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Johannes Bronkhorst *

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Article

Religion and the Brain - on Consciousness and Attention

Johannes Bronkhorst

johannes.bronkhorst@unil.ch

Abstract: There can be degrees of attention. Greater depth of attention is often referred to as concentration or absorption. Great depth of attention may affect the way we experience the world, leading in extreme cases to religious experiences. In spite of its importance, little is known about the neural correlates (NCCs) of those states. This paper makes a proposal as to those correlates. It suggests that certain serotonin receptors (5-HT_{2A}) play a decisive role. These receptors, when activated, dampen stimuli that can be either external or internal, or both. Attention, the paper further proposes, consists primarily if not exclusively in the exclusion of stimuli. Such being the case, attention corresponds to the activation of 5-HT_{2A} receptors. This understanding provides an objective measure of depth of attention in the form of degree of activation of those receptors. This in its turn is hypothesized to contribute to an understanding of the link between religion and the brain.

Keywords: Religion; brain; consciousness; attention; absorption; serotonin receptors

Introduction

Numerous studies try to identify the neural correlates of religious experience.[1] The recognition that mental absorption plays a key role in religious experience is gaining ground these days.[2] A combination of these two quests inevitably raises the question what the neural correlates of (state) absorption are. This question has barely been touched so far. The present paper will address it, keeping in mind that the three terms *absorption*, *concentration* and *attention* fundamentally refer to the same phenomenon.

Attention and consciousness often go hand in hand. Indeed, certain attempts to explain consciousness scientifically (so-called Theories of Consciousness, ToCs) claim that the two are inseparable, or even identical. This is what a recent survey says about the relationship between the two:

"[Are] attention and consciousness … one and the same thing?[3] This was the thinking, at least implicitly, for a long while, until researchers found ways to elicit attention-like effects in the lab with stimuli that were not consciously perceived."[4] (Herzog et al. forthcoming: 39.)

And again:

[1] See, for example, Saver and Rabin 1997; Azari et al. 2001; McNamara 2009 (with Feierman 2011, Pilch 2013); Schjoedt 2011; Cristofori et al. 2016; Elk and Aleman 2017; Woollacott and Shumway-Cook 2020; Asp 2021; McNamara 2023.

[2] See, for example, Coleman et al. 2017/2019; Lifshitz, Elk and Luhrmann 2019; Glicksohn and Ben-Soussan 2020; removed for peer review.

[3] Reference to Prinz 2012.

[4] References to Kentridge, Heywood et al. 1999; Kentridge, Heywood et al. 2004; Jiang, Costello et al. 2006; Schurger, Cowey et al. 2008; Wyart and Tallon-Baudry 2008.

 doi:10.20944/preprints202504.2087.v1

"Is [consciousness without attention] possible and does it even make sense? Well, it remains highly controversial. There is some evidence that consciousness can manifest 'in the near absence of' voluntary attention …,[5] but this only applies to the antecedent (anticipatory) voluntary allocation of attention, not the involuntary capture of attention. … [C]ertain theories, such as the Attention Schema Theory (AST) explicitly link attention to consciousness. For other theories, such as IIT [Integrated information theory], attention (and other cognitive processes) are deemed irrelevant to consciousness." (Herzog et al. forthcoming: 40.)

Most of these studies do not consider depth of attention.[6] And yet, ordinary language has words for forms of attention that are commonly thought of as being more or less deep, including (mental) *concentration* and (mental) *absorption*. A person can be in more or less deep concentration; she can be totally absorbed or less so.

There are reasons to think that there is a link between absorption and certain experiences and behaviours, including most notably religious experiences and behaviours. What is more, extreme depth of absorption appears to give rise to extraordinary experiences, including deep religious and mystical experiences.[7]

To my knowledge, there is at present no objective way of measuring depth of absorption (the state, not the trait).[8] It can yet be maintained that it corresponds to some aspect of physical reality. This makes it tempting to look upon depth of absorption as a variable that can be measured with the help of other variables that *can* be measured.

What measurable variables allow us to infer depth of absorption? And how do we know that such variables correspond, in one way or another, to depth of absorption?[9]

We start from the perhaps most striking feature of mental absorption. As we have seen, particularly deep states give rise to experiences that are radically different from standard (i.e., ordinary) awareness. Many religious experiences (including "mystical" experiences) fall in this category, as may certain other experiences. Their radical difference does not mean that there must be a precise breaking point beyond which experience becomes altogether different. There appears to be a continuity that presumably corresponds to the depth of absorption attained. Variables that correspond to depth of absorption, too, must be expected to attain extreme values that profoundly affect awareness, while yet being continuous with respect to less extreme values.

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[5] Reference to Li, VanRullen et al. 2002. See now also Nani et al. 2019; Bowins 2022.

[6] Not even the "attention control" of AST (see Wilterson et al. 2020) covers depth of attention. Note further that graded attention is to be distinguished from graded consciousness (whatever that may be; cf. Doerig et al. 2020: 43).

[7] removed for peer review. The joy that frequently accompanies such experiences cannot be considered in this paper; cf. Brahinsky 2024.

[8] Cf. Ott 2007: 262: "standards for the definition and assessment of *states* of absorption have not been established thus far." See further Mohr 2018: 118–119; Ben-Soussan et al. 2019. Ralph W. Hood (1975) developed a measure of reported mystical experience, the Hood's M-scale (see further Streib et al. 2021), which, however, measures a personality *trait*, not the depth of a mystical *state*. The Tellegen Absorption Scale (Tellegen and Atkinson 1974; Jamieson 2005; Kuijpers et al. 2014), similarly, measures a trait, not a state. removed for peer review

[9] Elsewhere (removed for peer review) attention has been drawn to the correlation between pupil dilution and attention. For more on this, see Hess and Polt 1960, Mathôt et al. 2013, Alnæs et al. 2014, Liao et al. 2016, Reimer et al. 2016, Joshi and Gold 2020, Strauch et al. 2022; Grujic et al. 2024. Pupillometry was already studied around 1900; Strauch 2024.

 doi:10.20944/preprints202504.2087.v1

Proposed Neural Correlate and Consequence for the Nature of Attention

Keeping this in mind, we note that a recent article ("Serotonin receptor dampens visual input to enhance internal processes"; Jancke 2024, based on Barzan et al. 2024) argues that the relative weight of sensory input and internal interpretation has an effect on perception: too much of the latter leads to hallucinations. The Summary puts it as follows:

The 5-HT2A receptor in the brain reduces incoming visual information, allowing more space for internal thought processes. Researchers found that this receptor, when overactivated, suppresses sensory input, potentially explaining the effects of hallucinations from drugs like LSD.

