others to a higher degree.

Table 1

Descriptive findings: Pre-experiment interview

Variable	Overall sample (N = 9)
Had prior experience with virtual reality	5 (55.6%)
Had prior experience with psychedelics	4 (44.4%)
„Please rate the subjective importance of finding a solution to your problem.“	M = 6.83 (SD = 1.68)
„What are your expectations in regards to the VR experience?“	
„I feel optimistic that the VR experience will be beneficial for me.“	6 (66.7%)
„I don’t feel particularly optimistic, but I am curious to find out.“	2 (22.2%)
„I’m sceptical and do not believe it will actually be beneficial for me.“	1 (11.1%)

Each participant had a creative problem which fit our criteria of inclusion. They were of a wide variety, differing from each other in almost every possible aspect – the field they operated in, the nature of their work, the particular problem and its nuances, the duration they had had that problem for (ranging from a few days to mostly a few weeks but even a couple of months), the context of the problem (i.e. deadlines or other time limitations), efforts already made, their self-efficacy and previous experiences and beliefs and habits and skills in terms of creative problem solving, and so on. To illustrate, here are three examples of the problems creatives experienced in this study:

1. For nearly two months, a participant had been struggling with writer’s block – they would regularly come up with novel ideas for non-fiction writings, but when they sat down and attempted to begin, the words just would not come out. They would get stuck too often, doubt themselves too much, write something just to delete it a while later, all that causing them to make no progress after several hours of work. This was frustrating them and with the help of this experiment, they hoped to break free of these constraints on their writing.

2. Tasked with labelling variables and domains for a large web development project, another participant was uncertain how to proceed. Choosing a good name was crucial, because it would be adopted by hundreds of other developers and, in case of adversities, changing it later would be very troublesome, in addition to annoying

many colleagues. Since labelling the variables was their responsibility – and they defined themselves as a perfectionist – this led to them feeling a considerable amount of stress and pressure due to the task. They felt an ominous sense of „something is not right“ and had rigid specific demands, which they had for two weeks been trying to implement to no avail. Deadline was a week away, and from this experiment they sought insightful answers.

3. This participant was in the process of writing an opinion article. They had already done a large amount of work, brainstormed and categorized their ideas, yet they felt that it was too dry, and they wished to add something intriguing and fun to spice things up. In other words, they felt like their opinion article resembled an academic research paper and they desired to make it more creative, but they had been unsuccessful in figuring out how exactly this may be achieved. To quote the participant: „*How do I put my genius into words?*“

The descriptive findings of the post-experiment questionnaire are presented in table 2. Notably, all except for one participant managed to solve their creative problem or some other unresolved problem at least partially. The one attributed their failure to make progress to the fact that they had not put much effort into it. Of the eight participants that made creative progress, two solved their problem during the experiment or 2 hours after that, and the rest of the participants solved their problem after between 3-10 days. Another important finding was that five participants reported analytic problem solving as the means they arrived at their solution, two reported insight, and one reported a combination of both (first there was an insight, which they began building their solution upon).

Table 2

Descriptive findings: post-experiment questionnaire

Variable	**Overall sample (N = 9)**
„Did you solve your creative problem?“	
„I completely solved my creative problem.“	5 (55.6%)
„I solved another problem [which we had not previously discussed].“	2 (22.2%)
„I partially solved my creative problem.“	1 (11.1%)
„I did not solve my creative problem.“	1 (11.1%)

Variable	Overall sample (N = 9)
„Please rate your satisfaction with the solution.“	M = 6.13* (SD = 0.84)
„How did you arrive at your solution?“	
„Analytic, step-by-step problem solving.“	5 (62.5%) *
„I experienced insight.“	2 (25%) *
„Combination of insight and analytic problem solving.“	1 (12.5%) *
„How important was the VR experience in terms of finding your solution?	
„I would not have found the solution without it.“	1 (11.1%)
„It was useful, but I would have found the solution on my own.“	6 (66.7%)
„It might have been somewhat useful.“	2 (22.2%)

Note. In findings marked with an asterisk (*), the calculation did not include the responses of the one participant who failed to solve any problems during the two-week period following the experiment.

Thematic analysis

From the written responses of the participants, 83 codes of relevance were generated. Thematic analysis revealed that these codes seemed to represent four broader themes: affective effects, elevated insightfulness, generating creativity and shift in perspectives. These themes and sub-themes, if applicable, are listed in table 3, ranked based on the number of participants whose response contained the according thematic.

