UNIVERSITY OF LIÈGE

FACULTY OF MEDICINE

Altered States of Consciousness and Their Neurophysiological Correlates: Toward Phenomenological Engineering and ASC-Psychotherapeutics

Larry D. FORT

Physiology of Cognition, GIGA-CRC Human Imaging
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Supervisor

Dr. Athena DEMERTZI

A thesis submitted in partial fulfilment of the requirements for the degree of Doctorate of Philosophy in Biomedical Sciences and Pharmacology
Academic year 2025-2026

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"There is another world, but it is in this one."
– Paul Éluard

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Note: Large language models (LLMs) were used in a limited capacity for editing (e.g., grammar and sentence clarity). All scientific content and interpretations in the thesis are the original work of the author with contributions from collaborators as indicated (Appendix C). Chapters 1 and 3 use verbatim text/figures from their published papers. Any citation should concern the published work where relevant.

Summary

Altered states of consciousness (ASCs) are typically defined as transient, reversible deviations from ordinary waking experience that are subjectively recognizable from the first-person perspective (Ludwig, 1966). As scientific efforts increasingly seek to operationalize and measure ASCs, this thesis characterizes their phenomenological structure and investigates their neurophysiological correlates with the goal of enabling the targeted modulation of their subjective features in clinical psychotherapy.

Chapter 1 synthesizes historical and contemporary classification schemes, particularly around ASC phenomenology, and proposes eight core features of altered subjective experience. This work establishes a principled foundation for structuring ASCs within a multidimensional phenomenological space.

Chapter 2 formalizes the core features proposed in Chapter 1 within an ASC phenomenon space model, in which they constitute an invariant inner structure that constrains and organizes a resulting state-space where inductions, both pharmacological and otherwise, can be mapped in a shared multidimensional system. This work provides a foundation for clinical translation by allowing induction methods to be directly compared and selected based on their phenomenological profiles.

Chapter 3 examines the neurophenomenology of psilocybin using a previously collected multimodal dataset. Psilocybin is shown to induce a recurrent hyperconnected brain state, which is selectively associated with the 5D-ASC dimension of Oceanic Boundlessness and experiential unity. This work evidences a selective association between large-scale brain dynamics and experiential dimensions, providing a neurophysiological context for phenomenological patterns.

Chapter 4 investigates a non-pharmacological induction method, the multi-modal Ganzfeld (MMGF), which combines sensory homogenization across visual and auditory modalities. The data indicate that red-light MMGF selectively enhances complex visual pseudo-hallucinations, whereas green-light MMGF preferentially alters perceptual meaning. These phenomenological differences are accompanied by dissociable physiological and cortical signatures, indicating that subtle sensory parameters can reliably bias the structure of ASC experience. This work demonstrates the capacity to systematically bias phenomenological profiles through tuning induction method parameters.

Chapter 5 directly compares the phenomenology of moderate-dose psilocybin and red-light MMGF using the 5D-ASC. Despite broader differences in experiential intensity, both induction methods yield equivalent levels of complex imagery, demonstrating a specific phenomenological convergence across pharmacological and non-pharmacological ASCs within a shared measurement framework with potential experimental and clinical relevance.

Finally, **Chapter 6** synthesizes the preceding conceptual and empirical findings into a phenomenological engineering framework for ASC-based psychotherapeutics. This framework is grounded in the identification of an invariant structure of altered subjective experience, which enables induction methods to be systematically mapped onto structured phenomenological profiles and their associated neurophysiological correlates. By clarifying which dimensions of altered experience are most relevant for therapeutic outcomes, phenomenological engineering provides a principled basis for the deliberate design, tuning, and combination of ASC induction methods.

Taken together, the thesis argues that rigorous characterization of ASC phenomenology is a prerequisite for the principled modulation of altered experience particularly in clinical contexts.

Contents

I

Altered States of Consciousness: Classification and Features

This chapter is replicated from the following publication except where otherwise indicated (*):

Fort, L., D., Costines, C., Wittmann, M., Demertzi, A.††, & Schmidt, T., T. †† (2025). Classification Schemes of Altered States of Consciousness. *Neuroscience and Biobehavioral Reviews*. DOI: https://doi.org/10.1016/j.neubiorev.2025.106178.

Content from the following informed some modifications to the chapter:

Schmidt, T., T. & **Fort, L. D.** (in press). Clarifying classification approaches to altered states of consciousness. *Psychology of Consciousness: Theory, Research, and Practice*.

†† refers to co-last authorship

See Appendix C for author roles

1.1 Introduction to Altered States of Consciousness

Altered states of consciousness (ASCs) have been observed throughout human history, with evidence dating back to the Paleolithic era, such as carvings of hunters in trace-like states and Neanderthal shrines to animal gods (Campbell, 1984; Grof, 2019). Long before modern science began its investigation, numerous cultures explored altered states of consciousness through varying schools of thought, such as Buddhism, influencing the vocabulary and conceptualization of early ASC classifications developed by prominent researchers in the sixties and seventies (Beischel et al., 2011; Fischer, 1992; Grof, 2019; Leary et al., 1992; Lilly, 1972/2017; Metzner, 1971; Shear, 2011; Ustinova, 2017). These early ASC classifications can then be viewed as transitions from spiritual and conceptual approaches into empirical approaches that form the foundation of modern research. ASCs are generally defined as transient and reversible changes in subjective experience from an average normal, waking state that are noticeable from a first-person perspective (Beischel et al., 2011; Farthing, 1992; Ludwig, 1966; Tart, 1975/1983).

The investigation of ASCs in modern psychology and neuroscience has been important for two reasons. First, ASCs were historically used to understand psychiatric conditions, as early pharmacology sometimes considered them models of psychosis[1] (Corlett et al., 2011; Fischer, 1957; Grof, 2019; Vollenweider et al., 1997; Vollenweider & Geyer, 2001). This research followed the idea that understanding the neuronal mechanism of experimentally induced ASCs may help to reveal the mechanisms underlying psychiatric

[1] Also referred to as "experimental psychoses," due to their transient nature (Grof, 2019).

conditions. Today, pharmacological and non-pharmacological induction methods of ASC phenomena, like hallucinations or out-of-body experiences, are used to reveal their neural correlates (Amaya et al., 2023b; Avram et al., 2021; Schmidt et al., 2020; Stephan et al., 2009; Vollenweider & Preller, 2020).
Second, ASCs have been investigated for their potential clinical merit (Grof, 2019; Wolff et al., 2020; Yaden & Griffiths, 2021).

Clinical research on psychedelic assisted psychotherapy, the combination of pharmacological inductions of ASCs with psychotherapeutic frameworks, shows clinical potential across different pathologies (Garcia-Romeu et al., 2015; Griffiths et al., 2008; Griffiths et al., 2006, 2011, 2016; Grob et al., 2011; Majić et al., 2015). While the exact mechanisms of these outcomes are still under investigation, it remains controversial if certain aspects of the experience, such as self-boundary dissolutions, acceptance, or mystical experiences might specifically support the clinical outcome (Aqil & Roseman, 2023; Letheby, 2021; Mortaheb & Fort et al., 2024; Rotz et al., 2023; Wolff et al., 2020), where specifically the intensity of positively experienced ASC features are current candidates for predicting therapeutic benefits (Holze, Gasser, et al., 2023; Holze et al., 2024; Roseman et al., 2017; Ross et al., 2016). To determine such contributions of specific ASC experiences, improvement in the nuanced conceptualization and measurement of ASC phenomenology are needed.
Here, we do not aim to compare different mechanistic models of brain function or offer competing mechanistic explanations of neurophysiological mechanisms. We focus on the most popular and reasonably advanced classification schemes, many which are noticeably influenced by their respective *Zeitgeist*. We begin by summarizing a typical definition of ASCs, followed by brief overviews of three types of classification schemes presented in historical order. To identify areas of conceptual agreement across authors, we then offer a synthesis of overlapping phenomenological

features, organized into clusters, derived from the reviewed classification schemes. While some reviews have provided brief historical overviews of certain ASC classification schemes, we expand on this work by offering a comprehensive summary of various schemes and their interrelationship while analyzing their commonalities (Beischel et al., 2011; Cofré et al., 2020; Passie, 2007; Yaden et al., 2024).

The systematic organization of ASCs is more accurately described as a classification system than a taxonomy. Taxonomies typically assume mutually exclusive and distinct classes, which is not intuitive for psychological phenomena that are expressed along continua and can co-occur to varying degrees (Bailey, 1994; Clifton et al., In press; Marradi, 1990). Although taxonomy does not require hierarchy, it is often associated with structured categorical arrangements. In contrast, classification systems provide a broader means of grouping based on selected criteria, which need not follow strict exclusivity. This distinction is well-established in psychiatric nosology (e.g., DSM, ICD), where disorders are classified by clusters of variably expressed symptoms rather than mutually exclusive diagnostic categories.

Over time, there have been different attempts in defining ASCs, often with accompanied changes in terminology. The question of how to define ASCs is central to their classification, as definitions and classification schemes are often conceptually intertwined. In this section, we summarize common defining criteria to delineate the scope of states addressed in later sections. Besides the term altered states (Ludwig, 1966; Tart, 1975/1983), other related concepts and terms are in use such as modified states (Freitas et al., 2016; Tassi & Muzet, 2001), global states (Bayne & Howy, 2016), alternate states (Evans, 1989), non-ordinary states (Oswald et al., 2023; Timmermann et al., 2023a), or patterns of phenomenological properties (Rock & Krippner, 2007; Rock & Krippner, 2011).

Additionally, other terms have been used to specify ASCs that produce specific phenomenology or are brought about by certain inductions such as holotropic states (Grof, 2008), hallucinogen-induced altered states of consciousness (Sayin, 2012), experimental psychoses (Grof, 2019), exalted states (Fischer, 1971), or exceptional states (Revonsuo, 2009). The term "altered states of consciousness," was popularized by Arnold Ludwig in Altered States of Consciousness, describing them as an "uncharted realm of mental activity," (Beischel et al., 2011; Ludwig, 1966, p. 225). From there, Ludwig defines ASCs as:

"[…] any mental state(s), induced by various physiological, psychological, or pharmacological maneuvers, or agents, which can be recognized subjectively by the individual […] as representing a sufficient deviation in subjective experience […] from waking consciousness," (Ludwig, 1966, p. 225).

A few years later, other researchers expanded on Ludwig's core definitions to further specify what constitutes an ASC (Beischel et al., 2011). Stanley Krippner, for example, adds that the sufficient deviation mentioned by Ludwig is represented by a

"[…] difference in psychological functioning from the individual's normal, alert state," (Beischel et al., 2011, p. 116).

Charles Tart further expanded this definition, adding that ASCs are represented by a qualitative and quantitative shift from "normal" wakefulness (Tart, 1975/1983). Importantly, Tart's work formalized the importance of a normal, wakeful state in what he would refer to as the baseline state of consciousness (b-SoC). In his conceptualization, any state of consciousness can be defined as

"[…] a unique, dynamic pattern or configuration of psychological structures," (Tart, 1975/1983, p. 5).

An ASC, therefore, is defined as a sufficient change (i.e. recognizable by the subjective observer) in unique pattern configuration from the b-SoC (Tart, 1975/1983).

Later in the book *The Psychology of Consciousness* Farthing, in an attempt to compile ASC research, defines an ASC as: “[…] a temporary change in the overall pattern of subjective experience, such that the individual believes that his or her mental functioning is distinctly different from certain general norms for his or her normal waking state of consciousness,” (Farthing, 1992, p. 205).

Throughout the years it has generally been agreed upon that ASCs must be a noticeable deviation from “normal” waking experience that it is “altered” concerning the normal, waking state from which it deviates, meaning an ASC must be compared against a reference state (Beischel et al., 2011; Farthing, 1992; Tart, 1975/1983). For an ASC to exist relative to its reference state, the changes must be identifiable by the person or an external observer; though recognition of this change may occur retrospectively (Farthing, 1992; Tart, 1975/1983). For the individual, this can result in the perception that reality has shifted, and only upon returning to the regular waking state do they recognize that it was their mental state, not reality, that changed. This supports the necessity of using third-person questionnaires for retrospective phenomenological assessment in ASC research (Farthing, 1992; Pekala, 2013). Additionally, ASCs seem to have a set time course and therefore last only minutes, hours, or sometimes days (Dittrich, 1998; Farthing, 1991; Majić et al., 2015; Nichols, 2016; Tart, 1975/1983). Transiency in ASCs implies their reversibility, both of which are reflected in various ASC definitional criteria and refer to the same concept of non-endurance (Cofré et al., 2020).

While many researchers agree that transiency is a definitional component of ASCs, some suggest that some states involving chronic conditions should also be considered ASCs. For example, there is ongoing discussion around whether sleep, disorders of consciousness (DOCs)[2], and/or psychiatric conditions should be included in the conceptualization of ASCs (Bayne & Howy, 2016; Giacino et al., 2014; Ludwig, 1966; Metzner, 2005a; Tart, 1975/1983; Vaitl et al., 2005). Some authors, such as Metzner and Vaitl, do not consider transiency by including psychiatric conditions, like schizophrenia, in the discussion of ASCs (Ludwig, 1966; Metzner, 2005a; Tart, 1975/1983; Vaitl et al., 2005). Conversely, some authors emphasize the importance of transiency in the definition of an ASC due to the need of a comparison state in order to call it “altered” (Costines & Schmidt, 2024). The “reference problem” arises when the normal, wakeful state is not the baseline state of consciousness, such as in psychopathology or DOCs with persistent changes that can be considered chronically altered. Accordingly, one can either see transiency as a defining criterium for an ASC or categorize ASCs as either “transitory” or “chronic/permanent.” Some ASCs can be entered voluntarily, or artificially induced, while other may result from ongoing physiological processes such as falling asleep (Cofré et al., 2020; Vaitl et al., 2005).

Multiple authors have argued that an ASC is characterized by changes across multiple dimensions of experience, not only changes in a single domain such as change in arousal or simple

[2] Disorders of Consciousness (DOCs) refer to severe and persistent alterations to the level of consciousness such that there is a reduced ability to maintain wakefulness or respond to the environment. They are often caused by factors such as stroke or traumatic brain injury. Examples include coma and the minimally responsive state (Gosseries et al., 2011).

perceptual illusions. These dimensions are sometimes referred to as properties (Krippner, 2011), aspects (Wittmann, 2018; Tart, 1975/1983), facets (Ludwig, 1966), characteristics (Ludwig, 1966), structures (Dittrich, 1975, 1985), subsystems or divisions (Tart, 1975/1983), features (Niikawa, 2020), but most commonly as dimensions (Berkovich-Ohana & Wittmann, 2017; Dittrich, 1998; Farthing, 1992; Pekala, 2013; Vaitl et al., 2005). To describe the overall culmination of these different dimensions of experience researchers will sometimes use phrases like "experiential" or "phenomenological" patterns to convey the larger scale subjective changes observed in ASCs (Costines & Schmidt, 2024; Mortaheb & Fort et al., 2024; Rock & Krippner, 2007, 2011; Schmidt & Fejer, 2021). The requirement of multidimensionality reflects the observation that ASCs typically entail coordinated changes across perceptual, affective, cognitive, and self-related domains, rather than isolated alterations in a single experiential feature (Schmidt & Fort, in press).

The phenomenological description of states of consciousness as positions within a multidimensional space, where each dimension represents a specific aspect of consciousness, has been termed and formalized in different consciousness state-space (CSS)[3] models (Berkovich-Ohana & Glicksohn, 2014; Berkovich-Ohana & Wittmann, 2017; Paoletti & Ben-Soussan, 2020; Werner, 2009). These models represent ASCs as specific positions in an n-dimensional space, where each dimension corresponds to a distinct aspect of consciousness. Each specific expression of a phenomenological dimension in time defines a position along n-

[3] Some authors also refer to this as a phenomenal (Metzinger, 2020) or phenomenological (Berkovich-Ohana & Wittmann, 2017) state-space as it visualizes dimensions of changed experience.

dimensions, and changes over time to define a trajectory in the n-dimensional CSS. The identification of the relevant dimensions to make the CSS formulation meaningful requires further research. The reviewed literature here contains many suggestions which can be interpreted as to suggest specific dimensions of a CSS model.

The suggestion of dimensions of consciousness are typically derived from conceptual or empirical approaches. Conceptual approaches often draw on a specific theoretical framework and/or qualitative descriptions and can develop into empirical approaches when using quantitative methods to analytically evaluate clusters, factors, or dimensions of ASC phenomena psychometrically (Dittrich, 1998; Pekala, 2013; Studerus et al., 2010). In sum, different attempts to specify the term ASCs point to the importance of both transiency and multidimensionality in changes from a baseline ("normal" or "average"), waking state that can be subjectively recognized by an individual or objectively by another through measurement. (Bayne & Howy, 2016; Farthing, 1992; Ludwig, 1966; Tart, 1975/1983).

1.2 Classification Schemes of ASCs*

Note: This section has been modified from its published version

In comparing classification schemes of ASC descriptions, one can find different approaches with varying emphasis on the characteristics that can be used for classification (see Figure 1 for a full timeline). We categorize these by ordering them into three different types of classification schemes: (1) Schemes based on the nature, variety, and intensity of subjective experiences (state-based), including conceptual descriptions and psychometric assessments, (2) schemes based on the technique of induction (method-based), and (3) schemes involving descriptions of neurophysiological mechanisms of ASCs (neuro/physio-based).

It is important to note that state-based and method-based classification schemes are distinct such that a state cannot be defined by its induction method. For example, the mere application of an induction technique, like meditation or hypnosis, does not guarantee the presence of an altered state. Examples of this include meditation practices that do not always lead to a meditative state and hypnotic practices that do not always lead to a hypnotic state (Tart, 1975/1983). Lastly, different induction methods can lead to similar states such as the state of sedation arising from pharmacological sedatives or exhaustion (Brasil-Neto et al., 1993; Zlott & Byrne, 2010). Taken together, confusing a state with an induction method entails several problems that can lead to difficulties in phenomenological investigation. As such, the description of a state of consciousness should be primarily based on their subjective effects, and ideally supported by descriptions in one's overall neurobiological and physiological state (Tart, 1975/1983).

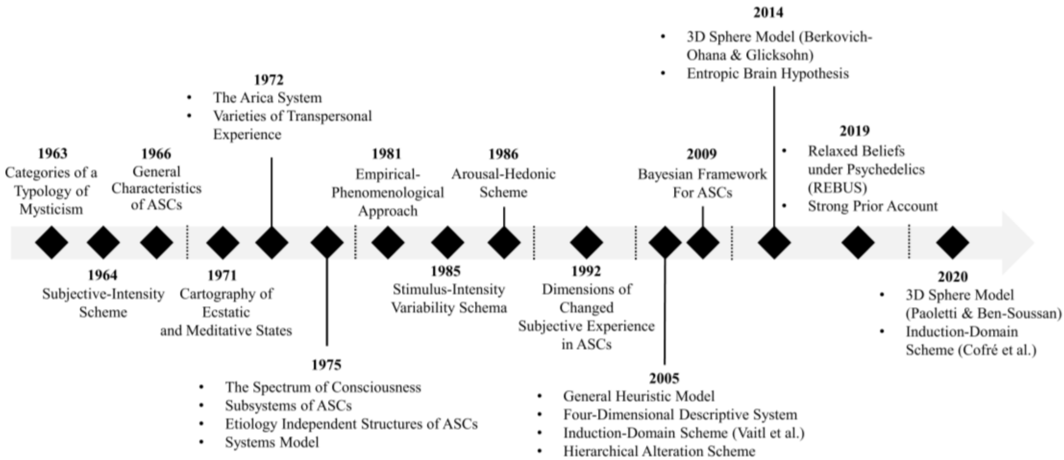

Figure 1. *Historical Timeline of Classification Schemes.* All reviewed classification schemes as they emerged across time. Dashed lines represent separation between decades (e.g., 1960s-1970s).

1.2.1 State-Based Classification Schemes*

Note: This section has been modified from its published version

The hypothesis that ASCs share common, experiential denominators dates back to the mid-nineteenth century. An early example is *Du hachisch et de l'aliénation mentale: études psychologiques* by psychiatrist J. Moreau de Tours where he explores the idea of ASCs sharing multidimensional changes in phenomenology through his experiences with various ASC-inducing agents (de Tours, 1845). This hypothesis can also be found in the writings of William James where he writes on his consumption of alcohol, nitrous oxide, and ether (James, 1902/2009). Together, these early accounts articulate the core intuition underlying state-based approaches to ASCs: that altered states are best understood by identifying recurring dimensions of experiential change.

This intuition has since become a central organizing principle in contemporary ASC research where it is generally agreed that ASCs affect multiple dimensions of experience and are multidimensional in nature rather than categorical (Costines & Schmidt, 2024; Dittrich, 1985). In multidimensional approaches, a state is characterized by its phenomenological profile (points across dimensions) rather than membership in a single discrete category. This framework avoids binary inclusion-exclusion logic and instead treats phenomenological features as continuously varying in intensity. Accordingly, the goal is not to assign experiences to fixed classes, but to locate them within a structured phenomenological space. Adopting a multidimensional framework carries an important conceptual implication, namely the need to clearly distinguish between altered states themselves and the phenomenological features along which they vary.

A central conceptual issue in the classification of ASCs is the conflation between states and the features that compose them. States refer to overall experiential configurations (e.g., trance or hypnagogic states), whereas features refer to phenomenological dimensions that vary in degree across states (e.g., visual imagery, sense of identity). Importantly, a state is defined by its pattern across multiple phenomenological features, not by any single feature in isolation.

Treating features as if they were types of states leads to ontological ambiguity and makes empirical classification difficult, since features can occur across multiple states and in varying degrees. For example, ego-dissolution phenomena can occur in meditation practices (Millière et al., 2018), psilocybin ingestion (Mason et al., 2020; Mortaheb & Fort et al., 2024), and near-death experiences

(Martial et al., 2021), yet each constitutes a distinct state because of its overall experiential profile.

A more coherent approach is to distinguish features from states and allow states to emerge as characteristic configurations in a state-space, as suggested or implied by recent synthesis efforts (Fort et al., 2025; Yaden et al., 2024). Such dimensions provide the axes along which states can be located and compared and thus offer a principled foundation for future ASC classification efforts.

Categories of a Typology of Mysticism. One of the earliest and most influential attempts to understand ASC experiences within a state-based framework was Walter Pahnke's Categories of a Typology of Mysticism, developed as part of his doctoral dissertation at Harvard (Pahnke, 1963). This framework was not intended to classify the full spectrum of ASCs, but rather to describe the phenomenological core of mystical experiences associated with them using a structured set of conceptual categories. Though focused on a narrower phenomenon, its historical and ongoing relevance to ASC research warrants its inclusion among other state-based schemes.

Pahnke, both a minister and a psychiatrist, is best known for his work aiming to bridge clinical psychiatry and mysticism. Supervised by Timothy Leary and Richard Alpert (later known as Ram Dass), he conducted the now-famous Good Friday Experiment to test whether psilocybin could induce experiences comparable to those described in mystical traditions (Mosurinjohn et al., 2023). Drawing on the work of philosopher W.T. Stace, Pahnke outlined nine core dimensions of mystical experience: (1) the Unity dimension divided into internal and external unity. Internal unity involves the loss of self and sense impressions without becoming unconscious while awareness of oneness is experienced and remembered. External unity is felt through the physical senses and occurs when one feels the separation between oneself and an external is no longer present in the sense that the external object and the self are part of the same undifferentiated unity; (2) the Transcendence of Time and Space dimension defined as the loss of the sense of time including "clock time," and one's sense of past, present, of future. Loss of the sense of space refers to a loss of usual orientation within one's three-dimensional perception of their environment. Sometimes this is referred to as feelings of eternity, and/or infinity; (3) the Deeply Felt Positive Mood dimension defined as universal elements of joy, blessedness, and peace at the highest levels that can sometimes be emotionally overwhelming. These can occur at peak experiences or in the ecstatic afterglow; (4) the Sense of Sacredness dimension defined as a feeling where one feels to be of special value, capable of being profaned with feelings of awe and wonder. It can be agnostic of religious beliefs and traditional theological terminology; (5) the Objectivity and Reality dimension defined by two interrelated elements of insightful knowledge/illumination and the authoritative nature of the experience. Insightful knowledge/illumination is felt intuitively on a non-rational level through direct experience, whereas authoritative nature is a certainty that such knowledge is truly real in an objective sense. This can be seen as the interplay between subjective and objective realities; (6) the Paradoxicality dimension defined as accurate and rational interpretations of mystical experiences that contradict logic. According to Pahnke, experiences of internal unity result in the loss of all experiential content such as the loss of the sense of self. Even amidst this loss of selfhood, it appears that a residual "I" persists to record and remember this experience, existing and not existing concurrently; (7) the Alleged Ineffability dimension defined as the experience being either beyond words or unable to be described accurately; (8) the Persisting Positive Changes in Attitude and Behavior dimension defined as lasting, positive effects of the mystical experience divided into four groups: toward self, toward others, toward life, toward the mystical experience itself. Toward self refers to a basic inward change of the personal "self" such as sustained increases in creativity and optimism. Toward others refers to outwardly directed personality changes such as increased sensitivity, compassion, openness, and tolerance. Toward life refers to marked changes in the philosophy of life, purpose/meaning, values, and new appreciation toward life as a whole. Lastly, the mystical experience refers to retrospectively viewing the experience as valuable and useful, seeing it as a high point in one's life from which one can grow. However Pahnke, in his doctoral thesis, expanded the framework through the addition of (9) the Transiency dimension defined as the inability of the experience to be sustained indefinitely, marked by a transient appearance of unusual dimensions of consciousness defined by typology, eventual disappearance, and return to the more usual Notably, the Transiency dimension did not come from Stace and was added by Pahnke himself (Barrett & Griffiths, 2018; Pahnke, 1963).

Although the item list from Pahnke's doctoral thesis was not formally named, it formed the conceptual and psychometric foundation for a series of influential measurement tools. In the late 1960s and 1970s, Pahnke and William Richards expanded this initial item set into a broader questionnaire designed for use in clinical settings (Barrett et al., 2015; Stocker et al., 2024). This questionnaire became known as the Psychedelic Experience Scale (PES) or States of Consciousness Questionnaire (SOCQ; Barrett et al., 2015; Stocker et al., 2024). This scale included items capturing sensory, emotional, and cognitive aspects of ASCs in addition to mystical features. In the early 2000s, researchers extracted a subset of 43 items specifically focused on the mystical dimensions from the Pahnke-Richards Scale. This version became known as the Pahnke-Richards Mystical Experience Questionnaire (MEQ43) and was used in a number of influential studies involving psilocybin (MacLean et al., 2012). The MEQ43 was subsequently refined through factor analysis into the MEQ30, a psychometrically validated short form that remains the most widely used version today (Barrett et al., 2015; MacLean et al., 2012). Most recently the MEQ and PES have seen further adaptations with the MEQ4 (Strickland et al., 2024) and the PES48 (Stocker et al., 2024).

Subjective Intensity Scheme. Originally delivered as a lecture in 1963 and later published, “The Seven Tongues of God” essay contains a state-based framework from Timothy Leary that we here refer to as the Subjective Intensity Scheme. This scheme is a unidimensional framework that maps five altered states across a vertical dimension of subjective intensity, referring to higher and lower levels of consciousness (Leary, 1964, 1998; Figure 2). This scheme was derived from Leary’s controversial work as a clinical psychologist and as a researcher who often employed self-experimentation. Leary is mostly known as a psychologist and political figure largely associated with the American counterculture of the 1960s. His early work involved clinical applications of interpersonal dynamics and personality theory. Later, after a personal experience with psilocybin, he started the Harvard Psilocybin Project. He was involved with two important studies in parallel. First, the Concord Prison Experiment which ran from 1961 to 1963 where he found that psilocybin in conjunction with psychotherapy led to a significant decrease in recidivism (Doblin, 1991). Second, was the Good Friday Experiment where Leary advised Walter Pahnke (see above).

Leary proposed that different levels of consciousness correspond to varying degrees of subjective intensity, with each drug activating a specific level (Leary, 1964). This idea, in part, could be inspired by anthropology and theology work that observed such ideas in ancient religions and cultures. According to Leary, however, it was primarily inspired by his personal use of drugs and observations of others on drugs. This led him to encourage others to try their own experiments with drugs to test his claims (Leary, 1964, 1998). Leary proposed seven levels of consciousness, ranging from the (1) “highest” state and to the (7) lowest wherein the name of each level describes its composition concerning energy manifestation (Leary, 1998; Figure 2): (1) The Atomic-Electronic Level of Consciousness induced by the strongest psychedelics such as lysergic acid diethylamide (LSD) and N,N-Dimethyltryptamine (DMT); (2) The Cellular Level of Consciousness induced by psychedelics such as peyote, mescaline, and psilocybin; (3) The State of Somatic Awareness induced by psychedelic drugs stronger than marijuana but weaker than the above such as hashish and 3,4-Methylenedioxymethamphetamine (MDMA); (4) The State of Sensory Awareness as being produced by any psychedelic drug such as LSD, mescaline, psilocybin, and marijuana specifically; (5) The State of Ego Consciousness induced by energizers such as pills that propel you into action. Coffee, tea, and caffeine are mild versions; (6) The State of Emotional Stupor induced by moderate doses of alcohol; and (7) The Anesthetic State induced by barbiturates, alcohol, and narcotics. Of note, some recent reports indicate that the experiences induced by LSD and psilocybin are actually not distinguishable, when directly compared in blinded studies (Holze et al., 2022; Ley et al., 2023), while meta-analyses are still not conclusive (Costines & Schmidt, 2024; Hirschfeld et al., 2023; Hirschfeld & Schmidt, 2021).

In sum, Leary’s Subjective Intensity Scheme can be considered an early state-based attempt at classification that uniquely proposes levels of higher and lower consciousness as they are plotted across the conceptual dimension of subjective intensity (Leary, 1964). However, Leary did attempt to include some method-based elements by describing how each level is reached through specific drugs. Theoretically, the Subjective-Intensity Scheme is inspired by anthropology and theology yet primarily driven by Leary’s own self-experimentation and observations of others. His work has left a lasting impact on ASC research, often being cited in current work investigating the clinical benefit of psychedelics and their safety regarding bringing about a mystical experience (Griffiths et al., 2008; Griffiths et al., 2011; Johnson et al., 2008).

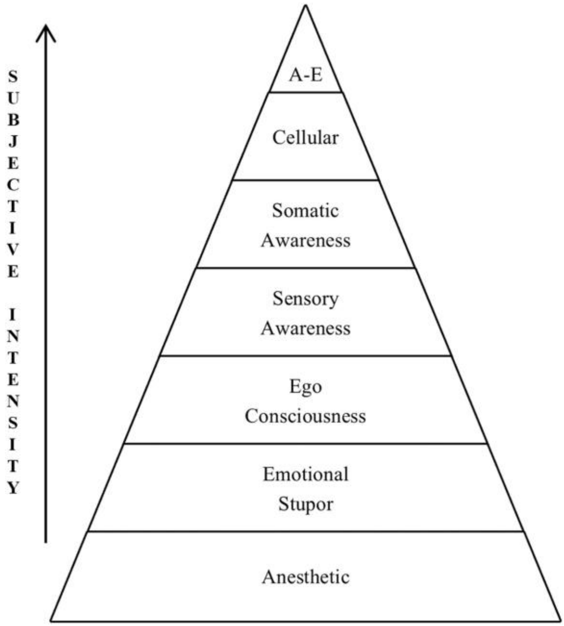

Figure 2. *Visualization of the Subjective Intensity Scheme.* The seven states of altered consciousness described by Timothy Leary as we have sorted them on a vertical dimension of subjective intensity. At the lowest levels of subjective intensity resides the anesthetic state. As one increases degrees of subjective intensity through different pharmacological ASC induction methods, one may find themselves in a higher state. The zenith of the pyramid represents the "highest" level at maximum subjective intensity known as the Atomic-Electronic (A-E) state.

General Characteristics of ASCs. An early influential attempt at a systematic description of ASCs comes from the psychiatrist Arnold M. Ludwig. His research in the 1960s involved studying cases of witchcraft, auditory phenomena in schizophrenia, hypnosis, mesmerism, trance, and hallucinogenic drugs. In 1966, Ludwig published "Altered States of Consciousness" in *The Archive of General Psychiatry* where he described ASCs as "uncharted realms of mental activity," (Ludwig, 1966). Given how little was known about these phenomena, he set out to review, integrate, and organize the knowledge of his time into a theoretical system. Through his review of literature, he supposed ten common denominators (i.e., conceptual dimensions) of related subjective phenomena. Ludwig's General Characteristics of ASCs therefore represent a state-based classification scheme which attempts to describe what it is like to be in an ASC. They are as follows (Ludwig, 1966): 1) the Alterations in Thinking dimension defined as disturbances in cognition such as memory and attention; 2) the Disturbed Time Sense dimension defined as an altered sense of time and chronology; 3) the Loss of Control dimension defined as a fear of losing "grip on reality," this may manifest as resisting the ASC; 4) the Change in Emotional Expression dimension defined as emotional extremes such as ecstasy, fear, and depression; 5) the Body Image Change dimension defined as depersonalization, a "schism of body and mind," and a dissolution of boundaries between the self and other; 6) the Perceptual Distortions dimension defined as hallucinations, pseudo-hallucinations, and increased visual imagery; 7) the Change in Meaning or Significance dimension defined as an increased meaning or significance to experience, "eureka" moments, feelings of profound truth; 8) the Sense of the Ineffable dimension defined as ineptness or inability to communicate the nature of the experience to another; 9) the Feelings of Rejuvenation dimension defined as a new sense of hope, feelings of rebirth, or a personal renaissance following the ASC; 10) the Hypersuggestibility dimension defined as an increased susceptibility to accept and/or automatically respond to statements, or cues; it is further defined as the increased ability to misperceive or misinterpret situations or stimuli based on inner fears.

Ludwig's General Characteristics of ASCs were influential in the progression of ASC work, often being cited by later researchers like Charles Tart and Stanley Krippner (Rock & Krippner, 2007; Tart, 1975/1983). Furthermore, one can see Ludwig's General Characteristics appear in many classification schemes that came after as he was one of the first modern scientists to review, integrate, and organize ASC work into a broad descriptive classification scheme (Dittrich, 1998; Farthing, 1992; Pekala, 2013; Tart, 1983; Berkovich-Ohana & Glicksohn, 2014; Paoletti & Ben-Soussan, 2020).

Cartography of Ecstatic and Meditative States. In the 1970s, another state-based classification scheme was proposed by Roland L. Fischer focused on the physiological and psychological dynamics of what it is like to be in the state (Fischer, 1971; Metzner, 2005a). With his research background in chemistry, Fischer was interested in how psychoactive drugs, like LSD, could serve as a model psychosis for understanding schizophrenia (Fischer, 1954, 1957). His state-based classification scheme was a map of inner space that he ultimately referred to as the Cartography of Ecstatic and Meditative States (Fischer, 1971). Fischer was inspired by the Ancient Greeks as well as both Eastern and Western theology in his conceptualization (Fischer, 1992). He intended to integrate knowledge between the objective and subjective worlds around continua of arousal states linked to different ASCs.

Fischer plotted arousal states along two continua: the Perception-Hallucination Continuum and the Perception-Meditation Continuum each representing increased levels of hyperarousal (ergotropic) and hypoarousal (trophotropic) respectively (Figure 3; Fischer, 1975, 1971, 1992). The Perception-Hallucination Continuum contains the three ergotropic states, each defined by arousal sub-states (Fischer, 1971; Metzner, 2005a): 1) the Aroused State defined as feelings of sensitivity, creativity, and/or anxiety; 2) the Hyperaroused State defined as catalepsy and acute hyperphrenia; 3) the Ecstatic State defined as involving the peak feeling of mystical rapture where the outside world retreats to the fringes of consciousness, leaving the individual to observe himself.

In contrast, the Perception-Meditation Continuum involves the two trophotropic states, each defined by hypo-aroused sub-states: 1) The Tranquil State defined by meditation, or *zazen* referring to Zen Buddhist meditation; 2) the Hypoaroused State defined as the presence of increasing levels of meditative and spiritual absorption which Fischer attempted to integrate with Buddhist texts by categorizing different levels of meditation within his classification scheme. This is evident via the explicitly named meditative levels of *Dhyana*, *Savichara Samadhi*, and *Nirvichara Samadhi* all which are taken from Buddhist writings to represent sub-states of the Hypoaroused state (Kesarcodi-Watson, 1982). Lastly, the classification scheme marks a Normal State/Point of Departure which is characterized by daily routine (i.e, leaning ergotropic) and relaxation (i.e., leaning trophotropic). Fischer reasoned that ergotropic and trophotropic systems are mutually exclusive, and as such, needed to be plotted on two distinct continua.