To investigate the effects of this receptor in the brain, light-sensitive receptor proteins were introduced into nerve cells, which allowed the selected receptor type to be turned on and off like a light switch. "Drugs like LSD" were not used in this experiment but are mentioned as a possible alternative to bring about the same, or similar, effects. The link between LSD and 5-HT_{2A} receptors is, as a matter of fact, well established: "The primary target for LSD to produce its acute psychedelic effects in humans appears to be the serotonin 5-hydroxytryptamine-2A (5-HT_{2A}) receptor because the typical acute subjective effects of LSD can be nearly completely blocked by pretreatment with the 5-HT_{2A} receptor antagonist ketanserin." (Holze et al. 2021: 1-2, with references to Preller et al. 2017; Holze et al. 2021a; see also Zhang 2015; Elk and Yaden 2022).

What this study suggests, then, is that the balance between external stimuli and internal interpretations has an effect on our awareness: too much of the latter can give rise to hallucinations, while an equilibrium between the two is linked to "normal" awareness, what we call standard awareness.[10]

What happens if, alternatively, the internal interpretations rather than the external stimuli are dampened? Interestingly, recent experiments (see Deevoy 2024, based on Tipado et al. 2024) suggest that certain psychedelics can cause the wholesale disruption and alteration of the brain's predictive processing hierarchies, i.e., the aspect of the brain largely responsible for interpretation: "activity in the brain's default mode network … — which is broadly thought to help us assess past events, plan for the future and construct our sense of self-awareness and ego — is dampened by many psychedelics" (p. 3); "psychedelics … relax the grip of our high-level expectations of what reality should be like. Reducing top-down control in this way then frees up the flow of bottom-up sensory information so that it exerts more influence." (p. 4). As Tipado put it: "We're suddenly given access to an almost raw feed of our visual world."[11]

It appears, then, that we can distinguish between two possibilities: (1) perceptual input can be reduced, thus disturbing the balance between external stimuli and internal interpretations in favour of the latter; and (2) interpretation can be weakened in favour of "an almost raw feed of our visual world". Interestingly, both alternatives are associated with 5-HT_{2A} serotonin receptors (and with psychedelics, which have an effect on those receptors). Both alternatives appear to be the result of dampened stimuli.

This appears to mean that activators of 5-HT_{2A} receptors have two different effects, on external and internal stimulation respectively.[12] However, both these effects can be described as a dampening of mental stimuli, whether external or internal. One feature of mental absorption (and of attention in general) is the exclusion of certain stimuli, which may be external or internal, or both. Britannica defines it as follows: "**attention**, in psychology, [is] the concentration of awareness on some

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[10] The internal interpretations can be considered to contribute to the predictive processing of the mind; see Elk and Aleman 2017; Andersen 2019.

[11] Quoted in Deevoy 2024.

[12] Michiel van Elk rightly points out that the situation is no doubt more complicated than this, as it depends on the brain regions involved. I am not at present in a position to take such complications into consideration.

 doi:10.20944/preprints202504.2087.v1

phenomenon to the exclusion of other stimuli."[13] If we assume that the stimuli to be excluded by attention can be external as well as internal, both experiences can in principle result from it. What is more, nothing stands in the way of the simultaneous exclusion of *both* internal *and* external stimuli. In that case the above definition will have to be amended. The part "concentration of awareness on some phenomenon" then becomes optional, leaving place for the possibility of absorption without object. Objectless absorption is claimed to be the goal of certain forms of meditation (e.g., Forman 1990; Metzinger 2020: § 2.1; Katyal 2023; Chowdhury et al. 2023; Agrawal and Laukkonen 2024) and we now see that this should not surprise us.[14]

If these reflections are correct, the exclusion (dampening) of internal and/or external stimuli is not just one feature of mental absorption out of several. Rather, it is its most essential feature. Attempting to measure depth of absorption should then amount to measuring the extent to which stimuli (both internal and external) are dampened. And mental absorption might then be defined as a state in which some (or all) stimuli are reduced or even suppressed. And indeed, recent experiments provide strong evidence that people adapt to conflicting information by suppressing task-irrelevant information rather than enhancing task-relevant information (Gheza and Kool 2025).

An interesting consequence is that, strictly speaking, there is no such thing as paying attention to an object. A better (but still approximate) way of formulating this would be "*not* paying attention to what is *not* the object". The question if we can "pay attention to an object or aspect of an object that is not consciously perceived" (Tsuchiya and Koch 2016: 72) acquires in this way an altogether different meaning. Note also that being conscious of the relevant sensory stimuli is not the same as consciously perceiving an object. Discerning an object (or aspect of an object) requires more than the relevant external stimuli; its identification as an object requires interpretation, which is provided by internal stimuli. That is to say, both external and internal stimuli are involved in "paying attention to an object". And our reflections suggest that it is possible to pay attention to external stimuli without consciously perceiving the object that is "behind" those external stimuli.

An Analogy

As we saw above, ways have been found (in the form of light-sensitive receptor proteins) to turn selected receptors (including 5-HT$_{2A}$) "on and off like a light switch"; no psychedelics are required. Does this mean that measuring the activation of 5-HT$_{2A}$ receptors could be the variable we are looking for? Can we look upon the activation of these receptors as the neural correlate of concentration / absorption?

So far, these thoughts should be taken with caution. To begin with, the studies we have considered deal primarily with visual phenomena. Mental absorption, on the other hand, covers more than only visual perception. What is more, measuring the activation of 5-HT$_{2A}$ receptors is far from simple and may have to be refined before it can usefully be employed. With these provisos in mind, we continue to look upon the activation of 5-HT$_{2A}$ receptors as the variable that informs us about depth of absorption.