Table 3

Themes, sub-themes, and their frequencies in the participants' responses

Theme	Frequency (N = 9)
Affective effects	9 (100%)
Positive affect	8 (88.9%)
Negative affect	3 (33.3%)
Elevated insightfulness	7 (77.8%)
Experience was meditating	4 (44.4%)
Cognitive flexibility	6 (66.7%)

Theme	Frequency (N = 9)
Generating creativity	7 (77.8%)
Experienced insight	5 (55.6%)
Inspiration	6 (66.7%)
Shift in perspective	6 (66.7%)

Affective effects

Every participant reported some sort of affective changes. These changes were local and acute, occurring either during the simulation or immediately after it. In addition, the effects had a short life span and vanished in a matter of hours. Within this theme, two sub-themes were identified: (1) positive affect; and (2) negative affect.

Positive affect. Most participants reported that the psychedelic simulation brought about positive and pleasant emotions. The VR experience was said to be fun, enjoyable, and aesthetically pleasing – both visually and musically. Furthermore, the simulation uplifted their mood and made them feel good.

> „[The VR simulation] was definitely valuable, at least as an aesthetic experience. It was also an introduction to a world of new sensations, visuals and sounds that I had only heard of before.“ (Participant 1)

> „I was in a good mood after the VR. I felt fresh and motivated.“ (Participant 6)

Negative affect. Three participants reported experiencing adverse or negative emotions in regards to the psychedelic simulation. In particular, two of them found the VR experience to be physically challenging at times, having to endure pain and discomfort – knowing that they may stop at any time, but making the decision to persevere instead of quitting. Moreover, two of them felt disappointed and underwhelmed with the simulated psychedelic experience.

> „Ideally, I would have liked the VR experience to have been more realistic. Unfortunately, I didn't really feel like I was in the middle of something, but I was like a spectator. I put it down to the fact that I am an IT person and I always expect maximum quality.“ (Participant 5)

Elevated insightfulness

Most participants reported some „symptoms“ of elevated insightfulness, as discussed by Tulver et al. (2021). It was rarely spelled out literally, but as a result of thematic analysis, I deduced that these seemingly different codes did actually talk about quite the same things. Within this theme, I identified two sub-themes: (1) the experience was meditative short-term; and (2) their cognitive flexibility was higher for a few days.

Experience was meditative. This sub-theme consists of codes about the various effects of meditation. For four participants, the VR experience was calming and it helped them relax; it helped them to focus and „take a step back“. Two of them said it literally that the experience was alike to meditating. In addition, it was described that the psychedelic simulation had some kind of mentally refreshing effect. Personally, I also observed that, after the experience, many participants were much less talkative and more introverted, withdrawn or dreamy.

> „It was nice. [After the VR experience] I was kind of tired and dizzy, though, like mentally spent. But I felt really peaceful and *zen*. I had zero thoughts, as if my head was empty. ... I think that it was a pretty good introduction to meditation.“ (Participant 3)

> „In addition to a breath-taking experience, it also worked on me as a kind of meditation (not only the deliberate meditation at the beginning, but the whole simulation in general), which is why I believe that it could also set the right/suitable mindset in the future to deal with something creative or just to channel my thoughts into something new and to see and analyze [the thoughts] from a different angle.“ (Participant 9)

Cognitive flexibility. Although in a variety of wordings, many participants said that they felt sort of liberated in their own heads in the sense that it helped them to dissociate from rigid thinking patterns, habits, and other restrictions. The experience fostered abstract thinking and it let their thoughts flow more loosely and smoothly. Interestingly, one participant noted having considerably more surreal dreams following the experiment. Such effects were usually sustained for several days.

> „[Commenting the effects of the VR experience] In my case, the solution was not so much the generation of creativity, but rather the dispersal of the self-imposed limitations standing in the way of creativity. This gradually enabled my creativity to start moving again. When I started to write, the same limiting and hindering thoughts and feelings of opposition still came to me, but I felt myself far away from them, as if it was all a random document or recording in my head. ... I discovered a certain ability to redirect my focus during the experience.“ (Participant 1)

> „[The experience] broadened my senses and let my thoughts fly unrestricted.“ (Participant 4)

> „A few nights later [after the experiment] I dreamt that my face and hands were covered with moss. Moss seemed to grow out of my hands and face and I tore the moss off of myself. It felt like some kind of rebirth or liberation.“ (Participant 8)

Generating creativity

Participants reported various ways in which the psychedelic simulation facilitated creativity. Of these reports, two sub-themes emerged: (1) experiencing insight; and (2) inspiration.

