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A Qualitative Report on the Subjective Experience of Intravenous Psilocybin Administered in an fMRI Environment

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Abstract: *Background*: This report documents the phenomenology of the subjective experiences of 15 healthy psychedelic experienced volunteers who were involved in a functional magnetic resonance imaging (fMRI) study that was designed to image the brain effects of intravenous psilocybin.

Methods: The participants underwent a semi-structured interview exploring the effects of psilocybin in the MRI scanner. These interviews were analysed by Interpretative Phenomenological Analysis. The resultant data is ordered in a detailed matrix, and presented in this paper.

Results: Nine broad categories of phenomenology were identified in the phenomenological analysis of the experience; perceptual changes including visual, auditory and somatosensory distortions, cognitive changes, changes in mood, effects of memory, spiritual or mystical type experiences, aspects relating to the scanner and research environment, comparisons with other experiences, the intensity and onset of effects, and individual interpretation of the experience. Discussion: This article documents the phenomenology of psilocybin when given in a novel manner (intravenous injection) and setting (an MRI scanner). The findings of the analysis are consistent with previous published work regarding the subjective effects of psilocybin. There is much scope for further research investigating the phenomena identified in this paper.

Keywords: ??

INTRODUCTION

Psilocybin is the pro-drug of psilocin, a tryptamine and classical psychedelic drug, and the active component of "magic mushrooms". Psilocybin was first isolated and identified by Albert Hofmann in 1957, and later synthesised by him in 1958 [1] Psilocybin acts as an agonist of the serotonin 5HT2A, 5HT2C and 5HT1A receptors [2].

Native people in Mexico have used the mushrooms in religious ceremonies and healing, with evidence of their use as early as 3000 years ago [3]. The effects of psychedelic mushrooms were described by R. Gordon Wasson in Life Magazine in 1957, following study of their ritual use in Mazatec Indian culture in Mexico. Wasson described colourful, and complex vivid visual hallucinations [4]

> *"they were in vivid colour, always harmonious. They began with art motifs, angular such as might decorate carpets or textiles or wall-paper or the drawing board of an architect. Then they evolved into palaces with courts, arcades, gardens–resplendent palaces all laid over with semi-precious stones... Later it was as though the walls of the house had dissolved, and my spirit had flown forth, and I was suspended in mid air viewing landscapes of mountains"*

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By 1965 there were over 20,000 scientific papers published about psilocybin and other psychedelic drugs, detailing their effects and use as a treatment, in 30-40,000 participants [5]. Psilocybin was clinically used by psychotherapists for conditions including alcoholism, addiction, depression, anxiety and compulsive disorders [6, 7]. Much of this research was based upon largely anecdotal reports [8, 9]. Psychedelic drug research came to a halt in the 1970s, due to legislation criminalising these drugs [5], severely limiting their availability to researchers [10]. Recently preliminary trials have been published, investigating the use of psilocybin to treat obsessive compulsive disorder [11], anxiety in patients with terminal cancer [12] and an initial investigation into anecdotal reports of psilocybin and LSD treating cluster headaches [13]. All have shown promising results for the potential clinical use of psychedelics such as psilocybin.

Most recent studies exploring the phenomenology of psilocybin have predominantly used psychometric scales, either general scales used in Psychological research including the Ego Pathology Inventory [14] State anxiety inventory STAI-X1 [15], or more specific scales related to altered states of consciousness [12, 16-18]. The 5-Dimentional Altered States of Consciousness (5D-ASC) is a visual analogue self-rating scale assessing five criteria of altered state of consciousness; 'Oceanic Boundlessness', 'Anxious Ego Dissolution', 'Visionary Restructuralisation', 'Auditory Alterations' and 'Reduction of Vigilance', and was initially developed as a generalised scale for measuring aetiology-independent constructs of altered states of consciousness. However further research has shown

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differentiation in rating between individuals exposed to different classes of drugs [19, 20]. The Hallucinogen Rating Scale is a 99-item questionnaire designed to assess the effects of the hallucinogenic drug N,N-Dimethyltriptine. It consists of six subscales to assess the effects of hallucinogens; "intensity", "somaesthesia", "affect", "perception", "cognition" and "volition" [16, 21, 22].

The use of rating scales means that descriptions of the experiences are constrained to the item and response format of the scale. This limits the opportunity for uncommon or unexpected effects to be reported and possibly stereotypes the effect description between individuals. Furthermore experiences in unusual settings, such as a scanner environment, may not be sufficiently described by these rating scales. There are few contemporary publications using Quantitative methodologies to assess the phenomenology of psilocybin [23].