Let me sum up what has been said so far. Both external and internal stimuli can be dampened by a process in the brain. Research so far suggests that 5-HT$_{2A}$ receptors play a central role in this process, but nothing is lost if further research were to show that other elements play a role. Importantly, there are no indications that consciousness itself is dampened when the stimuli are dampened in this manner.

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[13] Britannica, s.v. attention; https://www.britannica.com/science/attention, accessed 31-10-2024.

[14] Tononi and Koch (2015: 9) draw attention to a counterintuitive prediction of their theory of consciousness (IIT = Integrated information theory), viz. "that a system such as the cerebral cortex may generate experience even if the majority of its pyramidal neurons are nearly silent, a state that is perhaps approximated through certain meditative practices that aim at reaching 'naked' awareness without content."

 doi:10.20944/preprints202504.2087.v1

This situation can be visualized (imperfectly, to be sure) with the help of a simple analogy. Both external and internal stimuli can affect consciousness by passing through imaginary "windows". These windows can be shut (and here 5-HT_{2A} receptors appear to play a role) with the result that part of those stimuli will be dampened. Only the stimuli that pass through the windows that are "open" will affect consciousness. They will indeed constitute the contents of consciousness. If the windows that are left open let external stimuli pass, the result is likely to be awareness of the external world. If only internal stimuli can pass, hallucinations may result. Most often there will be a mixture of internal and external stimuli which will be experienced as "ordinary" awareness. We also considered the possibility that the extent to which the "windows" are closed provides a measure of the depth of absorption.

There are complications. There are other ways of reducing external stimuli than only by closing the "windows". All these stimuli are suppressed to the extent possible in isolation tanks (or flotation tanks) and in so-called OVO Whole-Body Perceptual Deprivation chambers.[15] Since in such circumstances presumably only (or almost only) internal stimuli remain, we may reasonably expect that hallucinations can occur. This, it appears, is indeed what can happen.[16] However, are the states here brought about states of absorption? In terms of our window analogy, the windows to external stimuli can be either open or closed in such a situation, without making a difference: There is no need to dampen stimuli if there are no stimuli to begin with. Indeed, Fallon (2015: 167) writes the following about the isolation tank: "Some subjects could stand the isolation tank for only an hour or two. Unable to focus, they became bored or agitated. Others managed to remain calmly in the tank for many hours in a state of deep meditation and even began to experience waking dreams and hallucinations." This suggests that absorption may or may not take place in an isolation tank.

A recent investigation of meditators in an OVO Whole-Body Perceptual Deprivation chamber concludes that "OVO-WBPD immersion [led] to a state of absorption in all participants" (Ben-Soussan et al. 2019). This conclusion must be considered with caution. It is, to begin with, based on first-person reports. Recall that there is as yet no objective means of measuring depth of absorption; this we have seen. There is further reason for caution. The participants in this particular experiment were meditators, most of whom scored higher than average on the Tellegen Absorption Scale. Against the background of our window analogy, it is hardly surprising that these participants entered a state of absorption: the analogy suggests that the participants were trained in "closing the windows". The question what potential participants who could not or did not "close the windows" would experience in that situation remains unanswered.[17]

If we agree with Llinás and Paré (1991: 521) that "the main difference between wakefulness and paradoxical sleep lies in the weight given to sensory afferents in cognitive images", it is hardly surprising that dreaming and psychedelic states broadly overlap (Kraehenmann 2017, Kraehenmann et al. 2017).

Is it possible to find adults who can "leave all their windows open"? This may not be easy. Alison Gopnik's observations on how infants experience the world are therefore all the more interesting. She describes the external consciousness of young children as being like a lantern and contrasts this with that of adults, which she compares with a spotlight (Gopnik 2009: 124):[18]

It's plausible that babies are actually aware of much more, much more intensely, than we are. The attentional spotlight in adults seems more like an attentional lantern for babies. Instead of experiencing a single aspect of their world and shutting down everything else they seem to be vividly experiencing everything at once. ...

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[15] See, e.g., Lashgari 2023; Glicksohn and Ben-Soussan 2020.

[16] Daniel and Mason 2015; Pellegrino et al 2023.

[17] Compare this with the following: "Meditation seems to enhance psilocybin's positive effects while counteracting possible dysphoric responses." (Smigielski et al. 2019.)

[18] See also Bloom 2009; Ananthaswamy 2014; Gopnik 2018.

 doi:10.20944/preprints202504.2087.v1

In terms of our window metaphor, this might mean that the windows of babies are wide open (or perhaps these windows are not even in place as yet), unlike the windows of adults, many of which are closed at any moment. Does this imply that babies are in a state of absorption? The answer should now be clear. As long as babies have not yet learned to concentrate (i.e., as long as they have not yet learned to "close certain windows"), they are not in a state of absorption, far from it. Perhaps one can say that babies are alert rather than focused.

Consciousness and Attention

The window metaphor does not concern the question if a person is *conscious in general* (i.e., in a conscious state, as opposed to being unconscious). On the other hand, it has a lot to do with the question what a person is *conscious of*. It may help us understand why people who are fully awake (in a conscious state) do not become *conscious of* a gorilla walking through a basketball game. Remember that becoming conscious of a gorilla requires interpretation that is only provided with the help of internal stimuli. And yet, many studies of consciousness focus on mental contents that people may or may not become *conscious of* while being in a conscious state all along.[19] The window metaphor reminds us that we should keep the two carefully apart. It even suggests that the study of what we are *conscious of* is not really a study of consciousness at all but rather a study of attention.[20]

Herzog et al., in their recent book *Empirical Theories of Consciousness: The Grand Tour* (forthcoming: 33), state the following: "Proponents of the 'back of the brain hypothesis' often dismiss findings supporting the 'front of the brain hypothesis' by claiming that the frontal processes actually reflect attention, or neural activities linked to the report instead of reflecting the activities truly linked to consciousness." At first sight this agrees with our observation. However, the immediately following sentence calls for caution: "One piece of evidence is that, indeed, frontal NCCs [neural correlates of consciousness] tend to diminish when using no-report paradigms." The problem is that no-report paradigms (described in chapter 2.3.1) do not isolate *being in a conscious state* from *being conscious of* certain contents.