Insight. Over half of the participants reported experiencing insight either during or after the VR experience. Such insights were in some cases related to their creative problem, but for others they were on a completely different topic. In addition to specific examples, participants also expressed more broadly that they thought about new things, discovered unexpected ideas or understandings, and made surprising observations during the experience.

> „The repetitions in the VR simulation made me think more universally about the concept of repetitions, followed by a eureka moment that everything is based on repetitions! ... [During the VR experience] I solved the big problem of the narrative of human life, which I had been thinking about for a long time (how is man a narrative animal?) ... It was so funny though that the whole day [of the experiment] I had been looking for my lost charger. I looked everywhere at home, went to my parents' to search from their basement and eventually I just went to the store and bought a new one. But then I did the VR thing with you and like 30 minutes later I suddenly remembered where it [their lost phone charger] was!“ (Participant 2)

> „[Reflecting on their insight during the experience] I began to think about the nature of the trip [the psychedelic VR simulation], which was a kind of endless circle. Then I got the idea for my solution. ... My video ends with the main character waking up in his room and getting ready to go out with his friends. He then steps outside and meets up with the same friends he originally went out with. The same event basically happens all over again, a closed circle with no escape.“ (Participant 3)

Inspiration. Two thirds of the participants reported word-for-word that the experience inspired them. It inspired unusual ideas as well as solutions to some other problems. They were inspired by the visuals and by the music. Moreover, the simulation was said to have inspired creativity and accelerated the incubation process. The Inspiration sub-theme also includes new thoughts and ideas, which would not qualify as insights: while this

distinction is subtle, these were not – to my judgement – associated with extreme truth-value and affective significance, the defining characteristics of insight (Tulver et al., 2021). However, they still were novel and fascinating for the participants.

> „I am still surprised and satisfied with the inspiration and pleasant experience that arose during the experiment.“ (Participant 7)

> „[Thanks to the VR experience] a creative venture I had had for a long time got a new and fresh impulse. After a few days of thinking about it and participating in a creative writing event after the experience, the interaction of the two inspired an essay I had long planned for, which I had thought about for a long time, but postponed due to lack of inspiration.“ (Participant 9)

Shift in perspective

This theme consists of codes describing some kind of change in the participant's perspectives. For some, this occurred during the simulation, yet others mentioned noticing novel perspectives after the experiment. However, these shifts were not always related to their creative problem: they were of a very wide variety, but the common denominator was that the perspective was novel, fascinating or of personal significance to the participant.

While this theme may seem to overlap to a large extent with the previous theme of Generating creativity, I believe that the Insight and Inspiration sub-themes are associated with much more specific revelations and concrete thoughts, ideas and solutions, whereas the Shift in perspective theme entails a broader alteration of viewpoint, analogous to changing the lens to look through as opposed to changing the object to look at.

> „It was as if I had moved from a state of "knowing" to a state of "asking" during the experience, if this thought makes sense. ... The patterns and colours and sounds and their depth created a sense of doubt in the word's very best meaning – almost like the boundaries of reality, thoughts and feelings were disappearing. ... After the experience, it was much easier to notice small interesting things in the world around me and feel in awe with them.“ (Participant 1)

> „[Having recently lost a loved family member] I had a strange dream the same night [after the VR experience]. I can't remember it now, but I woke up with a feeling that it's OK to experience grief, but to make someone's death so that I'm the sufferer is selfish toward the person who died. The specific wording in my head was in English: "*We make somebody's death about us – it is not.*" This new way of seeing it kind of helped me cope with the grief.“ (Participant 8)

> „[The VR experience] helped to change the perspective and tempo(!) of my thoughts. It as if stopped time for a while, or maybe stretched it out somehow, and thus enabled me to understand my thoughts at a completely different pace and from a clean perspective.“ (Participant 9)