The effects of psilocybin have been documented previously, both in the published literature discussed above, and available in a large number of anecdotal reports written by individuals and available on the Internet [24]. Commonly documented effects of psilocybin include: Visual disturbances and hallucinations [17, 18, 25]; Loss of attention to outside stimuli [18]; Changes in time perception [18, 26, 27]; Auditory perceptual changes [18]; Altered mood [16, 18], changes in thought and memory [18]; Mystical or spiritual experiences [16, 28-30]; Loss of sense of self or depersonalisation [28, 31, 32]

There is also evidence of psilocybin experiences having long-term personal meaning to participants [18, 33] and potentially causing lasting personality changes [29].

Effects and intensity are poorly predicted by drug dose [18]. It is possible that other pharmacological or non-pharmacological variables influence the intensity and nature of the experienced drug effects. For example the psychological state of the individual or the environment, often referred to as *"set and setting"* [18, 28, 34, 35]. Due to the impact of psychological and environmental factors on the psilocybin experience, there is a possibility of inducing a difficult experience or 'bad trip' if an individual is not in an appropriate state of mind or setting. Clinical environments may be particularly distressing, due to their 'antiseptic' appearance, with potentially noisy medical equipment, as well as connotations related to illness [34].

Much recent research into the effects of psilocybin in humans has been carried out in minimally clinical environments with the constant presence and support of the study team [12, 16, 35]. There have been a small number of studies using scanning equipment including Positron Emission Tomography (PET) using orally administered psilocybin [36, 37] and functional Magnetic Resonance Imaging (fMRI) using intravenous psilocybin [38, 39]. These studies provide valuable insight into the functional brain changes caused by psilocybin, and collected quantitative data on experience using a variety of self reported rating scales; the Hallucinogen rating scale [22] and scales used in Clinical Psychiatry including the Ego Pathology Inventory (14) and the State anxiety inventory STAI-X1 [15]. There is evidence of increased anxiety in participants receiving psilocybin in a scanner environment [35].

The present report documents the subjective experiences of 15 psychedelic-drug experienced volunteers who took part in an fMRI experiment in which they were injected with psilocybin [38, 39]. This is the first study where psilocybin has been administered in an fMRI scanner environment, as well as the first study involving intravenous administration in a scanner environment. The aim of this report is to describe the phenomenology provided by participants involved in this novel scenario. This will allow similarities and differences in subjective effects to be highlighted between this scenario and the previous published research, and further contribution to the body of descriptive evidence of the psilocybin experience.

METHODS

The study was approved by an NHS Research Ethics Committee and conducted in accordance with the Declaration of Helsinki and Good Clinical Practice

Guidelines. The study was designed according to Guidelines for Safety in Human Hallucinogen Research [34] to minimise risk of adverse events.

Fifteen volunteers (10 males, 5 females, mean age 34.1, SD 8.2) were screened and recruited for a research study designed to investigate the effect of intravenous psilocybin on cerebral perfusion using fMRI (arterial spin labelling) and the phenomenology of psilocybin effects within the scanner environment. Participants were recruited *via* word of mouth and were required to have previously taken a psychedelic drug. Screening prior to entry in the study involved collecting demographic information, a full medical history and physical examination, including electrocardiogram (ECG), routine blood tests, and urine test for drugs of abuse and pregnancy. A thorough psychiatric assessment was conducted and participants gave full disclosure of their drug taking histories. Participants completed the State Trait Anxiety Inventory (STAI) and the Beck Depression Inventory (BDI). Exclusion criteria were: less than 27 years of age, pregnancy, current or previously diagnosed psychiatric disorder, immediate family member with a current or previously diagnosed psychiatric disorder, substance dependence (including alcohol), cardiovascular disease, claustrophobia, blood or needle phobia, or a significant acute or persistent adverse response to a hallucinogenic drug [40].

Each participant underwent two consecutive fMRI scans separated by at least 7 days. Each functional scan lasted 18 min. Participants were cannulated and screened for magnetic resonance compatibility. Solutions (placebo and psilocybin) were infused manually over 60 seconds, beginning 6 minutes following the start of each functional scan. Participants were required to complete a 0-10 visual analogue scale task answering a number of questions to rate intensity of the drug effects, where 10 = extremely intense effect (See Table **1**). This task occurred at the start of the scan, immediately prior to infusion, 5-min post infusion and 12-min post infusion. The items in the visual analogue scale were chosen and modified from the 5D-ASC [20].

Participants received an infusion of saline during the first scan (placebo), and psilocybin (2mg) in the second scan. The

Table 1. Mean Visual Analogue scores rated at end of placebo and psilocybin scans.