As one can see, the Cartography of Ecstatic and Meditative States is named for the highest ergotropic state i.e., Ecstasy and the highest trophotropic state i.e., Hypoaroused comprised of arousal sub-states linked to meditation (Fischer, 1971, 1992). The two exalted states are defined as being both the peak of ergotropic and trophotropic arousal respectively. Ecstasy is the ergotropic exalted state defined by the arousal sub-state of mystical rapture.

Hypoaroused is the trophotropic exalted state only when it is experienced at the arousal sub-state of *nirvichar samadhi* (i.e., thoughtless awareness). This distinction exists because the Ecstasy state is defined by only one arousal sub-state whereas the Hypoaroused state is defined by three.

Given that Fischer's classification was not simply intended to map states but rather, as he formulates it, to integrate knowledge on the objective and subjective worlds he added the concepts of "I" and "Self" to his map. The normal state centers around the "I", that is, the objective self which interprets the internal world and is seen by the outside world through which the self can change the external environment (Fischer, 1971). The "Self" is, therefore, the subjective self which sees and knows, making the relationship between the "I" and the "Self" analogous to the "seer" and the "seen," with the objective "I" observing and the subjective "Self" interpreting (Fischer, 1971, 1992).

During the normal state, the "I" is experienced as independent from the environment; however, as ergotropic or trophotropic arousal increases experiences of ego dissolution occur leading to feelings of unity with the environment (Fischer, 1971). As such, moving along the two continua also moves one from the "I" and towards the "Self" which conceptually illustrates this dissolution in the mutual exclusivity of ergoptropic and trophotropic states. The "Self" of the Ecstatic state and the "Self" of the Hypoaroused (i.e., at its most intense sub-state of *Nirvichar Samadhi*) state are the same as both engender a departure from the experienced independence of self and environment (Fischer, 1971). This dissolution in mutual exclusivity is further seen via "trophotropic rebound" where the peak of ergotropic arousal (i.e., intense sympathetic excitation) can rebound into Hypoaroused (i.e., the *Samadhi* sub-states) as a physiological protection mechanism (Fischer, 1971). This is also observed in sleep where we travel through excited states in REM and tranquil, delta-EEG wave stages of sleep (Fischer, 1992). Because of these rebound reversal phenomena, a loop connects both ecstasy and samadhi to symbolize this relationship (Figure 3).

In sum, Fischer's approach to ASC generated a map that primarily sees consciousness as an adaptation of the organism in response to a changing environment. The world of experience is, therefore, constructed from the relationship between the "I" and "Self" where we are either hyper- or hypoaroused observers, respectively (Fischer, 1992). Because this cartography details ASCs on two extremes (i.e., ecstasy and hypoaroused) and highlights the independent, objective (i.e., environment oriented) "I" and the integrated, subjective "Self," respectively, it is sometimes called a Cartography of States of Consciousness or a Cartography of Cognitive and Non-Cognitive States (Fischer, 1992). This is because conceptual processes associated with the "I" are considered cognitive to maintain independence between person and environment. Processes associated with the "Self," however, are considered non-cognitive as they do not maintain separation of the individual and the environment. Fischer also referred to this map as a Cartography of Meaning based on his idea of an arousal-state bound nature of meaning, which refers to the meaning of an experience being largely dependent on the individual's level of arousal at the time of the experience (Fischer, 1992). Fischer's state-based taxonomical work on the energetics of a state laid the groundwork for later work such as the Arousal-Hedonic classification scheme (Metzner, 2005a).

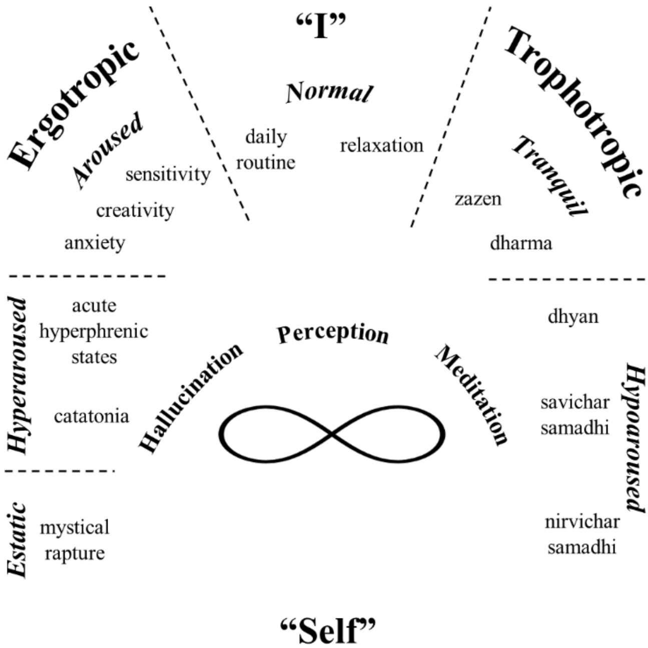

Figure 3. *Visualization of the Cartography of Ecstatic and Meditative States.* Fischer's cartography maps states of consciousness on a Perception-Hallucination Continuum, increasing ergotropic states (left) or increasing trophotropic states (right). The 'I' and the 'Self' are conceptual markers to the mapping that display one's peak objective experience (i.e., the boundary between self and environment intact) and one's peak subjective experience (i.e., the self-environment boundary dissolved) showing that as one increases in either ergotropic or trophotropic arousal they move towards the 'Self' from the 'I.' The infinity symbol represents the loop feature of trophotropic rebound where one peak state experience can quickly bounce to the other. Figure recreated by the authors from the source material (Fischer, 1971, 1992).

The Arica System. The Arica System is comprised of two conceptual dimensions: subjective intensity and emotional valence. These dimensions form a framework where states, illustrated as strata, are theorized to illustrate higher and lower levels of ASC experiences (Lilly, 1972/2017; Figure 4). The scheme was named after the Arica Desert where it was founded by the, often-controversial, neuroscientist John C. Lilly and philosopher Oscar Ichazo (Tart, 1975/1983). Of note, Lilly became known for increasingly unorthodox views and practices, gradually drifting away from mainstream science over the course of his career. The Arica System is first described in Lilly's 1972 autobiography *The Center of the Cyclone* (Lilly, 1972/2017). In addition to being a neuroscientist, Lilly was also a biologist, psychoanalyst, and physician famous for his invention of the isolation tank. His early work included high-altitude research during the Second World War; however, he is also known for his work with LSD and dolphins as he aimed to explore the nature of consciousness.

In the 1970s, after publishing the *Human Biocomputer*, Lilly explored ASCs using drugs, isolation tanks, and retreats involving deep meditative group work (Lilly, 1972/2017, 1977). In *The Center of the Cyclone*, Lilly suggested two conceptual dimensions of ASCs: subjective intensity and emotional valence. With subjective intensity mapped on the ordinate, these states can be presented as stratified, illustrating lower levels of consciousness to higher levels. In conjunction with the emotional valence dimension, Lilly suggested levels of ASC phenomenology spanning the experiences of what he conceived of as "heaven" and "hell." Lilly's strata of ASC experiences were grounded in the Gurdjieffian concept of vibrational numbers, which assign a vibrational frequency, or number, to everything in the universe (Nicolescu, 1997). These numbers represent degrees of discontinuous matter vibrations that are thought to make up the universe. They are used in the Arica System to label states of consciousness as having positive, neutral, and negative valence due to the idea that higher frequencies are associated with harmonious, positive states while lower frequencies are thought to align with disharmonious, negative states (Figure 4).

The Neutral or Baseline state, numbered ±48, represents the default setting for what Lilly calls the “human biocomputer” (Lilly, 1968/2014, 1972/2017). Ideally, this state is emotionally neutral, allowing for ordinary, day-to-day actions and creativity. It is akin to a meditative state with minimal “mental noise.” The Basic Professional State, numbered 24, involves activities well-known to the person, similar to a flow state (Lilly, 1972/2017). It’s defined by automaticity and reducing ego presence. Shifting out of this state can be dangerous, as in an athlete’s self-doubt mid-performance which could lead to performance error. This state relies on practice in the Neutral State (±48). The +24 state is experienced as intense enjoyment; the -24, is experienced as self-doubt or negative substance experiences. The Sharing Body State, numbered 12, is experienced as the body acting as a conduit for “cosmic forces,” marked by heightened body consciousness and intense emotions (Lilly, 1972/2017). The +12 state is experienced as intense bodily bliss; the -12 state is experienced as intense pain, like severe migraines. The Point as Self State, numbered 6, reduces consciousness to a point that moves through non-ordinary realities (Lilly, 1972/2017). It involves direct perception and ego dissolution, transitioning into cosmic unity. The +6 state is experienced as fusion with entities and feelings of energy and love; the -6 state is experienced as a purgatory-like state with fear and pain. The Classical Satori State, numbered 3, is the highest divine state of consciousness, involving complete detachment from the body and deity encounters (Lilly, 1972/2017). The +3 state involves blissful deity encounters; the -3 state involves wrathful deity encounters and existential struggles.

The Arica System represents an early attempt to categorize levels of consciousness along two dimensions of subjective intensity and emotional valence, conceptually expanding on the Subjective-Intensity Scheme. Through its integration of religious and spiritual ideas with psychological concepts, the Arica System illustrates the mid-transition phase of ASC classification from early, mystical understandings to psychological inquiry. Lilly's work, aside from the invention of the isolation tank, was crucial in the development of ASC research during the 1970s and 1980s (Tart, 1975/1983).

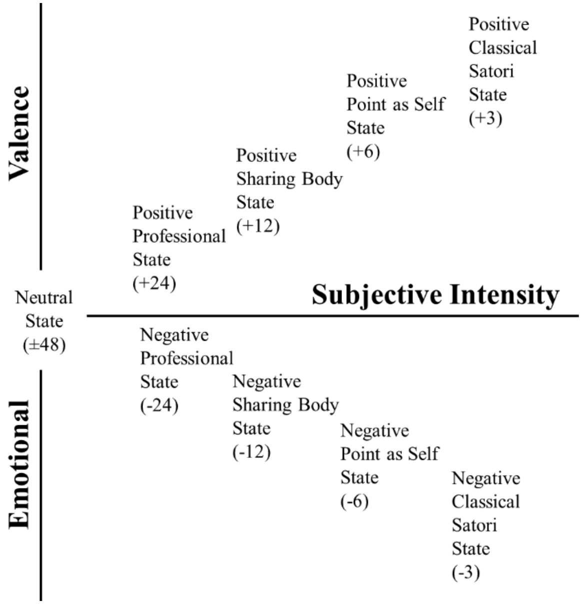

Figure 4. *Visualization of the Arica System.* This novel visualization as made by the authors displays the states of the Arica System as they are mapped in two-dimensional space where emotional valence (positive or negative) represents the ordinate and subjective intensity represents the abscissa. The abscissa illustrates that The Neutral State (±48) is minimally intense in terms of subjective experience and that the degree of subjective intensity can also be viewed as the degree of distance from consensus reality. This allows The Classical Satori State (3), in both its positive and negative iterations, to be the highest level of consciousness (i.e., high energy). The numbers of each state correspond to Gurdjieffian vibrational numbers (i.e. frequencies) which are then translated into a number delineating a level of consciousness of positive, neutral, and negative valence. In the case of neutral and positive values, these correspond directly to their frequencies. In terms of the negative values (-24, -12, -6, and -3), they correspond to the vibrational numbers 96, 192, 384, and 768 respectively.

Varieties of Transpersonal Experience. In the 1970s, Stanislav Grof assembled a classification scheme of ASCs that did not rely on any dimensionality. Rather, he proposed groupings based on the similarity of narrative themes patients reported after psychotherapeutic work with LSD (Figure 5). He framed these narratives as Varieties of Transpersonal Experience which are brought on by holotropic states of consciousness[4] (Grof, 1972). Grof is a Czech psychiatrist and altered states of consciousness researcher. His early work was heavily influenced by Freudian psychotherapy which inspired him to explore LSD as a tool for psychotic experiential training whereby psychiatrists and psychologists could use the drug to explore the subjective worlds of psychotic patients (Grof, 1973; Melton, 2001). From there, he continued to examine the therapeutic potential of psychedelic drugs. His work encompasses interests spanning from therapeutic and heuristic approaches of ASCs including pharmacological (e.g., LSD) and non-pharmacological (e.g., stroboscopic light), to shamanism and near-death experiences (Grof, 1976; Melton, 2001; Taylor & Piedilato, 2002). However, he is best known for his often-controversial work on transpersonal experiences.

Grof defines transpersonal experiences as those that involve expansion or extension of consciousness beyond the usual ego boundaries and limitations of time and space (Grof, 1972). These experiences transcend one of several limitations such as body image, existence within the boundaries of the physical body, space-time constraints on perception (i.e., the "normal" range of exteroceptors and internal perception), and the subject-object

[4] Holotropic states of consciousness are, according to Grof, ASCs involving the highest degrees of subjective intensity such as those induced with 'heroic' doses of psychedelic drugs (Grof, 2008).

dichotomy defined by ego boundaries (i.e., the duality of a subject and an object). Due to the intense nature of transpersonal experiences, they exclusively capture specific types of ASCs. Consequently, Grof's classification scheme falls short of encompassing the full spectrum of ASCs, addressing only a limited subset. For example, fantasy-play and vivid imagery may occur in some ASCs but are not considered transpersonal and are not covered by his definitions (Grof, 1972). Additional examples of non-transpersonal experiences linked to ASC include the perception of elementary imagery such as patterns and shapes. Since Grof's work focused on LSD therapy sessions, his overall conceptualization of the transpersonal stems from the psychology of religion and the development of psychotherapy. For brevity, we will not cover in detail all the varieties shown here. A comprehensive description can be found in both Grof's paper "Varieties of Transpersonal Experiences: Observations from LSD Psychotherapy" and his book *Realm of the Human Unconscious: Observations from LSD Research* (Grof, 1972, 1976).

Transpersonal experiences are firstly divided into experiential extensions Within or Beyond the framework of objective reality (Grof, 1972). Within extensions are experiences that are considered as expanding our existing subjective experiences while still operating under the framework of feasibility in the objective world. For example, ancestral experiences involve subjective feelings relating to ancestors that feasibly could have existed. Beyond extensions, on the other hand, are experiences that transcend the feasibility of objective reality such as experiences with other dimensions and wrathful deities. Within experiences encapsulate Temporal Expansion, Spatial Expansion, or Spatial Constriction of consciousness experiences. Temporal Expansion experiences are defined as those that transcend the normal, linear perception of time. One of the most prominent categories of these experiences is known as Perinatal Experiences which are related to the

circumstances of biological birth, seen as a reflection of an individual's early biological history (Grof, 1973).
Spatial Expansion experiences are another type of transpersonal experience that happens within the framework of the objective reality (Grof, 1972). Spatial Expansion experiences are those involving profound alterations to the sense of self, extending beyond the ego boundaries where one feels a larger sense of interconnectedness with a greater reality. For example, Experiences Of Ego Transcendence In Interpersonal Relations. These experiences often involve varying degrees of ego boundary loss and ultimately a merging union between one and another to the point of experiencing unity. Importantly, the subject always maintains awareness of their own identity, despite the intensity of the subjective merging.

Spatial Constriction of consciousness is the last type of transpersonal classification relating to those happening *within* the framework of the objective reality (Grof, 1972). These are classified as Organ, Tissue, And Cellular Consciousness. These experiences are considered constricting as they do not involve a subject expanding their consciousness to something else, or a greater reality. Rather, the subject experiences an authentic tuning to a part of their biology such as individual organs, tissues, or even cells.

The second major classification of transpersonal experience involves those Beyond the framework of the objective reality (Grof, 1972). As mentioned, these are transpersonal experiences that are not feasibly possible in the objective reality such as experiencing the "supracosmic and metacosmic void." This experience involves feelings of "primordial emptiness and "nothingness." Supra- and metacosmic refers to how the void is experienced as above and below the world of creation. It is reported as being beyond everything experienced or conceived of including good and evil, light and dark. It is considered an exceptionally rare and ineffable experience, often linked to the consciousness of the universal mind. In sum, transpersonal experiences beyond objective feasibility are those that could, in no way, be considered objectively possible.

To conclude, Grof's Varieties of Transpersonal Experience represents his attempt at a face-valid clustering of subjective reports based on narrative themes throughout his work in psychedelic assisted psychotherapy (Grof, 1972, 1976). While he speaks only of transpersonal experiences (i.e., those that generally transcend limitations of body, space, and or time) his work represents an attempt to discuss how ASCs are subjectively experienced. Grof's work had a profound influence on other researchers like John C. Lilly and Walter Pahnke (Lilly, 1972/2017), and it continues to inspire modern theories such as Carhart-Harris' Entropic Brain Hypothesis (Carhart-Harris et al., 2014).

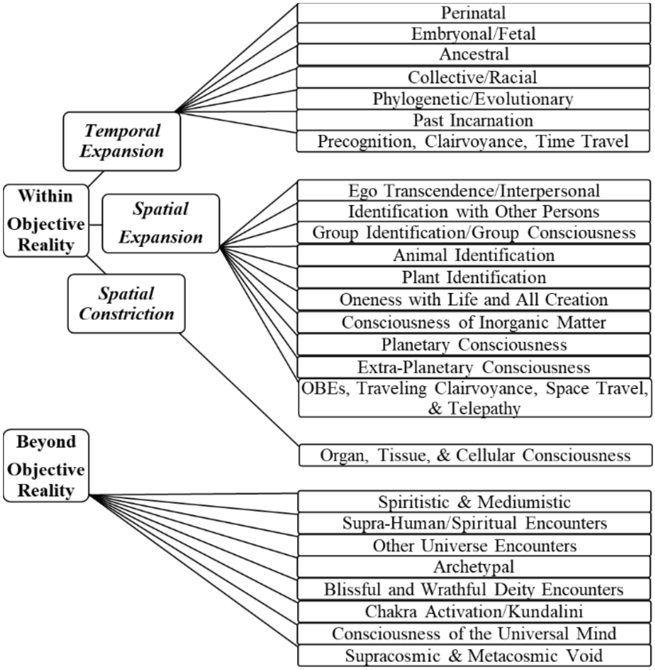

Figure 5. *Visualization of the Varieties of Transpersonal Experience.* This novel visualization as made by the authors categorizes Grof's narrative clusters of ASC phenomenology derived from patient reports after psychedelic assisted psychotherapy. These varieties of transpersonal experiences begin delineating Within and Beyond objective reality categorizations which serve to separate narratives thematically in what could feasibly occur and what could not feasibly occur. For example, Space Travel is considered Within (i.e., feasible) in this category as space objectively exists whereas Deity Encounters are considered Beyond as, according to Grof, they do not objectively exist. Within experiences are further broken down as Temporal Expansion, Spatial Expansion, and Spatial Constriction. Temporal Expansion broadly categorizes narratives that primarily deal with the extended experience of time dealing with past histories and cultures. Spatial Constriction broadly categorizes narratives that involve the experience of one's ego expanding to include others or transferring to something else. Spatial Constriction, on the other hand, broadly categorizes specific narratives that involve the experience of one's ego shrinking to experience layers within themselves such as identifying with one's organs, tissues, and/or cells.

The Spectrum of Consciousness. In an attempt to develop a *psychologia perennis* (i.e., a universal doctrine of nature and reality, inspired by Huxley), Ken Wilber proposed a model of consciousness aimed at providing a universal view of human consciousness (Huxley, 1945/2009b; Wilber, 1975). Wilber is known for his theoretical contributions to ASCs specific to the field of transpersonal psychology. His contributions have been controversially discussed, where they have been acknowledged for their depth in historical insight and logical clarity, while also being criticized for their lack of clinical knowledge (Beischel et al., 2011; Grof, 2016). His work draws inspiration from diverse religious traditions and a broad spectrum of mysticism, with a particular affinity for Buddhism (Wilber, 1975, 1977/1993).

For Wilber, consciousness in general was inextricably tied to a sense of identity that ranged from narrow, (i.e., ego-centric) to expanded (i.e., identifying with a cosmic consciousness; Wilber, 1975; Young, 2002). This view of consciousness set in motion The Spectrum of Consciousness which was first introduced in 1975 in the *Journal of Transpersonal Psychology* and later expanded upon in his book "The Spectrum of Consciousness." This model represents consciousness alteration as mapped progressively across a singular dimension of identity. Across the dimension of identity, he maps four levels of altered consciousness with three of the four each consisting of unique bands, or gradations, illustrating that the four levels shade into one another and cannot be separated (Figure 6; Wilber, 1975, 1977/1993; Young, 2002): (1) the Shadow Level was directly inspired by the work of Carl Jung whereby each ego is comprised of a persona (i.e., the socially acceptable mask) and a shadow (i.e., features of oneself contrary to society's expectations). According to Wilber, the Shadow Level is defined as the narrowest level of consciousness where one can dis-identify with parts of their psyche and shrink the overall concept of identity to parts of the ego, creating an inaccurate self-image. This is often done by relegating the undesirable aspects of oneself to the Shadow. The transition of this level into the next is represented by the Philosophic Bands which involve individual conditioned notions of self that are involved in the creation and maintenance of a shadow. (2) The Ego Level is defined as a level where one does not feel a direct identification with their psychophysiological organism, rather identification is with mental representations of that organism. The identification with this self-image leads to a duality of ego and body - a feeling of a disembodied psyche. Pure identification with this mental picture of oneself can lead to feelings of "I have a body," over "I am a body." The transition of this level into the next is represented by the Biosocial Bands that involve an internalized matrix of societal and familial premises put in place by social influences. Here, identity is shaped by the expectations of others, leading to warped and a conventionalized sense of reality. In essence, it illustrates how society shapes reality through various divisions and delineations. (3) The Existential Level is defined as a stratum of altered subjective experience where one is identified solely with their psychophysical organism. Here, there remains the boundary between self/other and self/environment from previous levels. It is discussed in Buddhist terms to represent a state of consistent existential, rational, and volitional awareness. The transition of this level into the next is represented by the Transpersonal Bands an area of the spectrum where one is not aware of their ego dissolution, yet their identity is not bound by their psychophysical organism. The area comprised by these bands is also referred to as supra-individual consciousness and can include astral travel, out-of-body experiences, traveling clairaudience, and some mystical states. (4) The Mind Level is defined as a stratum of intense subjective experience where one is melded with the universe; what Wilber calls the absolute mind or the only true consciousness. Any dualities that existed before this level are completely dissolved, such as the boundary between self and environment. It can be argued that the first three levels seem to deal more with Jungian personality psychology, whereas the latter three delve more into ASCs. For example, the Existential Level of increased awareness could apply to those in meditative states, whereas the Mind Level could apply to those in states induced by strong psychedelic drugs.

In a way similar to how Fischer included the 'I' and 'Self' in the Cartography of Meditative and Ecstatic States, Wilber creates a distinction between an environment, outward-oriented knowledge (i.e., symbolic) and internally focused, unitary knowledge (i.e., intimate) within The Spectrum of Consciousness (Fischer, 1971; Young, 2002). Symbolic knowledge deals with the understanding of representative symbols to maintain the duality between the knower and the known, subject and object, so that one can remain environment oriented. Intimate knowledge, then, represents a unitary and direct feeling of reality that is wholly internally directed. As such, when one is moving across the spectrum (i.e., their state of consciousness is more altered), the nature of how they interpret knowledge, how they experience reality, has shifted from the symbolic to the intimate. During this shift, one is believed to retain the ability to process symbolic knowledge but allow themselves to develop the ability to process intimate knowledge (Young, 2002).

In sum, The Spectrum of Consciousness maps six levels of consciousness alteration along a singular dimension of identity. Importantly, it suggests that the lowest level of consciousness has the most narrow and constricted sense of self. This means that as one progresses across the spectrum, from one level to the next, their consciousness progressively expands until eventually all dualities are dissolved into unity as a feeling of cosmic consciousness at the Mind Level.

Stanislav Grof wrote on Wilber's work, praising his approach of "spectrum psychology," even suggesting that The Spectrum of Consciousness was compatible with his Varieties of Transpersonal Experience should Wilber's model include prenatal existence and biological birth (Grof, 2016). One could also see the similarities between Grof and Wilber in how they both posit the importance of experiences involving consciousness constriction or narrowing in their classification schemes (Grof, 1972; Wilber, 1975). Wilber himself compared his Spectrum to the Arica System by suggesting that the Mind Level and Classical Satori State are the same, among other similarities (Lilly, 1972/2017; Wilber, 1977/1993).

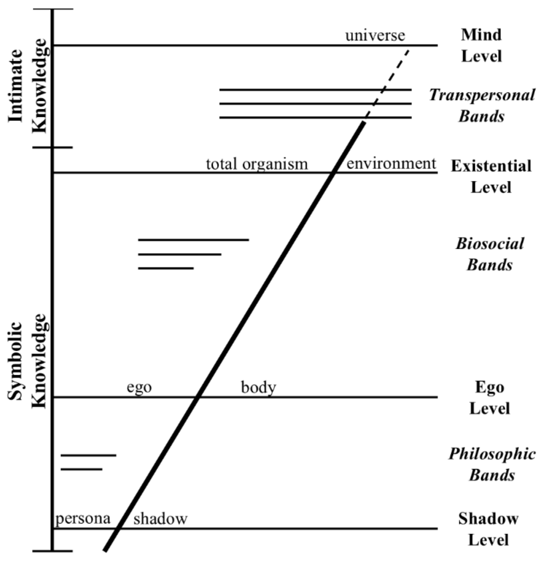

Figure 6. *Visualization of the Spectrum of Consciousness.* The left side of the panel depicts the duality of symbolic knowledge and intimate knowledge, illustrating the transition from subject-object duality to unity. The right side of the figure contains four horizontal lines, each representing a level in the spectrum from the lowest (Shadow) to the highest (Mind). Between the levels, there are three clusters represented by smaller lines which represent transitional gradients from one level into the next, known as bands. A diagonal line traverses through the levels (i.e., single horizonal lines) and some bands (i.e., three-line

clusters) to illustrate how the sense of self/identity changes across levels that are further represented by core dualities on either side. As one's state becomes more altered, their sense of identity can traverse the transpersonal bands where the line becomes dashed. This dashed line of identity symbolizes ego dissolution and the breakdown of previous dualities, resulting in unity at the Mind Level. A vertical line is added to this illustration to show how knowledge changes as one alters their state. Notably, this shows that transitioning to transpersonal bands involves a shift from symbolic to intimate knowledge (i.e., from outward, environment-oriented experience to inward, unitary experience. Figure created by merging concepts from various sources (Wilber, 1977/1993; Young, 2002).

Subsystems of ASCs. In his 1975 book, *States of Consciousness*, Charles Tart suggested that a state of consciousness is a functioning system comprised of 10 component structures/subsystems that represent "experiential divisions," within the state (Tart, 1975/1983). Tart, an American psychologist and parapsychologist, is renowned for his work on ASCs and his contributions to the development of transpersonal psychology (Tart, 1975/1983). His work spans investigating ASCs induced by various methods such as hypnosis and marijuana use (Hilgard & Tart, 1966; Tart, 1970; Tart, 1970) while also advocating for state-specific science[5] (Tart, 1972; Radin, 2023).

In the 1960s, Tart conducted a survey of graduate students, asking them how they recognized when they were in an ASC (Tart, 1975/1983). In *States of Consciousness*, he provides a table based on their answers, identifying components similar to The General Characteristics of ASCs (Ludwig, 1966; Tart, 1975/1983). Tart's 10 components of experiential criteria to detect an ASC became

[5] State-specific science is an approach to investigating ASCs through which a researcher conducts science (e.g., testing hypotheses) on an ASC of interest while in that ASC (Tart, 1972). It could be said that both the Subjective Intensity Scheme and Arica System were explicitly derived in this manner.

known as the Subsystems of ASCs which underlie his Systems Model (see Systems Model section under Method-Based Classification Schemes). Tart describes his subsystems as "clusters of phenomena that seem to hold together," and can be seen as a state-based addition to Systems Model. The subsystems are as follows (Tart, 1975/1983; Figure 7): 1) the Exteroception subsystem represents sensing the external world along with alterations in various sensory characteristics of the perceived world. 2) the Interoception subsystem represents sensing the body, alteration in body image (size and/or shape), and changes in detectable physiological parameters such as heart rate, respiration rate, etc. 3) the Input-Processing subsystem represents seeing meaningful stimuli and further sensory excitement, sensuality, enhanced or decreased sensory intensity, alterations of interactions between various sensory modalities, illusions, hallucinations, and perceptions of things unlikely to exist in the environment. 4) The Emotions subsystem represents alterations in emotional response to stimuli. This involves overacting, underreacting, not reacting at all, or in a manner entirely different to what is normally to be expected. This also refers to the extreme intensity of emotions. 5) The Memory subsystem represents changes in the continuity of memory over time, explicit checking of memory, gaps in memory continuity, checking of fine details in the perceived environment against memories to detect incongruities. 6) The Time Sense subsystem represents an unusual feeling of "here and now" -ness, a feeling of intense slowing or speeding of time, atemporal experiences, sense of a time quality, and orientation to past and/or future regardless of relation to present. 7) The Sense of Identity subsystem represents a feeling of unusual identity, or role. This can be seen in alienation, detachment, and different perspectives on what constitutes a "usual" identity or identity. 8) The Evaluation and Cognitive Processing subsystem represents alterations in rate of thought, quality of thought (sharpness, clarity), and rules of logic. 9) The Motor Output subsystem represents alteration in the amount of quality of self-control, change in how the body feels regarding motion and proprioceptive feedback, restlessness, tremors, and partial paralysis. 10) The Subconscious subsystem represents phenomena that occur outside of consciousness awareness from the reference point of a baseline state of consciousness. ASCs may make what was once unconscious, conscious.

Since the Subsystems constitute “experiential divisions,” of an ASC, Tart further details how they interact with one another (Tart, 1975/1983; Figure 7). Information from the outside world enters through Exteroception while information from our bodies enters through Interoception. This information enters Input-Processing (i.e., filtering and sorting). Input-Processing draws on Memory sending information into Awareness and our Subconscious, which in turn stimulates our Sense of Identity and Emotions. Our Sense of Identity, Emotions, and Space/Time Sense then alter this information before it is subjected to Evaluation and Decision Making to produce Motor Output. This output has an effect on the physical world detected by the body as Interoception and detected by the classical sense organs from the environment as Exteroception. This, in turn, constitutes two feedback routes to continually update information (i.e., one from the body and one from the environment).

In sum, the Subsystems represent a grouping of categories of changed experiences under ASCs. Further, Tart conceptualizes these categories of phenomena as interacting with each other through direct routes of information flow and feedback loops involving the external world and body.

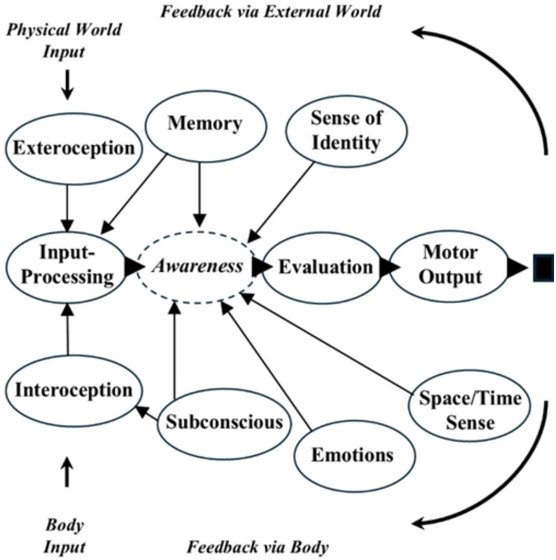

Figure 7. *Subsystems of ASCs.* The 10 subsystems of ASCs and their basic information flow routes. Minor interactions between subsystems are not visualized to reduce clutter. Solid ovals represent subsystems, while the dashed oval represents Awareness as a component essential to consciousness but importantly not a subsystem. Solid triangles represent the main route of information flow from Input-Processing through Motor Output, thin arrows represent the flow of information/interaction between other subsystems and components, sharp arrowheads represent incoming information from outside the subsystems (i.e., input from the physical world and the body), the black box represents the effect on the physical world while the thicker arrow lines stemming from it represent feedback loops. Information from the outside world enters through exteroception while information from our bodies enters through interoception. This information enters Input-Processing (i.e., filtering and sorting). Input-Processing draws on Memory sending information into Awareness. This information is then updated by our Sense of Identity, Subconscious, Emotions, and Space/Time Sense. It is further subjected to Evaluation where it later affects the physical world as it translates into Motor Output. This action by the body is detected by Interoception and the effects on the world are detected by Exteroception, constituting two feedback routes to continually update information (i.e., one from the body and one from the environment). Figure recreated by the authors from the source material (Tart, 1975/1983).

Etiology-Independent Structures of ASCs*
Note: This section has been modified from its published version

The Etiology-Independent Structures of ASCs (*Ätilogie-unabhängige Strukturen veränderter Wachbewusstseinszustände* in the original German), represents a conceptual framework of ASCs proposed by Adolf Dittrich in the 1980s (Dittrich, 1975, 1985). Dittrich proposed that ASCs share common features of multidimensional alterations referred to as etiology independence, meaning that alterations are shared independent of the mechanism of induction (Dittrich, 1998). To test this hypothesis, scales were created and revised most notably resulting in the creation of the 5-Dimensional Altered States of Consciousness (5D-ASC) Rating Scale, the most popular psychometric tool for measuring subjective experience in ASCs with its associated 11 factor scoring scheme (Schmidt & Berkemeyer, 2018; Studerus et al., 2010). It should be noted that the Etiology-Independent Structures of ASCs was conceptualized to understand a more complete phenomenological profile of ASCs, and not just a specific dimension of the experience as is done with the Categories of a Typology of Mysticism (Dittrich, 1975; Pahnke, 1963).

Dittrich, starting with the ASC definitional criteria of Ludwig and Tart, began operationalized his etiology-independent framework (*Ätiologie-unabhängige Strukturen veränderter Wachbewusstseinszustände*) in the 1970s through an extensive synthesis of existing questionnaires, clinical descriptions, and empirical studies covering both pharmacologically and non-pharmacologically induced ASCs as well as psychopathological states such as schizophrenia (Dittrich, 1985). Dittrich's operationalization was also shaped by Max Weber's description of Western rationalization and the Protestant ethic (Weber et al., 1904/2002). Weber argued that Western societies increasingly privileged disciplined, rational conduct and methodical self-control that led to a “disenchantment of the world,” or *Entzauberung* (Weber, 1917/2004; Weber et al., 1904/2002). Dittrich extended this to understand a Western cultural norm in which rational waking consciousness became the implicit standard. Within such a framework, deviations from this norm could be construed as irrational or pathological, leading to issues in how ASCs are conceptualized and measured in Western science. For contrast, Dittrich drew on ethnographic accounts documenting cultures in which mystical and ecstatic states are institutionalized and socially integrated. His etiology-independent approach can therefore be understood as an attempt to examine ASCs as patterned experiential configurations that recur across induction methods and cultural settings.

From this synthesis, he initially compiled a large pool of candidate items, which was subsequently refined to form the *Außergewöhnliche Psychische Zustände* (APZ) questionnaire. The APZ was then administered across multiple induction methods including psilocybin, meditation, hypnosis, and sensory deprivation. Analyses of responses across these diverse conditions yielded three recurring dimensions of ASC experience: Oceanic Boundlessness defined as positively valenced derealization/depersonalization and mystical type feelings, Dread of Ego Dissolution defined as negatively valenced derealization paired with fear, anxiety, and loss of control experiences, and Visionary Restructuralization defined as changes in visual perception such as hallucinatory and/or synesthesia experiences. These dimensions were intended to reflect shared phenomenological architecture across induction methods (etiology-independence).

To improve the psychometric sensitivity of the APZ, Bodmer and colleagues (1989, 1994) subsequently refined the instrument into what became known as the OAV (*Ozeanische Selbstentgrenzung* –

Angstvolle Ichauflösung – Visionäre Umstrukturierung) named after the name of each dimension in their original German. This revision replaced the original binary response of the APZ with visual analog scales, allowing for finer-grained measurement of phenomenological intensity, and expanded the item pool to a total of 66 items.