Discussion

The purpose of this study was to explore the subjective effects of a simulated VR psychedelic experience on creativity. Our subjects were stuck with solving a personally significant creative problem and, at the time of the experiment, they were experiencing mental pressure due to this unresolved creative problem. Our findings point to a variety of beneficial consequences, which were attributed to the VR experience. First and foremost, eight out of nine participants solved either their creative problem or some other previously unmentioned problem at least partially. To my surprise, the participants were on average very satisfied with their solutions, reporting a mean satisfaction of $M = 6.13$ ($SD = 0.84$) on a scale of 1 to 7. Furthermore, an overwhelming number of participants – six out of nine – reported that the VR experience was useful, although not paramount for their solving the problem. In terms of the specific effects attributed to the psychedelic simulation, it was often described that the experience facilitated creativity and increased the novelty of thinking: on the one hand, the experience was inspiring and enchanted participants with creative fuel, and on the other hand, it elevated insightfulness and liberated participants from mental constraints, at least temporarily. The VR experience increased the level of positive experiences (creativity and inspiration) and decreased the level of negative experiences (mental restrictions and constraints). This is further evidenced by insights and perspective shifts many participants experienced during or after the experience. Alas, these findings seem to offer encouraging evidence for the hypothesis that it may be possible to facilitate creativity by surreal sensory experiences, further testifying that chemical manipulation is not necessarily required for psychedelic effects.

In light of previous literature, the possibility of the surreal psychedelic simulation causing the effects on creativity is not outlandish. Regarding psychedelic therapy, the debate is still ongoing on whether the subjective effects of psychedelics are necessary for their enduring therapeutic effects or not (Olson, Yaden, & Fejer, 2021). For now, the consensus seems to be that while therapeutic effects can be achieved without subjective experience (Olson, 2020), the long-term therapeutic effects of psychedelics are primarily mediated through subjective effects (Yaden & Griffiths, 2020) – thus implying a dissociation of

neurochemical and subjective effects, but at the same time stressing that both are required for maximal efficacy. Similar to the results of Kaup et al. (2022), this study would – in the context of creativity – ideally support the hypothesis that subjective effects mediate the benefits of psychedelics. Namely, subjective effects can be understood as cognitive and affective processes that constitute the „what it feels like“ quality of being (Olson et al., 2021), and psychedelics convey some of their beneficial effects via these cognitive and affective processes (Olson et al., 2021). In a similar manner, so did our VR experience – a replication of the subjective psychedelic effects – elicit insightfulness (a more dissociated and aloof subjective state) and insights, a sense of inspiration, shifts in perspective, positive affect, and aesthetic appreciation (potentially with the emotions of surprise and awe) – all cognitive and affective effects that would – for reasons already discussed – contribute to or reflect enhanced creativity. However, conclusions about the subjective effects of psychedelics would assume that it indeed were the psychedelic properties of specifically this VR experience that inspired the changes, and we cannot assume so before other key factors have also been considered.

For one, even though participants were apt to attribute the causality of consequent changes to the simulated experience, we do not know which aspect of the experience really facilitated the reported effects. It might not have been about our psychedelic simulation specifically, but the experience of virtual reality in general; or it could have resulted from our special experimental situation, including the interview. Because we did not use a control condition in this study – more on this in the limitations section below – it is impossible to tell what caused the changes. Nevertheless, there is little reason to doubt if the changes reported by our participants – the affective effects, the insights, the inspiration, and the insightfulness – were true. In other words, it is highly probable that the effects we observed were real and plausible, but we do not know what caused them. Consequently, the present study can only serve as inspiration for more controlled future studies.

In terms of the subjective effects, a high prevalence of reports on elevated insightfulness was expected as it corresponds to previous literature about VR promoting changes in metacognition (Vasser et al., 2019) and cognitive flexibility (Rastelli et al., 2022), promoting the presence of mindfulness and detachment from familiar reality (Sekula et al., 2022) etc. Because of this, we would have anticipated for more participants to report insight as the way they found the solution to their creative problem – insight would, after all, be the final result of facilitating creativity by means of elevating insightfulness – yet only two out of

eight participants did. While it could be concluded that the experience was not intense enough for the expected effects to really emerge, I believe there are alternative explanations for this. For one, it could be that they did experience insight either during or after the psychedelic simulation, but the entire problem-solving process – including all the previous steps, even idea formulation and info-gathering – altogether still constituted an analytic process for the participants. Hence, this was the most common response. Furthermore, our findings highlight that over half of the participants did report experiencing a moment of insight, which they associated with the VR experience. This result is consistent with the idea that we prioritize solving the problem that is really causing us the most pressure (Tulver et al., 2021; Aru, 2022). Indeed, the insightful solutions tended to be generated in response to the most salient problems for any given moment: in some cases, it was the creative problem we had previously discussed, but another participant for instance „solved“ their far more pressing problem of grief, and another one solved the problem of their lost phone charger. Therefore, while at first glance it may seem that the experience was not particularly helpful for generating insight experiences, a closer look reveals that many participants did experience insight and thus solved their problem; it simply was not always the one creative problem we had picked out to focus on.