Visual Analogue Item	Placebo	Psilocybin
I saw my surroundings change in unusual ways	7.1	75.3
Things looked strange	8.1	69.9
My sense of size or space was altered	3.9	64.1
My imagination was extremely vivid	3.5	54.7
My sense of time was altered	6.3	55.4
The experience had a dreamlike quality	8.9	53.3
My thoughts wandered freely	11.0	57.7
Everything seemed 'alive'	1.5	47.1
I felt a sense of awe	3.1	48.0
I felt a sense of joy	5.1	45.9
My sense of self was altered	2.6	43.3
My thinking was muddled	5.9	40.9
The experience had a mystical quality	1.9	31.5
The experience had a magical or supernatural quality	2.4	31.7
The experience had a spiritual quality	2.7	28.2
I thought about myself and my past	4.8	22.9
I feared losing control of my mind	3.3	18.0
I felt afraid	5.8	13.7
I felt suspicious or paranoid	4.1	6.0

All items were rated at the end of each scan in a Visual Analog Scale format. Bottom anchor of "no more than usually" and a top anchor of "much more than usually." Scores are expressed as a percentage, with 100% being a mark adjacent to the top anchor "much more than usually." All items were rated significantly higher after psilocybin than placebo with the exception of "I felt afraid" and "I felt suspicious or paranoid" (t tests, P = 0.05). Data reproduced courtesy of Dr Robin Carhart-Harris et al. [38].

decision was made to use a fixed dose of 2mg psilocybin intravenously (IV) due to previous work by Hasler *et al.* (2004). 2mg psilocybin IV has subjective effects equivalent in intensity to approximately 15mg of orally administered psilocybin [17, 40], and is considered a moderate dose. All participants were informed that they would be administered IV psilocybin, but not at what point during the scan it would be infused. Participants were blinded as to which scan was a placebo scan, and which scan was the psilocybin scan. Further details regarding the neuroimaging study methods see [38, 39].

Prior to their scanning sessions participants were informed that there would be two scans, one placebo and one psilocybin scan, but blinded with regard to the order of these scans. They were also instructed about completing the Visual Analogue Scale task during the scan. Before undertaking their first scan, participants were advised regarding the safety precautions whilst in the scanner; a hand held alarm buzzer and monitoring of baseline physical observations. They were also given the opportunity to ask any further questions regarding safety in the scanner. In the scanner the participants were instructed to relax and focus on the displayed fixation cross. Participants were aware that they would be debriefed by the research team following each scan.

Following the second (psilocybin) scan, all participants were interviewed. The interviews were carried out by the same member of the research team (RCH) and took place immediately after the scan. The interviews were semi-structured, consisting of questions based on visual analogue scale items (see Table **1**), which the participants had completed in the scanner. Participants were invited to elaborate on these items in the interview, as well as to discuss any other aspects of the experience raised during the interview. In addition to the items from the visual analogue scale, participants were asked: *what was the first thing you noticed when the drug effects began?* and *during which scan did you receive psilocybin?*

These items directed the content of the interviews, however participants were invited to elaborate on other aspects of the experience raised during the interview. All interviews were videotaped and the contents were viewed and analysed by a researcher, who was not involved in the fMRI study (ST).

The interviews were analysed using Interpretative Phenomenological Analysis (IPA). Phenomenological methods are qualitative methodologies that aim to develop a better understanding of the content and quality of human consciousness and experience, with a focus on inquiry rather than the testing of hypotheses [41]. Due to the lack of previous research into the subjective effects of intravenous psilocybin within an MRI scanner, an exploratory analysis, as best provided by qualitative methods, has several advantages. Phenomenology is an area focussed entirely on the width and breadth of human experience, and therefore qualitative Phenomenological methodology would be the most appropriate to use to explore human experience.

Early proponents of Phenomenology included Husserl, who developed "Transcendental Phenomenology". Transcendental phenomenology theorises that the basis of human experience can be analysed by excluding biases, or human interpretation, to allow a *pure*, pre-reflective consciousness to be described [42]. However, it can be argued that the use of language to describe an experience is inevitably an interpretative process [43], and understanding cannot take place without preliminary assumptions made about the context and meaning of what one is trying to understand [41]. Interpretative Phenomenology recognises that both research participants and researchers are unable to fully exclude past knowledge and experience in their description and analysis of phenomena [44].

IPA is a form of Phenomenological Analysis using the principles of Interpretative Phenomenology to allow a researcher to identify and capture the quality and texture of individual experience. The researcher undergoes intensive and detailed engagement with the qualitative data, allowing important themes to emerge. Each theme can then be more fully explored and integrated into collections of similar themes, to produce a description of the experience under investigation. IPA accepts that it is impossible to directly access individuals' life worlds, and any investigation will incorporate both the researcher and participants' interpretation of the world [41, 45]. To further addresses the

issue of researcher interpretation, IPA requires the researcher to carry out reflexive practice [41, 44].

Each interview was transcribed, and the researcher engaged extensively with both the written and video data, reviewing each numerous times. During this initial engagement in-depth annotation of the transcription was created, including descriptive and interpretative commentaries, associations, comments on language use and descriptive labels. Following this was the creation of "themes", which are conceptual titles intended to capture ideas or concepts identified within the text. Each theme related to a specific aspect of phenomenological experience from the data of one participant, for example; seeing geometrical patterns, or a sense of anticipation. Themes from each individual participant were then grouped by commonality, such as all themes relating to mood. The resultant superordinate themes for each participant were then compared and combined with those from all other participants, and ordered in a matrix presented below. Included are quotations provided to enhance the narrative of the data presented. The majority of quotes are representative of the data, but a minority illustrate unique effects experiences by participants. The interpretative aspects of the analysis are presented in the Discussion section of this article.