Before continuing, we must eliminate a misunderstanding that the window metaphor might give rise to, the idea namely that the consciousness that "hides" behind the windows is a passive and inactive observer of the stimuli that have passed through the windows. This is almost certainly incorrect. Consciousness no doubt has a role to play, even if it is difficult to determine what exactly that role is and how it plays that role. In other words, consciousness does not have to be passive and inactive in order to fit the window metaphor. But the window metaphor strongly suggests that consciousness must be distinguished from the stimuli that provide it with contents.

Without wishing to engage in a comparative evaluation of the theories of consciousness (ToCs) described in *Empirical Theories of Consciousness*, it seems at first sight as if at least one of them fits the window metaphor rather well. It is the 'Felt Uncertainty' Theory of Consciousness (FUT), presented in the seventh chapter of that book. The author of the relevant section, Mark Solms, presents the following conclusion:

The conclusion … is that brainstem activation of the cortex (which everybody agrees is prerequisite for perceptual and cognitive consciousness) is affective in nature. This means that *the fundamental source* of consciousness is not perceptual but rather affective. Brainstem arousal is not a contentless power source; it is a fount of feeling. Cortical information processing is *intrinsically* unconscious, and it remains so unless and until it is aroused (or rather, modulated, because cortical activity can be regulated both upward and downward) by the brainstem reticular activating system.

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[19] On the contrast between conscious states and the contents of consciousness, see also Doerig et al. 2020: 42.

[20] If we call not seeing the gorilla "inattentional blindness" we risk mixing up interpretation and attention. See also Herzog and Doerig 2021.

 doi:10.20944/preprints202504.2087.v1

One could say that the reticular activating system *feels its way into* cortical information processing — it palpates it, as it were — and thereby renders it conscious. (Herzog et al. forthcoming: 101)

Consciousness (whose source is affective) is here clearly separated from the external and internal stimuli that account for perception and cognition.

We may contrast this with another widely accepted spotlight theory of consciousness, the Global Neuronal Workspace Theory (GNWT). Its followers describe the difference between conscious and unconscious processing as follows:

while unconscious processing is highly efficient, it is also stereotypical, meaning that the same input always gives rise to … more or less the same computations and actions. In order to solve novel problems, more flexibility is required, and, for that, we need information to be shared broadly across the many different specialists across the brain, namely across many different brain areas. Interconnection between processors through a "global workspace" opens a wide variety of functional possibilities, and allows to produce more flexible and adaptive behaviour. (Claire Sergent and Daphné Rimsky-Robert in Herzog et al. forthcoming: 58)

The unavoidable question is: Is that which distinguishes conscious processing (broad sharing across different specialists, etc.) the cause of consciousness or rather its effect? GNWT tends to accept the former:

An important proposition that often comes along with the global workspace is the notion of threshold: once information reaches a certain threshold, the workspace fully activates to broadcast it, a process called "ignition"; below that threshold, the information simply does not enter the workspace. (id., p. 59)

In other words, consciousness is the indirect effect of information reaching a certain threshold. Herzog et al. (forthcoming: 138) rightly comment: "consciousness comes along for the ride"; "consciousness plays no role, it just 'happens' when broadcasting occurs". Clearly, GNWT takes us far away from the window metaphor.[21]

The Voluntary Nature of Attention

One important aspect of mental absorption (and of attention / concentration) has not yet been addressed. It may yet play a crucial role in experiments designed to test its features. Mental absorption (attention / concentration) can be a *voluntary* affair, determined by choice on the part of the subject tested.[22] People can (or can learn to) regulate depth of absorption. We had occasion to observe that a stay in an OVO Whole-Body Perceptual Deprivation chamber may be experienced differently by meditators than by others. The same applies to experiments with chemical substances (psychedelic or other) that have an effect on the "windows" discussed above. Voluntary effort can determine how many of those "windows", and which ones, will be closed under the influence of the chemicals concerned. This means that experiments that merely administer such substances and then ask subjects how they experience this are not good enough; this experience depends on what the subject "does" with them.[23] It also reduces the significance of such experiments on non-human animals.

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[21] Integrated Information Theory (IIT) does not fare much better. It "explicitly specifies the magnitude of consciousness with a single scalar number ϕ. More ϕ = more consciousness. In this case, consciousness is not a useful supra-ordinate term. We could eliminate consciousness, and just use ϕ without losing major scientific insights" (Herzog et al. 2024: 144).

[22] Cf. Yang et al. 2024.

[23] A recent publication on the effects of psilocybin on attention (Yousefi et al. 2025) does not take depth of attention into consideration and is therefore of no help in our quest.

 doi:10.20944/preprints202504.2087.v1

There is more. If the hypothesis proposed in this paper is correct, it seems likely that a voluntary decision by the subject can determine (also while under the influence of the relevant chemical substances) whether windows to external stimuli or windows to internal stimuli (or to both) will be closed. The resulting experiences will be very different. In practice, this means that people who are experienced in regulating their depth of absorption (such as certain experienced meditators) must be chosen as subjects in order to obtain promising results.

As important as these observations are, they evoke a new problem. Don't they introduce a homunculus, an imaginary mannikin that pulls the strings from behind a (also imaginary) curtain? What happens in the brain when a subject decides to enter a state of absorption that is more or less deep? What are the neural correlates of such decisions?

Answering these questions satisfactorily is well beyond the scope of this paper (and beyond the capacities of its author). It is however possible that consciousness plays a role here. Recall, for example, the role of consciousness in the 'Felt Uncertainty' Theory of Consciousness (FUT), briefly discussed above. In that theory, consciousness is separate from external and internal stimuli. It "hides behind the windows" and might therefore conceivably play the role of "mannikin behind the curtain". Consciousness, it may be recalled, is here a fount of feeling (not a mannikin, of course). And it is not a passive observer. It has a role to play. Does this role also include choosing depth of absorption?