The finding that the experience elicited positive emotions and evoked aesthetic appreciation is significant: for instance, it has been well established that people tend to solve creative problems better when in a positive mood, and also that a positive mood enhances insight (Subramaniam et al., 2009). Also, several studies have testified that aesthetically moving experiences can serve as prompts for creative inspiration (An & Youn, 2018; Welke, Purton, & Vessel, 2021) and are also associated with positive affect (Mastandrea, Fagioli, & Biasi, 2019). Therefore, it seems that the psychedelic simulation facilitated creativity at least through indirect means by evoking positive emotionality.

In regards to negative affect, it is no coincidence that of the three participants who reported these experiences, two were IT workers. The same pattern has already been observed in earlier VR studies that IT workers – and generally people with a background in information technology – tend to be more critical as they usually pay more attention to the technical details of the VR experience (J. Aru, personal communication, January 5, 2023). As a result, they are less likely to proceed with an open mind, and ultimately less likely to experience elevated insightfulness.

One other result merits comment – a majority of participants reported that the VR experience was useful, but that they could have solved the problem on their own without it. While it may be true, there is reason to suspect that, due to the wording of this question, it might not reflect the actual importance of the experience. Firstly, this was a multiple-choice question – answers were presented in the same order for all participants – and the first option („I would not have found the solution without it.“) may have come off as intimidating and harsh, far too extreme. Secondly, even if in reality they actually would not have been able to solve the problem on their own, it would be difficult to pick this answer as it would imply some sort of acceptance of defeat, or it would be like admitting that they are not good enough, and to avoid confronting this thought, in self-defence, they still chose to respond with the answer „It was useful, but I would have found the solution on my own.“ To emphasize, this is an alternative explanation for the finding that most people reported.

Limitations

There are some limitations concerning the stimulus. As discussed by the authors of Psyrreal – the psychedelic simulation used in this study – it is not a picture-perfect replication of psychedelic experiences (Kaup et al., 2022). The replication is inevitably confined to the medium of virtual reality, which means that some elements of psychedelic experiences are inherently impossible to mimic. Additionally, the immersive powers of the VR experience are to a degree sabotaged by the quality of its graphics, which for now do not feel quite real enough. However, this flaw will likely be remedied in the coming years as technical developments in the field of VR are occurring rapidly.

On the topic of our sample, in addition to it being numerically small, it deserves critique that it was entirely a convenience sample. In addition, the participant selection process was somewhat arbitrary, in the sense that the decision was fully dependent on our judgements of whether their creative struggles were indeed creative and significant enough to be accepted into our study. I wish to emphasize, however, that finding suitable subjects who would (1) be fit in every respect to participate in our study, and (2) truly be willing to make the time investment to participate, proved to be far more troublesome than I previously would have imagined. So, despite my best efforts, due to the specificity of the niche we are operating in, a small experimental group and no control group had to suffice. Future studies should recruit larger samples in order to draw stronger conclusions.

Several limitations stem from the omission of control subjects. The most notable issue is that, as all subjects underwent the same process, it is virtually impossible to determine what caused the effects – was it the psychedelic simulation or the general experience of virtual reality? May it have been just the music, having nothing to do with the visual experience? If the effects were the result of a combination of factors, then what were the components, and how large were they proportionally? What were the impacts of our initial discussion and the guided meditation? For now, questions such as these remain unanswered, thus preventing us from making strong claims about this intervention. However, note that conducting this study without the control group was *a priori* deliberate choice, as we anticipated already before the experiment that gathering enough subjects even for the experimental group would be difficult (as it turned out to be). We decided to run this study without the control group, as clues from the reports of the post-experiment questionnaire offer support for answering the main research questions – what do people subjectively report and whether this relationship is worth studying further. Moreover, it being a feasibility study, distinguishing causality was not our goal; instead, the goal was to either bury the hypothesis or establish robust evidence of the potential this surreal sensory experience may have to enhance brain plasticity and facilitate creative insights. Hence, we sacrificed a controlled experimental design to channel all of our efforts towards exploration and potentially paving the way for more controlled future research. Given the present results, we now seek to recruit a control group to better understand the specific factors that led to the observed effects.