REFLEXIVE PRACTICE

The principal researcher (ST) analysing the qualitative reports had a broad prior knowledge of the previous published research in psychedelic drugs and the effects of psilocybin, as well as previous experience in clinical Psychiatry. The researcher had no previous experience of receiving a psychedelic drug in an MRI scanner or other clinical environment, but had undergone a task based functional MRI scan to allow a degree of understanding of the scanner environment. The researcher did not meet any of the research participants, but had the opportunity to discuss the interviews the interviewer (RCH) throughout the process of analysis to provide further details relating to the clinical research and scans. The researcher was attentive throughout the analysis to allow the qualitative data to provide the results, rather than allowing prior ideas or preconceptions to drive the analysis process.

RESULTS

The Onset and Intensity of the Effects

All participants commented on the rapid onset of the drug effects.

> *"like [hitting] a brick wall, and then you're somewhere else"*

> *"I didn't feel anything go into my arm at all... then suddenly you disappear... you just take off"*

These intense effects lasted 10-15 minutes after which they gradually subsided. Effects were described as *'barely noticeable'* about 60 minutes after the injection. However, *all* of the participants reported that they still felt the effects to a minor degree during their interview. All participants were lucid, alert and oriented during the interviews, giving clear, articulate and coherent answers to all questions, with appropriate body language. The fact that participants were still mildly affected by the drug did not appear to have an adverse effect on the interviews.

Nine participants reported altered visual perception as the first noticeable effect. Four reported physical sensations, and one reported altered auditory perception.

There were variations in the reported intensity of the effects. Two of the 15 participants described disappointment at the low intensity of the effects, whilst six described the effects as *'very intense'* in the interview (See Table **1** for VAS rating of intensity):

> *"[That was] undoubtedly the most intense psychedelic experience I've ever experienced."*

The remaining seven described the experience as *'intense'* and occasionally *'overwhelming'*.

All of the participants reported that the effects came in intermittent '*waves'* i.e. periods of intense effects alternating with periods of comparative normality:

> *"[The effects came] in waves. It would build up into something, and then fade away - and then build up again..."*

All participants correctly identified receiving an infusion of psilocybin during the second scan. Six participants reported mild perceptual changes during the placebo scan that they considered at the time to be possibly due to psilocybin.

Perceptual Effects

Altered somatosensory, visual, auditory and proprioceptive sensations were all reported. Almost all of the participants (14) described perceptual changes as the *primary* effect of the drug, and one described a positive mood change as the main effect.

> *"For me it's all about a visceral experience... It's all very visual, very here and now, that's the experience you have at that point in time"*

The perceptual changes were described *as if* they occurred in the external world - even though the participants acknowledged that the effects occurred because of altered brain activity:

> *"It seemed like things were actually happening outside of me."*

All of the participants reported visual effects. Typically these were described as fractal or geometric patterns, the appearance of shapes, changes in colour and hue, and static objects becoming dynamic (*i.e*. starting to move):

> *"Shades of pinks and purples and oranges, swirling around"*

> *"[When looking] at something with a definite solid shape, as you start to hallucinate, that shape starts losing its substance and changing."*

> *"I saw rivers and patterns… I imagined that I could see my capillaries, projecting my skin onto the surface of the scanner, seeing all the corpuscles play to-and-fro"*
>
> *"Shapes coming in and going back and forth in the peripheries"*
>
> *"I saw an owl facing the other way, then it turned its head round to look at me. [The owl] formed part of the grid, like a sketch of an owl"*

Twelve participants described physical sensations during the psilocybin effects, including sensations of tingling, warmth, moving, rushing, and a sense of dissolving or *'melting'* into their surroundings:

> *"[It was] certainly quite difficult at times to know where I ended and where I melted into everything around me."*
>
> *"I felt as if I was going up and down, and as if I was moving around very slowly"*

Thirteen participants reported changes in their perception of time; both a sense of time speeding up and slowing down:

> *"Time [became] another meaningless concept… I could have been there a minute or a million years."*
>
> *"I don't know how long I was in [the scanner]"*
>
> *"It seemed timeless almost. You don't know how long you're in or out [the scanner]"*
>
> *"[The experience] went on for a really long time, but then also it didn't"*

Nine participants reported that their spatial perspective of their surroundings changed, both opening up (expanding) and moving in closer to them (constricting):

> *"I was in a chamber, inside a massive space, standing there… In a big empty room [that was] bright white."*
>
> *"[My surroundings] were moving and they were fluid"*

Seven participants reported distortions in the sounds of the scanner:

> *"[I] heard a funny high pitch sound... interlaid into the repeating sound of the scanner"*

Five participants reported that the scanner sounds were influencing their visual hallucinations, a phenomenon known as 'synaesthesia', or the mixing of sensory modalities:

> *"Every buzz of the scanner would vibrate the [visual] patterns."*
>
> *"During the main part of the scan there was that loud telephone ringing sound, [the*
>
> *sound] had quite an impact on all this visual stuff"*
>
> *"The sound and the shapes and the light all melded into one... There was a rhythm to the scanner that was dictating the rhythm of the movement of things"*

Cognitive Effects

Thirteen participants reported altered cognition. Nine participants described muddled thoughts, or difficulty focussing or thinking clearly:

> *"[It was] a little tricky at times to keep my line of thought on what I wanted to think about"*
>
> *"I was a little confused... [I] didn't quite know what was going on"*
>
> *"Everything [became] very fragmented; things were all in bits and it was very hard to hold it all together in a coherent stream."*

Eight participants described their thoughts as *'free roaming', 'wandering'* or having *'less restriction'*:

> *"There was a definite sense of lubrication, of freedom, of the cogs being loosened and firing off in all sorts of unexpected directions."*

Seven participants reported a diminished awareness of their surroundings, a sense of being transported to another place, or derealisation:

> *"My sense of where I was changed. [I was] no longer in [the scanner] but in some kind of Turkish restaurant... It felt like I was in a different place"*
>
> *"I kept thinking I was on the beach"*

Five participants describe difficulty focussing their thoughts on anything other than the drug effects.

> *"I didn't really cognitively think about [the experience], I didn't label what was happening. It was happening, [and] I was preoccupied with It happening"*

Three participants described not thinking during periods of the experience or being *'thoughtless'*.

> *"[My thinking] was non-existent, my thinking was absent"*
>
> *"I don't know what I was thinking about... [I] wasn't trying to think"*

Ten participants reported a change in their sense-of-self. Description of this varied from reduced attachment to one's body, altered aspects of personality or even complete dissolution of self or *'ego loss'*. Most participants who agreed with a change in their sense of self had difficulty in expressing this experience in words.

> *"There was a certain sense of fear... of not being attached to your body quite as fully as you were before"*
>
> *"Obviously my ego is far too strong, [it has] too strong a hold on me... [I] didn't manage to escape it"*
>
> *"[That was] real ego death stuff, [a] total dissolving of the ego-boundaries... I only existed as a concept... as an idea."*

Three participants described thoughts of themselves during the psilocybin experience.

> *"[I was] thinking about how you exist... as an isolated being, interacting with other people very transiently... [I have] difficulty accepting this transient nature and letting go of people... despite the fact we are part of the same process"*

Six participants described normally insignificant thoughts or aspects of the environment deserving full attention, or taking on a more profound meaning.

> *"Meaningless nonsense like crosses became deserving of full attention"*

> *"The [scanner] sound [became] the sound of monks chanting."*

Nine participants reported a degree of loss of control, which in some cases was described as difficulty directing their own thoughts, an inability to control the perceptual changes, or a sense of being *'overwhelmed'*. Most participants using the term *'overwhelmed'* had difficulty expressing what this meant, although it was often used in conjunction with the term *'intense'*

> *"[The drug] was more in control of my thoughts that I was… It felt like the drug was dictating things."*

> *"[I] let [the experience] take me where it wants to take me"*

> *"I think [the experience] was just overwhelmingly intense"*

Five participants described some psychological resistance to the drug effects. Prior to injection of the drug, the participants had been advised to relax and 'submit' to the experience; however, five claimed afterwards that it would have been futile to resist the drug effects:

> *"[There was] minor resistance. I'd been prepared to not resist [the effects]"*

> *"I was at its mercy… in the presence of something unstoppable."*

One participant described active control in directing the experience:

> *"You can direct what you see... You can play with the green cross, you can zoom around [the cross] and head off in different directions... You can make the sky appear and zoom off"*

Mood Effects

Seven participants agreed that they had felt *'a sense of joy'* during the experience. Others described *'laughter'* (6 participants) *'happiness'* (3 participants), *'contentment'* (3 participants), and *'euphoria'* (3 participants). Three participants reported no mood changes.

> *"I felt extremely euphoric and very pleased with life"*

All participants reported some sense of anxiety in *anticipation* of the drug effects but this resolved following the onset of the drug effects.

> *"[I was] lying there, expecting it to happen, a sort of readiness. A fight or flight thing."*

All participants described a reduction in anxiety once the drug effects began, with only two reporting continued anxiety following administration of the psilocybin.