In parallel with the OAV, further empirical studies were conducted to explore whether some dimensions of experience might instead be etiology-dependent, that is, selectively tied to certain induction methods (for a review see (Dittrich, 1998). This work led to the development of the BETA (*Bewusstseinstrübung und Akustische Halluzinationen*) questionnaire, which was administered alongside the APZ and OAV across induction methods, such as DMT, nitrous oxide, cannabinoids, opiates, and sensory deprivation (Bodmer et al., 1994). These studies identified two etiology-dependent dimensions: Auditory Alterations and Vigilance Reduction. In 1998, the BETA dimensions were later integrated with the three OAV dimensions (e.g., Oceanic Boundlessness, Dread of Ego Dissolution, Visionary Restructuralization) to produce the 5-Dimensional Altered States of Consciousness (5D-ASC) Rating Scale. This integration formally combined three etiology-independent dimensions with two etiology-dependent dimensions, resulting in a hybrid five-dimensional space that indexed both shared and induction specific dimensions of ASC experience (Dittrich, 1998).

Despite its broad usage and conceptual breadth, the 5D-ASC was not the primary target of later large-scale psychometric refinement. This is because the 5D-ASC is a hybrid instrument, constructed by combining Dittrich's original three etiology-independent dimensions from the OAV with the two etiology-dependent dimensions from the BETA. While the 5D-ASC has been widely adopted, its expanded structure was never tested such that the

BETA-derived items underwent rigorous factorial validation, although the scale combined etiology-independent and etiology-dependent dimensions. As such, when Studerus et al. (2010) went about refining Dittrich's approach, they focused only on the OAV.

In 2010, Studerus and colleagues conducted a large-scale psychometric reanalysis of the OAV, drawing on pooled datasets from psilocybin, ketamine, and MDMA studies. Their aim was to evaluate whether the three original OAV dimensions adequately captured the latent structure of drug-induced ASC experiences. Confirmatory factor analyses revealed inadequate model fit for the original OAV dimensions (i.e., the hypothesized structure did not statistically capture the way responses clustered across items) prompting the use of exploratory analyses to discover a better fit. These analyses led to the derivation of 11 new factors (see Table 1), which were subsequently validated and show to possess greater internal homogeneity (i.e., the items within each factor cohered in a statistically consistent and conceptually meaningful way).
While not explicitly named in the Studerus et al. (2010) paper, this factor scheme is now commonly referred to as the 11-ASC (Costines & Schmidt, 2024). It is sometimes mistakenly called the 11D-ASC (see Bohn et al., 2023; Murray & Srinivasa-Desikan, 2022) which is misleading as Studerus et al. (2010) proposed statistical factors via factor analysis, not dimensions. In contemporary research practice, it is standard to administer the full 94-item 5D-ASC, score all five dimensions, and then rescore the 42 items comprising the 11-ASC separately, offering both a broad overview of ASC phenomenology and a more fine-grained, psychometrically optimized profile.

Overall, the Etiology-Independent Structures of ASCs is a highly important framework for modern ASC research, as one of its questionnaires, namely the 5D-ASC and its associated 11-ASC scoring scheme, are the most prevalent questionnaires in studies examining altered experiences across various states of consciousness including those induced by drugs and/or perceptual deprivation (Hirschfeld et al., 2023; Hirschfeld & Schmidt, 2021; Prugger et al., 2022; Schmidt & Berkemeyer, 2018). This framework provides a structured way of understanding and quantifying the subjective experiences of ASCs, facilitating comparison across studies and enhancing our understanding of the underlying dimensions of altered consciousness.

Factor	Factor Name	Description	Parent Dimension(s)	5D-ASC Items
1	Experience of Unity	Feelings of oneness, timelessness, absence of conflict, and merging with the environment.	OBN	18, 34, 41, 42, 52
2	Spiritual Experience	Religious or mystical-type experiences; feelings of awe and connection to a higher power.	OBN	9, 81, 94
3	Blissful State	Feelings of pleasure or ecstasy, peace, and love.	OBN	12, 86, 91
4	Insightfulness	Feelings of profoundness, creativity, and mental clarity.	OBN / VRS	50, 69, 77
5	Disembodiment	Detachment from the body, floating sensations, or altered bodily localization.	OBN	26, 62, 63
6	Impaired Control & Cognition	Mental disconnection; difficulty completing thoughts; impaired decision-making; reduced agency or control.	DED	8, 27, 38, 47, 64, 67, 78
7	Anxiety	Fear the altered state will not end; feelings of threat, strangeness, or terrifying perceptual distortions.	DED	32, 43, 44, 46, 56, 89
8	Complex Imagery	Seeing complete scenes with eyes closed or in darkness; vivid or elaborate mental imagery.	VRS	39, 72, 82
9	Elementary Imagery	Perception of colors, patterns, or flashes of light with eyes closed or in darkness.	VRS	14, 22, 33
10	Audio-visual Synesthesia	Cross-modal effects such as sounds influencing visual experience or altering colors or shapes.	VRS	20, 23, 75
11	Changed Meaning of Percepts	Enhanced meaning or emotional significance attributed to everyday objects.	VRS	28, 31, 54

Table 1. *11-ASC Factors, their Associated OAV Dimensions, and 5D-ASC Items.* The table displays all 11-ASC factors and their associated dimensions from the OAV. OBN refers to Oceanic Boundlessness, DED to Dread of Ego Dissolution, and VRS to Visual Restructuralization. Since it is standard to administer the full 94-item 5D-ASC, score all five dimensions, and then rescore the 42 items comprising the 11-ASC separately, this table illustrates which items of the 5D-ASC are linked to which factors of the 11-ASC (English and German versions). Of note, all factors are derived from items relating to one parent dimension except for Insight which has item 77 coming from VRS while the others are from OBN.

Empirical-Phenomenological Approach. In 1981, similar to the Etiology-Independent Structures of ASC, Ronald Pekala conceptualized the Empirical-Phenomenological Approach which famously led to the development of the Phenomenology of Consciousness Inventory (PCI) to capture the *noeses* (i.e., the process of perceiving) and the *noema* (i.e., the content of perception) in a state of consciousness (Føllesdal, 2006; Pekala, 2013; Pekala & Levine, 1981). The name is derived from Pekala's 1981 publication that established the research line leading to the development of the PCI (Pekala & Levine, 1981). Within the Empirical-Phenomenological Approach there are both major dimensions of experience and minor dimensions which constitute some of them, for example the PCI has the minor dimensions of Joy, Love and Sexual Excitement as part of the major dimension of Positive Affect (Pekala, 2013).

The first psychometric instrument developed from the Empirical-Phenomenological Approach was the Phenomenology of Consciousness Questionnaire (PCQ; Pekala, 2013; Pekala & Levine, 1981, 1982). The idea was to capture subjective ASC phenomena through the combination of ideas from Battista (phenomenology), Tart (subsystems), Krippner and Ludwig (ASC characteristics), and research on dimensions of attention (Pekala, 2013; Pekala & Levine, 1981, 1982). In 1983, The Dimensions of Consciousness Questionnaire (DCQ) arrived as a revision to the 37-item PCQ such that every dimension and subdimension contained four items. Positive and negative affect were also expanded to include eight items each to include subclasses of affect (Pekala, 2013; Pekala & Wenger, 1983). Ultimately, the DCQ was an 80-item scale that included the entire PCQ with added dimensions of alertness, rationality, and arousal (Pekala, 2013; Pekala & Wenger, 1983). An abbreviated version of this questionnaire consisting of only 40 items was also constructed, known as the Abbreviated Dimensions of Consciousness

Questionnaire (ADCQ), which essentially gave every dimension and subdimension two items instead of four (Pekala, 2013).

In 1986, the Phenomenology of Consciousness Inventory (PCI) was developed as a third-generation questionnaire directly from the (A)DCQ, which was then developed from the PCQ (Pekala et al., 1986; Pekala, 2013). The PCI assesses 12 major dimensions of consciousness and their constituent 14 minor dimensions (Pekala et al., 1986; Pekala, 2013): (1) the Positive Affect dimension is defined by its three minor dimensions involving ecstasy and extreme happiness (Joy), extent of intense sexual feelings (Sexual Excitement), and feelings of love and loving-kindness (Love); (2) the Negative Affect dimension is defined by its three minor dimensions involving being very angry, upset, or enraged (Anger), being very sad or unhappy (Sadness), and being very frightened, scared, or afraid (Fear); (3) the Altered Experience dimension is defined by its four minor dimensions involving the extent to which subject feels their bodily feelings expand into the world around them (Altered Body Image), the extent to which the flow of time changed drastically, whether it seemed to speed up or slow down (Altered Time Sense), changes in perceptions of the world in terms of color, form, size, shape, or perspective (Altered Perception), the extent to which a person reports an experience that might be labelled religious, spiritual, or transcendental, or has feelings of awe, sacredness, or reverence (Altered Meaning); (4) the Visual Imagery dimension defined by its two minor dimensions involving the quantity of visual imagery produced (Amount) and the extent to which imagery is vivid and three-dimensional, or as clear and vivid as objects in the real world (Vividness); (5) the Attention dimension defined by its two minor dimensions involving whether attention is directed toward the internal subjective experience or the environment (Direction – Inward) and whether the person was absorbed into what they were experiencing or whether they were continually distracted by extraneous impressions (Absorption); (6) the Self-Awareness dimension defined as the extent to which a person is aware of being aware of themselves, versus having lost consciousness of themselves, not being aware of being aware of themselves; (7) the Altered State of Awareness dimension defined as the extent to which a person is in an extraordinary unusual and non-ordinary state of awareness versus one's state of consciousness not differing from normal; (8) the Internal Dialogue dimension defined as the extent to which a person is silently talking to themselves; (9) the Rationality dimension defined as whether thinking is clear and distinct, rational and easy to comprehend versus thinking being confused, muddled, non-rational, and very hard to comprehend; (10) the Volitional Control dimension defined as the extent to which one has complete control over what they are paying attention to or willfully controlling versus becoming passive and receptive to experience, having images pop into one's mind without any control; (11) the Memory dimension defined as assessing what one can remember about everything they just experienced versus not remembering the experience; (12) the Arousal dimension defined as a measure of muscular tension, tense and tight versus not very tense and tight at all. One key difference between the PCI and similar measures like the MEQ and 5D-ASC is that the PCI was generally refined through experiments using hypnosis as seen in work with the PCI's predecessor scales (Pekala, 2013; Pekala & Wenger, 1983). While not used as frequently as the 5D-ASC, the Empirical-Phenomenological Approach's development of the PCI sees consistent use in modern research investigating altered experience (Hruby et al., 2024).

Arousal-Hedonic Scheme. Around 1986, Ralph Metzner developed a classification scheme that mapped ASCs based on two dimensions: first, how subjectively energetic, or aroused, they felt and second, how pleasurable they felt (Metzner, 1986, 2005a). This two-dimensional approach was known as the Arousal-Hedonic Scheme. Metzner was a German-American psychotherapist whose work began with Timothy Leary and Richard Alpert on the Harvard

Psilocybin Project (Leary et al., 1963). His work would later encompass everything from psychedelic plants, such as ayahuasca, to shamanism, and even writings about myths and metaphors relating to self-transformation (Metzner, 1998, 2001, 2005b). Metzner's work on understanding what he calls the "physiological energetics," of ASCs builds on similar work done by Roland Fischer (Fischer, 1971, 1992; Metzner, 2005a).

While Metzner agrees with much of Fischer's mapping, he raised concerns about grouping states like schizophrenia and creative inspiration in the same high-energy category. This led to the addition of a pain-pleasure continuum, or what he calls the hedonic continuum, to precisely define what "high" means in such a classification scheme. For example, high could either mean high arousal or stimulation or it can mean highly pleasurable. Metzner aimed to fix this with the addition of the hedonic continuum to the Cartography of Ecstatic and Meditative states (i.e. ergotropic versus trophotropic), leading to a two-dimensional classification scheme of altered states we call the Arousal-Hedonic Scheme (Figure 8). Here, the intersecting continua deal with the following dimensions: a) Arousal versus Sedation; b) Pleasure versus Pain.

Metzner attempted to apply the Arousal-Hedonic Scheme empirically by creating a scale based on the idea that individuals, with little preparation, can give numerical estimates on the hedonic and arousal continuums (Metzner, 2005a). This Altered State Graphic Profile (ASGP) was made of an upper scale for the arousal continuum and a lower one for the hedonic continuum, complete with a time scale at the bottom so that a time interval can be recorded for each report. Every 15 or 30 minutes, participants had to indicate on a scale of +3 to -3 their subjective sense of the two dimensions. The scores on the ASGP are defined on two continua: Arousal and Hedonic. The Arousal Continuum includes 0: Awake and calm, +1: Alert/Attentive, +2: Stimulated, +3:

Aroused/Excited, -1: Alpha/Meditative, -2: Drifting/Twilight, -3: Deep Trance/Sleep. The Hedonic Continuum includes 0: Neutral Point, +1: Pleasant, +2: Elated/Euphoric, +3: Ecstatic/Heaven, -1: Unpleasant, -2: Painful/Disturbing, -3: Agony/Hell. While the ASGP saw little use, it was published in a study examining the psychobiologic effects of MDMA (Grob et al., 1995).

In addition to Arousal and Hedonia, Metzner proposed a third dimension that is not visualized known as Expansion versus Contraction (Metzner, 2005a). This dimension is described as purely energetic, regardless of the content but is important to separate psychedelic drugs from substances such as stimulants and depressants. As such, he labels psychedelic drugs as Consciousness-Expanding defined by this addition of apperception (i.e., a phenomenon where the objective observer is added to the experience). Psychoactive stimulants and depressants, according to Metzner, merely move consciousness up and down the arousal dimension and away from pain or discomfort and, as such, are considered Consciousness-Contracting. This implies that the two-dimensional Arousal-Hedonic Scheme can only account for substances that are consciousness-contracting and that consciousness-expanding substances, like psilocybin or LSD, transcend the scheme. In sum, the Arousal-Hedonic Scheme can be viewed as an extension of The Cartography of Ecstatic and Meditative States. While its related scale, the ASGP, did not see much use, the overall scheme marked the emerging importance of understanding subjective arousal in ASCs.

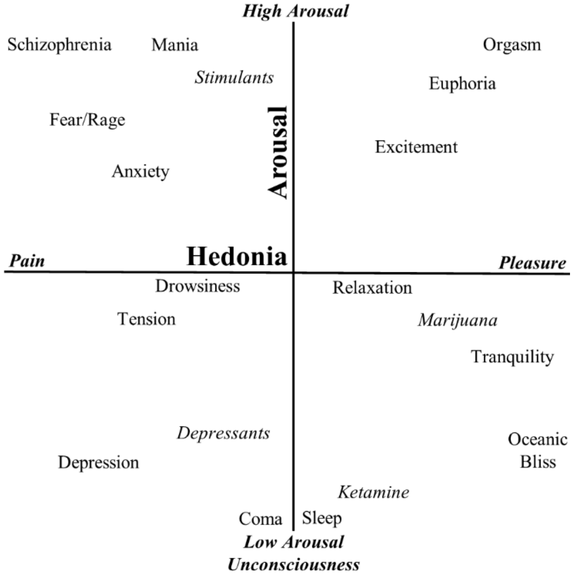

Figure 8. *Visualization of the Arousal-Hedonic Scheme.* The two-dimensional Arousal-Hedonic Scheme borrows from Fischer's Cartography of Ecstatic and Meditative States, in that it uses the arousal continuum, represented here on the ordinate. Arousal is represented as high at the top of the ordinate and low/unconscious at the bottom. The Hedonic Continuum, Metzner's addition, is represented on the abscissa characterized by pain on the left and pleasure on the right. Emotional states, pathologies, and classes of drugs are plotted accordingly. Drugs are plotted in italics. For example, ketamine represents low arousal, approaching that of sleep and coma while it is also characterized by a moderate amount of pleasure comparable to relaxation. Figure recreated by the authors from the source material (Metzner, 2005a).

Dimensions of Changed Subjective Experience in ASCs. In 1992, G. William Farthing published the textbook *Psychology of Consciousness* which, in part, aimed to compile and review research on ASCs similar to Ludwig's work from 1966 (Farthing, 1992; Ludwig, 1966). Through his literature review, Farthing supposed fourteen conceptual dimensions to ASCs. He simply called these Dimensions of Changed Subjective Experience in

ASCs. The fourteen dimensions are as follows (Farthing, 1992): (1) the Changes in Attention dimension defined as changes in attentional range such as internal, external, and the tendency to narrow one's focus such that they notice details about something they did not notice before (e.g. heightened engagement with music); (2) the Changes in Perception dimension defined as the recognition and interpretation of environmental objects and events such as perceptual illusions (i.e., the misidentification of objects and events) and synesthesia (i.e., one sensory modality being experienced in another) stemming from disruption in sensory-perceptual processes or the narrowing of attention; (3) the Changes in Imagery and Fantasy dimension defined as the vividness of mental imagery associated with increased fantastical thoughts, reverie (i.e., experiencing a series of thoughts or images occurring in a free association-like manner with no concurrent theme or narrative), real hallucinations (i.e., a perception believed to be real in the absence of a proper stimulus while the sense of reality is gone), and pseudo-hallucinations (i.e., a perception that is knowingly false as the overall sense of reality is still intact; Königsmark et al., 2021); (4) the Change in Inner Speech dimension defined as a decrease in narration associated with volitional thoughts becoming less connected to actions and the environment, overt speech becoming less coherent, and changes in verbal thought; (5) the Changes in Memory dimension defined as reduced recall, changes in associations between words, images, idea flow, and the stream of consciousness often leading to increases in creativity; (6) the Change in Higher-Level Thought dimension defined as difficulties in making decisions or solving problems due to changes in emotions, values, or disruption in short-term memory; (7) the Changes in the Meaning or Significance of Experiences dimension defined as feelings that certain thoughts or events are profoundly important or of mystical significance sometimes associated with extreme humor and feeling that one's ideas are more creative than normal; (8) the Changed

Time Experience dimension defined as experiencing change in temporal duration where external time usually seems to slow down (i.e., internal time judgments have sped up) involving both linear time experience and a nonlinear experience of timelessness; (9) the Changes in Emotional Feeling and Expression dimension defined as changes in emotional feeling ranging from negative emotions (e.g., fear, anger, depression) to positive emotions (e.g., humor, love, joy) and increases in emotionally reactivity (i.e., responding to events one may not normally respond to), emotional unresponsiveness (e.g., feelings of a "drugged stupor"), or uninhibited overt expressions of emotion (e.g., violent actions, affectionate touch); (10) the Changes in Level of Arousal dimension defined as extreme levels of arousal may be reached that are not possible in the normal, waking state. Extremely low arousal can be present in hypnagogic states and extremely high in some drug states like the one produced by amphetamines; (11) the Changes in Self-Control dimension defined as increases in impulsivity, disregard for social inhibitions, lethargy, disruption in executing complex motor functions, automaticity of voluntary functions without a sense of volition (e.g., hypnotic suggestions), a voluntarily abandonment of conscious control in order to experience more mystical phenomena, and depersonalization where the loss of self-control is complemented by a feeling of one's own actions happening to them without a sense of volition; (12) the Changes in Suggestibility dimension defined as responsiveness to suggestions/hypersuggestibility (i.e., communications from one person to another that induce changes in the other's behavior or beliefs with coercion) usually observed in hypnosis, shamanic rituals, and marijuana intoxication; (13) the Changed Body Image dimension defined as common feelings of change in perceived body proportions, weight, or inner sensory events (e.g., experiences of levitation or numbness) where changes affect personal identity such that they can be experienced as frightening or oceanic feelings (i.e., a feeling of boundlessness); (14) the Changed Sense of

Personal Identity dimension defined as changes in the overall sense of identity due to alterations in the other dimensions where one may feel that they are not themselves (i.e., they can no longer identify with their previous self-concept) that can be positive (e.g., feelings of rejuvenation and/or a feeling of being reborn) and negative (e.g., feelings that one is no longer in control of their thoughts or actions) that can occasion mystical type experiences involving a sense of unity, or oneness, with the environment which is typically felt as positive.

In sum, Farthing supposes 14 conceptual dimensions that he terms the Dimensions of Changed Subjective Experience in ASCs. This comprehensive review of previous ASC work is useful in that it can be seen as a successor to Ludwig's General Characteristics of ASCs. All of Ludwig's dimensions are included in Farthing's dimensions either conceptually or word for word. For example, Ludwig's Feelings of Rejuvenation dimension is represented as Farthing's Changed Sense of Personal Identity. Further, Ludwig's Sense of the Ineffable is represented as Farthing's Change in Inner Speech which explains ineffability in terms of the narrative component of consciousness which can be read about in Julian Jaynes' book *The Origin of Consciousness in the Breakdown of the Bicameral Mind* (Farthing, 1992; Jaynes, 1976; Ludwig, 1966). Lastly, Farthing's dimension of Change in the Level of Arousal can be seen as incorporating the idea of physiological energetics employed in Fischer's Cartography of Ecstatic and Meditative States, which would also inspire the later Arousal-Hedonic Classification scheme (Farthing, 1992; Fischer, 1971; Metzner, 2005a). Farthing's continuing inclusion and highlighting of the importance of changes in emotion, body image, and time sense from Ludwig could also be seen as laying theoretical groundwork for other classification schemes such as the Three-Dimensional Sphere (3DS) Models (Berkovich-Ohana & Glicksohn, 2014; Berkovich-Ohana & Wittmann, 2017; Farthing, 1992; Ludwig, 1966; Paoletti & Ben-Soussan, 2020).

General Heuristic Model of ASCs. The General Heuristic Model of Altered States was developed by Ralph Metzner to primarily examine ASCs induced by psychedelic drugs, though other inductions are included (Metzner, 2005a). Here, Metzner uses the term "heuristic" to indicate that this model serves as a framework for discovering and understanding states of consciousness, rather than providing an explanatory structure. He discusses how classification schemes have either focused on content, such as Stanislav Grof's perinatal matrices, or physiological energetics such as Fischer's Cartography of Ecstatic and Meditative States (Fischer, 1971; Grof, 1972; Metzner, 2005a). In this general model, Metzner outlines six dimensions in a state-based manner, but also centers them around the idea of set and setting being integral to the induction process (Figure 9). The six dimensions are as follows: (1) Thinking/Attitude, (2) Feeling/Emotion, (3) Perception/Sensation, (4) Sense of Time/Space, (5) Body Image, and (6) Sense of Self/Identity.

To bring about these multidimensional alterations, Metzner states that the content of a state of consciousness is a function of the internal set and external setting, mirroring the set and setting formulation of his colleague Timothy Leary. This hypothesis makes it clear that the content of a psychedelic experience is not so much a byproduct of the pharmacology but rather of the set defined as internal factors of expectation, mood, temperament, and attitude; and setting defined as the physical and social aspects of the external environment, including the internal states of the person administering the drug. Metzner points out that such a hypothesis explains why a psychedelic substance could be:

"…interpreted as a model psychosis (psychotomimetic), an adjunct to psychoanalysis (psycholytic), a treatment for addiction or a stimulus to creativity (psychedelic), and a facilitator of shamanic spiritual insight (entheogenic), or even by the U.S. Army and the Central Intelligence Agency, as a truth serum…" (Metzner, 2005a, p. 28).

Such observations make it clear that the set is primary as it helps to determine the choice of setting (Metzner, 2005a). This formulation led to the General Heuristic Model of Altered States of Consciousness which can be seen as a model that visualizes the role of set and setting in bringing about the multidimensional changes in ASCs[6].

Metzner's General Heuristic Model and his Arousal-Hedonic Classification Scheme are both a synthesis of previous work and attempts at ASC categorization. Beginning with the General Heuristic Model, one can see that it blended the set and setting hypothesis of Timothy Leary with multidimensional changes well documented by several previous researchers such as Arnold Ludwig and G. Willian Farthing (Farthing, 1992; Ludwig, 1966; Metzner, 2005a). Further, it appears to also integrate a time course of induction, done a few decades before by Charles Tart who conceptually mapped out how an ASC is induced in his Systems Model (Tart, 1975/1983).

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[6] One could argue that the General Heuristic Model is more method-based as it details how set and setting lead to alterations in experience, thereby describing mechanisms of induction.

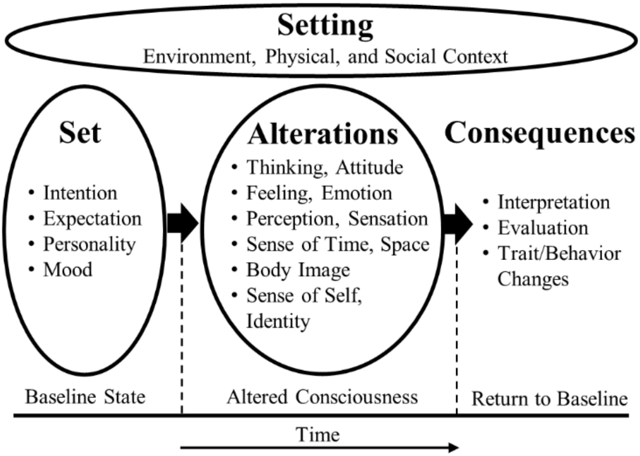

Figure 9. *Modified Visualization of the General Heuristic Model of Altered States of Consciousness.* The General Heuristic Model represents how one moves from a baseline state of consciousness to an altered state of consciousness, and ultimately, a return to baseline over time. Setting defined as the environment, physical, and social context, blanket the entire timeframe of this alteration. At the baseline state, set defined as intention, expectation, personality, and mood, directly implicates alterations in the altered state which are reflected phenomenologically (e.g. in thinking and attitude). During the return to baseline, consequences are reflected upon such as a search for meaning in interpretation, evaluation of the experience as good or bad, and trait and/or behavior changes. Figure recreated by the authors from the source material (Metzner, 2005a).

Four-Dimensional Descriptive System. In 2005, Vaitl et al proposed a descriptive system of what comprises an altered state through four conceptual dimensions: Activation, Awareness, Self-Awareness, and Arousal (Vaitl et al., 2005). These dimensions were derived from a reduction of experiential reports down to their essential features (Vaitl et al., 2005): (1) Activation defined as the readiness of an organism to interact with its environment. Subjectively represented by being alert, awake, responsive, and ready to act and react; characterized by Arousal (+) at the high end and Relaxation (-) at the low end of the spectrum; (2) Awareness defined as the variability of contents available to attention and conscious processing; reported mostly in post-hoc, reflective evaluation; characterized by awareness span, Wide (+) at the high end and Narrow (-) at the low end of the spectrum; (3) Self-Awareness defined as the "other pole of the bipolar self-world structure." Self-reflective experiences may be seen as truly "mine" or diminished in terms of forgetting oneself through the weakening of ego boundaries. A feeling of being "here and now," present in absorption and an intensified feeling of one's being reported mostly in post-hoc, reflective evaluation; characterized by Present (+) at the high end and Absent (-) at the low end of the spectrum; (4) Sensory Dynamics defined as the variety of experiences in the sensory and perceptual component of subjective experience. In ASCs, sensations can be reduced or enhanced. Some are characterized by the production of sensations and perceptions that do not have a contributing physical stimulus (i.e. hallucinations). The richness, vividness, structure, and content of these changes are often revealed in subjects' reports. They are characterized by Increased (+) at the high end and Decreased (-) at the low end of the spectrum.

Vaitl and colleagues mapped four of their five induction domains (see Induction-Domain Classifications) onto the Four-Dimensional Descriptive System (Vaitl et al., 2005). This allows us to view the Four-Dimensional Descriptive System as a state-based classification scheme whereby ASCs are characterized by the degree of experience along four different continua based on a review of neuroscientific literature. While Farthing's Changed Dimensions of Subjective Experience in ASCs can be seen as a review and expansion of ASC work starting with Ludwig's General Characteristics of ASCs, The Four-Dimensional Descriptive System can be seen as a review and constriction of such work. Given that these were conceptualized as essential dimensions of altered experience, the authors' inclusion of Arousal highlights

Fischer's work by underscoring the importance of physiological energetics in ASCs (Fischer, 1971, 1992; Vaitl et al., 2005). Awareness expands Farthing's dimension of Changes in Attention by providing both a wide and narrow span, while Self-Awareness deals conceptually with Fischer's idea of the "I" and "Self," the weakening of the self-environment boundary, or ego dissolution (Farthing, 1992; Fischer, 1971, 1992). Sensory dynamics can then be seen as a synthesis of conceptual dimensions relating to perceptual distortions and changes in imagery which are represented in both Ludwig and Farthing's work (Farthing, 1992; Ludwig, 1966).

Three-Dimensional Sphere (3DS) Models. The 3DS Models proposed by Berkovich-Ohana & Glicksohn (2014) and Paoletti & Ben-Soussan (2020) conceptualize ASCs as positions within a three-dimensional state space, where each axis represents a distinct phenomenological dimension.[7] What makes these state-space models unique is their shared use of spherical geometry as a metaphor for how these dimensions relate and interact. In both models, a specific consciousness state is defined by its location in this space (i.e., a unique combination of values on the three axes) but the sphere metaphor provides additional structure to the understanding of relationships among these dimensions. Both

[7] Both models were renamed here for clarity and consistency. The model proposed by Berkovich-Ohana and Glicksohn (2014) was originally called the Consciousness State Space model. However, this term is relatively broad, as many state-based classification schemes reviewed here can be considered state-spaces. Likewise, the model proposed by Paoletti & Ben-Soussan was originally named the Sphere Model of Consciousness (SMC) but the Consciousness State Space model of Berkovich-Ohana and Glicksohn also features a sphere-based structure. To reduce confusion and highlight their structural and dimensional similarities, both models are referred to here by their authors' names and grouped together under the label Three-Dimensional Sphere (3DS) Models.

models agree on two dimensions, namely (1) (Subjective) Time and (2) Emotion. The Berkovich-Ohana & Glicksohn Model suggests (3a) Awareness, while the Paoletti & Ben-Soussan Model suggests (3b) Self-Determination as the third dimension.

The Berkovich-Ohana & Glicksohn Model (see Figure 10) uses a spherical structure to reflect the nested relationship between core (minimal) and extended (narrative consciousness). States closer to the center are associated with minimal selfhood and embodied awareness, while those near the periphery involve narrative elaboration and increased psychological distance from the body. As such, distance from the center is interpreted phenomenologically as the degree to which one's sense of self expands from bodily immediacy toward abstract, autobiographical cognition.

The model builds on Damasio's work, particularly in the dimension of Awareness, which includes bodily and interoceptive sensations (Berkovich-Ohana & Glicksohn, 2014; Damasio, 1999, 2010). The dimension of Awareness spans from low phenomenal awareness on one end and high access awareness, drawing on Block's distinction between phenomenal consciousness (subjective, unreportable experience) and access consciousness (reportable, cognitively accessible content; Berkovich-Ohana & Wittmann, 2017; Block, 2007). The dimension of Subjective Time maps experiential orientation from the subjective past through the present toward the future, with the "now" at the center of this axis. The poles, representing extended temporal experience, are increasingly dissociated from immediate bodily presence. The Emotion dimension spans from pleasant to unpleasant, further subdivided into arousal (raw, bodily activation) and valence (evaluative tone shaped by past experiences; Berkovich-Ohana & Wittmann, 2017). Importantly, the Berkovich-Ohana & Glicksohn Model highlights two central phenomenological features of ASCs: (1) a collapse of temporal structure toward a state of timelessness, and (2) profound distortions or dissolution of the bodily self (Berkovich-Ohana & Wittmann, 2017). Various types of ASCs, such as psychedelic and meditative states, are modeled along these dimensions. For example, classic serotonergic psychedelics (e.g., psilocybin, LSD) may induce a breakdown in information integration related to bodily processing, which contributes to alterations in self-experience and temporal disintegration. This collapse of time perception, exemplified by rich, bizarre, and fast-paced experiences, can culminate in a sense of timelessness, located at the center of the time axis. These characteristics illustrate how this model can map ASCs as transient, but structured deviations along these phenomenological dimensions. Notably, this model has been applied to recent studies exploring psychedelics' effects on time perception and meditation's impact on bodily self-consciousness (Laukkonen & Slagter, 2021; Millière et al., 2018; Yanakieva et al., 2019).

The Paoletti & Ben-Soussan 3DS Model uses a spherical structure to represent a balanced state-space but emphasizes equidistance and neutrality. Here, the center symbolizes what they term the "place of pre-existence," a state in which consciousness is not identified with any particular content. It is conceived as a neutral equidistant point from all phenomenological dimensions, reflecting a state of non-attachment rather than the normal, waking state. This central point is a phenomenological ideal of stillness and openness, allowing for transformative or integrative experiences.
This model emphasizes the role of agency, balance, and non-identification in ASCs. The dimension of Self-Determination reflects one's degree of volitional engagement with conscious contents, spanning from a passive, reflective state to a heightened sense of autonomy and intentional transformation. The Subjective Time axis here refers to the experiential flow of time, ranging from rapid and fragmented perception to a timeless state of presence. The Emotion dimension, like in the Berkovich-Ohana & Glicksohn

Model, spans from unpleasant to pleasant affect with valence shaped by the level of emotional regulation and depth of experience.

Overall, the Paoletti & Ben-Soussan Model highlights how specific ASCs, especially those induced through meditative practices, can reflect movement toward the center of the sphere, marked by decreased identification with phenomenological content and increased self-regulation. For example, deep mediative states may be characterized by emotionality equanimity, a sense of timelessness, and enhanced volitional control, corresponding to proximity to the sphere's center. In contrast states marked by intense emotional reactivity, temporal dictation, and reduced self-determination, such as in certain drug-induced states, may be represented as occupying positions toward the periphery of the sphere. Notably, this model has been applied to recent research on meditation (Yamaya et al., 2021).

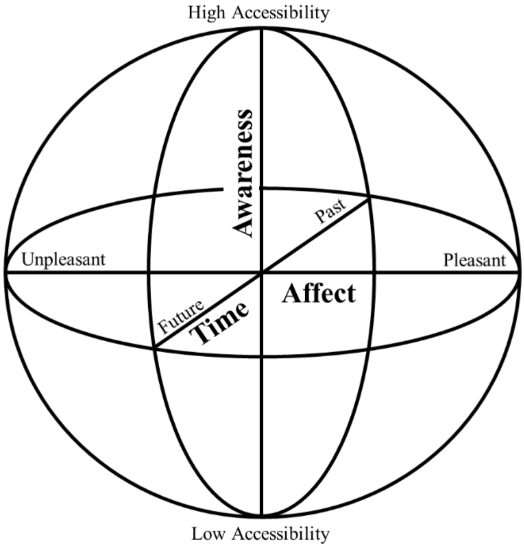

Figure 10. *Visualization of the Berkovich-Ohana & Glicksohn Three-Dimensional Sphere (3DS) Model.* Three dimensions encompass the Berkovich-Ohana & Glicksohn 3D-CS Model: Subjective Time, Awareness, and Emotion. Subjective time deals with subjective past, present, and future with the "now" being at the center while the past and present are anchored at the ends. The Awareness dimension involves low, phenomenal awareness on one end and high, access awareness, involving phenomenal awareness as being mostly unreportable and private with access awareness being reportable via its link with high-level cognitive functions such as memory. The Emotion dimension ranges from pleasant to non-pleasant which are further conceptualized as phenomenologically distinct arousal and valence. Arousal involves bodily fluctuations felt near the body and valence involves using prior experiences to make meaning of current emotions at the present moment. Figure recreated by the authors from the source material (Berkovich-Ohana & Glicksohn, 2014). For the Paoletti & Ben-Soussan Model where Awareness is replaced with Self-Determination see (Paoletti & Ben-Soussan, 2020).

1.2.2 Method-Based Classification Schemes

Method-based classification schemes categorize ASC according to their means of induction. Throughout history, human curiosity has given rise to a plethora of reports on how ASCs can be induced . In one abstract formulation such methods have been termed consciousness-modifying techniques, with the basic distinction between pharmacological and non-pharmacological inductions. For the latter, additional collective terms like "laboratory psychonautics," "technologies of the sacred" (Grof, 2019), "induction procedures" (Glicksohn, 1991), "induction techniques" (Tart, 1975/1983), "psychological/physiological maneuvers" (Vaitl et al., 2005), or simply "other means," (Cofré et al., 2020) can be found in the literature. These different terms point to the diversity among methods. A particular challenge in classification arises when techniques are combined, making it difficult to determine the appropriate level of granularity as different mechanisms may elicit different subjective effects. For example, various forms of yoga and meditation often integrate postures and breathwork to achieve desired subjective outcomes, however distinguishing between the effect of interoceptive (e.g., breathing) and proprioceptive (e.g., postures) engagement on these outcomes remains challenging (Wheeler et al., 2019).