One implication for future studies is that they ought to pay attention to confounding variables. In this study, we did not ask the participants to discuss what else it might have been that brought them their solution. However, as it turns out from the response of at least one participant, other unusual events and affairs also occurred after the experiment and prior to experiencing insight and/or solving their problem:

> „After a few days of thinking about it and participating in a creative writing event after the experience, the interaction of the two inspired an essay I had long planned for ...“ (Participant 9)

Another possibly limiting aspect of our study design was the facilitation of expectancy bias in the participants. Regarding the effects of the psychedelic simulation, a majority of participants had optimistic expectations, two held neutral positions and only one was skeptical. It indicates that our efforts at creating positive expectations could have been

fruitful, while also hinting at a stronger expectancy bias and a higher likelihood of false attributions. This is relevant because, particularly in the case of psychedelic compounds, the subjective perception and interpretation of the experience play major roles in both the acute and enduring effects (McClure-Begley & Roth, 2022). Subsequently, to some extent, our findings might be explained by the positive expectations which we ourselves created: besides the potential effects of social desirability and false attributions, the informing and raising awareness of our participants before the experiment could have manipulated their memory and later recollection of the experience, swaying the reports in a certain direction. On the other hand, while this was an open-label study, we did not promise the participants that they definitely would experience insight and solve the problem. Owing to this, while our briefing was informative, it also might not have had too much of an impact on the expectations held by the participants.

In addition to limitations concerning the design of the study, shortcomings may derive from practical misfortunes as well. Throughout all of the conducted experiments, it at times happened that the laptop computer which ran the VR simulation froze or began updating without a warning, halting the experience and abruptly breaking the participant's immersion. Sometimes, due to the unpredictable nature of the environments we were in, interferences such as car sirens, rustling flatmates, and loud neighbours altered the anticipated progression of the experiment. Other factors such as weather conditions, the time of day, attention-seeking pets, and physical disturbances such as an itchy mosquito bite or a need to blow one's nose were among the many other extraneous variables which we did not hold under control, yet which potentially affected the participants' experiences, for instance by impairing their ability to focus and breaking their immersion. If this were the case, then these errors would also be, to some indeterminable degree, reflected in our findings.

Finally, a noteworthy limitation is that our verbal and written questionnaires were developed entirely by ourselves. Therefore, as we have not tested or controlled their qualities, satisfactory levels of reliability and validity are not guaranteed. Potential pitfalls of the measures can among others include ambiguous sentencing, questions leading with an implicit bias, lack of nuance, incomplete options in multiple choice questions, or using excessively complicated vocabulary. Because of this, in some cases, different lateral meanings could have been extorted from the questions with different levels of clarity by each participant, which would influence their answers. In other words, the answers we collected to any given

question may not really reflect the responses to that particular question, but instead a range of more or less divergent variations of that question. However, the presence and influence of such a cryptic effect cannot be quantified, proven, or disproven. In addition, the post-experiment questionnaire was administered to the participants after some time – a maximum of two weeks – had passed. In that time, the natural erosion of their memories could have occurred, potentially affecting their responses and hence our results. Despite such limitations, it was our only option to create our own measures as, to the best of our knowledge, no alternatives exist. Hopefully, future researchers will have the advantage of using standardized measures with strong psychometric properties, applicable to purposes such as ours.

Conclusions

After experiencing Psyrreal in a VR environment, a vast majority of participants reported that the VR experience was useful, but not decisive for their solving the problem. Moreover, they attributed to the experience several positive effects, such as feeling inspired and free from mental constraints, seeing things from a new perspective and experiencing insight. This hints at a possibility that the psychedelic simulation had a facilitative effect on creativity, which would support the hypothesis of subjective experiences as mediators of beneficial effects of psychedelics. However, due to limitations regarding the study design, we cannot be certain about what caused the reported changes. More controlled future research is needed to determine causality and ultimately to assess the potential of VR environments as alternative options to traditional psychedelic compounds.