Another question that does not fall within the scope of this paper is why we have consciousness at all. Nor can it be our task to decide whether all or any of the theories that are compatible with the window metaphor are for that reason correct. There are other demands that such theories will have to fulfil.[24] We can only hope that the reflections presented in this paper will make a modest contribution to this debate.

Concluding Remarks

Where does all this leave us? The hypothesis here presented supports the view that there is such a thing as depth of absorption (attention / concentration) and that varying degrees of depth *can* have profound effects on the way we experience the world, both raw perception and its interpretation. It also supports the view that depth of absorption can be objectively measured, at least in principle.

The different experiences that accompany various depths of absorption are not proof that there is a different, higher reality "out there", as religious thinkers may be tempted to conclude. And yet, probably the best and most widely applicable definition of religion in general is "belief in some kind of transcendental world (that may or may not coincide with our observable physical world) inhabited by spirit beings or forces (that may or may not take an interest in and influence the physical world in which we live)." (Dunbar 2022: xvii).[25] Our analysis shows that there is no need to postulate a transcendental world "out there". The experiences here studied, on the other hand, are real, even though they are not "out there", but "in our heads". What is more, it looks as if research is on its way to find out what processes in the brain give rise to them, and why.

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[24] See Herzog et al. forthcoming: chapter 10.

[25] Experience of a spiritual presence, according to Weisman and Luhrmann (2025), is facilitated, beside absorption, by *porosity*, "the idea that to some extent, in some ways, the boundary between mind and world is permeable".

 doi:10.20944/preprints202504.2087.v1

Referencess

1. Agrawal, Vismay and Laukkonen, Ruben Eero. 2024. Nothingness in meditation: Making sense of emptiness and cessation. To appear in: *The Varieties of Nothingness*. Chiron Publications. https://osf.io/preprints/psyarxiv/tygdf_v1.
2. Alnæs, Dag; Sneve, Markus Handal; Espeseth, Thomas; Endestad, Tor; van de Pavert, Steven Harry Pieter and Laeng, Bruno. 2014. Pupil size signals mental effort deployed during multiple object tracking and predicts brain activity in the dorsal attention network and the locus coeruleus. *Journal of Vision* 14(4): 1. https://doi.org/10.1167/14.4.1.
3. Ananthaswamy, Anil. 2014. Into the minds of babes: Studies of psychoactive stimulants and consciousness can shine a light on how we viewed the world as an infant. *New Scientist* 223(2983): 40-43. https://doi.org/10.1016/S0262-4079(14)61632-8.
4. Andersen, Marc Malmdorf. 2019. The Bayesian observer and supernatural agents. *Religion, Brain & Behavior* 9(1): 99-104. https://doi.org/10.1080/2153599X.2017.1387597
5. Asp, Erik W. 2021. Toward a neurobiological explanation of mystical experience. *Biological Psychiatry* 15(91): 330-331. https://doi.org/10.1016/j.biopsych.2021.11.011.
6. Azari, Nina P.; Nickel, Janpeter; Wunderlich, Gilbert; Niedeggen, Michael; Hefter, Harald; Tellmann, Lutz; Herzog, Hans; Stoerig, Petra; Birnbacher, Dieter and Seitz,, Rüdiger J. 2001. Neural correlates of religious experience. *European Journal of Neuroscience* 13: 1649-1652.
7. Barzan, Ruxandra; Bozkurt, Beyza; Nejad, Mohammadreza M.; Süß, Sandra T.; Surdin, Tatjana; Böke, Hanna; Spoida, Katharina; Azimi, Zohre; Grömmke, Michelle; Eickelbeck, Dennis; Mark, Melanie D.; Rohr, Lennard; Siveke, Ida; Cheng, Sen; Herlitze, Stefan and Jancke, Dirk. 2024. Gain control of sensory input across polysynaptic circuitries in mouse visual cortex by a single G protein-coupled receptor type (5-HT$_{2A}$). *Nature Communications* 15: 8078. https://doi.org/10.1038/s41467-024-51861-1
8. Ben-Soussan, Tal Dotan; Mauro, Federica; Lasaponara, Stefano; Glicksohn, Joseph; Marson, Fabio and Berkovich-Ohana, Aviva. 2019. Fully immersed: State absorption and electrophysiological effects of the OVO Whole-Body Perceptual Deprivation chamber. *Progress in Brain Research* 244: 165–184. https://doi.org/10.1016/bs.pbr.2018.10.023.
9. Bloom, Paul. 2009. What's inside a big baby head? *Slate*, August 9, 2009. https://slate.com/culture/2009/08/alison-gopnik-s-the-philosophical-baby.html.
10. Bowins, Brad. 2022. Sliding scale theory of attention and consciousness/unconsciousness. *Behavioral Sciences* 12(2): 43. https://doi.org/10.3390/bs12020043.
11. Brahinsky, Josh; Mago, Jonas; Miller, Mark; Catherine, Shaila and Lifshitz, Michael. 2024. The spiral of attention, arousal, and release: A comparative phenomenology of jhana meditation and speaking in tongues. *American Journal of Human Biology* 36(12): e24189. https://doi.org/10.1002/ajhb.24189.
12. removed for peer review.
13. removed for peer review.
14. Chowdhury, Avijit; Lutterveld, Remko van; Laukkonen, Ruben E.; Slagter, Heleen A.; Ingram, Daniel M. and Sacchet, Matthew D. 2023. Investigation of advanced mindfulness meditation 'cessation' experiences using EEG spectral analysis in an intensively sampled case study. *Neuropsychologia 190: 108694.* https://doi.org/10.1016/j.neuropsychologia.2023.108694.
15. Coleman, Thomas J.; Bartlett, James E.; Holcombe, Jenny M.; Atkinson, Andrew; Swanson, Sally B.; Silver, Christopher F. and Hood, Ralph W. 2017/2019. Absorption, mentalizing, and mysticism: Sensing the presence of the divine. *Journal for the Cognitive Science of Religion* 5(1). https://doi.org/10.1558/jcsr.37551.
16. Cristofori, Irene; Bulbulia, Joseph; Shaver, John H.; Wilson, Marc; Krueger, Frank and Grafman, Jordan. 2016. Neural correlates of mystical experience. *Neuropsychologia* 80: 212-220. http://dx.doi.org/10.1016/j.neuropsychologia.2015.11.021.
17. Daniel, Christina and Mason, Oliver J. 2015. Predicting psychotic-like experiences during sensory deprivation. *BioMed Research International*, Volume 2015, Issue 1/ 439379. https://doi.org/10.1155/2015/439379.