While many classification schemes focus on subjective experiences, fewer authors compiled overviews on these consciousness-modifying techniques which allow the identification of commonalities across these diverse practices. Ludwig, however, does briefly describe these so-called "productions of ASCs" in his seminal paper "Altered States of Consciousness" (Ludwig, 1966). Here, he suggests that ASCs arise in any setting in which agents (i.e., pharmacological inductions) or maneuvers (i.e., non-pharmacological inductions) interfere with the inflow of sensory or proprioceptive stimuli, the outflow of motor impulses, emotional

tone, or the normal flow and organization of cognitive processes. He ultimately suggests that an optimal range of external information is necessary for the maintenance of the normal, waking state and that diverse environmental stimulation is required for normal cognitive, perceptual, and emotional experience.
We summarize three formal examples of method-based classification schemes: A general conceptual framework describing how specific triggers can induce the re-organization of psychological processes (Tart, 1975/1983), a two-dimensional classification system with a focus on sensory stimulation methods (Dittrich, 1985), two schemes that sort induction methods that we call Induction-Domain Classifications (Vaitl et al., 2005; Cofré et al., 2020), and a representative classification scheme for psychoactive drugs (Zohar et al., 2015).

Systems Model. In his book *States of Consciousness*, Tart describes a state of consciousness as consisting of structures/systems (i.e., permanent fixtures of functions, systems, and subsystems) in the mind/brain that act on and transform information (Tart, 1975/1983). These can be activated by the allocation of attention/awareness, or what he calls psychological energy. Tart's systems model then details alterations of these states of consciousness primarily through transformation of the baseline state of consciousness (b-SoC) to an ASC and back, centering his work as primarily method-based. To evidence this induction method, he first outlines four stabilization processes that are involved in maintaining the integrity of a state of consciousness at any given time. These four processes are as follows: (1) Loading Stabilization defined as keeping attention/awareness deployed in desired structures with appropriate task orientation; (2) Negative Feedback Stabilization defined as correcting a subsystem when it is deviating too far from what one perceives as the "normal" range; (3) Positive Feedback Stabilization defined as strengthening activity and/or providing rewarding experiences when subsystems are acting in ways to maintain stability; (4) Limiting Stabilization defined as restricting the range of functioning of subsystems that would destabilize the existing state of consciousness.

Tart continues to describe these subsystems as integral in the process of ASC induction (Figure 11). To do so, he outlines how a state of consciousness, beginning at the b-SoC can become an ASC through two induction operations: disruption and patterning. Disruption is characterized by disruptive forces that break the integrity of subsystems, for example, by overloading or by depriving them of stimuli, or similarly, by providing ambiguous stimuli. This can also be done by withdrawing attention or awareness from certain subsystems, such as certain meditations that instruct the user to focus on their thoughts (i.e., disruption of Motor Output). Disruptive forces do not always guarantee an altered state as sometimes the stabilization processes still hold together, meaning multiple stabilization processes need to be disrupted to ensure an ASC induction. Therefore, an ASC cannot be assumed from an induction method alone (see Introduction).
Patterning is characterized by patterning forces that are psychological and physiological actions that structure incoming subsystems into a new system (i.e., an ASC; Tart, 1975/1983). The ASC must then develop its stabilization process to endure. Patterning forces can also serve to destabilize a state of consciousness meaning a disruptive force can also be a patterning force. A good example of this is flicker light stimulation (Amaya, et al., 2023a; Bartossek et al., 2021). Here, Exteroception and Input-Processing are disrupted through overloading the visual system with stimuli, yet entrainment (i.e., the process of the brain synchronizing with the rate of flicker) is evidence of how it is also a patterning force.

To review, a successful induction must employ the operations of disruption and patterning. If successful, disruptive forces will result in the destruction of the b-SoC's integrity, leading to a transitional and disorganized period (Tart, 1975/1983). During this period, patterning forces will drift in to lay the groundwork for the new ASC which must develop its stabilization process to endure. This process in reverse is known as de-induction. In a method-based manner, the systems model can classify whether the degree of induction is enough for one to remain at the b-SoC, enter a transitional state, or fully develop into an ASC.

It can be argued that nearly all neurobiological explanations of how ASCs are induced are, in some conceptual manner, compatible with the Systems Model as they involve temporary disruption and a transient period of sustained alteration in the brain when compared to the baseline state (Carhart-Harris et al., 2014; Corlett et al., 2009; Tart, 1975/1983; Vaitl et al., 2005; Vollenweider & Geyer, 2001). Tart's emphasis on a baseline state of consciousness in itself is still highly relevant in the debate around whether psychiatric conditions can be considered ASCs because a baseline state is necessary to avoid the "reference problem" (see Introduction; Bayne & Howy, 2016; Metzner, 2005a; Tart, 1975/1983; Vaitl et al., 2005).

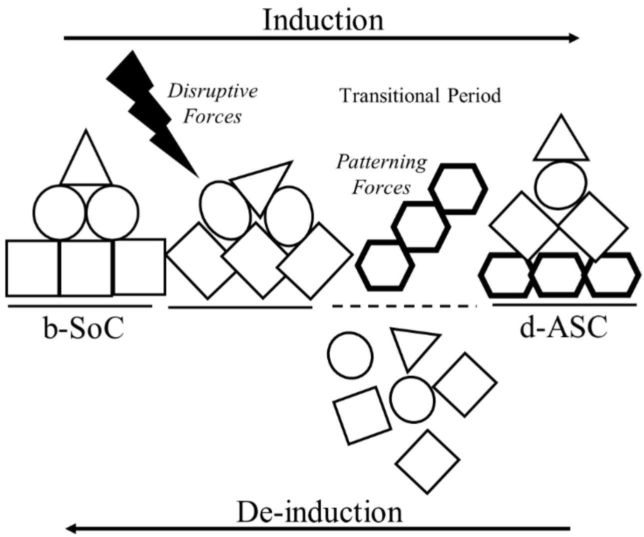

Figure 11. *Visualization of the Systems Model.* The figure displays shapes that loosely represent psychological structures and sub-structures that make up a discrete state of consciousness. Starting from the baseline state of consciousness (b-SoC), disruptive forces (manipulations of subsystems) destabilize its integrity. If these disruptive forces are strong enough, patterning forces (continued manipulations of subsystems) enter during a transitional period to lay the groundwork for a discrete altered state (d-ASC) complete with a new arrangement of psychological structures and sub-structures. This process is known as Induction. Since the default state is the b-SoC, the d-ASC will weaken over time back to a b-SoC, though this process can be expedited through anti-psychotics for example. This process is known as De-induction. The diagram was recreated by the authors from the source material (Tart, 1975/1983).

Intensity-Variability Scheme. Adolf Dittrich, who is best known for the development of the previously described 5D-ASC Rating Scale, acknowledged in his dissertation, that besides the study of subjective experiences, there is also knowledge to be gained from the systematic analysis of techniques that can induce ASCs. In 1985, he detailed the Intensity-Variability Scheme to describe inductions driven by a change in sensory stimulation such as sensory or perceptual deprivation and sensory overload (e.g., stroboscopic light stimulation). Dittrich placed these on a two-dimensional coordinate plane within the orthogonal axes of intensity and variability which can be increased or decreased from average levels of daily stimulation (Figure 12). Despite the scheme's simplicity, multiple additional methods, which Dittrich did not discuss could be placed. Techniques such as chanting or the whirling dervish [8]comprise the core dimension of affecting variability in not only sensory stimulation but also one's behavior. To the best of our knowledge, the addition of further axes has never been systematically followed up.

[8] The whirling dervish is a form of spiritual meditation often used in religious practice involving rhythmic music and simultaneous spinning movements in a small group. It is largely associated with the Sufi sect of Islam (Harel et al., 2021).

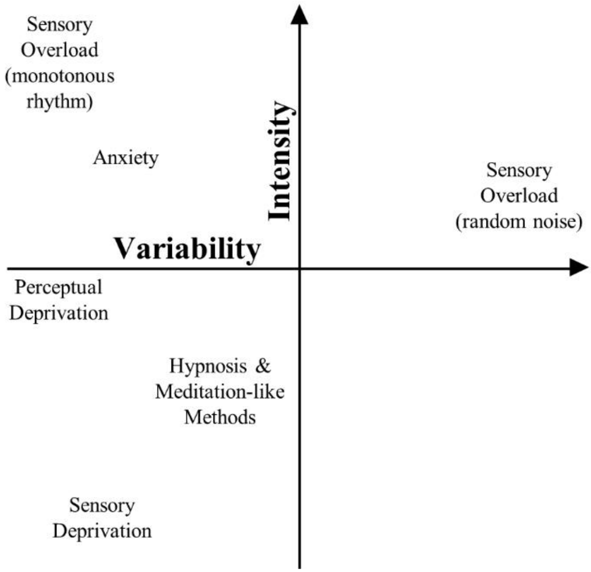

Figure 12. *Visualization of Dittrich's Intensity-Variability Classification Scheme.* The two dimensions (continua) of variability and intensity are represented by orthogonal axes creating a plane on which different ASC induction techniques are placed. For example, sensory overload, exemplified by stroboscopic light stimulation, exists at the high end of the variability continuum because of the intense randomness of incoming light. Figure recreated by the authors from the source material (Dittrich, 1985).

Induction-Domain Schemes. Induction-Domain Schemes are a subset of method-based schemes that attempt to classify by ASCs by the general category or domain of their induction method. In reviewing the literature, two attempts to sort ASC inductions into categories (i.e., domains) appear in 2005 and 2020. First, in their 2005 article, Vaitl and colleagues proposed a classification for ASC inductions based on the methods used to induce them (Vaitl et al., 2005). This Induction-Domain Scheme derives five categorical domains of induction method classification (Vaitl et al., 2005): (1) Spontaneously Occurring ASCs are defined as those that happen during daily activities due to spontaneous fluctuations in alertness and vigilance. The authors suppose a wakefulness-drowsiness-sleep continuum on which these ASCs are phenomenally experienced. The four major classes of spontaneously occurring ASCs are states of drowsiness, daydreaming, hypnagogic states, and sleep/dreaming. Near-death experiences are also considered spontaneously occurring. (2) Physically and Physiologically Induced ASCs encompass techniques that affect physiology. This classification involves extreme environmental conditions, starvation, forced respiratory maneuvers, and sexual activity/orgasm. (3) Psychologically Induced ASCs cover a wide range of techniques that stem from Eastern cultures, religions, and philosophy in addition to experimental stimulation procedures and clinical interventions including sensory deprivation, homogenization, and overload such as during rhythm-induced trance (drumming and dancing), relaxation, meditation, hypnosis, and biofeedback. (4) Disease Induced ASCs refer to multiple pathological conditions that result in various "degrees of ASC," (Vaitl et al., 2005). These disorders can affect brain structures, either directly or indirectly, resulting in shifts on the waking-coma axis and including psychotic disorders, coma and vegetative state, epilepsy with other diseases implicated such as Alzheimer's disease, Morbus Parkinson, and frontotemporal dementia (Vaitl et al., 2005). (5) Pharmacologically Induced ASCs are not reviewed by the authors but are still considered a part of the overall classification. One may consult drug classification schemes such as the Neuroscience-based Nomenclature (see below) or others for further description (Vaitl et al., 2005; Volgin et al., 2019; Zohar et al., 2015).

Vaitl et al's induction-domain classification can be seen, first, as a formal attempt to distinguish pharmacological from non-pharmacological ASC inductions through the supposition of categories, an approach that was also used later in 2020 by Cofré et al. In this article, researchers categorized ASCs by their method of induction (Cofré et al., 2020): (1*)* Natural or Endogenous referring to states within the sleep cycle such as deep sleep and dreaming; (2) Pharmacological referring to ASC induction via a psychoactive agent such as general anesthesia or production of the psychedelic state via psilocybin or LSD; (3) Induced by Other Means, such as meditation and hypnosis; (4) Pathological defined as ASCs brought about by neurological or psychiatric pathological processes such as DOCs, brain death, and epilepsy. Additionally, the authors further distinguish ASCs as either transitory or permanent based on their mechanism of induction. For example, the psychedelic state, as induced by LSD or psilocybin, is defined as transitory, brain death is defined as permanent, and DOCs are defined as either transitory or permanent.

In sum, the induction-domain classification schemes of both Vaitl et al. (2005) and Cofré et al. (2020) represent attempts at categorizing types of induction methods. Such approaches have experimental merit wherein the use of an agreed-upon Induction-Domain Schemes can assist in the operationalization of induction methods leading to greater generalizability and comparability among ASC data. Of note, both induction-domain classifications suggest the inclusion of DOCs and psychiatric conditions as being ASCs, first by Vaitl et al. via the Disease Induced domain and then by Cofré et al. via the Pathological domain both of which do not fall into the typical definition of ASCs (Farthing, 1992; Ludwig, 1966; Tart, 1975/1983).

Neuroscience-based Nomenclature (NbN). Different classifications for psychoactive drugs have been proposed as method-based classification schemes for ASCs. While some focus on chemical formulations, others emphasize the induced effects or mechanisms of action. These various approaches, and their refinement over time, reflect growing understanding of how pharmacological activity relates to subjective effects. For example, psilocybin, mescaline, lysergic acid diethylamide (LSD), and N,N-

Dimethyltryptamine (DMT) may be classified as hallucinogens referring to their subjective effects or alternatively as 5-HT_2A receptor agonists. In the latter case, the classification is focused on the main neuropharmacological mechanisms related to the drug effects (Becker et al., 2023; Holze et al., 2021; Klaiber et al., 2024; Rickli et al., 2016; Vollenweider et al., 1998). These various labels differ in whether they prioritize experiential outcomes or biological mechanisms.

While multiple drug classification systems could inform ASC research, we focus here on the Neuroscience-based Nomenclature (NbN) due to space constraints. The NbN was developed to shift away from traditional disease-based categorizations (e.g., antidepressant, antipsychotic) in favor of a framework grounded in mechanisms of action and targeted neurotransmitter systems (Zohar et al., 2015). In the context of ASC classification, the NbN contributes a neuropharmacological perspective to identify the relevant neural mechanisms to induce specific subjective effects. The popular Anatomical-Therapeutic-Chemical classification system of 1976, under the broad term psycho-analeptic (i.e., to exert a stimulating effect on the mind), had a disease-based focus (Zohar et al., 2015). However, its shortcomings were pointed out in a 2009 editorial by David Nutt (Nutt, 2009; Zohar et al., 2015). The NbN aimed to integrate contemporary scientific knowledge and focus on pharmacological domains and modes of action. For the 108 included drugs, 11 pharmacological domains were identified based on what neurotransmitter system they affect: Acetylcholine, Dopamine, GABA, Glutamate, Histamine, Ion Channel, Lithium Mimetic, Melatonin, Norepinephrine, Opioid, and Serotonin. At the same time, 10 modes of action are defined based on any given drug’s effect on neurotransmission: Receptor Agonist, Receptor Partial Agonist, Receptor Antagonist, Reuptake Inhibitor, Reuptake Inhibitor and Releaser, Reuptake Inhibitor and Receptor Antagonist, Enzyme Inhibitor, Ion Channel Blocker, Positive

Allosteric Modulator (PAM), and Enzyme Modulator (Zohar et al., 2015). While most of the contained drugs do not qualify as ASC-inducing agents (according to the typical definitions previously discussed), the NbN can be seen as a bridge between the purely method-based classification and neuro/physio-based classification systems. In sum, all types of purely pharmacology-based drug classification schemes could be seen as method-based classification schemes when ASC-inducing drugs are of interest. More advanced schemes like the NbN draw attention to the downstream neurobiological mechanisms that are stimulated by the drug.

1.2.3 Neuro/Physio-Based Classification Schemes

The evolution of psychoactive drug classification exemplifies how advancements in understanding physiological mechanisms can reshape classification schemes (Zohar et al., 2015). The first phase of this evolution begins with observations of a specific agent inducing ASCs which highlight the eventual identification of molecule-receptor interactions governing drug action, such as with psilocybin. The next phase involves pinpointing relevant physiological mechanisms underlying ASC experiences. For instance, hallucinations can occur as a result of 5-HT$_2$A receptor stimulation (e.g., classic serotonergic psychedelics), NMDA receptor antagonists (e.g., atypical psychedelics like ketamine), or sensory homogenization, indicating diverse pathways to similar phenomena. Neural correlates of hallucinations likely lie in computational principles activated by various ASC-inducing agents or techniques. Ongoing research reports numerous candidate mechanisms, correlates, and neurophysiological principles, including shifts in brain dynamics and measures from EEG and MRI studies (Amaya et al., 2023b; Carhart-Harris et al., 2014; Carhart-Harris & Friston, 2019; Corlett et al., 2009; Mortaheb & Fort et al., 2024; Schmidt et al., 2020; Vollenweider & Geyer, 2001). While neuronal mechanisms are commonly assumed as neural-correlates of consciousness, the term neuro/physio-based acknowledges other physiological processes that could serve as relevant correlates until further neural processes are understood such as blood CO_2 concentration or heart rate entropy (Havenith et al., 2024; Rosas et al., 2023).

Neurobiological and computational models of consciousness may have implications for ASC classification schemes, such as in the refinement of our understanding around neural correlates of consciousness as criteria for classification (see below). Ultimately, all theories of consciousness that describe neural mechanisms underlying ASC phenomena can inform a classification scheme (for an overview see Seth & Bayne, 2022).

Cortico-Striato-Thalamo-Cortical (CSTC) Feedback Model. The cortico-striato-thalamo-cortical (CSTC) Feedback Model is one example of a neurobiological model that can be used for ASC classification. The CSTC model suggests that phenomenological outcomes of ASC experience can be explained, in part, by the perturbance of feedback loops involving the thalamus (Vollenweider & Geyer, 2001; Vollenweider & Preller, 2020). Here, feedback signals control thalamic filtering of incoming sensory information, partially through the striatum, to determine which signals reach the cortex. While under normal circumstances, this filtering process removes irrelevant information, its perturbation is thought to be central in hallucination production, feelings of ego-dissolution, cognitive alterations in ASCs (Vollenweider & Preller, 2020). Certain ASC inductions, namely psychedelics, are thought to disrupt thalamic filtering allowing excess information to reach the cortex. This excess information is therefore unable to be processed due to disrupted communication between cortical brain areas (Geyer & Vollenweider, 2008; Vollenweider & Geyer, 2001; Figure 13).

The CSTC-feedback loop model primarily aims to explain the actions of psychedelic drugs inspired by psychosis research specific to the 5-HT$_2$A receptor (Vollenweider & Geyer, 2001; Vollenweider & Preller, 2020). Given its prominence and specificity, it can contribute to informing ASC classification schemes. For example, there is recent research specifically investigating thalamocortical connections of various ASCs on whether they are hypo- or hyper-connected (Amaya, et al., 2023b; Avram et al., 2022; Moujaes et al., 2023; Preller et al., 2019; Schmidt et al., 2020). As such, the CSTC Feedback Model can be considered a classification scheme whereby thalamocortical connectivity is considered a dimension with its high end represented by hyper-connectivity and its low end represented by hypo-connectivity. On that dimension, ASCs can be placed based on whether they are thalamocortically hyper- or hypo-connected as follows: (1) Thalamocortical Hyper-connected States such as those induced by propofol, LSD, ketamine, D-Amphetamine, MDMA, and flicker light stimulation; (2) Thalamocortical Hypo-connected States induced through multi-modal Ganzfeld[9] and potentially meditation, trance, and hypnosis (Amaya, et al., 2023b; Avram et al., 2021, 2022; Hove et al., 2016; Monti et al., 2013; Moujaes et al., 2023; Schmidt et al., 2020). Some induction methods, such as psilocybin use, can be classified as either depending on how thalamocortical connectivity is analyzed (Gaddis et al., 2022).

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[9] Multi-modal Ganzfeld (MMGF) is an ASC induction method done through mechanical sensory homogenization. In this induction, one is subject to a visual and auditory ganzfeld (whole field) typically through wearing ping-pong ball goggles and listening to white noise. While under this induction, participants can report pseudo-hallucinatory experiences such as the perception of colors changing, the appearance of shapes, and even witnessing dream-like imagery (Wackermann et al., 2008).

The CSTC model, in summation, is a neuro/physio-based classification scheme that suggests phenomenological outcomes of ASC are largely explained by the perturbance of CSTC feedback loops via the thalamus. It is supported by a growing body of neuroscientific literature showing how some ASC inductions reduce thalamic filtering of incoming information and increase information flow between the thalamus and cortical regions while simultaneously reducing connectivity between association cortices and the rest of the brain (Vollenweider & Preller, 2020).

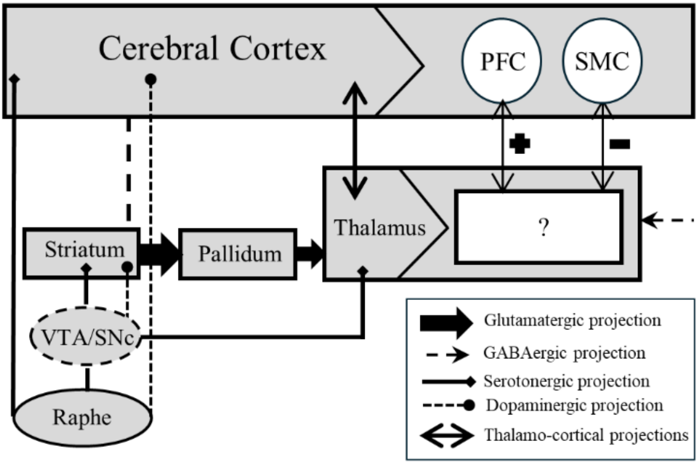

Figure 13. *Visualization of the Cortico-Striato-Thalamo-Cortical (CSTC) Feedback Loop Model.* Under psychedelics key brain circuits are engaged. Serotonergic projections from the raphe nuclei directly reach the striatum, thalamus, and the cortex (thick, diamond-end arrows). Dopaminergic projections from the ventral tegmental area/substantia nigra (VTA/SNc) target the striatum and cerebral cortex (dotted, circle-end arrows). The striatum, integrating both serotonergic and dopaminergic inputs, projects glutaminergic signals to the pallidum, which extends to the thalamus (thick block arrows). The thalamus, receiving serotonergic and glutamatergic inputs, exchanges bidirectional signals with the cerebral cortex (thick, bidirectional arrow). The cerebral cortex, reciprocating with the thalamus, receives serotonergic and dopaminergic inputs and sends GABAergic projections (dotted, pointed arrow) to the striatum. Within this circuit, the prefrontal cortex (PFC) and sensorimotor cortices (SMC) exhibit

shallow thalamic hyper-connectivity (thin, bidirectional arrow '+') and deep thalamocortical hypo-connectivity (thin, bidirectional arrow '-') with unspecified thalamic subdivisions (question mark) which also receive GABAergic projections. Figure adapted from the source material (Avram et al., 2021).

Hierarchical Alteration Scheme. In their 2005 paper, Vaitl et al. proposed an abstract neuro/physical model of ASC induction we call the Hierarchical Alteration Scheme (Figure 14; Vaitl et al., 2005). The Hierarchical Alteration Scheme illustrates that consciousness depends on the proper functioning and interplay of multiple brain systems that can be impaired such as brain tissue damage, neurotransmitter imbalance, hypo- or hyper-synchronization, dysconnectivity in neuronal firing, and fluctuations in arousal, as well as the effect of perceptual and cognitive alterations. This conceptual and abstract hierarchical organization helps display the interdependence of the levels and how they can be altered in parallel with any given induction method via their interconnectedness. The scheme's hierarchical nature is further exemplified by how lower levels lay groundwork through higher level changes. For example, changes in brain dynamics can lead to cascading changes in arousal and self-control, displaying a progression of influence at lower levels to higher levels.

One way to use the Hierarchical Alteration Scheme to inform ASC classification is to view each layer as a description of a state's primary mechanism of induction. In this sense, the hierarchy can be used like the method-based induction-domain classifications where each mechanism of induction is categorized by its primary association with a given level, for example: (1) Self-Control altered by techniques that affect cognition and self-regulation such as biofeedback, meditation, and hypnosis (2) Arousal altered by techniques that reduce vigilance such as drowsiness, hypnagogic states, sleep, and dreaming. (3) Sensory Input altered via perceptual hypo- or hyperstimulation techniques such as rhythmic stimulation, sensory flooding, deprivation, and homogenization. (4) Neurochemical/Metabolic Processes (Chemistry) altered primarily via conditions like starvation and near-death experiences. (5) Brain Dynamics are altered primarily by conditions such as epilepsy, psychotic disorders, and psychedelic drugs. (6) Structural (brain tissue) is altered primarily by DOCs, such as coma or the minimally conscious state.

For example, one could classify multi-modal Ganzfeld[9] as primarily a Sensory Input induction because its mechanism rests primarily on sensory homogenization; however, its effects are also heavily associated with reduced vigilance at the Arousal level as it mimics hypnagogic states (Wackermann et al., 2008). Additionally, MMGF has known effects at the Brain Dynamics level, meaning it must also have an impact on the Neurochemical level (Schmidt et al., 2020; Wackermann et al., 2008). Additionally, even primary associations themselves can be blurred. For example, psilocybin can be considered primarily associated with the Neurochemical level and the Brain Dynamics level based on its prominence in association with both the 5-HT_2A receptor and whole-brain hyperconnectivity (Mortaheb & Fort et al., 2024; Nichols, 2016). Although useful, this classification oversimplifies the complex parallel interactions among different levels.

The Hierarchical Alteration Scheme also informs further classification by describing an induction method, and its ensuing effects, at different levels of organization. LSD, for example, can be described at the Self-Control level by impacting emotional regulation, cognitive regulation, and introspection (Kaelen et al., 2015; McGlothlin et al., 1967). At the Arousal level, LSD can lead to disruptions in wakefulness, attention, and alertness (Jarvik et al., 1955; Kay & Martin, 1978). At the Sensory Input level, LSD can lead to vivid complex, and elementary imagery (Schmid & Liechti, 2018). At the Neurochemical level, LSD effects are highly associated with the 5-HT_2A receptor and changes in neurochemical signaling (Nichols, 2016). At the Brain Dynamics level, LSD is associated with whole-brain hyperconnectivity (Avram et al., 2024). At the Structural level, while LSD does not produce damage to brain tissue, prominent effects on neural networks have been reported (Schmidt et al., 2018). In sum, the Hierarchical Alteration Scheme can be interpreted as a neuro/physio-based classification scheme that can further inform classification based on how it produces organizational levels for the description of a given induction method.

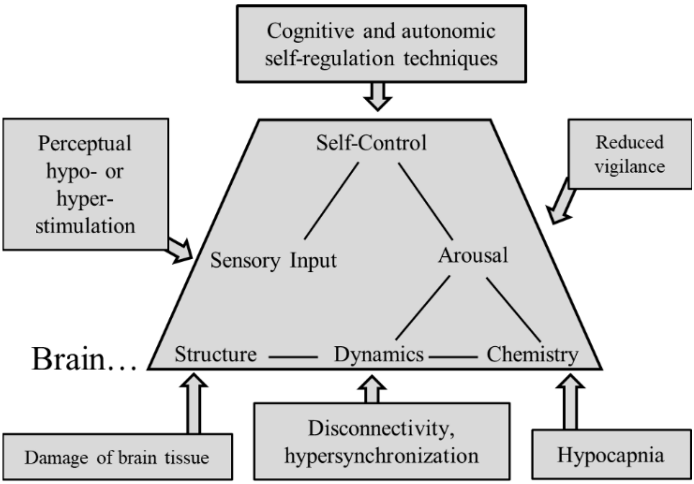

Figure 14. *Visualization of the Hierarchical Alteration Scheme.* The Hierarchical Alteration Scheme illustrates three levels of alteration horizontally set in the pyramid and their manner of altered state induction. The lines between levels represent their strong interdependence. The first level is that of Self-Control which can be altered by cognitive, autonomic, and self-regulation techniques. The next level is represented by Sensory Input and Arousal which can be altered via perceptual hypo-/hyperstimulation and reduced vigilance respectively. The third level represents Brain Structure, Dynamics, and Chemistry which can be altered by brain tissue damage, dysconnectivity/hypersynchronization, and hypocapnia respectively. Figure recreated by the authors from the source material (Vaitl et al., 2005).

Entropic Brain Hypothesis (EBH). EBH integrates principles of physics, neurobiology, and psychoanalysis, proposing that ASCs result from changes in entropy, or disorder, of a previously stable brain state like the normal waking state (Figure 165; Carhart-Harris et al., 2014; Carhart-Harris, 2018). Entropy, as defined by the authors, refers to the measure of randomness or disorganization in neuronal firing and the corresponding information content of any dynamic system (Carhart-Harris et al., 2014a; Carhart-Harris, 2018). As such, one can view ASCs as being classified across this singular dimension of entropy whereby ASCs are marked by changes in entropy, and the normal waking state is viewed as being at a point of criticality between high and low entropy.

Criticality is then a property of a system poised for transition between order and disorder. Super criticality represents chaotic and random neuronal activity which can be seen in seizures, severe mental health episodes, and some ASCs (Carhart-Harris et al., 2014a). High entropy can mark the emergence of psychedelic states and low entropy can mark DOCs such as coma and the vegetative state. This point of criticality marks the division between Primary States and Secondary States of ASCs (Carhart-Harris et al., 2014a). Primary States are defined as high entropy ASCs involving regressed cognition such as those experienced through LSD, DMT, ketamine, psilocybin, and potentially breathwork (Lebedev et al., 2016; Lewis-Healey et al., 2024; Schartner et al., 2017; Viol et al., 2017). Secondary States are, therefore, low entropy, or entropy suppressed, states involving narrow cognition and, at their most extreme, bring about reduced consciousness (e.g., DOCs). The normal, waking state is maintained at existing just before the point of criticality and therefore relies on entropy suppression to maintain itself.

A follow-up on EBH proposed that the subjective quality of any conscious state (i.e., qualia; e.g., the vividness of color or the feeling of pain) can be indexed by measuring the magnitude of entropy in a given spontaneous parameter of brain activity, such as EEG (Carhart-Harris, 2018). This equates uncertainty and information content as almost equal, suggesting the Primary States as both high in entropy and high in phenomenological content. EBH is extended as imposing upper and lower bounds of criticality from which ranges of states can arise to comprise the critical zone where the state exists as balancing flexibility and stability, yet it is maximally sensitive to perturbance (Figure 15B). Moving to this formulation of EBH where the point of criticality becomes the "critical zone," allows for a more nuanced understanding of how entropy indexes Primary and Secondary States by introducing more space for states to occupy within the critical zone as illustrated by the state range.

In sum, the general themes of EBH are as follows (Rankaduwa & Owen, 2023): 1) Conscious states are classified by the degree of the system's entropy; 2) higher entropy equals greater uncertainty over the system from an external perspective of any observer or technique; 3) the two main states are primary and secondary, where primary represents the primitive, regressed cognition of the pre-ego and secondary represents the normal, waking state; 4) The ego uses entropy suppression to modulate activity and finesse world representations to maintain secondary consciousness; 5) primary states involve higher criticality than secondary states where psychedelic states are a paradigmatic example of primary consciousness (Carhart-Harris et al., 2014a; Carhart-Harris, 2018).

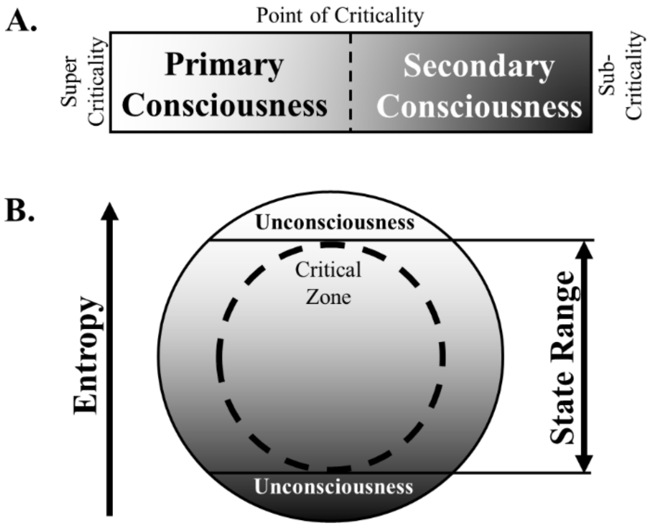

Figure 15. *Visualization of the Entropic Brain Hypothesis.* The figure illustrates the basic principles of the entropic brain hypothesis. A) A gradient from white (high entropy) to black (low entropy) represents the dimension of entropy and its change. Primary consciousness represents the area where primary states can be mapped via high entropy, and secondary consciousness represents the area where secondary states at low entropy can be mapped. These two types are divided by the point of criticality where the system is balanced between flexibility and stability, yet maximally sensitive to perturbation. The normal, waking state exists just before this point. B) The bottom figure represents revisions to EBH. The gradient now visualized as a circle where the point of criticality has become a zone existing between high entropy unconsciousness and low entropy unconsciousness. Within this zone, the state is still maximally sensitive, and the range of possible states exists between the upper and lower bounds of this zone. This visualization shows greater variation and space for Primary and Secondary states to occupy as marked by the State Range. Figure recreated by the authors from the source material (Carhart-Harris et al., 2014a; Carhart-Harris, 2018).

Bayesian Predictive Coding Models. The concept of predictive coding can be traced back to the work of Hermann von Helmholtz who formulated that unconscious inference allows one to infer the causes of incoming sensory data (Helmholtz, 1867). The ensuing view that most of our brains' computations are based on probabilistic learning and statistical inference has become popular in neuroscience under the catch-all term “Bayesian Brain Hypothesis” (Friston, 2012). Multiple authors formulated hypotheses on how corresponding computational principles might be affected in ASCs, opening the potential for classification of ASCs based on these principles (Carhart-Harris & Friston, 2019; Corlett et al., 2009, 2019). In particular, Predictive Coding Models have become popular as a framework for how Bayesian inference is realized in hierarchically organized cortices.

In short, the cortical hierarchies are thought to implement a generative model which predicts future events in order to make perception and action efficient. Predictions are propagated as top-down signals throughout the hierarchy to be compared to sensory bottom-up information. This comparison of these is happening on every hierarchical level in terms of Bayes’ Theorem: predictions (i.e., also termed beliefs or expectations) are priors, which are combined with sensory input/observation (i.e., likelihood) to compute the actual experienced percept (i.e., posterior probability).

This computation is thought to make the interpretation of noisy sensory information particularly efficient. Whenever the inner generative model diverges from the actual sensory input, a prediction error is generated and is then used for learning and updating priors (i.e., ascending prediction errors; Friston, 2005) In sum, the interpretation of any given sensory input can be considered as the “best-guess” interpretation of noisy sensory signals, given previous learning. Thereby, it is thought that an organism adapts to its dynamic environment in an energy efficient way by more accurately interpreting sensory irregularities. Predictive models of brain function have been formulated with different degrees of detail and focus. As illustrated in Figure 16A, hierarchical cortices interact by bottom-up and top-down glutamatergic signal transmission. Bastos et al. suggested detailed circuitries and specify the neuronal populations within a cortical column, which are thought to realize the central computations on every level of the hierarchy (Bastos et al., 2012). Mostly superficial and deep layer pyramidal cells are thought to implement the computation of Bayes' Theorem, in a balance of inhibitory and excitatory circuitries. Additionally, the balance of NMDA and AMPA receptor signaling in forward and backward projections is thought to be relevant in maintaining normal perception (Corlett et al., 2019; Sterzer et al., 2018).

When predictive mechanisms become unbalanced, the underlying computational principles could explain altered processing seen in psychosis or under the influence of psychedelics, leading to phenomena such as perceptual anomalies (Carhart-Harris & Friston, 2019; Corlett et al., 2019; Sterzer et al., 2018), ego dissolution phenomena (MacLean et al., 2011), delusional beliefs (Corlett et al., 2009; Sterzer et al., 2018), and/or hypersuggestibility (Lebedev et al., 2023). Consequently, Predictive Coding Models can be used to classify ASCs in terms of their specific computational aspects (i.e., model parameters) which are altered to produce different types of ASCs. As recent mathematical formulations of Predictive Coding Models are biologically inspired, the affected model parameters can either be termed as biological mechanism (e.g. NMDA-receptor overstimulation) or in computational terms such as changes in the precision of priors.