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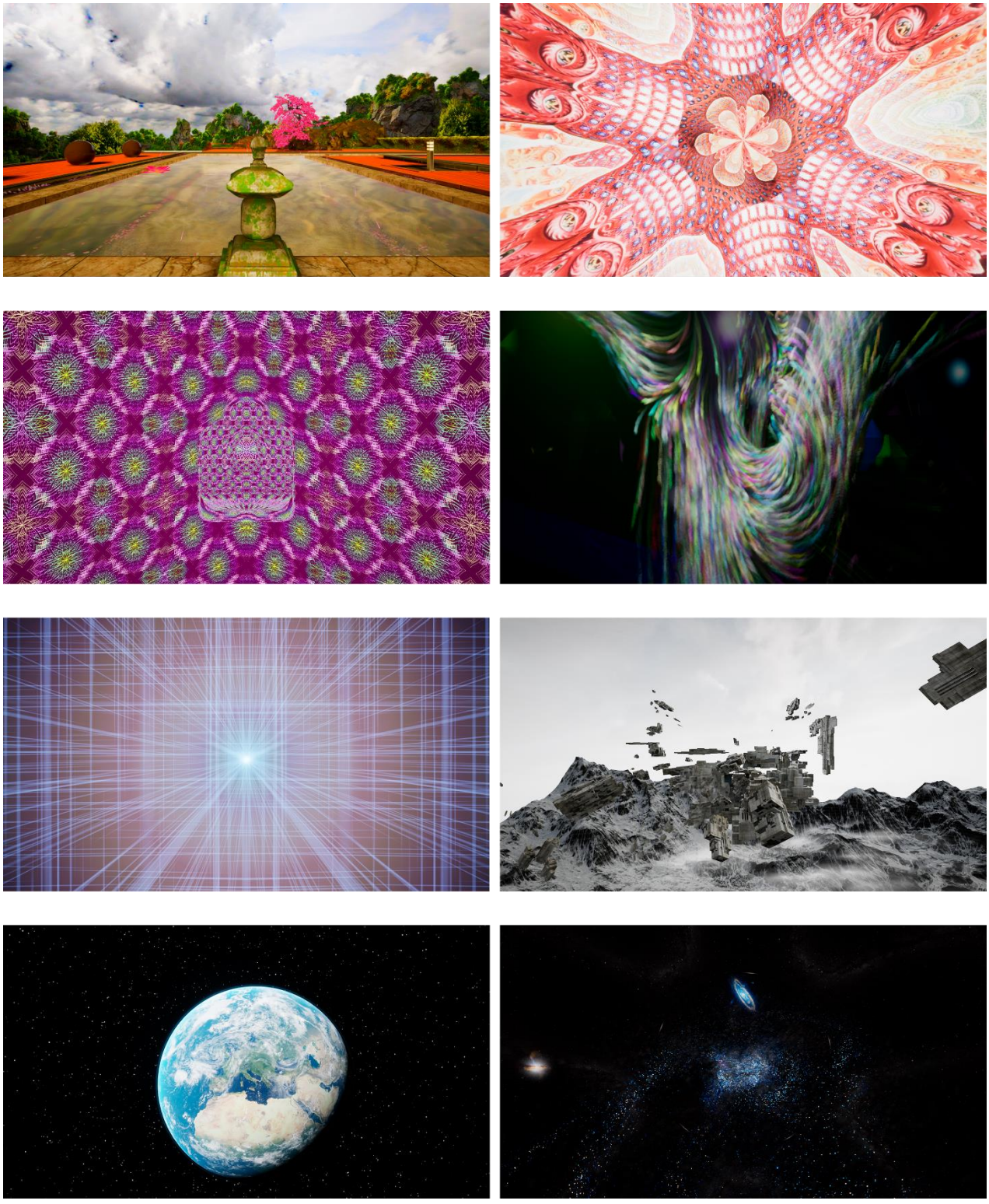
Appendix A

Visual examples of the simulated psychedelic experience



Appendix B

Questions of the interview

1) Mis probleemile sa lahendust oled üritanud leida?

2) Mis on selle probleemi valdkond?

3) Kas sa oskaksid oma probleemi sõnastada ühelauselise küsimusena?

4) Kas sul on olemas teadmistetükid, et see probleem lahendada, või on midagi veel puudu?