 doi:10.20944/preprints202504.2087.v1

18. Deevoy, Ruby. 2024. How psychedelics and VR could reveal how we become immersed in reality. *New Scientist*, 28 October 2024. https://www.newscientist.com/article/2453586-how-psychedelics-and-vr-could-reveal-how-we-become-immersed-in-reality/
19. Doerig, Adrien; Schurger, Aaron and Herzog, Michael H. 2020. Hard criteria for empirical theories of consciousness. *Cognitive Neuroscience* 12(2): 41-62. https://doi.org/10.1080/17588928.2020.1772214.
20. Dunbar, Robin. 2022. *How Religion Evolved, and Why it Endures*. London: Penguin Books UK.
21. Elk, Michiel van and Aleman, André. 2017. Brain mechanisms in religion and spirituality: An integrative predictive processing framework. *Neuroscience & Biobehavioral Reviews* 73: 359-378. https://doi.org/10.1016/j.neubiorev.2016.12.031.
22. Elk, Michiel van and Yaden, David Bryce. 2022. Pharmacological, neural, and psychological mechanisms underlying psychedelics: A critical review. *Neuroscience & Biobehavioral Reviews* 140: 104793. https://doi.org/10.1016/j.neubiorev.2022.104793.
23. Fallon, Michael. 2015. The other side of silence. *New England Review (1990-)* 36(4): 159-171. https://www.jstor.org/stable/24772692.
24. Feierman, Jay R. 2011. Review of McNamara 2009. *Journal for the Scientific Study of Religion* 50(1): 219-220.
25. Forman, Robert K. 1990. *The Problem of Pure Consciousness: Mysticism and philosophy*. Oxford: Oxford University Press.
26. Gheza, Davide and Kool, Wouter. 2025. Distractor-specific control adaptation in multidimensional environments" *Nature Human Behaviour*. https://doi.org/10.1038/s41562-024-02088-z.
27. Glicksohn, Joseph and Ben-Soussan, Tal Dotan. 2020. Immersion, absorption, and spiritual experience: Some preliminary findings. *Frontiers in Psychology* 11: 2118. https://doi.org/10.3389/fpsyg.2020.02118.
28. Gopnik, Alison. 2009. *The Philosophical Baby. What Children's Minds Tell Us about Truth, Love, and the Meaning of Life*. New York: Farrar, Straus and Giroux.
29. Gopnik, Alison. 2018. Why babies are more conscious than we are. https://www.youtube.com/watch?v=gtG7hn9Mr3g
30. Grujic, Nikola; Polania, Rafael and Burdakov, Denis. 2024. Neurobehavioral meaning of pupil size. *Neuron* 112(20): 3381-3395. https://doi.org/10.1016/j.neuron.2024.05.029.
31. Herzog, Michael H. and Doerig, Adrien. 2021. Why our best theories of perception and physics undermine realism. *PsyArXiv Preprints*. https://doi.org/10.31234/osf.io/r4sf9
32. Herzog, Michael; Schurger, Aaron and Doerig, Adrien. Forthcoming. *Empirical Theories of Consciousness: The Grand Tour*. Cambridge: Cambridge University Press.
33. Hess, Eckhard H. and Polt, James M. 1960. Pupil size as related to interest value of visual stimuli. *Science* 132(3423): 349–350. https://doi.org/10.1126/science.132.3423.349.
34. Holze, Friederike; Avedisian, Isidora; Varghese, Nimmy; Eckert, Anne and Liechti, Matthias E. 2021. Role of the 5-HT_{2A} receptor in acute effects of LSD on empathy and circulating oxytocin. *Frontiers of Pharmacology Section Neuropharmacology* 12, 711255, pp. 1-8. https://doi.org/10.3389/fphar.2021.711255.
35. Holze, Friederike; Vizeli, Patrick; Ley, Laura; Müller, Felix; Dolder, Patrick; Stocker, Melanie; Duthaler, Urs; Varghese, Nimmy; Eckert, Anne; Borgwardt, Stefan and Liechti, Matthias E. 2021a. Acute dose-dependent effects of lysergic acid diethylamide in a double-blind placebo-controlled study in healthy subjects. *Neuropsychopharmacology* 46(3): 537–544. https://doi.org/10.1038/s41386-020-00883-6.
36. Hood, Ralph W. 1975. The construction and preliminary validation of a measure of reported mystical experience. *Journal for the Scientific Study of Religion* 14: 29–41. (Reprint: Hood 2001: 20–31.)
37. Hood, Ralph W. 2001. *Dimensions of Mystical Experiences: Empirical Studies and Psychological Links*. Amsterdam & New York: Rodopi.
38. Jamieson, Graham A. 2005. The modified Tellegen absorption scale: A clearer window on the structure and meaning of absorption. *Australian Journal of Clinical and Experimental Hypnosis* 33(2): 119–139.
39. Jancke, Dirk. 2024. Serotonin receptor dampens visual input to enhance internal Processes. *Neuroscience News*, September 21, 2024. https://neurosciencenews.com/serotonin-receptor-visual-neuroscience-27650/
40. Jiang, Yi; Costello, Patricia; Fang, Fang; Huang, Miner and He, Sheng. 2006. A gender- and sexual orientation-dependent spatial attentional effect of invisible images. *Proceedings of the National Academy of Sciences (PNAS)* 103(45): 17048-17052. https://doi.org/10.1073/pnas.0605678103.