Here, we will focus on three popular suggestions to explain different types of ASCs, namely the Bayesian Framework for ASCs (Corlett et al., 2009), the Relaxed Beliefs Under Psychedelics (i.e., REBUS) and Anarchic Brain (Carhart-Harris & Friston, 2019), and the Strong Prior Account (Corlett et al., 2019). All these models share that ASCs are characterized by a disruption in the balance of top-down (i.e., predictive) and bottom-up (i.e., sensory) signaling; however, they focus on different model parameters.

Originally referred to as the Bayesian Framework for Psychosis, Corlett et al. aimed to explain the emergence of delusions and hallucinations in terms of predictive coding such that psychotomimetic symptoms (e.g., ASC phenomena) arise with either top-down or bottom-up domination in hierarchical processing (Corlett et al., 2009). This framework allows for the comparison of both pharmacologically and non-pharmacologically induced ASCs. For example, amphetamine (single dosing) and sensory deprivation are considered to induce top-down dominated processing, whereas ketamine, LSD, and cannabinoids are considered to enhance bottom-up signaling. Taken together, the model of Corlett et al. is of historic importance, although today multiple of its described mechanisms are better understood with more details (i.e., model parameters) that go beyond the mere focus on top-down or bottom-up dominant states.

Building on the Bayesian Framework for ASCs, Corlett et al. more recently proposed the Strong Prior Account of ASCs, suggesting that hallucinations occur when prior beliefs (i.e., top-down signaling) exert strong influence on perception (Corlett et al., 2019). In this model, hallucinations are thought to primarily originate from increased precision of priors (i.e., when priors are considered as Gaussian, this corresponds to a narrower distribution; Figure 16B). Consequently, perception is dominated by these overly precise priors, which result in perceptual distortions and hallucinations.

Carhart-Harris and Friston (2019) formulated a predictive coding model to explain the effects of psychedelic drugs, called the Relaxed Beliefs Under Psychedelics (REBUS) and the Anarchic Brain model. It combines the central idea of the EBH, i.e., that increases in entropy lead to ASCs (see above; Carhart-Harris et al., 2014), with Bayesian predictive processing. The REBUS model suggests that priors with less precision (i.e., flatter Gaussian distribution; Figure 16B), but higher influence, can lead to perceptual misinterpretations when interacting with strong unfiltered sensory bottom-up signals (Carhart-Harris & Friston, 2019). Furthermore, the model posits that this "relaxation" of priors increases the brain's computational flexibility to allow for the updating of priors that may be overly strong (i.e., maladaptive or rigid) in psychiatric illnesses.

Taken together, Predictive Coding Models offer the opportunity to classify ASCs in terms of neurobiological, neurochemical and computational mechanisms (Carhart-Harris & Friston, 2019; Corlett et al., 2009, 2019). The existing models for ASCs are formulated with different degrees of granularity, reflecting the progress in understanding the effects of different model parameters on the biological and computational level. Thereby models developed starting from mere groupings based on one parameter (e.g., top-down or bottom-up domination) can inform more complex classification by considering multiple model parameters, such as specific neurotransmission, entropy measures, and modulation of priors' precision on different levels of the hierarchy. Future extensions of these models might incorporate active inference to explain the effects of repetitive, monotonous induction methods, such as chanting or the whirling dervish ritual, which create highly predictable sensory stimulation and thereby facilitate entrance into ASCs (Brown et al., 2013; Vilas et al., 2022).

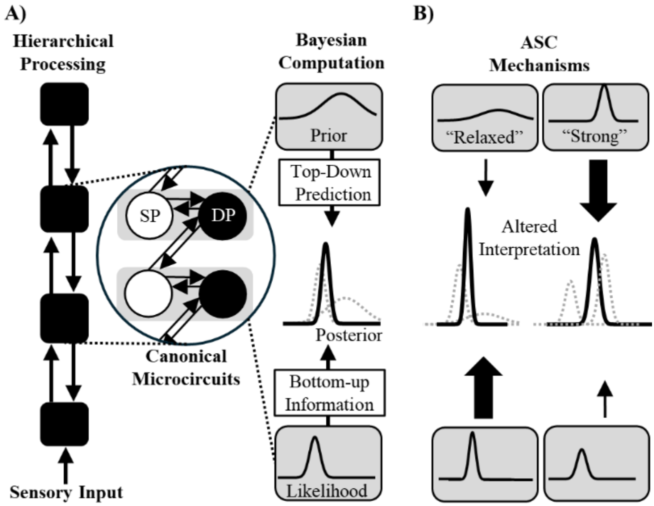

Figure 16. *Visualization of the General Predictive Coding Model.* A) In an average wakeful state sensory input enters the brain's cortical hierarchy as bottom-up signals. In the specification of the most relevant circuitries of predictive coding, termed canonical microcircuits (Bastos, 2019), neuronal populations (i.e., circles) of superficial (SP) and deep layer pyramidal (PS) cells are considered computationally relevant. In a dynamic interplay of bottom-up and top-down signaling, their interaction is thought to implement the computation of Bayes' Theorem in an exchange between each level of the cortical hierarchy. At its core, this computation corresponds to the calculation of the difference signal (i.e., prediction error) between top-down predictions (based on priors) and sensory bottom-up information (i.e., likelihood). The application of Bayes' Theorem results in the posterior, corresponding to the interpretation of a stimulus. The prediction error is consequently used to update the brain's generative model by updating prior beliefs in terms of probabilistic learning. B) Within this computational formulation, different computational aspects (i.e., model parameters) can be altered during ASCs. Carhart-Harris and Friston (2019), speculated that the effects of psychedelics are likely to be explained by "relaxed" priors (less precision), which result in stronger ascending prediction errors. In combination with stronger sensory bottom-up signals (i.e., sensory flooding due to altered thalamic function), perceptual interpretation is less supported by previously learned world knowledge and hallucinations are more likely to occur. In contrast, Corlett et al. (2019) suggest that hallucinations and delusions can be explained by an increased precision of priors. Here, it is thought that the enhanced impact of priors biases perception towards expectations and

therefore promotes misinterpretations of sensory signals. These different suggestions illustrate that predictive coding models provide a framework for classification of ASC phenomena based on different neurobiological or computational parameters (e.g., reduced bottom-up signaling due to NMDA blockage, modulation of precision of priors or likelihood, strength of bottom-up or top-down effects, and altered propagation of prediction error).

1.3 Core Features of ASCs

Across the reviewed state-based classification schemes some concepts reappear. To better understand these commonalties, we informally extracted 113 terms that best represented their respective state-based classification schemes via explicitly named features or terms that best represented what a given classification was trying to convey as different features of ASCs. We then organized the extracted terms based on conceptual meaning rather than specific wording (see Appendix A for a list of the original terms and how they were coded for the analysis). After assigning a frequency to each term, they were organized into eight clusters in a face-valid manner where synonymous or overlapping constructs were assigned to shared categories to reduce terminological redundancy. The clusters were then visualized into word clouds using the tm and wordcloud packages in RStudio (Figure 17; R Core Team, 2025).

Here, the size of the terms reflects the frequency of these concepts across the reviewed classification schemes. Additionally, Table 2 shows how these eight clusters appear across the reviewed state-based classification schemes. This method complements recent work by Yaden et al. (2024) but differs in its broader historical score and clustering across frameworks beyond psychedelic questionnaire data. In the present review, we go beyond ASCs induced by psychedelics and aim to provide an overview and synthesis for all types of ASCs. For example, while Yaden et al. cluster terminology across selected questionnaires used in psychedelic drug studies, we cluster terminology across frameworks that span the whole history of ASC research. Finally, while Yaden et al. performed clustering on questionnaire terms, it was done in a purely face-valid manner whereas our clustering is supplemented by coding key words and terms (see Appendix A). Ultimately, these reviews complement each other when aiming to search for clinically relevant phenomenology.

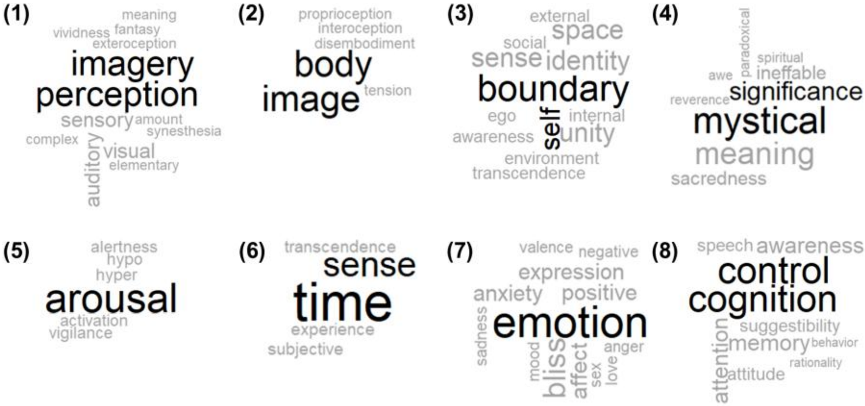

Figure 17. *Core Features of ASCs: A Provisional Eight-Dimensional Framework.* The figure represents word-cloud clustering to visualize the common core features of subjective experience implicated under ASCs as they are covered across the reviewed classification schemes. 113 extracted terms generated eight clusters/core features which could be termed as follows: (1) Perception and Imagery, (2) Bodily Sense, (3) Self-Boundary, (4) Mystical Significance, (5) Arousal, (6) Time Sense, (7) Emotion, and (8) Control and Cognition. The size of the terms reflects the frequency of these concepts across the reviewed classification schemes.

	Bodily Sense	Arousal	Self-Boundary	Perception & Imagery	Time Sense	Emotion	Mystical Significance	Control & Cognition
Categories of a Typology of Mysticism			X		X	X	X	X
Subjective-Intensity Scheme				X			X	
General Characteristics of ASCs	X			X	X	X	X	X
The Arica System				X		X	X	
Cartography of Ecstatic and Meditative States		X						
Varieties of Transpersonal Experience							X	
The Spectrum of Consciousness			X				X	
Systems Model (Subsystems)	X		X	X	X			X
Etiology-Independent Structures of ASCs	X	X	X	X		X	X	X
Empirical-Phenomenological Approach	X	X		X	X	X	X	X
Dimensions of Changed Subjective Experience in ASCs	X	X		X	X	X	X	X
General Heuristic Model of ASCs	X		X		X	X		X
Arousal-Hedonic Scheme		X				X		
Four-Dimensional Descriptive System		X	X					X
Three-Dimensional Sphere (3DS) Models					X	X		X
Total	**6**	**6**	**6**	**7**	**7**	**9**	**9**	**9**

Table 2. *Classification Schemes Implicated in the Core Features of ASCs.* The core features of ASCs and which classification scheme mentions them as visualized in a table.

(1) Perception and Imagery. Most classification schemes consider distortions of perceptions, such as auditory and visual hallucinations, as integral parts of ASC experiences with gustatory, olfactory, tactile, and kinesthetic changes also mentioned (Dittrich, 1998; Farthing, 1992; Ludwig, 1966; Pekala et al., 1986; Studerus et al., 2010; Tart, 1975/1983; Vaitl et al., 2005). These changes in the Perception/Imagery feature are viewed as quintessential to many ASC experiences, e.g., psychedelics are sometimes referred to as hallucinogens (Nichols, 2004; Osmond, 1957). Some authors emphasize the difference of a percept being considered as real compared to the ability of a person to identify it as illusory perception. This differentiation is sometimes referred to as the distinction between hallucinations and pseudo-hallucinations (Hare, 1973; Jaspers et al., 1913/1963; Königsmark et al., 2021). Another distinction can be found between changes in how the outside world is sensed and changes in fantasy or mental imagery, while both might be more or less under volitional control (Farthing, 1992). A further common distinction within the cluster is made between simple and complex content, e.g., the 11-ASC has both the Elementary Imagery factor and the Complex Imagery factor (Studerus et al., 2010). Simple visual phenomena are typically described to include basic shapes, colors and patterns, while more complex visual phenomena includes dream-like imagery with various content, such as seeing archaic dream motifs (Grof, 1972; Wackermann et al., 2008) or perceiving fantastical beings or gods (Gallimore & Luke, 2015; Grof, 1972; Leary et al., 1964/1992; Lilly, 1972/2017; Luke, 2011; Tramacchi, 2006). Specifically complex visual content is often thought to interact with other aspects of ASCs, for example with mystical experiences or affect such as in the case of unfamiliar visual content causing anxiety.

(2) Bodily Sense. Various ASC classification schemes mention changes in the sense of one's own body and/or implicate bodily systems such as proprioception and interoception (Dittrich, 1998;

Farthing, 1992; Ludwig, 1966; Metzner, 2005a; Pekala et al., 1986; Studerus et al., 2010; Tart, 1975/1983). The PCI and 5D-ASC include measures for this, with items assessing experiences like feeling expanded beyond one's body boundaries (Dittrich, 1998; Pekala et al., 1986; Studerus et al., 2010). Intense ASCs, such as those brought about by strong psychedelic drugs or near-death-experiences, can sometimes lead to out-of-body experiences which exemplify Body Image alterations (Fritz et al., 2023; Lilly, 1972/2017; Timmermann et al., 2018). For instance, Lilly described feeling disembodied during a near-death experience, later resembling his LSD experience (Lilly, 1972/2017). While such anecdotes abound, there is still debate around whether there is enough empirical data to consider out-of-body experiences an essential component of near-death experiences (Fritz et al., 2023, 2024; Parnia, 2014). Together, investigations on changes in the Bodily Sense feature, and its interrelatedness with the Time Sense and Self-Boundary features, can offer insights into ASC mechanisms and consciousness research (Hruby et al., 2024; Kent & Wittmann, 2021).

(3) Self-Boundary. The dissolution of self-boundary, sometimes referred to as a sense of unity or oneness, is a central theme across multiple ASC classifications[10] (Dittrich, 1998; Farthing, 1992; Ludwig, 1966; Pahnke, 1963; Pekala et al., 1986; Studerus et al., 2010; Tart, 1975/1983; Wilber, 1975). Diverse terminology describing this experience can be found across the literature such as losing the sense of self (Millière et al., 2018), oneness with life or the universe (Grof, 1972), depersonalization and derealization

[10] It is important to note that a sense of oneness and self-boundary dissolution are not inherently linked as one can feel a sense of oneness with the self-boundary still intact; however, they often coincide. For simplicity, they were reviewed together under the Self-Boundary cluster.

(Lindahl & Britton, 2019; Millière et al., 2018; Sleight et al., 2023), ego-loss (Leary et al., 1964/1992; Nour et al., 2016), ego-dissolution (Dittrich, 1998; Klee, 1963; Nour et al., 2016), ego disintegration (Nour et al., 2016; Sachar et al., 1970), ego-death (Grof, 1980; Nour et al., 2016), or unity (Pahnke, 1963; Studerus et al., 2010). When such experiences include positive valence, it has been more broadly, and metaphorically, termed Oceanic Boundlessness (Dittrich, 1998). Conversely, Dread of Ego Dissolution is used when these experiences involve negative affect (Dittrich, 1998). Lilly previously referred to this relationship between Self-Boundary dissolutions and emotional valence in the formation of the Positive and Negative Classical Satori States (Lilly, 1972/2017).

The concept of unity experiences is closely linked to the Self-Boundary feature as it often describes a sense of oneness with the environment that can arise from its dissolution. For example, Unity, according to the MEQ, can be experienced either internally or externally. Internal unity refers to a dissolution of the self/other boundary, leading to a feeling of merging with pure awareness (Pahnke, 1963). On the other hand, external unity involves a sense of oneness with external objects, animate or inanimate (Pahnke, 1963). Modern ASC research further explores self-boundary dissolution through depersonalization and derealization experiences, which involve disconnect from the self and altered perceptions of reality (Lindahl & Britton, 2019; Millière et al., 2018; Sleight et al., 2023).

(4) Mystical Significance. A heightened feeling of significance during and after ASC experiences are described by multiple authors (Dittrich, 1998; Farthing, 1992; Ludwig, 1966; Pekala et al., 1986; Studerus et al., 2010) that can also be experienced as mystical or religious[11] (Grof, 1972; Leary, 1964; Lilly, 1972/2017; Pahnke, 1963; Wilber, 1975). The most notable examples were reported by Pahnke and replicated by Griffiths et al, where participants of the Good Friday experiment rated their psilocybin-induced experiences as among the most significant experiences of their lives (Griffiths et al., 2006; Nichols, 2016; Pahnke, 1963). There appears to be a relationship between the significance and overall intensity of an ASC, especially when the experience is perceived as meaningful in a spiritual or mystical context. For example, items such as "I experienced a kind of awe," contribute to the factor Spiritual Experience (Dittrich, 1998; Studerus et al., 2010), while "I felt very profound," and "I gained clarity into connections that puzzled me before," belong to the factor of Insightfulness. Research has shown that the mystical-type effects measured by both the 5D-ASC and MEQ are strongly intercorrelated when used to measure the same subject undergoing an ASC, such that Oceanic Boundlessness shows a strong, positive correlation with total mystical scores (Liechti et al., 2017).

Sometimes, mystical experiences are reported as ineffable due to their felt incongruence with the objective reality (Ludwig, 1966; Pahnke, 1963). Language limitations often hinder their full articulation, leading to the use of metaphoric, archaic, or religious terminology that can introduce conceptual difficulties (Grof, 1972; Leary, 1970; Pahnke, 1963). Glicksohn (1993) formulated the suggestion that ineffability might come with a neurocognitive shift to right-hemispheric dominance, favoring non-language dependent

[11] Due to the nebulous nature of the term "mystical" (see Mosurinjohn et al., 2023) we decided to name this cluster alongside its second most frequent term (meaning or significance) for better context and clarity.

cognition, however, hemispheric asymmetries did not gain major attention in contemporary neuroimaging work on ASCs. Psychometric tools capture the variation of these mystical experiences. For example, the PCI's minor dimension of Altered Meaning is mainly comprised of items related to mystical interpretations. Similarly in the MEQ, the concept of Sense of Sacredness is formulated, which implicates feelings of awe and relevance that must involve, per their definitions, elevated feelings of meaning (Pahnke, 1963; Pekala et al., 1986). The aim of these measures is to quantify the personal significance that is often associated with such experiences. However, the term "meaning" is not always used to refer to the significance or personal relevance of an experience. For example, the 11-ASC factor Changed Meaning of Percepts relates to interpretation regarding perceptual processes, and therefore relates more to Perception/Imagery (Dittrich, 1998; Studerus et al., 2010). Taken together the conceptualizations of changed meaning in the literature varies and thereby emphasizes the non-independence of perception/imagery, mystical interpretations, and the general evaluation of an event as important for oneself.

A particular limitation of this cluster is that it may lack sufficient phenomenological exclusivity. Mystical experiences often involve several other phenomenological features, such as vivid imagery, heightened emotion, and alterations in self-experience. This raises the question of whether Mystical Significance should be treated as a fundamental first-order dimension of experience or instead as a higher-order evaluative cluster that integrates multiple experiential components. A related concern is articulated by Mosurinjohn et al. (2023), who argue that the construct of psychedelic "mystical experience" is conceptually heterogeneous, combining phenomenological descriptions, affective responses, and judgments of personal or spiritual significance. Such heterogeneity

complicates the assumption that mystical experience reflects a single, unitary psychological process.
One way to understand this pattern is that mystical-type experiences tend to occur when several phenomenological features are strongly activated at the same time. For example, intense positive emotion, vivid imagery, altered time perception, and dissolution of self-boundaries may co-occur within a single episode. When multiple features are expressed at high intensity simultaneously, the overall experience may be interpreted as sacred, profound, or deeply meaningful. In this view, Mystical Significance may not represent a distinct first-order dimension of experience, but rather a higher-order appraisal that emerges from the combined activation of other experiential processes. Thus, greater subjective intensity increases the likelihood that multiple features will co-occur, thereby increasing the probability that an experience will be interpreted as mystical.

For example, Griffiths et al., (2008) showed that high-dose psilocybin (30mg/70 kg) frequently occasioned experiences later rated as among the most personally meaningful of participants' lives, with mystical-type measures statistically mediating these long-term attributions even when controlling for variance in intensity. Extending this work, Griffiths et al., (2016) demonstrated that comparable enduring benefits and mystical-type effects do not reliably occur at low doses (3mg/70kg), suggesting that a minimum level of subjective intensity is required to evoke mystical-type phenomenology. Taken together, these findings suggest that subjective intensity must reach a sufficient threshold for mystical-type phenomena to become probable, but elevated intensity alone does not guarantee that such experiences will occur. This interpretation evidences a potential conceptual limitation in the Core Features framework that presents Mystical Significance alongside first-order phenomenological features.

(5) Arousal. Across ASC classification schemes, changes in awareness, reactivity, vigilance, and wakefulness are described in a varied manner (Dittrich, 1998; Farthing, 1992; Fischer, 1971; Metzner, 2005a; Vaitl et al., 2005). While the term "arousal" lacks precision in distinguishing between emotional and physiological arousal, it is clustered here based primarily on its conceptual and psychometric use in relation to how energetic one feels.
While Fischer and Metzner frame arousal similarly, what differs is Metzner's inclusion of the Hedonia dimension, Metzner suggests that arousal together with emotion are sufficient to categorize ASCs (Fischer, 1971, 1992; Metzner, 2005a). Through the dimension of Activation, defined as the readiness of an individual to interact with their environment, Vaitl et al. also refer to the importance of arousal. This concept of readiness relates to wakefulness, as discussed by Farthing, who defines the dimension of Changes in Arousal as including specific arousal states, such as hypnagogic states related to sleep (Farthing, 1992).
The concept of arousal is also captured in questionnaire items measuring wakefulness or vigilance. For example, the 5D-ASC includes the dimension of Vigilance Reduction to assess how awake one is (Dittrich, 1998). The Arousal cluster could also be referred to as Wakefulness or Alertness; however different authors use varied terminology.

(6) Time Sense. The impact of ASCs on subjective time has been extensively documented in various writings and classification schemes. Early 20th-century philosopher Walter Benjamin and author Aldous Huxley both described the time-altering effects of substances like hashish and mescaline, highlighting a sense of timelessness and eternity (Benjamin et al., 2006; Huxley, 1928/2009a; Wittmann, 2018). Grof's work categorized ASC experiences, such as Temporal Expansion, where one's sense of time encompasses past, present, and future (Grof, 1972). Changes in Time are represented in psychometric measurements like the

MEQ, capturing experiences of time standing still or feeling endless where it sometimes referred to as eternity or infinity (Pahnke, 1963). The 5D-ASC and PCI also measure changes in the Time feature, with the former assessing both positive and negative valences of this phenomenon (Dittrich, 1998; Pekala et al., 1986; Studerus et al., 2010).

Empirical evidence suggests that changes in the Time feature are not limited to pharmacological inductions but are observed across various ASC induction methods, including sensory deprivation, sensory homogenization, and meditation (Berkovich-Ohana et al., 2013; Glicksohn et al., 2017; Kübel et al., 2021). These distortions are intricately linked to the Self-Boundary and Bodily Sense features, indicating a weakening of the sense of body boundaries (Dittrich, 1998; Pahnke, 1963; Studerus et al., 2010). Recent research has demonstrated such weakening together with a distortion of the Time feature in Floatation-REST (Restricted Environmental Stimulation Therapy; Hruby et al., 2024) which are comparable to the weakening of body boundaries during meditation in meditation-naïve (Dambrun, 2016) and experienced meditators (Linares Gutiérrez et al., 2022) with the latter also reporting a diminished sense of time (Berkovich-Ohana et al., 2013; Droit-Volet & Dambrun, 2019). In sum, the Time Sense feature represents an aspect of ASCs that are heavily interrelated with Self-Boundary dissolutions and changes in Bodily Image.

(7) Emotion. Emotional experiences are central to many ASC classification schemes (Berkovich-Ohana & Wittmann, 2017; Dittrich, 1998; Farthing, 1992; Lilly, 1972/2017; Ludwig, 1966; Metzner, 2005a; Pekala et al., 1986; Studerus et al., 2010). Both positive emotions such as love, bliss, joy, sexual excitement, and negative emotions such as sadness, fear, pain, and anxiety are commonly reported during ASCs. The conceptual importance of the Emotion feature in ASCs is notably explored by Lilly where he attempted to map states in regard to their subjective intensity and emotional valence (Lilly, 1972/2017). For instance, the Positive Classical Satori State represents a peak blissful experience while the Negative Classical Satori State is defined as a feeling of hell. This demonstrates how the Emotion feature is deeply interrelated with the Mystical Significance feature.

Psychometrically, the MEQ demonstrates this interrelatedness of the Emotion and Mystical Significance features. For example, two dimensions of the MEQ are Deeply Felt Positive Mood and Persisting Positive Changes in Attitude and Behavior which evidence how positive emotions are measured as part of a mystical experience. This is seen in the Good Friday Experiment where participants described intense joy, bliss, and love under psilocybin (Pahnke, 1963). The 5D-ASC similarly assesses the Emotion feature via the Oceanic Boundlessness dimension (i.e., positive) and the Dread of Ego Dissolution dimension (i.e., negative). These are represented more specifically by factors such as Blissful State and Anxiety (Dittrich, 1998; Studerus et al., 2010). The PCI also assess the Emotion feature through the minor dimensions of Joy, Love, and Sexual Excitement (i.e., positive) and through the minor dimensions of Anger, Fear, and Sadness (i.e., negative; Pekala, 2013; Pekala et al., 1986). Of interest, research has shown interrelatedness between ratings of emotion such that positive mood measures in the MEQ show a strong, positive correlation with Oceanic Boundlessness in the 5D-ASC (Liechti et al., 2017).

(8) Control and Cognition. Various alterations in cognitive functions, including memory distortions, impaired rational thought, increased suggestibility, and reduced volitional control, are frequently reported across ASC literature. These effects, broadly understood as changes to cognition, are often interrelated yet conceptually independent, encompassing a range of higher-order processes. Within the 5D-ASC, for example, difficulties in decision-making or maintain coherent thought are evaluated, particularly in states like alcohol intoxication, though these features are less prominent in "classic psychedelic states." In addition, decreased volitional control is reflected in subjective reports of lacking agency or feeling controlled "like a marionette" (Dittrich, 1998; Studerus et al., 2010).

Importantly, while control is a subset of cognition, it emerged so prominently in ASC literature that it sometimes appears alongside cognition rather than within it. This is evident primarily in the 11-ASC scoring scheme where Impaired Control and Cognition is a distinct factor suggesting their conceptual entanglement. This is also supported by our informal synthesis of core features across state-based schemes where control and cognition appear to be discussed with similar frequency and importance. As such, the cluster Control and Cognition[12] is meant to represent the particular importance of control, or volition, in ASCs when talking about broad changes to cognition.

Several researchers attempt to parse the functions of cognitive changes under ASCs in varying ways. Ludwig separates Alterations in Thinking, Hypersuggestibility, and Loss of Control which is similar to the distinction of different cognitive functions found in Farthing's work (Farthing, 1992; Ludwig, 1966). The PCI assesses the Cognitive feature through major dimensions like Internal Dialogue (e.g., as a result of decreased volitional control), Rationality, Control, and Memory (Pekala et al., 1986; Pekala, 2013). Farthing mentions Changes in Attention, Changes in Inner

[12] It is important to note that this cluster could have also been called Volition and Cognition as the term volition is often used interchangeably with control. Some psychometric instruments, like the PCI, places the terms side by side as evidenced by the major dimension of Volitional Control.

Speech, Changes in Memory, Changes in Higher-Level Thought, Changes in Self-Control, and Changes in Suggestibility as separate, orthogonal dimensions (Farthing, 1992). Tart separates Memory from Evaluation and Cognitive Processing, but does not further subdivide dimensions relating to Cognition (Tart, 1975/1983). Metzner implicates Cognition via the dimension of Alterations in Thinking and Attitude, which represents a broader attempt at classifying changes to cognition under ASCs (Metzner, 2005a).

Of additional interest is where ASC classification schemes overlap in their contextualization of Cognition. Ludwig, through the General Characteristics of ASCs, discusses cognitive alterations as "subjective disturbances," where "archaic modes of thought predominate," echoing Jaynes' bicameral mind hypothesis and Carhart-Harris' entropic brain hypothesis (Carhart-Harris et al., 2014; Jaynes, 1976; Ludwig, 1966). While Jaynes suggests archaic consciousness through the bicameral mind hypothesis, Ludwig and Carhart-Harris propose ASCs as a regression to a primal state, marked by impaired reality perception and blurred cause-effect distinctions. According to Jaynes, lack of volitional control may lead to internal speech proliferation associated with archaic consciousness, implying susceptibility to inner dialogue perceived as divine commands (Farthing, 1992; Jaynes, 1976).

Taken together, the Control and Cognition feature is a “catch-all” cluster for diverse cognitive functions affected by ASCs. It is plausible that diverse cognitive impairments can occur during ASCs. While most classification schemes discuss some of them, there is no proper consensus on whether they should be considered as defining features of ASCs or rather are simply epiphenomena of other features. Nonetheless, the prominence of volitional disruption across these state-based schemes suggests that future attempts at classification may benefit from explicitly addressing the intersection of control and cognition.

1.4 Review*

Note: This section has been modified from its published version

This section synthesized the development of classification schemes for ASCs, tracing their evolution across three major domains: subjective experience (state-based), induction methods (method-based), and underlying neurophysiological mechanisms (neuro/physio-based). In total, we reviewed 23 ASC classification schemes: 15 state-based, four method-based, and four neuro/physio-based. Our aim was to clarify how historical, conceptual, and empirical developments have shaped ASC classification and to unify overlapping, but previously disconnected frameworks, to lay a foundation for future research.

The conceptualization of human consciousness, and our understanding of its alterations, whether in psychopathology or induced states, has co-evolved alongside developments in the philosophy of mind, psychology, and medicine, as well as broader societal influences, including religious and cultural worldviews. Contributions to the field have come from a wide range of authors across disciplines and with varying degrees of scientific rigor. Some, like Timothy Leary, offered more conceptual and culturally influential ideas, while others, such as Adolf Dittrich or Ronald Pekala, pursued empirical, data-driven approaches to classification (Dittrich, 1975; Leary, 1964; Pekala & Levine, 1981). As a result, the scientific quality and methodical grounding of the classification schemes discussed in this review are variable. This diversity in origins and approaches laid the foundation for how ASCs would later be framed within more clinical and neuroscientific paradigms. For example, the work of Stanislav Grof influenced some modern neuroscientific models (Carhart-Harris et al., 2014a).

As psychology and neuroscience co-evolved, early classifications of ASCs were increasingly shaped by clinical frameworks. Early neurophysiological models were often rooted in psychopathology, exemplified by the terms “model psychoses” or “psychotomimetic” referring to ASCs induced by psychedelic drugs (Costines & Schmidt, 2024; Hofmann, 1959; Osmond, 1957). These ideas reflected the broader *Zeitgeist* of psychiatry at the time, in which some ASC experiences were compared to symptoms of schizophrenia or depersonalization (Blankenburg, 1971/2012; Scharfetter, 1981, 1995). More recent approaches have moved beyond purely psychopathological framings toward formalized neurocognitive models, reflecting broader shifts in neuroscience. Frameworks such as the Cortico-Striato-Thalamo-Cortical (CSTC) Feedback Loop Model, Entropic Brain Hypothesis (EBH), and Bayesian Predictive Coding Models interpret ASCs in terms of changes in neural dynamics, connectivity, and information processing (Carhart-Harris et al., 2014a; Carhart-Harris & Friston, 2019; Corlett et al., 2019; Vollenweider & Geyer, 2001; Vollenweider & Preller, 2020). Taken together, the historical development of ASC classification reflects the prevailing *Zeitgeist* in terms of terminology, conceptualization, purpose, and emphasis on mechanistic explanation.

While state-based classification schemes remain the most conceptually distinct due to the irreducible nature of first-person phenomenology, method-based and neuro/physio-based schemes increasingly overlap in their shared grounding in physical mechanisms. Understanding how these three classification types interrelate remains crucial for ongoing research, particularly in clinical contexts where the therapeutic effects of ASCs may depend on the interaction between induction method and phenomenological quality.

In Fort et al., 2025 method-based and neuro/physio-based classification schemes were extensively reviewed. Method-based classification schemes focus on the methods used to induce ASCs rather than the subjective experiences or neuro/physiological mechanisms. Neuro/physio-based classification schemes, while similar, differ in that they focus on specifying neurobiological and physiological mechanisms underlying ASCs which can be used to suggest their classification.

State-based and neuro/physio-based classification schemes address different levels of description. Neuro/physio-based schemes describe the underlying biology of how an ASC may arise while state-based schemes describe the subjective character of the experience (i.e., what does a particular ASC feel like). These are not interchangeable. A biological account does not capture the quality of an experience. Describing pain as C-fiber firing, as noted by Joseph Levine, leaves out what pain actually feels like (Levine, 1983). Physical processes can be fully specified in objective terms, but subjective experiences cannot because they are bound by the first-person perspective. In essence, physical processes alone cannot fully explain subjective experience and attempt to refine ASC classification schemes, or generate new ones, must respect that boundary. To identify neural correlates of consciousness (NCCs) of specific subjective ASC phenomena it will be beneficial to refine method-based classification schemes. With a better understanding of the setting (i.e., physiological and/or environmental conditions), the set (i.e., internal factors captured with state or trait measures), and the induction method (e.g., psilocybin or flicker light stimulation) researchers can better use ASCs for basic or applied investigation.

In general, classification schemes are designed as tools to address specific questions or problems, and their utility often depends on the context of the inquiry. For example, one may find the Subjective-Intensity scheme useful in contextualizing work on subjective experiences in pharmacologically induced ASCs. However, their context-specific nature highlights the need for expanding and refining classification schemes. One candidate for possible expansion in this review involves the Vaitl et al. Induction-Domain Classification Scheme previously covered (see Induction-Domain Classification Schemes; Vaitl et al., 2005). For a brief review, the nomenclature from Vaitl et al. conceptualized a clustering of ASC induction methods, such as those that are psychologically or pharmacologically induced. However, psychological inductions seem to be extremely variable in their mechanisms of induction as they include sensory deprivation, homogenization, sensory overload, rhythm-induced trance (e.g., drumming and dancing), relaxation, meditation, hypnosis, and biofeedback. Since research has shown that perceptual deprivation shares similarities with both hypnagogia (i.e., the transition period from wakefulness to sleep) and hypnosis, it is clear that their induction is not primarily driven by sensory homogenization, meaning there is room for the classification scheme to expand and become more descriptive (Marcusson-Clavertz et al., 2012; Moujaes et al., 2023; Wackermann et al., 2008).

Pharmacologically induced ASC classifications, by contrast, are void of this issue by usually involving some sort of further classification to distinguish their mechanism of action, such as the Neuroscience-based Nomenclature (NbN) and other specific drug classification schemes (Volgin et al., 2019; Zohar et al., 2015). The lack of mechanistic distinctions between psychological inductions compared to their pharmacological counterparts necessitates further classification beyond merely being psychologically induced with different practices. Empirical work on sensory inductions involving sensory overload via flicker light stimulation, sensory homogenization via MMGF, and sensory deprivation via Floatation-REST exemplifies how they can exist as a further classification of psychological inductions (Amaya, et al., 2023a Amaya, et al., 2023b; Hruby et al., 2024; Montgomery et al., 2023; Schmidt et al., 2020; Schmidt & Prein, 2019).

Generating new, and extending current, classification schemes is also relevant for potential clinical applications of ASCs, such as in psychedelic assisted psychotherapy (see also Yaden et al., 2024). Significant, and sometimes, ineffable experiences in ASCs can be challenging to understand giving the prominence of mystical and religious language used to describe them (Leary, 1970). Yet, these experiences appear relevant in modern psychiatry, particularly in studies involving psychedelic compounds (Griffiths et al., 2008; MacLean et al., 2011; Rotz et al., 2023; Timmermann et al., 2024; Yaden & Griffiths, 2021). This suggests the importance of these experiences under psychedelic drugs for positive clinical outcomes. Such empirical work aligns with Aldous Huxley's notion of a universal need for self-transcendence through these supposed “doors of perception,” (Huxley, 1954/2009a). Andrew Weil further expanded on this idea, suggesting a biological drive to alter consciousness surpassing even the urge for sexual gratification (Grof, 2019; Weil, 2004). Together, generation and expansion of classification schemes could assist in unraveling these experiences to pinpoint their precise phenomenology components for clinical benefit (for a more comprehensive overview see Mosurinjohn et al., 2023).