5) Kas see probleem koosneb ühest sammust või mitmest vahesammust?

6) Kuidas saad aru, et probleem on lahendatud? Mis täpselt on eesmärk?

7) Millal see probleem esimest korda esile kerkis?

8) Kui kaua sa probleemi lahendamisele pühendunud oled olnud?

9) Kas sa tegeled probleemile lahenduse otsimisega aktiivselt ka praegu?

10) Kui oluline selle probleemi lahendamine sinu jaoks on? Palun vasta hinnanguliselt skaalal 1-10, kus “1” tähistab totaalset ebaolulisust ja “10” tähistab kriitilist olulisust.

11) Kuivõrd kujutad sa probleemi lahendust ette juba praegu?

12) Kui tihti sul selliseid probleeme või loomingulisi tupikuid ette tuleb?

13) Kui edukalt sa neid tavaliselt lahendanud oled?

14) Kui kaua selliste probleemide lahendamine sul tavaliselt aega võtab?

15) Kuidas sa tavaliselt lahenduse leiad? Kas see on pigem järkjärguline protsess või kipuvad lahendused sinuni jõudma ootamatult ja järsku?

16) Milline on su praktiline lähenemine selliste probleemide korral ehk kas sul on mingi oma protsess, mida tavaliselt järgid?

17) Mis sa arvad, kas meie VR võib aidata sul lahendust leida, või tundub see pigem jabur?

18) Kas sul on endal mingisuguseid küsimusi ükskõik mille kohta tekkinud?

Appendix C

Items of the post-experiment questionnaire

Question in original language	Answer format
Kas sa lahendasid oma esialgse loovprobleemi ära? Kui ükski vastus ei tundu päris õige, siis palun vali "Muu" ja täpsusta oma sõnadega!	Multiple choice (choose one): a) Jah, lahendasin kogu probleemi ära b) Lahendasin osa probleemist ära c) Lahendasin mingi teise probleemi ära d) Ei ole midagi ära lahendanud e) Muu (palun täpsusta)
Kui sul midagi selle vastu pole, siis palun kirjelda oma lahendust. Sa ei pea sellele küsimusele vastama, kui sa ei taha!	Open-ended
Millal sa vastuseni jõudsid? Kui täpselt öelda ei oska, siis vasta nii nagu tundub kõige õigem! Kui sa ei jõudnud vastuseni, siis võidki selle vastuseks panna :)	Measured in the number of days that had passed since the experiment, with absolute zero being the occurrence of the simulated psychedelic experience.
Kui rahul sa tulemusega oled?	On a scale of 1-7 („1“ meaning „Üldse ei ole rahul“ and „7“ meaning „Äärmiselt rahul“)
Soovi korral võid eelmise küsimuse vastust oma sõnadega täpsustada!	Open-ended
Kumb järgnevatest kirjeldustest su lahenduseni jõudmise protsessiga kõige sarnasem on? Kui mitte kumbki ei tundu päris õige, siis palun kirjelda lühidalt oma sõnadega protsessi, kuidas sa lahenduseni jõudsid.	Multiple choice (choose one): a) Ahhaa-elamus (ehk mõttevälgatus) – su sees toimus justkui nagu „ahhaa“ või „heureka,“ sest said millestki järsku aru. b) Analüütiline probleemilahendus – üks samm korraga, lahenduse ehitamine tükk tüki haaval. c) Muu (palun täpsusta)

Question in original language	**Answer format**
Kui kasulik VR-kogemus lahenduseni jõudmiseks sinu hinnangul oli?	Multiple choice (choose one): a) Ma ei oleks ilma selleta lahenduseni jõudnud b) Oli kasulik, aga oleksin ka ilma selleta lahenduseni jõudnud c) Natuke kasulik võibolla oli d) Pigem ei olnud kasulik e) Ei avaldanud mingit mõju ehk polnud kasulik f) See avaldas takistavat mõju ja tegi lahenduseni jõudmise raskemaks
Mis rolli see mängis? Kuidas VR-kogemus sind lahenduseni jõudmisel aitas?	Open-ended
Kas sul on mingeid mõtteid seoses selle katse või uurimusega, mida tahaksid jagada? Kas see kogemus oli sinu jaoks kuidagi väärtuslik? Mis moel? Kui ei - samuti, miks? Need ja kõik teised mõtted on siia oodatud!	Open-ended

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/Timo Siimon/