 doi:10.20944/preprints202504.2087.v1

41. Joshi, Siddhartha and Gold, Joshua I. 2020. Pupil size as a window on neural substrates of cognition. *Trends in Cognitive Sciences* 24(6): 466–480. https://doi.org/10.1016/j.tics.2020.03.005.
42. Katyal, Sucharit. 2023. Reducing and deducing the structures of consciousness through meditation. *Frontiers in Psychology* 13: 190-205. https://doi.org/10.3389/fpsyg.2022.884512
43. Kentridge, R. W.; Heywood, C. A. and Weiskrantz, L. 1999. Attention without awareness in blindsight. *Proceedings of the Royal Society B: Biological Sciences* 266(1430): 1805-1811. https://doi.org/10.1098/rspb.1999.0850.
44. Kentridge, R. W.; Heywood, C. A. and Weiskrantz, L. 2004. Spatial attention speeds discrimination without awareness in blindsight. *Neuropsychologia* 42(6): 831-835. https://doi.org/10.1016/j.neuropsychologia.2003.11.001.
45. Kraehenmann, Rainer. 2017. Dreams and psychedelics: neurophenomenological comparison and therapeutic implications. *Current Neuropharmacology* 15: 1032–1042. https://doi.org/10.2174/1573413713666170619092629.
46. Kraehenmann, Rainer; Pokorny, Dan; Vollenweider, Leonie; Preller, Katrin H.; Pokorny, Thomas; Seifritz, Erich and Vollenweider, Franz X. 2017. Dreamlike effects of LSD on waking imagery in humans depend on serotonin 2A receptor activation. *Psychopharmacology* 234(13): 2031–2046. https://doi.org/10.1007/s00213-017-4610-0.
47. Kuijpers, Moniek M.; Hakemulder, Frank ; Tan, Ed S. and Doicaru, Miruna M. 2014. Exploring absorbing reading experiences: Developing and validating a self-report scale to measure story world absorption. *Scientific Study of Literature* 4(1): 89–122. https://doi.org/10.1075/ssol.4.1.05kui.
48. Lashgari, Elnaz; Chen, Emma; Jackson, Gregory and Maoz, Uri. 2023. A systematic review of flotation-restricted environmental stimulation therapy (RESR). medRxiv 2023.11.29.23299203. https://doi.org/10.1101/2023.11.29.23299203.
49. Li, Fei Fei; VanRullen, Rufin; Koch, Christof and Perona, Pietro. 2002. Rapid natural scene categorization in the near absence of attention. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* **99**(14): 9596-9601. https://doi.org/10.1073/pnas.092277599.
50. Liao, Hsin-I; Yoneya, Makoto; Kidani, Shunsuke; Kashino, Makio and Furukawa, Shigeto. 2016. Human pupillary dilation response to deviant auditory stimuli: effects of stimulus properties and voluntary attention. *Frontiers in Neuroscience* 10: 43. https://doi.org/10.3389/fnins.2016.00043.
51. Lifshitz, Michael; Elk, Michiel van and Luhrmann, T. M. 2019. Absorption and spiritual experience: A review of evidence and potential mechanisms. *Consciousness and Cognition* 73: 102760. https://doi.org/10.1016/j.concog.2019.05.008.
52. Llinas, R. R. and Paré, D. 1991. Of dreaming and wakefulness. *Neuroscience* 44(3): 521-535.
53. Luhrmann, T. M. 2020. *How God Becomes Real: Kindling the presence of invisible others*. Princeton: Princeton University Press.
54. Mathôt, Sebastiaan; van der Linden, Lotje; Grainger, Jonathan and Vitu, Françoise. 2013. The pupillary light response reveals the focus of covert visual attention. *PLoS ONE* 8(10): e78168. https://doi.org/10.1371/journal.pone.0078168.
55. McNamara, Patrick. 2009. *The Neuroscience of Religious Experience*. Cambridge: Cambridge University Press.
56. McNamara, Patrick. 2023. Religion and the brain: Jordan Grafman's contributions to religion and brain research and the special case of religious language. *Cortex* 169: 374-379. https://doi.org/10.1016/j.cortex.2023.10.015.
57. Metzinger, Thomas. 2020. Minimal phenomenal experience: Meditation, tonic alertness, and the phenomenology of 'pure' consciousness. *Philosophy and the Mind Sciences* 1(I): 1-44. https://doi.org/10.33735/phimisci.2020.I.46.
58. Mohr, Christine. 2018. Are there varying depths in flow? *Journal of Consciousness Studies* 25(11–12): 115–130.
59. Nani, Andrea; Manuello, Jordi; Mancuso, Lorenzo; Liloia, Donato; Costa, Tommaso and Cauda, Franco. 2019. The neural correlates of consciousness and attention: Two sister processes of the brain. *Frontiers in Neuroscience* 13: 1169. https://doi.org/10.3389/fnins.2019.01169.