There are also several classification schemes that are less well known but deserve acknowledgement. The historical perspective on the contributions from the German literature, could be more thoroughly integrated into the main discussion to provide a richer context for contemporary classification efforts. For example, Passie (2007) summarizes several notable approaches in German that are briefly mentioned here as they have not enough international attention to warrant reviewing them to a greater extent (Passie, 2007). Among these are Müller-Freienfels’ *Psychologie der Erregungszustände* (Müller-Freienfels, 1910), Siegfried Behns’ work that provided a suggestion for classification which was extended by Gruehn (Gruehn, 1926; Passie, 2007); Rosenfeld's *Enzyklopädie der Bewusstseinsstörungen* (Rosenfeld, 1929), Thomas' work that differentiated between *überwache* and *unterwache*, that is, over-awake and under-awake states (Thomas, 1973), and Fromm's work that elaborated on the description of primary and secondary processes that are rooted in Freudian theory, similar to other classification schemes such as the Entropic Brain Hypothesis (Carhart-Harris et al., 2014a; Fromm, 1977; Grof, 1976).

Alexander ("Sasha") and Ann Shulgin describe a simple rating method that contributed to their foundational work[13] in characterizing psychoactive drug effects (Shulgin & Shulgin, 1990). They rated subjective effects of drugs on five levels of intensity to denote the strength and clarity of the experience. Overall, this method is similarly reductionistic as both Leary's Subjective-Intensity Scheme and the Arica System of John Lilly (Leary, 1964; Lilly, 1972/2017). Similarly, modern psychedelic drug research uses simple ratings of positive and negative drug effects as global indices of psychedelic experience (Holze et al., 2023). While these methods allow a systematic comparison between subjective effects, they are somewhat too simplistic to be considered a classification system of ASCs and therefore are not discussed further here.

Of note, there is a noticeable lack of attention to non-Western perspectives on ASCs, which could provide valuable cross-cultural

[13] The collected foundational work of the Shulgins refers both to their books *Phenethylamines I Have Known and Loved (PiHKAL): A Chemical Love Story* and *Tryptamines I Have Known and Loved (TiHKAL): The Continuation* both of which are considered landmark publications in psychedelic science (Andrews & Wright, 2022; Shulgin & Shulgin, 1990, 2002).

insights into altered states. Considering the exclusion of these perspectives, this section does not provide a full history of every ASC classification scheme. Instead, it represents a contemporary endeavor aimed at consolidating and simplifying present-day terminology through a comprehensive narrative review.

1.5 Transition*

Note: This section is not part of the original publication

The vast history of ASC classification spans over half a century in Western science (see Figure 1), wherein the generation of classification schemes stems from multiple disciplines including theology, psychology, neuroscience, pharmacology, and philosophy. The historical background of these schemes reflects the interdisciplinary nature of ASC research which can partially account for the lack of an agreed upon paradigm, particularly around what aspects of experience comprise any given ASC. A large portion of ASC classifications are state-based, indicating that many differing attempts were made, particularly at the onset of the 1960s, into answering that question. While the idea of etiology-independent structures of ASCs (i.e., a shared phenomenological space across induction methods) was not formalized until the work of Adolf Dittrich in 1975, such discussions were happening as far back as the 19th century. Even with the foundational work of Dittrich, the core question of what experiences comprise the phenomenological space elicited by ASCs remains debated. While this is in part due to the wide disciplinary scope of the field, ASC research has a unique history that may further explain why we still exist in a state of disarray and disorder.

As mentioned, ASCs have been explored throughout human history, with evidence suggesting possible trance-like Neanderthal rituals, no formal investigation of these states emerged until the mid-20th century (Grof, 2019; Ludwig, 1966). While, Buddhist texts offered in-depth phenomenological mappings of consciousness[14] and early scientific inquiries by figures like Franz Anton Mesmer and James Braid elucidated questions surrounding hypnosis, none of these investigations of ASC phenomenology garnered sufficient academic interest to establish an explosion of research (Green et al., 2014; Metzner, 1971; Tart, 1975/1983). The foundations of ASC research were rather laid later by pharmacology's rapid discovery of "psychedelic" substances in the early 20th century.

In 1897, German chemist and pharmacologist Arthur Heffter published *Ueber Pellote: Beiträge zur chemischen und pharmakologischen Kenntniss der Cacteen Zweite Mittheilung*, marking the first isolation of a naturally occurring "psychedelic" substance (mescaline) from the peyote cactus (Heffter, 1898). This historically important publication foreshadowed a coming century dominated by pharmacology's discovery of psychedelic substances, resulting in profound scientific and political ramifications. Early 20th century milestones include the synthesis of 3,4-methylenedioxymethamphetamine (MDMA or Ecstasy) in 1912 by German chemist Anton Köllisch (Freudenmann et al., 2006), the investigation of the ethnobotanical context and psychoactive properties of peyote via Alexandre Routhier's *Le Peyotl: La plante qui fait les yeux émerveillés* in 1926 (Shulgin & Shulgin, 1990), and the phenomenological analysis of mescaline via Kurt Beringer's *Der Meskalinrausch - Seine Geschichte und Erscheinungsweise* in 1927 (Shulgin & Shulgin, 1990). These

[14] Many other religious, spiritual, and philosophical approaches also mapped phenomenological levels of consciousness with evidence in the I Ching, tarot, and astrology (Metzner, 1971). The evident cultural wall between "Western" and "Eastern" methods of understanding ASCs should also be noted here as the lack of early cross-cultural dialogue likely impacted the historical development of the field.

developments set the stage for Albert Hofmann's pivotal synthesis of lysergic acid diethylamide (LSD) in 1938 (Hofmann, 1979/2019).

While some might consider 1938 to be the beginning of modern psychedelic research, the intense subjective effects of LSD were not discovered until 1943 (Hofmann, 1979/2019). A few years later, Sandoz marketed LSD as *Delysid* for use in psychiatry believing it could alleviate symptoms of anxiety and depression. This idea was furthered by psychiatrist Humphrey Osmond who suggested similarities between schizophrenia and psychedelic drugs, hypothesizing a shared chemical imbalance in the early 1950s, though the idea was not well received at the time (Kaplan, 2016). Osmond's work famously caught the attention of English writer and philosopher Aldous Huxley, who asked for Osmond to supervise a mescaline trip in 1953 (Carhart-Harris et al., 2014). After the trip, the pair famously discussed what to call this class of drugs, deciding to call them psychedelics[15] inspired by the original Greek to mean "mind-manifesting." A year later, Huxley recounts this experience in his essay *The Doors of Perception* (Huxley, 1954/2009a).

Not long after, American ethnomycologist R. Gordon Wasson published *Maria Sabina: Sanadora* where he details his participation, alongside his wife, in a Mazotec healing ritual involving psilocybe fungi (Krippner & Winkelman, 2012). Followed by a 1957 publication in *Life* magazine entitled *Seeking the Magic Mushroom*, Wasson began to popularize the idea of "shrooms." Around the same time Huxley and Wasson's writings

[15] At the time both hallucinogen and psychotomimetic (i.e., mimicking the symptoms of psychosis) were popular terms for this class of drugs. Huxley proposed phanerothyme to suggest bringing forth the spirit or soul, but the term psychedelic was ultimately settled on (Carhart-Harris et al., 2014).

helped to bring public attention to psychedelic substances (Wasson, 1972), Hofmann isolated psilocin and psilocybin (Petersen, 2025). The cultural phenom of Maria Sabina eventually brought Timothy Leary to Mexico at the invitation of Wasson to experience the magic mushrooms himself (Ulrich, 2018). This led to the establishment of the Psilocybin Project at Harvard and the beginnings of not only the Mystical Experience Questionnaire (see Section 1.2.1 for a review) but also of the study of psychedelics in the psychology of religion and psychotherapy.

In sum, the first half of the 20th century in ASC research was dominated by pharmacology and the search for new substances with the formal beginning of psychedelic science starting with Hofmann's discovery of LSD's subjective effects in 1943. This emerging emphasis set the stage for a late 20th century explosion of psychedelic research and the formalization of a proper ASC academic field that prominently shifted from pharmacology to psychology and psychiatry. Yet, this progress ended in a dark age marked by the United States' government designating LSD, psilocybin, and MDMA as Schedule I drugs, effectively shutting down most psychedelic research, and by association, negatively impacting ASC research through the termination of drug studies and the forced return of substances. In *Center of the Cyclone*, John C. Lilly recounts being forced to return LSD to Sandoz and the termination of his research after the enaction of the law:

"…this series was terminated by the national negative program which started in 1966 against LSD. Such work was no longer to be done under the new regulations and new laws. Each investigator was asked to return his LSD to the Sandoz Company…" (p. 44, Lilly, 1972).

This suppression extended across decades, maintaining structural constraints on psychedelic, and adjacent ASC research, well into the late 20th and 21st centuries (Ohler, 2024; Wittmann, 2018).

While we may currently exist in a quasi-golden age of psychedelic research sometimes termed the “psychedelic renaissance” (Rhee et al., 2023), ASC science, kicked off by the golden age of pharmacology and largely dominated by drug research, must undergo repair from decades of forced intellectual poverty. These decades of forced research termination, imprisonment, and removal of psychedelic substances from research environments led to downstream effects such as intellectual discrimination against ASC researchers and the stigmatization of ASC research itself. In the epilogue of his book *Altered States of Consciousness*: *Experiences out of Time and Self*, Marc Wittmann describes the historical context of ASC research as something that is only very recently being considered “…the subject of serious neurological research.” (Wittmann, 2018, p. 116). To reinforce just how deep the stigma against ASC research went, Wittmann writes:

“The prevailing advice was not to out yourself as a consciousness researcher before achieving permanent tenure or employment...” and that consciousness research was considered “unworthy” with “[…] no need to investigate altered states of consciousness” (Wittmann, 2018, p. 116).

Taken together, the proliferation of ASC classification schemes reflects a failure to converge on a shared level of description, particularly around phenomenological structure. Early approaches saw the rise of many different state-based schemes often from theological, philosophical, and psychological perspectives that were generally not reconciled with one another. Just as formalized efforts toward such a structure began to emerge (e.g., the work of Adolf Dittrich) the field’s development was abruptly disrupted by regulatory suppression following the Controlled Substances Act. This interruption contributed to the prevention of consolidation around a unifying framework, leaving behind a landscape of disarray and disorder that persists in the present resurgence.

The next chapter addresses this problem directly by providing a provisional structure of the field's meta-space including how we must work toward an agreed upon definition of ASCs and toward a unified structure of etiology-independent phenomenology where the Core Features can represent early candidate dimensions. From this, the chapter aims to illustrate how development in concept and theory can shape measurement, and in turn, clinical application as research continues on the efficacy of psychedelic assisted psychotherapy and ASC-psychotherapeutics more broadly.[16]

[16] The term ASC-psychotherapeutics is used to broaden the scope of psychedelic-assisted psychotherapy to include non-pharmacological inductions of ASCs which have also demonstrated therapeutic effects (Feinstein et al., 2018a; Feinstein et al., 2018b; Garland et al., 2024).

II

Structuring the ASC Phenomenon Space

This chapter is based on

Fort, L., D., Wittmann, M., Yaden, D., & Demertzi, A. (under review). Toward an Invariant Structure of Altered States Phenomenology: Rethinking Subjective Measures for Clinical Application. In M.S. Overgaard & A. Kirkeby-Hinrup (Eds.), Subjective measures in clinical contexts. Springer.

See Appendix C for author roles

2.1 Toward an Invariant Structure of ASCs

Across the history of ASC research, numerous classification schemes have been proposed, often using divergent terminologies to describe overlapping experiential phenomena (see Chapter 1). The present section suggests that, despite surface-level heterogeneity, state-based frameworks converge on a limited set of recurring phenomenological dimensions. Our clustering of terms across historical and contemporary schemes yields eight provisional core features that can be treated as candidate axes of changed subjective experience. Importantly, these features are not altered states themselves, but dimensions along which altered states vary; specific inductions are therefore better understood as characteristic profiles across a shared multidimensional space.

Given the field's disarrayed and disordered state, movement toward a cumulative science of ASCs must accelerate in line with the resurgence of research on psychedelic drugs. This movement must prioritize clarity about what counts as an ASC in the first place (the outer boundary), what the shared experiential space between ASC is regardless of induction method (the inner boundary) and a principled way to represent induction-specific signatures as locations or regions within the resulting space (state-space representation). In the next section, we introduce the ASC phenomenon space as a nested framework that organizes these tasks and makes explicit how definitional and measurement choices can expand, restrict, or distort the phenomenological space researchers seek to map.

2.2 Measurement of ASCs

ASCs are typically measured through self-report scales sometime after the experience has occurred when the person has returned to their normal, waking state. This is often referred to as retrospective phenomenological assessment (Pekala, 2013). The scales used in this assessment often begin as theory-driven, conceptual frameworks that map which experiences are common and relevant in ASCs. In other words, conceptual frameworks define an initial latent (not directly observable) structure of experience, which then lays the foundation for the development of ASC self-report scales. Importantly, this process is iterative and reflects a standard in psychometric research as early conceptual assumptions constrain which features of the ASC experience can be measured. Empirical feedback from questionnaire assessment can in principle, refine, revise, or expand those assumptions. However, if the data collected from these questionnaires are empirically narrow, such as ASC assessments only aggregating data from drug-induced ASCs, this iterative process risks becoming circular by systematically reinforcing the initial conceptual constraints instead of correcting them.

A prominent example of this development is the 5-Dimensional Rating Scale of Altered States of Consciousness (5D-ASC), a questionnaire developed from Adolf Dittrich's Etiology-Independent Structures of ASC framework (see Fort et al., 2025 for a review). The 5D-ASC is the most used questionnaire for retrospective phenomenological assessment (Schmidt & Berkemeyer, 2018) along with its associated 11-ASC factor structure (Dittrich, 1985; Studerus et al., 2010). In this chapter, we will suggest that the 11-ASC factor structure introduced a pharmacocentric bias to the conceptual framework originally proposed by Dittrich because the 11-ASC factor structure was derived only from drug-induced ASC experiences whereas the initial framework suggested by Dittrich shared phenomenological dimensions regardless of induction method. We suggest that reliance on the 5D-ASC and its associated 11-ASC limits the usefulness of investigation when comparing across ASCs induced by various means, highlighting their conceptual incongruence with one another.

The following section begins by introducing the ASC phenomenon space, a nested framework that organizes definitional and structural questions surrounding ASCs into a coherent model capable of supporting cumulative scientific progress. We then turn to the developmental trajectory of the 5D-ASC and the associated 11-ASC as a case study for how measurement practices can distort this phenomenon space, reshaping the field's conceptual and empirical boundaries. Building on this, we then review three contemporary frameworks: the Acute Psychedelic Effects (interpreted here as a framework or proto-taxonomy (Yaden et al., 2024); the Core Features of ASCs (Fort et al., 2025); and the Expert-Derived Categories of ASCs (Cardeña et al., 2025), each highlighting the need for next generation questionnaires. Finally, we discuss how these conceptual issues impact clinical translation, showing how distortions in the ASC phenomenon space can hinder the development of effective ASC-psychotherapeutics and how a unified, empirically grounded framework of changed subjective experience under ASCs could advance both scientific and clinical precision.

2.3 Conceptual Drift and the Need for Structure

ASC research currently operates in a conceptual landscape that lacks unified definitions and frameworks. In the absence of a shared framework of ASC phenomenology, researchers often address distinct constructs under the same label or, conversely, treat similar experiences as unrelated, a pattern known as the jingle-jangle fallacy (Kelley, 1927). Mindfulness research provides an illustrative example of this joint fallacy (Van Dam et al., 2018). Here, the jingle fallacy can be seen when vastly different practices are labeled as “meditation,” from five-minute app-guided breathing sessions to three-month monastic retreats, despite their divergent subjective intensity and context. Conversely, the jangle fallacy can be seen when overlapping experiential constructs like “awareness,” “attentional focus,” and “non-reactivity” are often treated as unrelated simply because they’re measured under different theoretical labels.

This conceptual drift produces incommensurate findings in consequential ways. For example, with the jingle fallacy two studies may each claim to study meditation yet operationalize the term in an incompatible manner such as, in the example above, one using a brief, low intensity breathing task, while the other uses an extended body scanning technique in a retreat setting. The issue arises because these procedures generate qualitatively different experiences as one study may report only mild state changes in a variable of interest (e.g., emotional regulation), while the other finds repeated and profound state-related shifts which in the long run can even lead to changes in personality. When these results are compared as if they reflect the same construct, literature gives the false impression that meditation both does and does not significantly alter emotional regulation. With the jangle fallacy, the opposite problem occurs. For example, the term “meaning” is operationalized differently across instruments. For example, in the 11-ASC scoring scheme of the 5D-ASC, “Changed Meaning of Percepts” refers to altered interpretation of sensory content, whereas in measures such as the Mystical Experience Questionnaire or Phenomenology of Consciousness Inventory, meaning is often tied to sacredness or existential significance (Fort et al., 2025).

When similar terminology is used to index partially overlapping experiential phenomena, apparent distinctions may reflect differences in framing rather than clear phenomenological separation. A prominent and parallel example exists in the ASC field. Unlike more established disciplines such as chemists agreeing on chemical elements or personality psychologists agreeing generally on a five-factor personality structure (Srivastava & John, 1999), the ASC field lacks a widely accepted definition of what an ASC is, in addition to lacking agreement on what latent phenomenological structure underlies it (Cardeña et al., 2025; Fort et al., 2025). For example, both (Vaitl et al., 2005) and (Cofré et al., 2020) consider DOCs as ASC based on their classifications of disease-induced and pathological ASC, despite these states being historically excluded (see Fort et al., 2025 for a review). This jingle fallacy, arising from a lack of definitional consensus, can lead to cascading problems within the field. Specifically, (Laureys et al., 2004) considered coma and its resulting states as ASC which then informed a restrictive phenomenological mapping consisting of only two dimensions: awareness and wakefulness (Laureys, 2005). This restrictive mapping was used in future work to claim ASC as multidimensional based on this two-dimensional structure derived from DOCs ultimately leading to DOCs being used interchangeably with ASC (Boly et al., 2008). Since DOCs often involve states with restricted, or absent, access to self-report, deriving two dimensions from their study and broadly applying them to ASC (say, of meditation or psychedelic research) creates an insufficient classification due to a highly restricted and biased phenomenological space.

This restriction of a phenomenological space illustrates how jingle fallacies in ASC lead to findings that are difficult to compare or integrate. This aligns with what Thomas Kuhn termed a “pre-normal science” phase, where progress is stifled by unresolved foundational issues (Clifton et al., in press; (Kuhn, 1996). Taken together, jingle-jangle fallacies erode conceptual clarity and impede measurement, halting the advance of cumulative knowledge-building. ASC work must establish clear definitions and frameworks for the field to transition into a Kuhnian "normal science" where effort is put into research questions that extend an agreed upon paradigm, rather than attempting to overturn and refute foundations.

To help progress fields toward cumulative knowledge building, Clifton et al. (in press) recently proposed the phenomenon space defined as categories of existing things that researchers seek to study. These phenomenon spaces are represented by outer boundaries (i.e., what separates the phenomenon from another) and inner boundaries (i.e., what separates one dimension of the phenomenon from other dimensions of the same phenomenon). With this chapter, we apply and extend Clifton et al.'s phenomenon space to the ASC field to demonstrate how a structured phenomenon space can: (1) define what should count as an ASC, (2) articulate a candidate invariant phenomenological architecture, and (3) provide a state-space in which induction-specific signatures can be systematically mapped.

2.4 The ASC Phenomenon Space

In practical terms, moving beyond the pre-normal phase requires a shift from expert- driven frameworks to an empirically grounded, integrative model that specifies what ASCs are and how they can be systematically described. The ASC phenomenon space provides such a structure. It can be conceptualized as a layered model with three interrelated components (Figure 18), each serving a different function in organizing ASC research.

First, the outer boundary concerns the limits of the ASC category, for example what counts as an ASC and what does not. As mentioned, this is a crucial issue as what is considered inside and outside the ASC category directly determines the scope of what researchers compare and generalize. Next, the inner boundary identifies the core phenomenological dimensions that underline ASC as defined by the outer boundary, such as hallucinatory or ego dissolution phenomena. While this can begin though expert consensus or theoretical synthesis (*a priori*), it can later be refined through psychometric development. Simply put, this layer defines the main axes along which ASC experiences vary. Finally, state-space representation occurs when those core dimensions are translated into a coordinate system in which specific ASC-induction methods (e.g., psilocybin, breathwork) can be plotted as distinct signatures. The resulting phenomenological pattern, or profile, of each induction method provides an empirical way to compare different induction methods based on which dimensions they engage and how strongly they do so.

Although these layers are presented in order, the relationships between them are not strictly unidirectional. Decisions at the outer boundary can influence what dimensions researchers look for at the inner boundary, which in turn shapes the resulting state-space. Likewise, evidence from lower levels can feed back to refine higher levels. For example, an inner boundary may initially propose that hallucinatory phenomena is a core dimension of ASC, but if new psychometric or neurophenomenological work shows that certain included states do not cluster along that dimension, this can prompt a revision of the outer boundary itself. In this way, mapping the ASC phenomenon space becomes a recursive, self-correction process that tightens conceptual clarity over time. For example, if a proposed dimension (e.g., hallucinatory phenomena) consistently fails to emerge as psychometrically distinct across diverse induction methods, or shows weak convergence with theoretically related items, this would suggest that the inner boundary requires revision. Conversely, if novel experiential clusters reliably appear across pharmacological and non-pharmacological samples but are not captured by the existing framework, this would motivate expansion or reorganization of the inner boundary. Thus, empirical findings serve as constraints on both the inner and outer boundaries of the phenomenon space.

As a worked example, the 5-Dimensional Altered States of Consciousness (5D-ASC) provides an especially useful case. Not only is it the most widely used questionnaire in contemporary ASC research (Schmidt & Berkemeyer, 2018), it has also become the de facto benchmark for measuring ASC phenomenology across numerous induction methods including psychedelic drugs (Mason et al., 2020; Mortaheb & Fort et al., 2024), sensory homogenization (Schmidt et al., 2020; Schmidt & Prein, 2019), sensory flooding (Bartossek et al., 2021), hypnosis (Corlett et al., 2025), and breathwork (Kartar et al., 2025). Because of its wide usage, the structure of the 5D-ASC and its associated 11-ASC exerts disproportionate influence on how researchers conceptualize ASC dimensions, compare induction methods, and design experiments. This makes the 5D-ASC/11-ASC a uniquely consequential tool for evaluating how measurement affects the broader ASC phenomenon space.

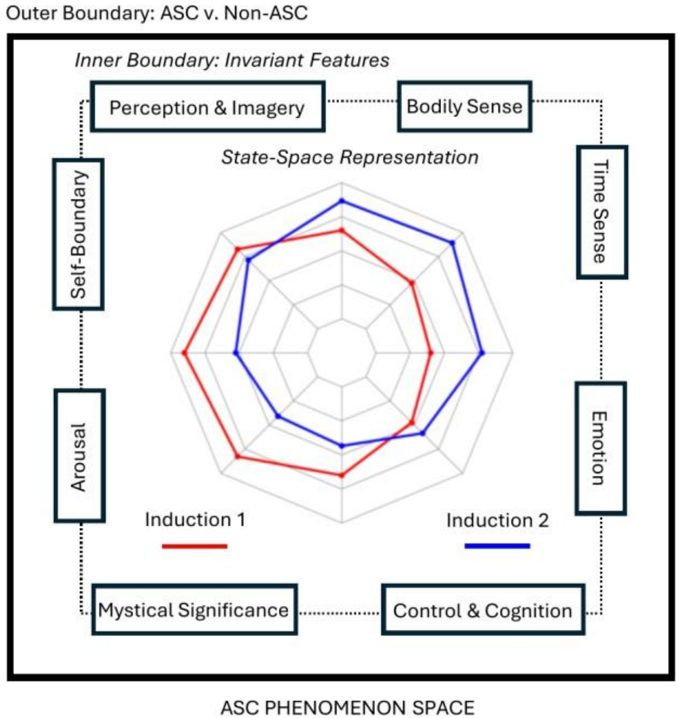

Figure 18. *The ASC Phenomenon Space.* Conceptual diagram of the ASC phenomenon space using the Core Features of ASCs derived by Fort et al. (2025). The ASC phenomenon space consists of three nested components. The outer boundary distinguishes ASC from non-ASC, establishing the definitional limits of the category. Within this outer boundary, the inner boundary identifies core phenomenological dimensions that recur across ASC experiences (e.g., Time Sense, Arousal, or Mystical Significance). These dimensions then constrain the state-space representation, providing the axes along which specific ASC-induction methods can be plotted. The radar plot depicts two hypothetical induction methods and their associated phenomenological profiles in the state space. Although primarily hierarchical, as the outer boundary constrains the inner boundary which constrains the state-space, the relationships are not strictly unidirectional: empirical findings can feed back to revise both the inner and outer boundaries.

2.5 Pharmacocentrism and the 5D-ASC

Given the 5D-ASC's centrality to ASC research, examining how it was developed offers a clear window into how measurement practices can reshape the ASC phenomenon space. Although the scale is now used across an impressive range of induction methods, it originated from Adolf Dittrich's (1985) hypothesis that ASCs share a set of etiology-independent phenomenological dimensions. The questionnaire was meant to capture features that recur across pharmacological and non-pharmacological ASCs; however, as discussed below, later psychometric refinements, namely the 11-ASC, shifted the measure away from its etiology-independent intent towards a pharmacocentric structure dominated by data sets of drug-induced phenomenology. This shift provides a concrete example of how methodological choices can distort the outer and inner boundaries of the ASC phenomenon space.

While the 11-ASC represented a major methodological advance in terms of psychometric precision, its derivation exclusively from pooled pharmacological datasets (e.g., psilocybin, ketamine, and MDMA) raises the possibility of a conceptual calibration bias. Because the factor structure was identified within drug-induced samples, the resulting dimensions may be preferentially sensitive to phenomenological patterns that are prominent under pharmacological induction. This potential pharmacocentrism could represent a departure from Dittrich's original etiology-independent framework, which aimed to identify invariant dimensions of experience across both pharmacological and non-pharmacological induction methods. Accordingly, it remains an open empirical question whether the 11-ASC structure generalizes equally well to non-pharmacologically induced ASCs. However, through the privileging of drug-induced phenomenological data, the 11-ASC may embody a subtle form of pharmacocentrism which, in turn, reframes the inner boundary of the ASC phenomenon space.

This potential pharmacocentric bias has consequences for how the ASC phenomenon space is constructed, in turn, narrowing the scope through which ASC experiences are measured. When psychometric refinement is driven solely by drug-induced datasets, the resulting inner boundary (i.e., the set of dimensions assumed to underlie ASC experiences) is calibrated to the phenomenology of pharmacologically induced ASCs. This can introduce a distortion as experiences that are prominent in pharmacologically induced ASCs may become overrepresented, while experiences arising from non-pharmacological induction methods (e.g., sensory deprivation) may be underrepresented or excluded entirely.

Because the inner boundary sets the axes of the subsequent state-space, the distortion trickles downward, shaping how induction methods can be compared and interpreted. It can also feed upward if drug-derived dimensions become the dominant basis for ASC identification they can influence outer boundary judgments, leading researchers to discount or reclassify non-drug ASCs as marginal or atypical. For example, if the inner boundary emphasizes mystical experience as a core dimension of ASC experience, then induction methods that do not reliably evoke such states (e.g., non-pharmacological inductions such as hypnosis or sensory deprivation) may appear less altered (state-space distortion) or even fall outside the scope of what researchers consider an ASC (outer boundary distortion).

Taken together, this pharmacocentric distortion of the ASC phenomenon space can lead to misleading comparisons where non-pharmacological induction methods are excluded from study because they do not strongly emerge under the drug-shaped dimensions of the questionnaire. As such, the 11-ASC shows how a tool originally designed to capture common structures of ASC experience can end up reinforcing a narrower, pharmacocentric direction. Over time, this risks sidelining experiences that are less pronounced in drug-induced ASCs, making them harder to detect, harder to compare, and ultimately easier to overlook in both theory and practice.

Although the 11-ASC highlights how narrow data sources can warp how researchers conceptualize and measure ASCs via its distortion of the ASC phenomenon space, it speaks to larger issue in moving toward a supposed invariant structure of ASC experience to begin with. In response to a fragmented academic landscape and the limitations of ASC questionnaires, such as the 5D-ASC and its 11-ASC counterpart, several new frameworks have emerged. These recent approaches attempt to conceptually systematize ASC phenomenology, offering syntheses and expert-derived categories that can act as a candidate inner boundary in the ASC phenomenon space. While they have not yet yielded new psychometric instruments, they reflect a growing recognition that future measurements tools are needed and must incorporate data from diverse induction types. The next section examines these three prominent examples: the Acute Psychedelic Effects framework (Yaden et al., 2024), the Core Features of ASCs (Fort et al., 2025), and the Expert-Derived Categories of ASCs (Cardeña et al., 2025).

2.6 Contemporary Approaches

The pharmacocentric bias introduced by the 11-ASC may have conceptually narrowed the field's most prominent instrument, despite Dittrich's original etiology-independent intent. While this may remain a unique problem to the 11-ASC, it has not prevented the push for new conceptual frameworks and calls for new measurement tools in the wake of a generally fragmented field (Fort et al., 2025; Yaden et al., 2024). These frameworks can be seen as suggesting a new conceptual scaffolding for ASC science. While they differ in derivation, some grounded in large scale synthesis and others in expert-driven "consensus", they remain firmly conceptual, not yet translating into a new psychometric instrument. Collectively, they signal a growing recognition that whatever the next generation ASC measures are, they must integrate diverse induction types, achieve empirical validation, and move beyond pharmacocentrism and authority-derived definition.

The Core Features of ASCs. See Section 1.3 for a review of the Core Features of ASCs (Fort et al., 2025).

Acute Psychedelic Effects Framework. Yaden et al. (2024) reviewed prominent questionnaires that were used explicitly in the context of measuring phenomenology after drug-induced ASCs. These Acute Psychedelic Effects we suggest here imply a useful framework, or proto-taxonomy. The authors collated the phenomenological features captured by 11 psychedelic drug questionnaires: the Awe Experiences Scale, the Mystical Experience Questionnaire, the 11-ASC subscale of the 5D- ASC, the Challenging Experiences Questionnaire, the Psychotomimetic States Inventory, the Hallucinogen Rating Scale, the Acceptance/Avoidance-Promoting Experiences scale, the Ego Dissolution Inventory, the Emotional Breakthrough Inventory, and the Psychological Insight Questionnaire. The authors then proposed an organized structure of these features to show what current scales claim to be measuring using abstract categories. The resulting framework centers on the acute subjective effects of psychedelic drugs and can be interpreted as suggesting a preliminary set of vital phenomenological features in ASCs.

Yaden et al.'s framework identifies several overarching domains that characterize the psychedelic experience. These include (1) Connectedness defined as feelings of unity or enhanced relatedness to self, others, or the world; (2) Auditory and Visual Perception defined as visual and auditory distortions or hallucinations; (3) Affect such as positive mood and grief; (4) Effects on Cognition defined as shifts in thought patterns such as paranoia and insight; (5) Sense of Time and Space largely involving time dilation; (6) Physiological Sensations such as somaesthesia; and (7) Sense of Self involving changes to the ego.

Given that the Yaden et al. (2024) article specifically reviewed the acute subjective effects of psychedelic drugs, their resulting summary is purely drug-derived phenomenology.

If interpreted as a preliminary set of important changed subjective experience under ASCs, it could be seen as underrepresenting non-pharmacologically induced ASC phenomenology.

Regarding this matter, Yaden et al. note that insights from their synthesis could inform "non-psychedelic" ASCs as well, a notable future direction of its applicability. They explicitly note that the grouping of experience domains is conceptually arranged for demonstration purposes and will require further empirical research to validate the dimensional structure. In practical terms, this means that the framework illustrates blank spaces in current measurement.

The review, if interpreted as a preliminary framework, is promising as it suggests which subjective phenomena merit closer study and how one might begin constructing more comprehensive ASC assessments. The authors advocate for a systematic, data-driven process to refine these concepts into measurable constructs, recommending techniques like latent variable modeling and hierarchical factor analysis to empirically derive an optimal structure of psychedelic effects. Such efforts point toward the eventual development of a new psychometric instrument or improvement of existing ones, but as of now the Acute Psychedelic Effects Framework remains conceptual. It provides a much-needed organizing schema for changed subjective experience under ASCs across a litany of questionnaires, clarifying how drug-induced experiences can be categorized and related to clinical outcomes, yet it also exemplifies the ongoing issue of pharmacocentrism and the privileging of drug-induced phenomenology.

Expert-Derived Categories of ASCs. Cardeña and colleagues (2025) offer a consensus-based framework in ASC research to attempt to organize the field, referred to here as the Expert-Derived Categories of ASCs. Rather than deriving this phenomenology-focused framework from literature review or questionnaire synthesis, the authors utilized a modified Delphi-method approach finalizing in consensus-derived categories from selected experts. In this modified Delphi approach (i.e., no anonymous participants), the first author contacted expert authors in various ASC areas such as coma, psychedelics, and meditation, complementing this with a selection from different backgrounds such as neuroscience and anthropology. They were asked if they were interested in "developing a taxonomy of ASCs," through a series interviews and revised drafts. Four guiding principles shaped this taxonomical construction taxonomy: theoretical grounding, orthogonality, semantic clarity, and practical utility. Although the authors aim for mutually exclusive types through the principle of orthogonality (i.e., a member of one category cannot belong to another), they explicitly acknowledge that real-world ASCs are fuzzy sets with gradients and transitions.

After several drafts, the panel arrived at eight phenomenological categories covering a wide spectrum where the first term defines the “cardinal characteristic” of the state followed often by subcategories. These are: (1) Proto and Transitional States (auras/prodromal, dizziness/confusion, into/out of sleep); (2) Delirium States (activated, somnolent), (3) States

of Minimal or No Awareness (no awareness of stimuli or ongoing experience, minimal or no awareness/uncertainty about experiences, minimal or no awareness of stimulus, ongoing experience); (4) Experiential Detachment States (self out of the body, estrangement from the self/environment; (5) Enhanced Physicality (perception/agility, intense energy/heat); (6) Altered Identity (changed identity or “trance,” co-consciousness, substitution of usual identity); (7) Imaginal/Fantasy/Visionary (simple imagery, complex imagery); (8) Unity/Mystical (with sensory experiences, pure consciousness).

Conceptually, this taxonomy is an explicit move beyond pharmacocentrism. By decoupling phenomena from their causes, it gives equal footing to non-drug ASCs such as dreaming, hypnosis, meditation, trauma-related states, alongside drug-induced ones. That shift matters clinically as it could possibly suggest the beginning of an invariant structure of ASCs which can lead to more informed designs of ASC-psychotherapies and phenomenological targeting (i.e., the selection of clinically relevant dimensions of experience under ASCs for psychotherapeutic use).

While a degree of selection bias is arguably present in most narrative reviews, often via implicit choices made by first authors when assembling co-authors or citing preferred frameworks, the Expert-Derived Categories makes this bias explicit through its modified- Delphi process. Unlike synthesis-based reviews, like Yaden et al. (2024) and Fort et al. (2025), which derive structure through systematic extraction and clustering of published features, this approach depends on a hand-picked group of experts without clearly stating inclusion criteria. As such, the resulting categories may reflect an aggregation of expert opinion rather than a systematic integration of prior evidence.

Despite these limitations, the Expert-Derived Categories show a need to bring structure to a disorganized, often fragmented field. It represents a commendable first effort in informing what this ordered, invariant structure will ultimately look like. Similar to the Core Features of ASCs framework, it explicitly moves past pharmacocentrism by embracing the principles of etiology-independence as its categories embrace states induced pharmacologically and non- pharmacologically. Ideally, the reconciliation of the contemporary approaches such as this consensus taxonomy, the Core Features, and the Acute Psychedelic Effects framework could produce one of the most comprehensive conceptual frameworks that can support future questionnaire development.

2.6 Clinical Relevance

Up to this point, we have covered what ASCs are, why the field requires definition and underlying conceptual structure via an illustrated nested model, and how case examples (such as the 11-ASC) show how such a structure can easily become biased or skewed due to a focus on a single induction method. In this section, we aim to translate these conceptual issues and measurement problems into clinical relevance and explain how these create hurdles when using ASC-psychotherapeutics. ASC-psychotherapeutics is used here as a broad term describing any sort of mental health therapy that primarily revolves around the use of an altered state in promoting healing or recovery. The assumption in ASC-psychotherapeutics is that episodes of changed subjective experience in the right context can be used for mental health treatment.