> *"[It was] beyond normal anxiety and paranoia, much more existential questions, than if anything on this planet could possibly harm me"*

One participant explained that previous experience of psilocybin reduced the levels of anxiety she experienced. There was no difference between ratings of acute anxiety under psilocybin and placebo (38). Five participants commented that the scanner environment contributed to their anticipatory anxiety:

> *"It's an anxiety provoking experience, being in the scanner"*

Nine participants described prior concern that the drug effects would be too intense. Importantly, positive mood effects were far more common than negative:

> *"Once the drug kicked in, the anxiety changed, and a sense of awe overtook."*

Three participants described some minor paranoid or suspicious thoughts during the psilocybin experience.

> *"I did feel a bit suspicious, paranoid... probably because of being in the scanner"*

Effect of Memories

Three participants described recent memories influencing the contents of their experience, similar to the influence of recent thoughts and experiences on dream content:

> *"I've just been on holiday in Tunisia… [I] kept seeing Tunisian-Moroccan imagery in my mind."*

Eleven participants described no thoughts of their past during the experience.

> *"I didn't think about the past... [I was] rooted in the visceral experience and my surroundings"*

One participant reported a significant autobiographical recollection related to a distressing memory. He described experiencing the same emotions as he had felt at the time, as if he were 'reliving' the event.

> *"[It was as if] I was back there and it was deeply and profoundly stressful and horrible."*

This participant described finding it difficult to shift his mind away from this negative memory and on to happier thoughts, although he did achieve this. Overall he summarised his experience as positive.

Surroundings and Environment

The scanner featured in all of the participants' accounts. Eleven commented that the scanner environment had a negative effect on the psilocybin experience. The scanner was described as *'strange'* (seven participants), *'enclosed'* (four participants), *'machine'* (five participants), *'tube'* (3 participants), *'womb-like'* (2 participants). Other terms used to describe the scanner included *'box'*, *'confined'*, *'claustrophobic'*, *'cramped'*. One participant described particularly enjoying being in the scanner during his psilocybin experience, using terms such as *'warm'*, *'safe'* and *'nice'* to describe being in the scanner.

The scanner was described like *'sensory deprivation'* by eight participants and as *'isolating'* by four.

> *"There is a sensory deprivation aspect to it. There is just you and the noise."*
>
> *"[The scanner was] like a flotation tank, totally senseless"*
>
> *"Once I knew I was going to get out of [the scanner], I felt really happy... A sense of relief of coming out"*

Ten participants reported difficulty dealing with the scanner noise.

> *"[There was] an annoying phone ringing noise"*
>
> *"[The anxiety was] exacerbated by the noise and the surroundings"*

Six participants reflected on the placebo scan and reported perceptual changes in this scan. Three of these participants attributed these changes to the scanner environment:

> *"Just being in [the scanner] and focussing on this cross, things were looking pretty weird"*
>
> *"I thought something had happened [during the first scan]... Probably due to the scanner – a hypnotic thing to be in"*

Descriptions of the fixation cross appeared in all of the participants' accounts. For nine participants, it was the focus of their visual hallucinations, and for three the cross was the main focus of the entire experience.

> *"I was focussed on [the cross]... it seemed often to be the centre of [the experience]"*
>
> *"[Whilst] trying to focus on the little green cross, around the periphery that was distorting... and that kind of psychedelic visualisation going into the cross"*

Eleven participants described the research environment as sub-optimal for a psychedelic experience, with nine stating a preference for a more '*natural'* setting.

> *"Its kind of the opposite of what you should be doing when you're having a trip. [The best location] to be tripping is a forest or a beach... somewhere quite natural. This is a very clinical kind of surrounding"*

All participants described an awareness of being part of a research study during the experience with five describing thoughts of concerns about '*ruining*' the experiment, wanting to leave the scanner, or difficulty completing the rating scales. It should be noted however that no participants attempted to leave the scanner during their psilocybin experience and tolerated the research environment well. There was a consensus that the research environment was safe and well controlled.

Spiritual or Mystical Experiences

When asked about spiritual or mystical experiences, six reported difficulties differentiating between terms such as *'mystical'*, *'spiritual'* and *'magical'*. Three participants described their experience as mystical but not spiritual. Six participants described a sense of 'awe', and nine described spiritual aspects, with one participant describing the experience as something that would "*change the way you look at life*".

> *"I guess it was quite spiritual, a mother earth-type experience"*
>
> *"I do wonder about psilocybin, the Green Man, the god... is there something there?"*
>
> *"Hindu gods mixed up with paisley shawls... like one of those nineteen sixties record covers"*

Six described a sense of an external presence or external direction during the drug effects:

> *"[There was] a feeling of another presence maybe, something outside of myself. Maybe myself outside of myself"*
>
> *"At times [the experience] did have a feeling of agency. Like there's something, sort of, behind it"*

Six described their experience as something that *may* have held spiritual meaning for them *if* they had been inclined to interpret it in this way:

> *"If I was religious, then that would have been an intensely religious experience."*
>
> *"In terms of normal daily encounters with mystical things, [the experience] would definitely be a time when you would have a mystical experience"*
>
> *"It was all really in the mind... there wasn't really anything outside of the mind influencing it"*

Six participants reported the clinical and scanner setting decreased the chances of a spiritual experience. Three participants explained that their personal views on spirituality or mysticism reduced the likelihood of the experience being interpreted that way.