 doi:10.20944/preprints202504.2087.v1

60. Ott, Ulrich. 2007. States of absorption: In search of neurobiological foundations. In *Hypnosis and Conscious States: The Cognitive Neuroscience Perspective*. Ed. Graham A. Jamieson. Oxford: Oxford University Press. Pp. 257–270.
61. Pellegrino, Michele; Glicksohn, Joseph; Marson, Fabio; Ferraiuolo, Francesco and Ben-Soussan, Tal Dotan. 2023. The cloud of unknowing: Cognitive dedifferentiation in whole-body perceptual deprivation. *Progress in Brain Research* 277: 109-140. https://doi.org/10.1016/bs.pbr.2022.12.004.
62. Pilch, John J. 2013. Review of McNamara 2009. *Journal of the American Academy of Religion* 81(1): 295-298. https://doi.org/10.1093/jaarel/lfs131.
63. Preller, Katrin H.; Herdener, Marcus; Pokorny, Thomas; Planzer, Amanda; Kraehenmann, Rainer; Stämpfli, Philipp; Liechti, Matthias E.; Seifritz, Erich and Vollenweider, Franz X. 2017. The fabric of meaning and subjective effects in LSD-induced states depend on serotonin 2A receptor activation. *Current Biology* 27(3): 451–457. https://doi.org/10.1016/j.cub.2016.12.030.
64. Prinz, Jesse J. 2012. *The Conscious Brain: How Attention Engenders Experience*. New York: Oxford University Press.
65. Reimer, Jacob; McGinley, Matthew J.; Liu, Yang; Rodenkirch, Charles; Wang, Qi; McCormick, David A. and Tolias, Andreas. 2016. Pupil fluctuations track rapid changes in adrenergic and cholinergic activity in cortex. *Nature Communications* 7: 13289. https://doi.org/10.1038/ncomms13289.
66. Saver, Jeffry L. and Rabin, John. 1997. The neural substrates of religious experience. *Journal of Neuropsychiatry and Clinical Neurosciences* 9: 498-510.
67. Schjoedt, Uffe. 2011. The neural correlates of religious experience. *Religion* 41(1): 91-95. https://doi.org/10.1080/0048721X.2011.553132.
68. Schurger, Aaron; Cowey, Alan; Cohen, Jonathan D.; Treisman, Anne and Tallon-Baudry, Catherine. 2008. Distinct and independent correlates of attention and awareness in a hemianopic patient. *Neuropsychologia* 46(8): 2189-2197. https://doi.org/10.1016/j.neuropsychologia.2008.02.020.
69. Shimegi, Sotoshi; Kimura, Akihiro; Sato, Akinori; Aoyama, Chisa; Mizuyama, Ryo; Tsunoda, Keisuke; Ueda, Fuyuki; Araki, Sera; Goya, Ryoma and Sato, Hiromichi. 2016. Cholinergic and serotonergic modulation of visual information processing in monkey V1. *Journal of Physiology-Paris* 110(1-2): 44-51. https://doi.org/10.1016/j.jphysparis.2016.09.001.
70. Smigielski, Lukasz; Kometer, Michael; Scheidegger, Milan; Krähenmann, Rainer; Huber, Theo and Vollenweider, Franz S. 2019. Characterization and prediction of acute and sustained response to psychedelic psilocybin in a mindfulness group retreat. *Scientific Reports* 9(1):14914. https://doi.org/10.1038/s41598-019-50612-3.
71. Strauch, Christoph. 2024. The forgotten wave of early pupillometry research. *Trends in Neurosciences* 47(8): 571-572. https://doi.org/10.1016/j.tins.2024.06.002.
72. Strauch, Christoph; Wang, Chin-An; Einhäuser, Wolfgang; Van der Stigchel, Stefan and Naber, Marnix. 2022. Pupillometry as an integrated readout of distinct attentional networks. *Trends in Neurosciences* 45(8): 635-647. https://doi.org/10.1016/j.tins.2022.05.003.
73. Streib, Heinz; Klein, Constantin; Keller, Barbara and Hood, Ralph W. 2021. The mysticism scale as measure for subjective spirituality: New results with Hood's M-scale and the development of a short form. In *Assessing Spirituality in a Diverse World*. Ed. Amy L. Ai, Paul Wink, Raymond F. Paloutzian and Kevin A. Harris. New York: Springer. Pp. 467–491. https://doi.org/10.1007/978-3-030-52140-0_19.
74. Tellegen, Auke and Atkinson, Gilbert. 1974. Openness to absorbing and self-altering experiences ('absorption'), a trait related to hypnotic susceptibility. *Journal of Abnormal Psychology* 83(3): 268–277.
75. Tipado, Zeus; Kuypers, Kim P. C.; Sorger, Bettina; Ramaekers, Johannes G. 2024. Visual hallucinations originating in the retinofugal pathway under clinical and psychedelic conditions. *European Neuropsychopharmacology* 85: 10-20. https://doi.org/10.1016/j.euroneuro.2024.04.011.
76. Tononi, Giulio and Koch, Christof. 2015. Consciousness: here, there and everywhere? *Philosophical Transactions of the Royal Society B* 370: 20140167. https://doi.org/10.1098/rstb.2014.0167.
77. Tsuchiya, Naotsugu and Koch, Christof. 2016. The relationship between consciousness and top-down attention. *The Neurology of Consciousness*. Second edition. Ed. S. Laureys, O. Gosseries and G. Tononi. Pp. 71-91. http://dx.doi.org/10.1016/B978-0-12-800948-2.00005-4.

 doi:10.20944/preprints202504.2087.v1

78. Weisman, Kara and Luhrmann, Tanya Marie. 2025. Shifting between models of mind: New insights into how human minds give rise to experiences of spiritual presence and alternative realities. *Topics in Cognitive Science* (2025): 1-36. https://doi.org/10.1111/tops.70002.
79. Wilterson, Andrew I.; Kemper, Casey M.; Kim, Noah; Webb, Taylor W.; Reblando, Alexandra M. W. and Graziano, Michael S. A. 2020. Attention control and the attention schema theory of consciousness. *Progress in Neurobiology* 195: 101844. https://doi.org/10.1016/j.pneurobio.2020.101844.
80. Woollacott, Marjorie and Shumway-Cook, Anne. 2020. The mystical experience and its neural correlates. *Journal of Near-Death Studies* 38(1). https://doi.org/10.17514/JNDS-2020-38-1-p3-25.
81. Wyart, Valentin and Tallon-Baudry, Catherine. 2008. Neural dissociation between visual awareness and spatial attention. *Journal of Neuroscience* 28(10): 2667-2679. https://doi.org/10.1523/JNEUROSCI.4748-07.2008.
82. Yang, Winson F. Z.; Sparby, Terje; Wright, Malcolm; Kim, Eunmi and Sacchet, Matthew D. 2024. Volitional mental absorption in meditation: Toward a scientific understanding of advanced concentrative absorption meditation and the case of jhana. *Heliyon* 10(10): e31223. https://doi.org/10.1016/j.heliyon.2024.e31223.
83. Yousefi, P.; Lietz, Morten P.; O'Higgins, F. J.; Rippe, R. C. A.; Hasler, G.; van Elk, M. and -Geppert, S. Enriquez. 2025. Acute effects of psilocybin on attention and executive functioning in healthy volunteers: a systematic review and multilevel meta-analysis. *Psychopharmacology*. https://doi.org/10.1007/s00213-024-06742-2.
84. Zhang, Gongliang and Stackman, Robert W. 2015. The role of serotonin 5-HT_{2A} receptors in memory and cognition. *Frontiers in Pharmacology* 6: 225. https://doi.org/10.3389/fphar.2015.00225.