As reviewed, distortions in how the ASC phenomenon space is defined can propagate through and warp each part of the framework. For example, when the outer boundary (i.e., what qualifies as an ASC) or the inner boundary (i.e., the supposed invariant dimensions of changed subjective experience under ASCs) are inaccurately specified, the resulting state- space representation (i.e., a coordinate system of mapping phenomenological signatures induced by any given induction method), becomes skewed – either constrained at the exclusion of possible candidate-constructs or broadened at the inclusion of too many possible candidate-constructs. This bias then extends into clinical applications, influencing the selection of possible clinically relevant dimensions for ASC-psychotherapeutics to target and how those outcomes are measured.

These conceptual biases are not just theoretical concerns, as they have implications for clinical practice. When the inner boundary of the ASC phenomenon space is distorted, as may be the case with the 11-ASC, the tools to assess therapeutic effects may fail to capture meaningful change in non-drug-based ASC-psychotherapeutics. This limits both the scope of clinical insight and the ability to compare outcomes across different ASC induction methods.

In clinical contexts, this conceptual bias may have cascading consequences. At present, most ASC-assisted interventions evaluate efficacy primarily in terms of symptom reduction (e.g., depression, anxiety), while the ASCs themselves are not yet systematically investigated as primary clinical objects. Nevertheless, assumptions about which features of the ASC experience are typical, salient, or therapeutically relevant, can shape how interventions are designed. These assumptions can influence which features of the ASC experience clinicians aim to elicit, support, or integrate during ASC-psychotherapeutic protocols. If the proposed invariant phenomenological structure of

ASCs (i.e., the inner boundary) is derived predominantly from pharmacologically induced methods (e.g., those elicited by psychedelic drugs), then clinical protocols involving preparation and integration practices, will be shaped by the kind of experiences typically elicited by those substances. This can include intense ego dissolution (i.e., ego death) or mystical experiences. However, such features could be over-represented simply because they are frequent in pharmacological contexts and result in them being mistaken for universal features of ASCs. As a result, clinical models may underrepresent or entirely miss the importance of features that are more prominent in non-pharmacologically induced ASCs, such as breathwork, Floatation-REST, and meditation. This could ultimately narrow the therapeutic scope and neglect potentially valuable therapeutic targets that are more accessible via non-pharmacological induction methods.

Second, even when therapeutic effects occur in non-drug contexts, existing measurement instruments, if built on pharmacocentric assumptions, may fail to detect or accurately characterize them. While broad outcomes like clinical symptom reduction, appropriately the primarily endpoint in clinical contexts, will always be captured, more nuanced therapeutic mechanisms as mediators of outcomes (e.g., temporal distortion, ego dissolution, hallucinatory experience) could go unmeasured. This limits both the interpretability of clinical results and the ability to compare outcomes across induction methods. Without measurement tools that account for the full phenomenological spectrum of ASCs, the field remains vulnerable to biased conclusions, undermining progress toward a generalized and mechanistically informed model of ASC-psychotherapeutics.

Finally, this fragmentation impedes personalized treatment design. A richly mapped ASC Phenomenon Space with an inner boundary derived from conceptual rigor and empirical refinement, would allow clinicians to better match induction methods to the therapeutic goal. For instance, if visual hallucinatory phenomena are shown to be clinically beneficial in a particular case, for example in reducing depression symptoms, then selecting LSD over psilocybin might be preferable given LSD's stronger propensity to reliably induce that experience (Shinozuka et al., 2024). Ultimately, this approach allows clinicians to intentionally shape ASC experiences by selecting and fine-tuning induction methods to reliably elicit specific, therapeutically relevant dimensions, guided by a well-defined and empirically grounded ASC Phenomenon Space.

2.7 Review

ASC science is currently stalled at the level of definition. The field lacks agreement on what defines an ASC, on which phenomenological dimensions are invariant across inductions, and how those dimensions should be organized into a mathematical space. We showed how this absence of structure keeps ASC research in a Kuhnian "pre-normal" phase where studies "talk past each other," measures drift, and clinically promising phenomena become hard to isolate or compare. Using the 5D-ASC and its 11-ASC counterpart as a case example, we show that when the empirical base narrows, such as to include the phenomenology of only drug-induced ASCs, the conceptual space narrows with it. That narrowing recursively reshapes what is treated as foundational phenomenology, and therefore what is even available to measure, target, and translate clinically. In other words, we show how a measurement choice biases a conceptual boundary which in turn becomes a clinical filter.

The path forward seems to be the creation of a next-generation questionnaire that is able to draw on vast repositories of cumulative knowledge to create a uniquely strong conceptual foundation. The contemporary frameworks we reviewed from Cardeña et al., (2025), Fort et al., (2025), and Yaden et al., (2024) represent different attempts to organize and propose that foundation. Taken together with the concept of the phenomenon space from Clifton et al., (in press), they outline what a mature ASC field requires: First, clear outer boundaries (i.e., what is an ASC?); second, a valid inner boundary (i.e., supposed invariant structure) to identify which phenomenological dimensions recur and matter; and third, a resulting state-space map that can accommodate the phenomenological signatures of pharmacological non-pharmacological induction methods. Both the second and third step necessitate the construction of a broad, next generation ASC questionnaire, while such an instrument could also recursively inform the first. Only with such scaffolding and its resulting instrument can ASC-psychotherapeutics move towards precision via identifying clinically relevant dimensions of experience from a conceptually strong inner boundary (empirically refined via questionnaire development) and the targeting of such dimensions in clinical practice.

2.8 Transition

This chapter established a provisional meta-structure of the ASC field by formalizing a nested model that locates the need for operationalization of the phenomenon of interest, its following invariant phenomenology, and its resulting state-space. This ASC phenomenon space underscores that ASCs are best understood as configurations within a phenomenological space carved out by an invariant structure. While this provisional meta-structure provides an interesting way of organizing the ASC field around definition and phenomenology, it does not make any attempt to account for underlying neurophysiological correlates. However, there have been previous attempts at unifying phenomenology with neurophysiology. For example, Vaitl et al. 2005 suggested a phenomenological space (see Section 1.2.1; the Four-Dimensional Descriptive System) with the explicit intent to map it to a neurobiological space.

While a one-to-one correspondence between neurophysiological outcomes to phenomenal experience is unlikely to be achievable (see Section 1.4), there is value in understanding various induction methods within a biological context. ASCs are primarily psychological constructs, but key questions concern how changes in phenomenological structure relate to brain and bodily dynamics, which provide measurable indicators of the conditions under which such experiences emerge and vary.

The following investigations in this thesis do not attempt to explain experience in biological terms, rather to use neurophysiological correlates to contextualize phenomenological findings. This follows the Jamesian pragmatic orientation, that the value of any exploratory layer is determined by its consequences for intervention and outcome (James, 1921). In the context of psychedelic-assisted psychotherapy, or here widened to ASC-psychotherapeutics to accommodate non-pharmacological induction methods, the primary target is not neural or physiological changes, but rather therapeutic change which is mediated by certain features of the invariant structure of experience. From this standpoint, phenomenology occupies a privileged position as the most proximal mediator of outcome, while neurophysiological processes operate at a more distal level, shaping conditions under which phenomenological patterns may arise.

The following chapter investigates the relationship between a prototypical phenomenological pattern brought about by moderate-dose psilocybin and its resulting neuro-dynamics to understand how features of the phenomenological space relate to identifiable patterns of large-scale brain dynamics.

III

Psilocybin and the Egotropic Brain

This chapter is replicated from the following publication except where otherwise indicated (*):

Mortaheb, S.†, **Fort, L., D.†,** Mason, N., L., Mallaroni, P., Ramaekers, J., G.††, & Demertzi, A.†† (2024). Dynamic functional hyperconnectivity after psilocybin intake is primarily associated with oceanic boundlessness. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*. DOI: 10.1016/j.bpsc.2024.04.001.

† refers to co-first authorship, †† to co-last authorship

See Appendix C for author roles

3.1 Introduction

Hallucinogens are psychoactive drugs that, historically, have been used to alter conscious experience (Mason et al., 2020; Metzner, 1998). These drugs are divided into the classes of serotonergic psychedelics (e.g., psilocybin), antiglutamatergic dissociatives (e.g., ketamine), anticholinergic deliriants (e.g., scopolamine) and kappa-opioid agonists (e.g., salvinorin A; Volgin et al., 2019). Research on classical hallucinogens has focused largely on serotonergic psychedelics, such as lysergic acid diethylamide (LSD), ayahuasca, psilocybin, N-dimethyltryptamine (DMT), and mescaline (Nichols, 2016). Among them, psilocybin has been one of the most studied psychedelics, possibly due to its potential contribution in treating different disorders (Kwan et al., 2022), such as obsessive-compulsive disorder (Moreno et al., 2006), death-related anxiety (Grob et al., 2011), depression (Andersen et al., 2021; Carhart-Harris et al., 2012, 2021; Ross, et al., 2016), treatment-resistant depression (Carhart-Harris et al., 2016, 2017, 2018), major depressive disorder (Davis et al., 2021), terminal cancer-associated anxiety (Griffiths et al., 2016; Ross et al., 2016), demoralization (Anderson et al., 2020), smoking (Johnson et al., 2017), and alcohol and tobacco addiction (Bogenschutz et al., 2015; Garcia-Romeu et al., 2019; M. W. Johnson et al., 2014).

The acute phase of psilocybin administration leads to the psychedelic state, which is a specific altered state of consciousness associated with consuming psilocybin and LSD (Bayne & Carter, 2018). By "state" we here refer to the combination of neurobiological and experiential patterns that are associated with the psychedelic experience (Rock & Krippner, 2007). In terms of the general experiential alterations, the psychedelic state has been associated with ego dissolution, i.e., the reduction in self-referential awareness, ultimately disrupting self-world boundaries with increasing feelings of unity with others and own surroundings (Nour

& Carhart-Harris, 2017; Studerus et al., 2010), unconstrained and hyper-associative cognition (Girn et al., 2020; Mason et al., 2021), profound alterations in the perception of time and space (Carhart-Harris et al., 2014; Griffiths et al., 2006), perceptual alterations, synesthesia, amplification of emotional state (Preller & Vollenweider, 2018), and emotional volatility (Majić et al., 2015). Long-term and enduring effects have also been reported on personality and mood, such as increases in openness and extraversion, decreases in neuroticism, and increases in mindful awareness (Erritzoe et al., 2018; MacLean et al., 2011; Madsen et al., 2020). In terms of the neurobiological pattern, the psilocybin administration resulted in increased cerebral connectivity with reduced modularity, whether in the acute or post-acute phase (Daws et al., 2022; Preller et al., 2020; Roseman et al., 2014). Region-wise, there were reports of decreased activity in the thalamus, posterior cingulate cortex, medial prefrontal cortex (Carhart-Harris et al., 2012), and altered connectivity of the claustrum (Barrett et al., 2020). Network-wise, decreased connectivity was reported within the default mode network-DMN (Carhart-Harris et al., 2012; Mason et al., 2020), visual network (Mason et al., 2020), and executive control network (McCulloch et al., 2022), as well as reduced segregation of the dorsal attentional network and executive control network (Madsen et al., 2021). These neural counterparts indicate that the subjective effects of psilocybin are linked to alterations in the activity and connectivity of important brain regions involved in information integration and routing when averaged signal analysis is concerned. Dynamic analyses of connectivity patterns after psilocybin administration have shown that the brain tended to recurrently configure into transient functional patterns with low stability (Petri et al., 2014). In addition, under psilocybin, there were higher probabilities for the brain to configure into a connectivity pattern characterized by a global cortex-wide positive phase coherence (Lord et al., 2019). In terms of state transition dynamics, a recent study calculated the minimum network control energy required to transition between states (or maintain the same state) and found that the network control energy landscape was flattened under LSD and psilocybin, meaning that there were more frequent state transitions and increased entropy of brain pattern dynamics (Singleton et al., 2022). Taken together, averaged and dynamic connectivity analyses suggest that psilocybin alters brain function such that the overall neurobiological pattern becomes functionally more connected, more fluid, and less modular.

Of interest is the link between the brain's functional dynamic reconfigurations and the psychedelic state's experiential patterns. A recent investigation correlated the occurrence rates of prominent connectivity patterns (i.e., frontoparietal subsystem and a globally coherent pattern) with subjective drug intensity (SDI) measured on a 10-point Likert scale (Lord et al., 2019; Olsen et al., 2022). As much as this approach has provided insights into the ensuing psychedelic state, it can be argued that, due to its simplicity, the SDI cannot capture the complexity of the psychedelic state's phenomenological pattern. Here, we adopt a neuro-experiential approach, defined here as the quantification and comparison of both the neurobiological and experiential patterns. This approach allows the investigation of psilocybin's effects on cerebral functional dynamics and, further, the linking of these dynamic spatiotemporal fingerprints with reported experiential alterations measured retrospectively with standardized assessment.

3.2 Method

This study was conducted according to the code of ethics on human experimentation established by the Declaration of Helsinki (1964) and amended in Fortaleza (Brazil, October 2013). This study was in accordance with the Medical Research Involving Human Subjects Act (WMO) and was approved by the Academic Hospital and the University's Medical Ethics Committee (Maastricht University, Netherlands Trial Register: NTR6505). All participants were fully informed of all procedures, possible adverse reactions, legal rights, responsibilities, expected benefits, and their right to voluntary termination without consequences.

Participants. The present study analyzed previously collected data on 49 healthy participants with previous experience with a psychedelic drug, but not within the past 3 months of the experiment (Mason et al., 2020). Participants were randomized to receive a single dose of psilocybin (0.17 mg/kg, n=22; 12 male; age=23±2.9 y) or placebo (n=27; 15 male; age=23.1±3.8 y).

Procedure. Participants were familiarized with the test day procedures on a separate training day prior to the treatment conditions. Participants were instructed to refrain from drug use, including psychedelic drugs (≥ 3 months), MDMA/ecstasy (≥ 14 days), alcohol (≥24 hours), and all other drugs of abuse (≥7 days) prior to their testing day. Additionally, participants were asked to refrain from caffeine and nicotine use on the day of the test day. On arrival of a test day, the absence of drug and alcohol use was assessed via a urine drug screen and a breath alcohol screen. An additional pregnancy test was given if participants were female. If all tests were found to be negative, participants were allowed to proceed. After measurements, the treatment was administered orally in a closed cup containing bitter lemon (placebo) or bitter lemon and psilocybin (powder). After 40 minutes, participants were placed in the MRI scanner, where resting state scans and magnetic resonance spectroscopy were performed throughout a 1 hour time window. Six minutes of resting state fMRI were acquired from the participants with eyes open. At the end of the test day (approximately 6 hours after treatment administration), participants were asked to complete measures of retrospective subjective experience (5-Dimensional Altered States of Consciousness (5D-ASC). Participants stayed under supervision until the testing day was complete, and the researcher deemed they were fit to go home.

3.3 Data Analysis

Phenomenological Assessment. The 5D-ASC Rating Scale is a 94-item self-report scale that assesses the participants' subjective experience after an altered state of consciousness, and as such, is termed a retrospective phenomenological assessment (Dittrich, 1998; Pekala, 2013). In this questionnaire, participants are asked to make a vertical mark on the 10-cm line below each statement to rate the extent to which the following statements applied to their experience: "No, not more than usual" to "Yes, more than usual." The 5D-ASC comprises five dimensions and 11 factors (Studerus et al., 2010; see Section 1.2.1, Table 1).

Analysis encompassed an initial assessment for normality assumptions of the 5D-ASC and its 11-ASC factors using Shapiro-Wilk tests set at α=0.05. In case of violations of normality, non-parametric Mann-Whitney U tests would compare the 5D-ASC and 11-ASC scores between the two groups. P-values were corrected using the Bonferroni method with a significance level set at α=0.05. The effect size was calculated based on Glass rank biserial coefficient (rg).

Neuroimaging Setup. Images were acquired on a 7T Siemens Magnetom scanner (Siemens Medical, Erlangen, Germany) using 32 receiving channel head array Nova coil (NOVA Medical Inc., Wilmington MA). The T1w images were acquired using a magnetization-prepared 2 rapid acquisition gradient-echo (MP2RAGE) sequence collecting 190 sagittal slices following parameters: repetition time (TR) = 4500 ms, echo time (TE) = 2.39 ms, inversion times TI1 /TI2 = 900/2750 ms, flip angle1 = 5°, flip angle2 = 3°, voxel size = 0.9 mm isotropic, bandwidth = 250 Hz/pixel. In addition, 258 whole-brain EPI volumes were acquired at rest (TR = 1400 ms; TE = 21 ms; field of view=198 mm; flip angle = 60°; oblique acquisition orientation; interleaved slice acquisition; 72 slices; slice thickness = 1.5 mm; voxel size = 1.5 × 1.5 × 1.5 mm).

Analysis encompassed:

- Preprocessing**:** fMRI data were preprocessed using a local pipeline based on SPM12 (Penny et al., 2011) and FSL 6.0.4 (Jenkinson et al., 2012). After realignment and susceptibility distortion correction (FSL topup; Andersson et al., 2003), functional data were registered to the high-resolution T1 image, then normalized to the standard MNI space, and finally smoothed using a Gaussian kernel with a full width at half maximum (FWHM) of 6mm. After segmentation of the structural T1 image into grey matter (GM), white matter (WM), and CSF masks, the bias-corrected structural image and all the extracted masks were normalized to the MNI space. Further, WM and CSF masks were eroded by one voxel to remove any overlapping between these tissues and the GM voxels. To denoise functional time series, we used a locally developed pipeline written in Python [nipype package(Gorgolewski et al., 2011)]. In this pipeline, a general linear model (GLM) was fitted to each voxel data separately, regressing out the effect of six movement parameters (translation in x, y, and z directions, and rotation in yaw, roll, and pitch directions) and their first derivative, constant and linear trends using zero-order and first-order Legendre polynomials, 5 principal components of signals in the WM and CSF masks. In addition, outlier detection was performed using the ART toolbox (http://web.mit.edu/swg/software.htm), and outliers were modeled as nuisance regressors in the GLM. Any volume with a movement value of greater than 3 mm, rotation value of greater than 0.05 radians, and z-normalized global signal intensity of greater than 3 was considered an outlier. After regressing out these nuisance regressors, the remaining signal was filtered in the range of [0.008, 0.09] Hz and was used for further analysis. The Schaefer atlas with 100 ROIs and a resolution of 2mm (Schaefer et al., 2018) was used to extract the averaged BOLD signals inside each ROI.

- Estimation of Averaged Functional Connectivity. Pearson correlations were calculated between the BOLD time series for every pair of ROIs, subsequently Fisher transformed, resulting in the generation of a 100×100 connectivity matrix for each individual participant. An Independent t-test was used to compare the 4950 possible between-region connectivity values between the two groups. FDR correction was performed to correct for multiple comparisons. Further, the average of the connectivity values over the whole brain was calculated for each participant and was considered as the overall connectivity value of the brain. An independent t-test was performed to compare the overall connectivity values between psilocybin and placebo groups.
- Estimation of Time-varying Functional Connectivity**.** We used phase-based coherence to extract between-region connectivity patterns at each time point of the scanning session(Barttfeld et al., 2015; Demertzi et al., 2019). For each participant i, after z-normalization of time series at each region r (i.e., $x_{i,r}[t]$), the instantaneous phase of each time series was calculated via Hilbert transform as:

$$\hat{x}_{i,r}(t) = \frac{1}{\pi t} * x_{i,r}(t)$$

where * indicates a convolution operator. Using this transformation, we produced an analytical signal for each regional time series as:

$$x_{i,r}^{a}(t) = x_{i,r}(t) + j\hat{x}_{i,r}(t)$$

where $j = \sqrt{-1}$. From this analytical signal, the instantaneous phase of each time series can be estimated as:

$$\varphi_{i,r}(t) = \tan^{-1}\left(\frac{\hat{x}_{i,r}(t)}{x_{i,r}(t)}\right)$$

After wrapping each instantaneous phase signal of $\varphi_{i,r}(t)$ to the $[-\pi, \pi]$ interval and naming the obtained signal as $\theta_{i,r}(t)$, we calculated a connectivity measure for each pair of regions as the cosine of their phase difference. For example, the connectivity measure between regions r and s in subject i was defined as:

$$conn_{i,r,s}(t) \triangleq \cos\left(\theta_{i,r}(t) - \theta_{i,s}(t)\right)$$

By this definition, completely synchronized time series lead to a connectivity value of 1, completely desynchronized time series produce a connectivity value of zero, and anticorrelated time series produce a connectivity measure of -1. Using this approach, we created a connectivity matrix of 100×100 at each time point t for each subject i that we called $C_i(t)$:

$$C_i(t) \triangleq \left[conn_{i,r,s}(t)\right]_{r,s}$$

After collecting the connectivity matrices across all time points and participants, k-means clustering was applied, with 500 repetitions and 200 iterations at each repetition. With this technique, four robust and reproducible patterns were extracted as the centroids of the clusters, and each resting connectivity matrix was assigned to one of the extracted patterns. For comprehensive purposes, we performed supplementary analyses by varying the number of clusters k=3- 7.

We calculated the occurrence rate of each pattern defined as the proportion of connectivity matrices assigned to that pattern and was calculated for each subject separately. Independent two-tailed t-tests were used to compare the occurrence rate of each FC pattern between the psychedelic and placebo groups. Bonferroni correction was used to correct the p-values for multiple comparisons across the four connectivity patterns.

- Dynamic state transition modeling**.** To investigate the temporal evolution of the identified connectivity matrices, we defined the extracted patterns as the distinct states of a dynamical system transitioning between them over time using Markov modelling (Demertzi et al., 2019). Using this approach, the data of a sample participant could be stated as a sequence of connectivity patterns over time (i.e., $\{P_t \mid t{:}\, 1, \ldots, T \ and \ P_t \in \{1, \ldots, M\}\}$, where M is the number of patterns and T is the number of signal time points). In this case, the probability of transitioning from Pattern I to Pattern J defined as $p(I \to J)$, considering $I, J \in \{1, .., M\}$, can be calculated as the number of consecutive I, J pairs in the sequence, divided by the total number of transitions from pattern I:

$$p(I \to J) = \frac{\sum_{t=0}^{T-1}[(P_t == I)\ \&\ (P_{t+1} == J)]}{\sum_{j=1}^{M}\sum_{t=0}^{T-1}[(P_t == I)\ \&\ (P_{t+1} == j)]}$$

This transition probability was estimated for each possible between-state transition and each subject separately. With this approach, we could compare any significant difference in transition probabilities between two groups of subjects. To detect significantly different transition probabilities between the two groups, Wilcoxon rank-sum test was performed on each transition and p-values were FDR-corrected.

- Regional BOLD Amplitude Analysis**.** The Euclidean norm of the BOLD signal was calculated at each ROI as a measure of the power of the signal. Independent t-test was used to compare the regional BOLD signal power between two groups, and p-values were FDR-corrected due to multiple comparisons.
- Neuro-experiential Analysis. A canonical correlation analysis (CCA) was conducted using the sixteen dynamic patterns transition probability variables as features of the neuronal space and the 11-ASC variables as features of the

phenomenological space to evaluate the multivariate shared relationship between the two variable sets. CCA is a multivariate latent variable model that identifies associations between two different data modalities (Mihalik et al., 2022). Considering matrix $X^{N \times M}$ contains M neuronal features of N subjects, and $Y^{N \times P}$ contains P questionnaire features of N subjects, the objective of the CCA is to find pairs of neuronal and questionnaire weights $w_x^{M \times 1}$ and $w_y^{P \times 1}$ such that the weighted sum of the neuronal and experiential variables maximizes the correlation between the resulting latent variables (canonical variates):

$$\max_{w_x, w_y} corr(Xw_x, Yw_y)$$

After finding latent variables Xw_x and Yw_y that have the maximal correlation, the features in each data modality that have a stronger correlation with their respective latent variable are also significantly associated with one another. To account for over-fitting, we used a permutation test to calculate the significance of correlation values. This was achieved by random shuffling of observations in the neural space compared to the observations in the phenomenological space. The procedure was repeated 100,000 times, and at each iteration, a CCA model was fitted to the data, and the correlation values were calculated. These values were used to construct the null distribution and to calculate the p-value of the observed correlation value in the main analysis. The obtained p-values were FDR-corrected to account for the multiple comparisons.

- Validation of the Results. We analyzed the potential effects of motion, atlas parcellation, and global signal regression on the main results. To quantify motion, we calculated the mean framewise displacement (FD; Power et al., 2014) for each subject as well as for each time-varying connectivity pattern. Independent t-tests were used to compare the mean FD between Placebo and Psilocybin groups as well as between time-varying connectivity patterns. Furthermore, the Pearson correlation between the Mean FD and either mean functional connectivity or mean BOLD signal amplitude was calculated. To investigate the role of sub-cortical regions, we incorporated 19 sub-cortical regions (Brain Stem together with the Thalamus, Caudate, Putamen, Pallidum, Hippocampus, Amygdala, Accumbens area, VentralDC, and Cerebellum in the right and left hemispheres) sourced from the Human Connectome Project (Fischl et al., 2002; Glasser et al., 2013; Griffa et al., 2022), into the initially utilized Schaefer atlas, resulting in an atlas with 119 regions of interest. Then, we performed both averaged and dynamic functional connectivity analysis using this combined atlas. Finally, to verify the effect of the global signal on the analysis results, we also performed all the analyses after global signal regression (GSR).

3.4 Results

Experiential Assessment. All variables of the 5D-ASC and its 11-ASC factors violated the assumption of normality. As a result, Mann-Whitney U tests compared the phenomenological outcomes in the two groups. Analyses revealed significant differences in all dimensions and factors with large effect sizes, such that the psilocybin group had more substantial effects than the placebo (Figure 19A and 19B).

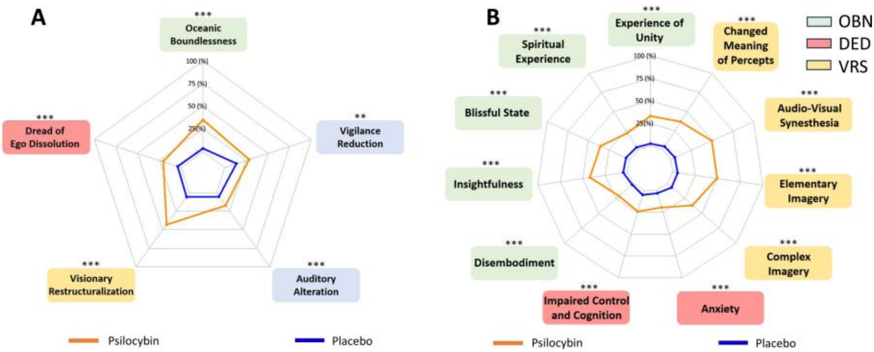

Figure 19. *Phenomenological Assessment of Psilocybin*. A) The assessment of five dimensions of altered states of consciousness questionnaire (5D-ASC) showed that the administration of psilocybin significantly altered subjective experience in all dimensions. B) The same effect can also be observed considering the 11 factors of altered states of consciousness (11-ASC). OBN: Oceanic Boundlessness, DED: Dread of Ego Dissolution, VRS: Visionary Restructuralization. Radar plots illustrate group means for each dimension/factor.

Neuroimaging. After psilocybin, whole-brain averaged connectivity increased (independent t-test: t=3.087, p=0.004; Figure 20A). This overall increase was further observed as a cortex-wide increase in the connectivity matrix values (independent t-test on the between-region connectivity values with FDR correction; Figure 20B) and an increase of the averaged connectivity values in the transmodal regions (independent t-test on the regional averaged connectivity values with FDR correction). These alterations in the connectivity values were also accompanied by changes in the BOLD signal amplitude. By calculating the Euclidean norm of the BOLD time series related to each ROI, we found that regional BOLD signal amplitude decreased after psilocybin administration in both posterior and anterior regions compared to the placebo group (independent t-test, FDR-corrected; Figure 20C). While somatomotor, limbic network, and temporal regions of the DMN did not show significant changes in their signal norm, the highest decrease in BOLD signal amplitude was related to the posterior cingulate cortex and parietal regions of the external control network.

Time-varying analysis revealed variant and distinct patterns of complex inter-areal interactions: one of both correlations and anti-correlations (Pattern 1), one of anti-correlations of the DMN with other networks (Pattern 2), one of global cortex-wide positive connectivity (Pattern 3), and one of low inter-areal connectivity (Pattern 4). Pattern 3 occurred significantly more often in the psilocybin group when compared to the placebo group (independent t-test: $t=3.731$, $p=0.001$, $\alpha_{bonferroni} = 0.05/4 = 0.0125$, Figure 20D). Supplementary analyses using k=3-7 clusters showed that the same connectivity patterns were replicable, and hyperconnectivity had a higher occurrence rate in the psychedelic state. In terms of dynamic transitions, the psilocybin group showed significantly higher transition probabilities towards Pattern 3 from Pattern 1 (Wilcoxon Rank-Sum test: $z=2.744$, $p=0.006$), Pattern 3 ($z=2.291$, $p=0.022$), and Pattern 4 ($z=2.000$, $p=0.045$; Figure 20E). In addition, the psilocybin group showed lower transition probabilities from Pattern 2 to itself compared to the placebo group ($z=-2.452$, $p=0.014$).

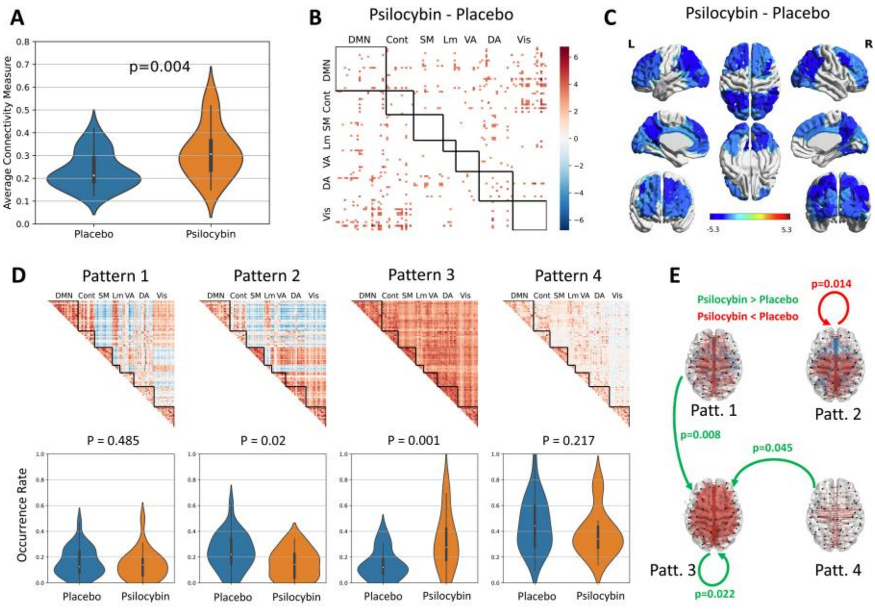

Figure 20. *Neurobiological Assessment of Psilocybin.* A) Averaged functional connectivity expressed as Fisher-transformed correlation values increased significantly after psilocybin administration compared to the placebo group. B) There were higher inter-regional connectivity values in the psilocybin group. The matrix represents t-values comparing the connectivity matrices of the psilocybin group and those of the placebo group (contrast: psilocybin minus placebo). Only significant difference values are colored. C) The BOLD amplitude of posterior and anterior brain regions decreased after psilocybin administration, while the amplitude of somatomotor and limbic areas, as well as the temporal regions of default more network (DMN), remain unchanged. Colors are based on t-values comparing the Euclidean norm of BOLD time series in the psilocybin group and the placebo group at each ROI; only significant difference values are colored. D) The functional connectome reconfigures in four connectivity patterns, ranging from complex inter-areal interactions (Pattern 1) to a low inter-areal connectivity profile (Pattern 4). After psilocybin administration, there was a significant increase in the occurrence rate of the global cortex-wide positive connectivity (Pattern 3). The connectivity matrices are colored based on the connectivity value: from dark blue to dark red corresponds to connectivity values from -1 to +1. Violin plots represent the distribution of patterns' occurrence rates across participants. E) The transition probability from other patterns to Pattern 3 increased in the psilocybin group. Arrows indicate transitions between functional connectivity states. Green corresponds to significantly higher transition probabilities (Wilcoxon Rank-Sum test) for the psilocybin group compared to the placebo, and red corresponds to significantly higher transition probabilities for the placebo compared to the psilocybin group.

The neuro-experiential link was investigated with canonical correlation analysis (CCA), by which we estimated the first canonical vector for both the behavioral and neural space that maximized the shared correlation between two spaces ($r=0.97$, $p<0.001$). Considering the neural space, the transition probabilities from Pattern 1 to Pattern 3 showed the highest correlation with the first canonical vector of the neural space ($r=0.86$, $p<0.001$, Figure 21A). In addition, the transition from Pattern 4 to Pattern 3 ($r=0.40$, $p=0.016$) showed a lower significant correlation with the first canonical vector of the neural space. In the questionnaire space, factors related to oceanic boundlessness (experience of unity:

$r=0.80$, $p=0.008$, blissful state: $r=0.74$, $p=0.010$, insightfulness: $r=0.68$, $p=0.013$, spiritual experience: $r=0.62$, $p=0.044$) and visionary restructuralization (elementary imagery: $r=0.67$, $p=0.012$ and audio-video synesthesia: $r=0.61$, $p=0.021$) showed the highest correlations with the first canonical vector of this space (Figure 21B). To account for over-fitting, we used a permutation test to calculate the significance of correlation values. This was achieved by random shuffling of observations in the neural space compared to the observations in the questionnaire space. The procedure was repeated 100,000 times, and at each iteration, a CCA model was fitted to the data, and the correlation values were calculated. These values were used to construct the null distribution and to calculate the p-value of the observed correlation value in the main analysis. The obtained p-values were FDR-corrected to account for the multiple comparisons. To validate the results, we also performed a CCA analysis between the dimensions of the 5D-ASC and the between-state transition probabilities. At the neural space, the transition probability from Pattern 1 to Pattern 3 showed the highest correlation with the first canonical vector of the neural space ($r=0.89$, $p<0.001$), and at the questionnaire space, oceanic boundlessness showed the highest correlation with the first canonical vector ($r=0.93$, $p=0.0145$).

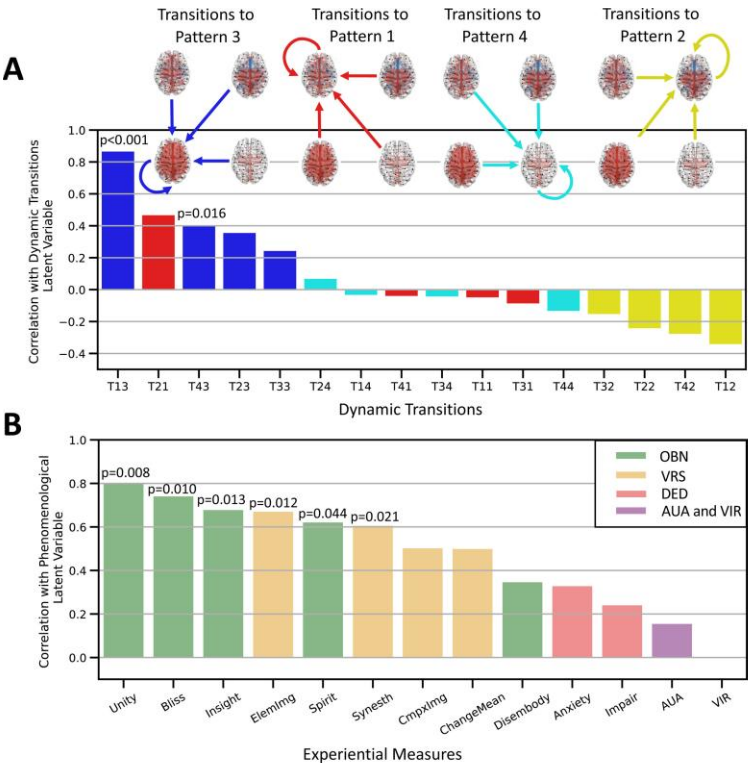

Figure 21. *Neurophenomenological Assessment of Psilocybin.* A) In the neural space, the canonical correlation analysis showed that the transition probabilities to the hyperconnected pattern had the highest correlation with the first canonical vector of the space. Notes: Demonstrated p-values are related to significant correlation values and are FDR-corrected. The x-axis represents pattern transitions, e.g. T13: transition from Pattern 1 to Patten 3. B) In phenomenological space, factors related to the dimension of oceanic boundlessness and visionary restructuralization showed the highest correlation with the first canonical vector of the space. Bars represent correlation values of each factor to the first canonical vector of its associated space. Notes: OBN: oceanic boundlessness, VRS: visionary restructuralization, DED: dread of ego dissolution, Unity: experience of unity, Bliss: blissful state, Insight: insightfulness, Spirit: spiritual experience, Disembody: disembodiment, ElemImg: elementary imagery, Synesth: audio-visual synesthesia, CmpxImg: complex imagery, ChangeMean: changed meaning of percept, Impair: Impaired control and cognition, AUA: auditory alterations, VIR: vigilance reduction.