> *"My background is science and I'm a rationalist at heart. I embrace the spiritual dimension, but the idea of the mystical and the supernatural I find an anathema... so I guess I just reject it"*

Five participants reported that the fixation-cross took on a religious significance:

"It felt as if I was a civilisation and we were worshiping the cross. That was our central point. We existed to be there with it."

"The fact that it was a cross seemed a bit mystical. [There] were religious connotations to it, touching on a mystical world"

Participants' Interpretation of the Experience

Interpretations of the experience varied from participant to participant. Common words used to describe it were '*intense*' and '*weird*'. Nine participants reported that it was difficult to describe aspects of the experience, with one using the word '*ineffable*':

"[It's difficult] trying to find words to describe it... You really need to be a poet!"

"It's kind of weird to describe"

Eleven participants described the overall experience as pleasant and positive, and no one described it as overwhelmingly unpleasant or expressed any regret at having experienced it. Four participants described it as neither pleasant nor unpleasant, but rather as just *'intense'* or *'overwhelming'*:

"In some ways it wasn't either pleasant nor unpleasant, it was just overwhelming - so much of it!"

Eleven participants agreed with the term dreamlike as a description of the experience.

Four participants used the term *'roller-coaster'* to describe the experience, referring to a sense of excitement and thrill. One described how she had no option but to *'ride-out'* the experience:

"[It was] similar to going on a roller-coaster: [You] volunteer, queue and get on, [and] once you're on that's it, you're going. Bits of it are scary - but that's why you choose to do it"

Comparing the Experience

Eleven participants compared aspects of the psilocybin experience to previous experiences they have had. These included prior experiences with psilocybin and other drugs (*e.g.* ketamine, cannabis, and ecstasy) as well as hypnotism and meditation:

"I'll have the same sort of [experience] during cannabis... same sort of effect, but [psilocybin] is a lot more intense"

"[I had a] similar feeling following a long meditation session; [I had been] meditating a lot over a few days. For the next few weeks I felt a little like I do now… relaxed, slightly distanced from everything... more objective, not swept up in stress."

Two participants expressed that intravenously administered psilocybin was preferable to oral, due to the shorter effect duration, and reduced nausea as a side effects.

DISCUSSION

The study provided a unique opportunity to document the experiences of 15 research participants receiving intravenous psilocybin while in an fMRI scanner. Nine broad categories of phenomenology were identified in the phenomenological analysis of the experience; perceptual changes including visual, auditory and somatosensory distortions, cognitive changes, changes in mood, effects of memory, spiritual or mystical type experiences, aspects relating to the scanner and research environment, comparisons with other experiences, the intensity and onset of effects, and individual interpretation of the experience. Although there were variations in the description of certain phenomena and intensity of the effects, the majority of the reported phenomenological changes following administration of psilocybin were reproduced in all participants. These phenomena are consistent with previous literature on psilocybin [17, 18, 26], as well was literature relating to Altered States of Consciousness [19, 20, 46]. There were a number of phenomena that were reported by participants during periods of particularly intense drug effects. For example, sensations of melting or merging, timelessness, depersonalisation, derealisation and mystical-type phenomena were all associated with intense experiences.

Most participants had difficulty describing certain aspects of the psilocybin experience. This manifested itself by either a frank admission of difficulty finding the correct language, or by the use of certain terminology without explanation such as '*overwhelming*' or '*intense*'. Previous literature relating to Altered States of Consciousness has documented this "Sense of the Ineffable" [46, 47]. This may relate to the uniqueness of the experience compared to normal waking consciousness and therefore a lack of suitable vocabulary to describe certain effects. Many subjects made comparisons between the psilocybin, and other drug and non-drug induced altered states of consciousness. There is evidence that both psilocybin [38, 39] and meditation [48-50] have been found to have certain similarities in their alterations of brain function. Moreover, there is evidence that the normal competition between brain networks subserving inner-thought and external awareness is disturbed in deep meditation [51] and the psychedelic state [39]. If it is found that other states share important neurobiological features with the psychedelic state, then this may further our ability to understand both the drug state and these other states of consciousness.

There was variation in how participants described mystical or spiritual aspects of the experience. Certain phenomena that presented themselves in this study, such as sensing an external presence, are similar to those described in classical spiritual or mystical experiences [16]. Some participants explicitly stated that aspects of the experience would have spiritual meaning if they were inclined to interpret them this way, and others that the research environment decreased the likelihood of having a spiritual experience. Certain previous studies have shown very high levels of reported spiritual experience [16, 30]. The study by Griffiths and colleagues [16] recruited individuals with a specific interest in spirituality, and utilised the research environment to try and promote these types of experiences.

This suggests that certain phenomena, such as spiritual experience, are more open to personal interpretation.

A number of participants actively described how their belief systems and cultural background influenced how they interpreted certain aspects of their experience. In most cases this related to the discussion of spiritual or mystical interpretations of the experience. Psychedelic drugs have been known to Western culture since the 1960s, and a counterculture developed around their recreational use [5, 52, 53]. The social construction of psychedelic use and its portrayal in popular culture may influence, or *prime*, participants' responses their use of terminology. For instance, a participant mentioned "*nineteen sixties record covers*" in their description of the experience. Other examples of terminology occurring in this study that are used frequently within the community of psychedelic users are "*fractals*", "*ego loss*" and "*tripping*" [24]. Further indication of the potential societal effects on the experience or its interpretation, is in the descriptions of the fixation cross, displayed throughout the scans. A number of participants described the religious symbolism or meaning associated with the cross. This may be related to the long history of Christian religious influence in Western Europe and calls to question whether individuals recruited from non-Christian societies with different cultural religious symbolism would have described the same association.

Further possible instances of priming to consider are the Visual Analogue Scale (See Table **1**) and the clinical research environment. Participants completed the VAS scale four times in each scan, a total of six times prior to the psilocybin infusion. The VAS scale consists of items individuals might expect to experience following the administration of psilocybin, and hence prime participants to experience and report these effects. Participants would be aware that they are part of a research study investigating the effects of psilocybin. This may have influenced how they reported their experience, making them more inclined to report effects they believe to be typical of psilocybin, and downplay the negative effects such as anxiety or paranoia. This is a recognised effect in research called 'Demand Characteristics', by which participants interpret the experiment's purpose and unintentionally modify their behaviour to fit the interpretation [54]. Additionally, participants discussed their experience with a researcher whilst being recorded with a video camera, rather than in private with friends or family. As a result they may be inclined to avoid discussing aspects of the experience of a close personal nature.

The research and scanner environment featured in all participants' accounts. The majority consensus was that this environment is not ideal for experiencing the effects of psilocybin, possibly diminishing positive effects and spiritual or mystical qualities. Furthermore the scanner environment was associated with anxiety, as was the anticipation of awaiting the blinded infusion of psilocybin. This could explain the possibly paradoxical anxiolytic effect of psilocybin in this study. Overall the scanner environment was well tolerated by all participants.

All participants described experiencing some residual effects of psilocybin during the interview, albeit at a much-reduced intensity compared to the peak effects. There are possible beneficial and detrimental factors to carrying out the interview directly after the scan. The aim of the study was to collect the phenomenology of psilocybin within the scanner, and by carrying out the interview as soon as possible, there is more chance of capturing the *raw* experience, by reducing the time for the participants to rationalise or compartmentalise the experience, or simply forget certain aspects. Participants may not have had enough time to interpret the experience leading to difficulty generating the suitable vocabulary to describe the experience.

Our broad research question and unfocussed interview questions do not provide detailed data relating to any specific single aspect of the experience, but rather identify the major important categories of the experience and the phenomenological themes within. As discussed in the Methods section of this paper, proponents of Interpretative Phenomenology argue that it is impossible to access pure experience without some degree of interpretation. This is why Interpretative Phenomenological Methodology was used for this analysis. The descriptive Phenomenology is presented in the Results section, whilst an interpretative discussion can be found in the Discussion section.

The study size is relatively large for a phenomenological study. This reduces the level of individual richness of the data presented in the results. Nevertheless, the advantage of the study is that it identifies certain key effects that are reproducible between subjects, and also reports on a wider range of potential individual effects that may be of further interest.

The functional MRI results from this study showed reduction in cerebral blood flow in both cortical and subcortical and cortical regions [38]. One particular area showing a reduction in cerebral blood flow, the Posterior Cingulate Cortex, is closely associated with the Default Mode Network [55], and has been hypothesised to be involved in consciousness [56], constructs of self [57], and as a "connector hub" with functions integrating different brain regions [58, 59]. The integrative functions may be the reason that alteration of the function of these brain regions causes the profound and unusual effects on consciousness described in this report. These results are concordant with previous studies reporting the effects of psilocybin [17, 18]. This indicates IV psilocybin is comparable in subjective effects to oral psilocybin. Furthermore it may provide further validation for the fMRI data [38] as a representation of the functional brain changes caused by psilocybin, rather than the fMRI data being a result of the scanner environment.

The aim of this analysis was to identify key phenomena of intravenous Psilocybin within an MRI scanner. This study has identified a large area for future research, investigating correlations between changes in brain function and, as well as further exploration of the Psilocybin experience. Further Qualitative Phenomenological research may be more focussed, using smaller numbers of individuals, with more focussed interviews to explore experiences identified in both this study, and the broader published literature. This may allow a greater degree of interpretative abstraction to not only understand the experience more fully, but also the personal factors leading to individual variations in reports.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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