Validation. The analysis of the effect of motion revealed comparable values in terms of mean framewise displacement between the Psilocybin and Placebo group (independent t-test, t=-0.31, p=0.76), as well as between the connectivity patterns. Additionally, no significant correlations were observed between mean framewise displacement and either mean functional connectivity values (r=0.23, p=0.12) or mean BOLD signal amplitude (r=0.11, p=0.43; Figure S4.C). Furthermore, the connectivity results were replicated even after adding subcortical regions to the parcellation atlas. However, regressing out the global signal led to the absence of a significant increase in functional connectivity values within the psilocybin group, as well as the absence of a hyper-connectivity pattern in the dynamic functional analysis as also previously shown (Mortaheb et al., 2022). Given that the GS amplitude was lower in the Psilocybin group, and that motion values were comparable between the Psilocybin and Placebo groups, we do consider that GS might contain inherent information about the psychedelic state. Therefore, we opted to retain the GS in the main analyses.

3.4 Review

We investigated the effect of the serotonergic hallucinogen psilocybin on the brain's functional connectome to link it with consciousness alterations to better comprehend how resulting neural and phenomenological changes are interconnected. Overall, we found that psilocybin administration led to a tendency of the brain to recurrently configure in a globally hyperconnected pattern, which was linked to heightened reports of oceanic boundlessness (experience of unity, blissfulness, insightfulness, and spiritual experience), and visionary restructuralization (complex imagery, elementary imagery, audio-visual synesthesia, and changed meaning of percepts).

Regarding experiential changes, the psilocybin group exhibited significant increases across all dimensions and factors compared to the placebo, including derealization, depersonalization, loss of self-control, visual pseudo-hallucinations (both elementary and complex), audio-visual synesthesia, unity experiences, spiritual insight, bliss, and disembodiment (Dittrich, 1998), as previously reported (Mason et al., 2020). These findings demonstrate that a moderate psilocybin dose produces a distinct phenomenological pattern compared to a placebo. Previous research on psilocybin administration also noted measurable changes in various dimensions with dosages ranging from 45 to 315 µg/kg body weight compared to a placebo (Hasler et al., 2004; Quednow et al., 2012). Our data aligns with this dose-dependent phenomenological pattern associated with psilocybin consumption.

Regarding neural changes, the psilocybin group exhibited an overall increase in whole-brain functional connectivity, consistent with previous reports (Roseman et al., 2014). Serotonergic psychedelics, including psilocybin, have been shown to alter the brain's functional organization, promoting greater global integration with increased short-range and long-range functional connections (Petri et al., 2014; Tagliazucchi et al., 2016; Timmermann et al., 2023b). The dynamic analysis revealed a higher probability of the brain transitioning to a hyperconnected pattern under psilocybin compared to the placebo group, a pattern reported in other psychedelic studies (Lord et al., 2019). This hyperconnected state, previously shown to be characterized by maximal integration and minimal segregation (Demertzi et al., 2019), aligns with the flattened landscape theory, where specific connectivity patterns become less dominant under psychedelics, resulting in increased transition probabilities to the functionally non-specific hyperconnected pattern (Carhart-Harris & Friston, 2019; Singleton et al., 2022; Timmermann et al., 2023b).

Additionally, the hyperconnectivity pattern in the psilocybin group was associated with cortex-wide decreases in BOLD signal amplitude. Despite the ongoing debate about global signal (GS) removal in denoising processes due to its reflection of various fMRI nuisance sources, we chose to retain GS in our analysis (Chang & Glover, 2010; Colenbier et al., 2020; Murphy & Fox, 2017; Power et al., 2017; Zhu et al., 2015). This decision was based on our recent finding that GS can complement extracted connectivity patterns (Mortaheb et al., 2022). Specifically, we observed that when the hyperconnected pattern coincided with high GS amplitude during wakeful rest, participants were more likely to report instances of mind blanking (Mortaheb et al., 2022; Ward & Wegner, 2013). Previously, the GS amplitude served as an indirect measure of general arousal levels, with higher amplitude indicating lower arousal and lower amplitude linked to higher arousal (Fukunaga et al., 2006; Liu et al., 2018; Nilsonne et al., 2017; Wong et al., 2013). After LSD intake, similar results were observed, showing a decrease in signal variance, which eventually leads to a decrease in GS (Carhart-Harris et al., 2016). In our study, the hyperconnectivity pattern was associated with reduced GS amplitude, further contributing to the understanding of the psychedelic state as mediated by high cortical arousal (Carhart-Harris et al., 2013). It is important to mention that the hyperconnected pattern was sensitive to GS removal and did not show such signal configuration after the regression (Supplementary Information), which is consistent with our previous work with this method (Mortaheb et al., 2022).

In neurophenomenological terms, we found a significant association between higher transition probabilities into the hyperconnected pattern and the factors of oceanic boundlessness (OBN) and visionary restructuralization (VRS). OBN entails a positive mood, insight, and unity experiences (Studerus et al., 2010). Previous studies linked positive ego dissolution and oceanic boundlessness to reduced hippocampal glutamate (Mason et al., 2020) and increased insight to reduced DMN within-network static functional connectivity (Mason et al., 2021). Our whole-brain dynamic analysis extends this by demonstrating that recurrent hyperconnected states after psilocybin intake can explain unity experiences, characterized by a disruption of the self-world boundary, contrasting with the hyperconnected pattern's atypical minimal segregation profile (Demertzi et al., 2019). We propose that unity feelings and visual pseudo-hallucinatory experiences under psilocybin are linked to the brain's inclination for highly integrated patterns, showcasing its capacity for diverse mental associations. This is supported by improved creative thinking dimensions (Girn et al., 2020; Mason et al., 2021) attributed to increased between-network functional connectivity of DMN and the frontoparietal network,(Mason et al., 2021) which resembles the hyperconnected pattern.

Three OBN factors (unity, bliss, insight) had the highest canonical correlations in our analysis, followed by VRS factors. Dimensional-level canonical correlations reinforced OBN's highest association with transition probabilities to the hyperconnected pattern. Despite serotonergic psychedelics being historically labeled as hallucinogens, our findings align with psilocybin studies, emphasizing OBN's primary role in phenomenological outcomes (Metzner, 2005a; Nichols, 2016; Rotz et al., 2023). OBN’s overall importance in the psychedelic state is further supported by research showing that it is linked to increased 5-HT2AR receptor binding potential (Hasler et al., 2004; Quednow et al., 2012), that it predicts functional connectivity changes (Smigielski et al., 2019), and that it positively correlates with somatomotor network disconnection (Preller et al., 2018). Since OBN is defined as the positive valence associated with depersonalization and derealization, it is a key psychometric dimension describing ego phenomenological modifications (Dittrich, 1998; Studerus et al., 2010). We performed CCAs on both the 5D-ASC and 11-ASC to show that OBN and its factors have the strongest correlations with the latent variable of the neurobiological space. This may suggest OBN as the primary driver of psilocybin’s experiential pattern, prompting consideration of more precise terms such as "egotropic" over "hallucinogenic” when discussing its clinical relevance. This is not to suggest that the other psychometric dimensions/factors do not have importance or clinical relevance. Rather, we mean to raise a discussion around how egotropic effects of psilocybin may be overlooked as reflected in how the drug is labelled or categorized.

Our study has several limitations. First, the absence of concurrent physiological recordings during fMRI scanning restricts tracking arousal levels, leaving us to use GS amplitude as a proxy for cortical arousal. Simultaneous physiological and electrophysiological recordings in future studies could enhance the understanding of neuronal firing during hyperconnected patterns. Second, the between-subject design, which also requires brain anatomy normalization to the MNI space, could hamper the reproducibility of the findings. A proper within-subject design is required in future studies to mitigate this shortcoming. We further recognize that, even with classic mitigations at preprocessing, the effect of motion can still influence the obtained findings. Similar effects can also come from the shift in the neurovascular coupling during psychedelics, as recent work in mice with calcium imaging has shown (Padawer-Curry et al., 2023). Fourth, we are aware that due to methodological differences using an eyes-open condition during rest our results are not fully in line with other protocols where the psychedelic effects are were maximized with eyes closed. However, as in our past study we showed that the characteristic psychedelic effects could be found in this cohort of subjects even in the eyes open (Mason et al., 2020), we remain assured that here we also characterize this state adequately. Also, in our past work we identified differences in the DMN which in the present analysis was not a straightforward finding. We think that this discrepancy is due to the adoption of a whole-brain network characterization, using an atlas-based parcellation with multiple ROIs, which can reduce the sensitivity of capturing network-level alterations. Lastly, the analysis' reliance on the recruited population may limit generalizability, though previous studies demonstrated replicability and universality of recurrent connectivity patterns in different datasets and brain parcellations (Demertzi et al., 2019; Mortaheb et al., 2022).

In sum, psilocybin induces significant alterations in both brain function and subjective experience, promoting a functionally non-specific hyperconnected organization. The hyperconnected state correlates with reported experiences of oceanic boundlessness and visual pseudo-hallucinations, highlighting the complex interplay between brain dynamics and subjective phenomena potentially reflecting the ability to entertain variant mental associations. In total, these findings illuminate the intricate interplay between brain dynamics and subjective experience under psilocybin and providing insights into the neurophysiology and neuro-experiential qualities of the psychedelic state.

3.5 Transition*

Note: This section is not part of the original publication

Chapter 3 established that ASCs induced by moderate-dose psilocybin exhibit relationships between large-scale brain dynamics and specific features of phenomenal experience. The emergence of a hyperconnected brain state was shown to align broadly with the 5D-ASC dimension of Oceanic Boundlessness, with the most prominent factor being unity, suggesting an important role for egotropic experiences. Such a finding demonstrates that features of ASC phenomenology align with structural neurobiological patterns.

Pharmacological inductions alone, however, present a limitation for the broader aims of this thesis as they subtly slip into pharmacocentric biases (Chapter 2) and operate with limited parameter-level control, constraining the ability to demonstrate a proof-of-principle of phenomenological engineering, in which specific features of ASCs can be modulated through controlled manipulation of induction parameters.

For example, while psilocybin produces a robust and reliable means of eliciting profound alterations in experience, even at moderate doses, it achieves its effects in ways that are not easily decomposed, therefore not easily tuned. For example, while psilocybin achieves its effects by acting as a partial agonist at serotonin 5-HT_2A receptors, this primary interaction originating in the dorsal raphe nucleus, initiates a cascade of downstream effects across multiple neurotransmitter systems, including serotonergic, dopaminergic, and glutamatergic pathways (De Gregorio et al., 2018).

In particular, activation of cortical 5-HT_2A receptors lead to increased glutamate release in the prefrontal cortex, altering excitatory signaling and promoting widespread changes in network-level activity and synaptic plasticity (De Gregorio et al., 2018). At the same time, psilocybin indirectly modulates dopaminergic signaling and interacts with additional serotonergic receptor subtypes, further contributing to its distributed effects across cortical and subcortical systems (De Gregorio et al., 2018).

As a result, the phenomenological alterations induced by psilocybin emerge from the simultaneous perturbation of multiple interacting systems. This ultimately renders the resulting ASC difficult to decompose into discrete mechanistic contributions and therefore making it more resistant to precise parameter-level control.

To move toward the aim of designing ASCs with intention (i.e., phenomenological engineering), the utility of certain non-pharmacological inductions of ASCs must be considered, and ultimately, studied. For one, the phenomenology elicited from these inductions helps to normalize candidate dimensions of an ideal, etiology-independent inner boundary of the ASC phenomenon space. Second, the ability to simply turn on and off some of these inductions at will (e.g., darkness retreats, stroboscopic light stimulation, and multi-modal Ganzfeld or MMGF), can allow for more convenient tuning of parameters such as color of light, sound, and/or frequency of flicker for the explicit use of modulating specific features of the experience. Given its low-risk safety profile compared to that of stroboscopic light which increases risk of seizure (Hewitt et al., 2025), MMGF represents an understudied and useful experimental tool to reach the aims of this thesis.

The following chapter examines whether the targeted adjustment of induction parameters, specifically the color of light, can modulate the structure of phenomenological experience under MMGF. In doing so, Chapter 4 extends the neurophenomenological association established in Chapter 3 toward testing whether specific dimensions or factors of ASC experience can be intentionally modulated through controlled manipulation of induction parameters. While these effects are partially contextualized by neurophysiological correlates (e.g., EEG power spectral density and heart rate), the primary focus remains on the extent to which phenomenological features can be selectively shaped, consistent with a Jamesian pragmatic emphasis on clinical outcomes (see Section 2.8, James, 1921).

IV

Engineering Experience in the Multi-Modal Ganzfeld

This chapter is based on:

Fort, L., D., Beauté, R., Wittmann, M., & Demertzi, A. Red Light Selectively Amplifies Complex Imagery in the Multi-Modal Ganzfeld: A Phenomenological and Neurophysiological Investigation (in prep).

See Appendix C for author roles

4.1 Introduction

Altered States. Altered states of consciousness (ASCs) can be defined as transient, multidimensional changes in subjective experience different from a normal, waking state (Farthing, 1992; Ludwig, 1966; Tart, 1975/1983). ASCs are often best characterized not as discrete categories of experience but as configurations or patterns, across multiple phenomenological features that vary in degree (see Schmidt & Fort, in press). These features can be conceptualized as dimensions within a phenomenological state space, such that a given induction corresponds to a characteristic region within that space.

Although the precise dimensional structure of ASCs remains debated, converging classification efforts suggest the presence of relatively invariant phenomenological features, such as changes in perception and imagery, cognition, and affect (Cardeña et al., 2025; Fort et al., 2025; Yaden et al., 2024). At a broad level, ASC induction methods are commonly divided into pharmacological (e.g., psilocybin) and non-pharmacological (e.g., meditation) categories. Because non-pharmacological induction methods allow greater experimental control and avoid pharmacological confounds, they can be important experimental tools for isolating and probing specific features of ASC phenomenology and their neurophysiological correlates.

Situated within the broader classification of non-pharmacological ASC inductions, the multi-modal Ganzfeld (MMGF) offers a well-controlled experimental model for studying the phenomenology of pseudo-hallucinations under ASCs. MMGF combines visual and auditory sensory homogenization, typically through diffuse colored light and unstructured noise, to reliably induce pseudo-hallucinatory experiences wherein perceptual imagery emerges endogenously while participants retain insight into the unreality of the experience (Schmidt & Prein, 2019; Wackermann et al., 2008). From an experimental standpoint, MMGF is particularly well suited for isolating phenomenological features of ASCs. Since sensory homogenization remains constant, specific parameters such as light wavelength or auditory noise characteristics can be systematically manipulated to test if any meaningful difference in phenomenology can occur from such fine-grained changes to the induction method. Insights from such investigations can have both experimental and clinical relevance. To understand why MMGF is a promising experimental tool in this way, some background is required on its history.

Brief History. The Ganzfeld (German for "whole field") paradigm originated in early vision research examining the perceptual consequences of prolonged exposure to spatially homogeneous stimulation. By minimizing edges and contrast, such stimulation provides little structured sensory information, revealing the extent to which perception depends on spatial and temporal variation (Metzger, 1930). Sustained exposure to a Ganzfeld reliably produces characteristic perceptual effects, including depth ambiguity, intermittent "blank-out" episodes, and the emergence of hallucination-like imagery. These phenomena are commonly attributed to perceptual fading (i.e., the Troxler effect), whereby stable visual input is progressively suppressed and the field approaches eigengrau, the uniform gray perceived in the absence of structured stimulation (Knau & Spillmann, 1997).

By the mid-twentieth century, Ganzfeld stimulation was explicitly linked to the emergence of spontaneous visual pseudo-hallucinations ("Ganzfeld imagery"; Goldberger, 1961). The later addition of auditory homogenization, typically in the form of unstructured noise, marked the transition to MMGF, which was found to reliably induce hypnagogic-like experiential states (Witkin & Lewis, 1965). Subsequent research contributed to protocol standardization and systematic documentation of MMGF phenomenology. Importantly, early Ganzfeld studies also demonstrated that core perceptual properties of the homogeneous field depend on illumination parameters: field appearance, fading dynamics, and post-stimulation darkness vary systematically with light wavelength, with shorter wavelengths producing slower fading and stronger sensations of darkness than longer wavelengths (Gur, 1989). Despite this well-characterized structure, it remains unclear which specific induction parameters, such as light wavelength or auditory noise characteristics, selectively influence distinct aspects of MMGF experience.

Phenomenology. The phenomenology of MMGF can, in a multidimensional view of ASCs, be seen as spanning several features of subjective experience at differing intensities. Across studies, MMGF is shown to reliably produce pseudo-hallucinatory experiences that are both elementary and complex across both visual and auditory modalities. Elementary pseudo-hallucinations are typically comprised of simple perceptual phenomena, such as changes in the uniform visual field (e.g., achromatization, fog-like textures), geometric patterns, light spots, or basic auditory sensations (e.g., ringing, humming, or flowing sounds). These experiences often emerge rapidly, sometimes within minutes of exposure, and may fluctuate in presence, abruptly appearing and disappearing (Wackermann et al., 2008). In contrast, complex pseudo-hallucinations involve more elaborate, dream-like imagery, including scenes, objects, faces, animals, or familiar auditory content such as voices or music. These experiences tend to emerge later and develop more gradually.

Importantly, simple and complex pseudo-hallucinations are not mutually exclusive. In MMGF, pseudo-hallucinations are most commonly reported in the visual modality, while auditory hallucinations are comparatively less common (Schmidt & Prein, 2019). Rarely, these phenomena may co-occur creating coherent scenes accompanied by corresponding sounds (Pistolas et al., 2025a). Despite their vividness, MMGF pseudo-hallucinations are typically accompanied by preserved insight and narrative coherence as participants generally recognize the internally generated nature of the imagery and can describe it as unfolding in a continuous, comprehensible manner (Wackermann et al., 2008).

In this respect, Ganzfeld imagery differs from dreaming which is often marked by fragmented narrative structure, reduced insight, and diminished linkage to autobiographical context (Wackermann et al., 2008). A distinct class of perceptual phenomena reported under MMGF includes transient experiences of perceptual absence often described as “blank-outs.” Following sustained exposure to the homogenous field, some participants report a temporary loss of visual sensation, characterized by an entirely black or void-like visual field accompanied by uncertainty as to whether the eyes are opened or closed. These experiences are typically brief and reversible. Beyond perceptual content, MMGF experiences may vary in affective tone. Reports commonly include states of relaxation or calmness, but may also involve anxiety or unease (Kübel et al., 2021; Wackermann et al., 2008). Further, MMGF inductions have been known to affect the sense of time, such that duration of the experience is often overestimated. In some cases, MMGF has also been associated with kinesthetic or proprioceptive alterations, such as sensations of bodily lightness, extension, or vertical movement (Pistolas et al., 2025b; Tsuji et al., 2004). Taken together, these observations indicate that MMGF induces a multidimensional phenomenological profile highlighted primarily by visual pseudo-hallucinations, but also auditory pseudo-hallucinations, emotional changes, changes to time sense, and to one’s bodily sense.

Neurophysiology. The neurophysiological profile of prototypical MMGF ASCs suggests a distinct shift in brain dynamics favoring internally generated processing. EEG studies examining phasic cortical dynamics show alpha rhythm acceleration, especially in fast alpha (α2: 10-12Hz) range, with transient α2 bursts reliably preceding the formation of pseudo-hallucinations (Pistolas et al., 2025a; Pütz et al., 2006; Wackermann et al., 2008). After this formation, a surge of beta is reported while a steady increase in alpha continues. These oscillatory dynamics, namely α2 increases alongside beta power bursts, are interpreted as reflecting thalamo-cortical feedback loops involved in memory retrieval and perceptual construction (Wackermann et al., 2008). Supporting this, fMRI data indicates that during sustained MMGF exposure, the thalamus progressively decouples from primary sensory cortices despite high intensity sensory input, while Default Mode Network (DMN) regions become more globally connected (Schmidt et al., 2020). This combination of bottom-up sensory gating and DMN dominance mirrors a predictive coding architecture in which diminished precision of external input causes top-down priors (i.e., beliefs or expectations) to override perception. Currently, little is known about autonomic physiological changes during MMGF, such as cardiac, respiratory, or electrodermal activity.

MMGF & Wavelength of Light. Several studies have investigated how specific stimulus parameters affect the ASC phenomenology induced by Ganzfeld and MMGF stimulation. Of these, light wavelength, or perceived color, has emerged as a parameter of interest given that it appears to be more dominant in the overall experience than audition (Pistolas et al., 2025a; Schmidt & Prein, 2019). Support for the role of wavelength in shaping MMGF experiences comes from early research on visual field fading. In the visual domain, prolonged exposures produces wavelength dependent fading dynamics: the colored field undergoes achromatization; the bright homogenous field fades into *eigengrau* and once stimulation stops, participants often report a secondary sensation of additional darkness (Gur, 1989). Importantly, the speed and quality of this fading process is wavelength dependent. Short-wavelength (e.g., blue, 400-500nm) leads to slow fading and a deeper subjective darkness, whereas long-wavelength light (e.g., red, 620-700nm) fades more quickly and evokes a weaker sensation of darkness.

While such work explains the effect of light color on visual field dynamics, more specific experiments testing the effect of light color on MMGF phenomenology show effects on arousal, affect, sense of time, and kinesthetic phenomena. Studies comparing red and green illumination under otherwise identical MMGF conditions have shown that red light increases subjective arousal, negative affect, and perceived duration whereas green light tends to induce relaxation and a compressed sense of time (Kübel et al., 2021). The same wavelength dependent differences were observed in visual-Ganzfeld-only work where red was found to yield richer bodily and emotional experiences compared to green or blue fields (Tsuji et al., 2004). However, not all studies have found significant wavelength effects; in an MMGF psi-telepathy study using red versus green conditions, Lieb et al., (2024) observed no differences between the colors in arousal, emotional valence, and subjective passage of time.

Though less studied, color has been implicated in modulating spatial and thematic aspects of experience. Under MMGF conditions with dynamic color-changing fields, participants often report qualitative depth alterations such as red fields feeling nearer while blue fields are described as distant or expansive (Pistolas3). These perceptual impressions are consistent with known effects of long and short wavelength light on visual depth perception and accommodation (Gur, 1989; Knau & Spillmann, 1997). In terms of imagery content under MMGF, blue light was reportedly associated with water-themed hallucinations such as scenes of oceans, rain, or underwater life thought to be assisted by the static white noise (Pistolas et al., 2025a).

However, it is critical to note what these studies have not shown. No existing study has directly tested whether specific wavelengths affect the content or structure of pseudo-hallucinations produced by MMGF. While color-linked thematic associations have been reported qualitatively as in blue light being associated with water-like imagery, they have not been experimentally isolated and tested quantitatively within subjects across color conditions. Thus, while prior work supports the view that wavelength modulates the emotional tone, time sense, depth perception, and thematic associations of imagery qualitatively, the question of whether color of light affects the intensity of pseudo-hallucinatory experience under the induction remains empirically unresolved.

The present study addresses this empirical gap by manipulating the wavelength of visual stimulation within a controlled MMGF paradigm to assess its impact on pseudo-hallucinatory experience. Building on prior findings showing that red light sustains higher arousal levels compared to shorter-wavelengths (Kübel et al., 2021) and that it is associated with increased emotional and somatic vividness (Tsuji et al., 2004), we hypothesize that red light will produce more intense pseudo-hallucinations than green light in the domains of elementary and complex imagery. In addition to this confirmatory hypothesis, we examine whether red-light and green-light MMGF sessions produce distinct neurophysiological profiles to better contextualize phenomenological findings.

4.2 Method

Participants. The study was approved by the University of Liège Centre Hospitalier Universitaire (CHU) ethics committee (Nr Belge: B707202300039) and conforms with the Declaration of Helsinki and the European General Data Protection Regulation (GDPR). Before the experiment, participants provided informed consent for their participation in the study. Participants were blinded to the hallucinatory experiences often produced by MMGF via deception. Participants received monetary compensation for each day of acquisition. At the end of the experiment, participants were debriefed about the true nature of the experiment and signed a debriefing form.

Healthy participants were recruited through an online university database where the study was advertised as testing heart rate response to sensory homogenization. The potential hallucinatory outcome of MMGF was concealed from participants via deception-based blinding to control for possible demand characteristics on outcome. Given regional constraints, participants were native French speakers. All questionnaires and interviews were done in French. Inclusion criteria were that one must be a native French speaker whereas exclusion criteria prohibited red-green color blindness, previous knowledge of MMGF, and history of developmental, psychiatric and/or neurological illness to participate.

Procedure. The study employed a within-subject, crossover, baseline-controlled design to examine wavelength-dependent effects of MMGF stimulation. Participants completed a two-day protocol, with red and green light MMGF administered once per day in a counterbalanced order (Figure 22). This design controlled for order effects, novelty effects, and interindividual variability, while minimizing demand characteristics through deception-based blinding. All questionnaires were administered in French. To reduce novelty effects associated with first-time MMGF exposure, Day 1 began with a familiarization (training) session consisting of 25 minutes of white-light MMGF, followed immediately by completion of the 5-Dimensional Altered States of Consciousness Rating Scale (5D-ASC). This procedure follows prior work demonstrating that initial exposure to Ganzfeld stimulation can produce exaggerated or unstable phenomenological responses that diminish with repeated exposure (e.g., Schmidt & Prein, 2019). After the familiarization phase, participants were equipped with electroencephalography (EEG), electrodermal activity (EDA), heart rate (HR), and respiration electrodes for recording. Participants then completed a brief baseline recording period (5 min) under resting conditions.

Before arrival at the laboratory, several trait level questionnaires were completed online by participants. These included French versions of the DES-II, Big Five, Tellegen Absorption Scale, and VVIQ (see Data Analysis – Questionnaires). Immediately prior to the experimental MMGF session, participants completed the Karolinska Sleepiness Scale (KSS) to assess momentary vigilance. They then underwent their first color MMGF session (25 min) under either red or green illumination, with condition order randomized across participants. Following MMGF exposure, participants remained in a reclined position and completed the KSS again, then the retrospective phenomenological assessment consisting of the 5D-ASC and a free association narrative interview in French (Halamová et al., 2018). The order of these two measures was randomized to control order effects on retrospective reporting. Day 2 followed the same structure as Day 1, excluding the familiarization session. After the electrode montage and a brief baseline recording, participants completed the alternate color MMGF condition (red or green; counterbalanced), preceded by the KSS and followed by the KSS again and the same phenomenological assessments with randomized order. Sessions were scheduled approximately 24 hours apart and conducted at similar times of day for each participant to minimize circadian and sleep-related confounds.

To further reduce demand characteristics, participants were blinded to the expected phenomenological outcomes of MMGF through deception. Participants were not informed that MMGF is known to elicit hallucination-like or imagery-rich experiences, nor that the primary hypotheses concerned such effects. Instead, the study was described in general terms as examining perceptual and physiological responses to light. Expectancy and prior knowledge were explicitly assessed using structured verification questionnaires administered at the end of Day 1 and Day 2 (Verification Forms; see Supplemental Materials). These questionnaires probed: prior familiarity with MMGF stimulation, the nature and content of any prior knowledge, participants' perceived understanding of the study aims, and any information about MMGF acquired outside the study between acquisition days.

Participants were explicitly instructed not to seek external information about MMGF until completion of all experimental sessions. Following completion of all experimental sessions and verification measures, participants were fully debriefed regarding the true aims of the study and the methodological necessity of deception for minimizing expectancy-driven reporting biases. Participants provided written confirmation that they had been appropriately debriefed. No participants were able to guess the hypothesis of the study.

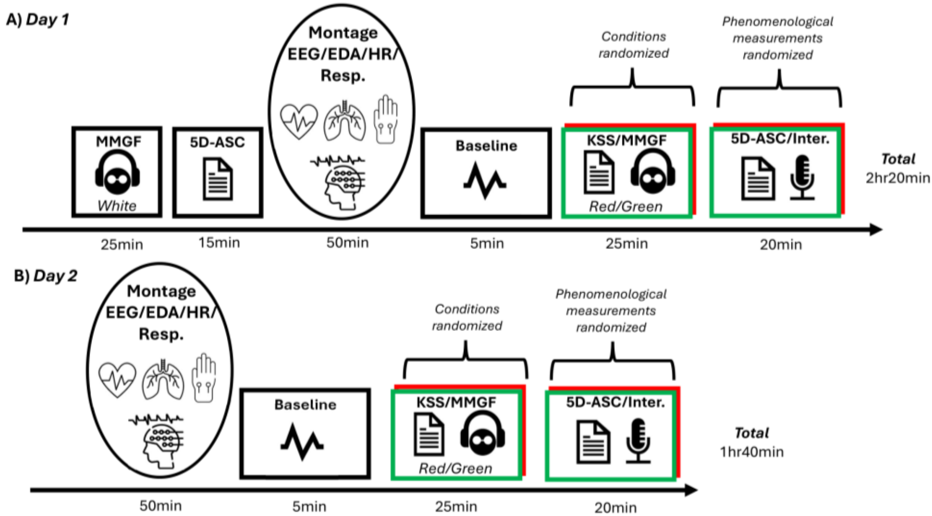

Figure 22. Design and Procedure. Participants completed a two-day within-subject protocol to assess wavelength-dependent effects of multi-modal Ganzfeld (MMGF). *(A) Day 1* began with a white-light MMGF session followed by the 5D-ASC questionnaire to minimize novelty effects. Participants were then fitted with sensors for EEG, electrodermal activity (EDA), heart rate (HR), and respiration recording. After a brief baseline period, they completed the Karolinska Sleepiness Scale (KSS) and underwent their first color-induction session (red or green MMGF; order randomized). This was followed by phenomenological assessments consisting of the 5D-ASC and a free association interview, with the order of these two measures randomized. *(B) Day 2* followed the same structure, including baseline, the alternate color-induction session (counterbalanced), and phenomenological assessments with randomized order. Sessions were scheduled approximately 24 hours apart and conducted at similar times of day to control for sleep-related and circadian influences.

The MMGF setup included an RGB LED light setup to produce red, green, and white light that projected onto goggles over the participants' eyes in order to produce a uniform field of vision (Figure 23C). The goggles consisted of plastic, oval-shaped, transparent, and frosted material, able to disperse the incoming light uniformly over the participant's eyes. The goggles were padded using white foam for comfort and were equipped with an adjustable headband and multiple inter-ocular distance bands for optimal fit on all subjects. The subject's field of vision was illuminated uniformly with an RGB spotlight/floodlight (approximately 1000 Lumens, 40W total power; Figure 23A). After instructing the subject to reach a relaxed position, the light was placed approximately 40 cm from the eyes (Figure 23B) as done previously (Schmidt & Prein, 2019). The wavelengths of the emitted light were measured using a spectrometer and showed the following for each color condition: Red (600-680nm) and Green (500-550nm). Auditory homogenization was delivered using high-fidelity closed-back, over-ear headphones. White noise was played for the entire duration of the experiment. The volume was adjusted before the onset of the experiment in coordination with the participant, as loud enough to facilitate immersion without being uncomfortable.

Figure 23. Equipment and Setup. *A) Left – Flood Light*: 40W total power, approximately 1000 lumens in each individual color setting (red and green). *B) Center – Custom made Ganzfeld goggles*: Created using plastic, transparent material cut at a curve such that placement over the eye orbits would create a homogenized visual field. The orbits of the plastic were padded using white foam for comfort and connected with adjustable inter-ocular distance bands and an adjustable headband. *C) Right – Medical Bed:* In a typical MMGF session with red light and white noise, a prospective participant would lie on the reclined medical bed with the goggles fitted comfortably and properly (i.e., the cover the eye orbits and prevent light leakage). The lamp is placed such that it is approximately 40cm from the eyes. The volume of the white noise is adjusted per participant to what they find comfortable.

An a priori power analysis for a one-way repeated measures ANOVA at 0.95 power via Gpower 3.1 determined n = 32 as sufficient to find a true effect (Faul et al., 2007). To estimate this effect we used reports from a previous experiment which employed the Phenomenology of Consciousness Inventory and specific measures for subjective time and arousal to study red and green light ganzfeld conditions, which we find most appropriate for our contrasts (Kübel et al., 2021). In part, this was chosen due to the availability of the results presented by the selected study, allowing for more transparent power analysis. Previous work has suggested that hallucinatory phenomena are more likely in situations of medium to high physiological arousal, supporting the low reportability of their occurrence in sensory deprivation (Vaitl et al., 2005; Zuckerman et al., 1969). Therefore, we chose to estimate our effect off of the following: time duration was estimated significantly higher in red light $^{\mu}$red = 23.1 min, $^{\mu}$green = 19.8 min ($\Delta M = 3.3$), $t(64) = -2.35$, $p = .011$, $d = 0.59$; 95% confidence interval = 0.95; Bonferroni adjusted (Kübel et al., 2021). Effect size d (0.59) was converted into Cohen's f (.295) for power calculations. A Gpower 3.1 computation (A priori: ANOVA: Repeated measures, within factors) was then run as follows: (Effect size f: 0.295, error: 0.05, power: 0.95, groups: 1, measurements: 3, correlation among repeated measures: 0.5, non-sphericity correction: 1).(Faul et al., 2007) This resulted in a total sample size of 32. The final sample consisted of 33 participants (18 female, 15 male) with a mean age of 33.24 years (SD = 13.78).

4.3 Data Analysis

Questionnaires. The 5-Dimensional Altered States of Consciousness (5D-ASC) Rating Scale was used for retrospective phenomenological assessment because of its ability to capture pseudo-hallucinations in the auditory domain, the visual domain, and its ability to psychometrically distinguish between elementary and complex imagery (Dittrich, 1998). The 5D-ASC is a 94-item visual analogue scale measuring five dimensions and 11 factors of phenomenological experience (Studerus et al., 2010; see Section 1.2.1, Table 1). Example items include: “I saw regular items or geometric shapes.” Momentary vigilance prior to each MMGF session was assessed using the Karolinska Sleepiness Scale (KSS; Shahid et al., 2011). The KSS is a single-item, 9-point scale ranging from “extremely alert” to “very sleepy, fighting sleep”, and is widely used to index state-dependent fluctuations in arousal and alertness. Participants rated their current level of sleepiness immediately before each experimental session.

To characterize individual differences relevant to altered experiences and imagery production, several trait-level questionnaires were completed online prior to laboratory participation. All of these questionnaires were given in their validated French versions. Dissociative tendencies were assessed using the Dissociative Experiences Scale – II (DES-II; Carlson & Putnam, 2022). The DES-II consists of 28 items measuring the frequency of dissociative experiences in everyday life, scored as the percentage of time an experience occurs. An example item is: “Some people find that they have no memory for some important events in their lives.” Personality traits were assessed using the Big Five personality inventory, measuring Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Items are rated on Likert scales reflecting agreement with trait-descriptive statements, such as “I am someone who is curious about many different things.” Trait absorption, reflecting a disposition toward deep experiential involvement and imaginative engagement, was measured using the Tellegen Absorption Scale (TAS; Tellegen & Atkinson, 1974). The TAS consists of 34 Likert-type items assessing openness to immersive sensory and imaginative experiences. An example item is: “I can be deeply moved by a sunset.” Visual imagery vividness was assessed using the

Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973). The VVIQ measures the clarity and vividness of mental imagery across common scenarios, with items such as “Visualize a rising sun. How clear is the image?” Responses are rated on a multi-point scale ranging from no image at all to perfectly clear and vivid imagery.

Free-Association Interview Reports. Free-association interview reports were analyzed using the Mapping of Subjective Accounts into Interpreted Clusters (MOSAIC) framework (Beauté et al., 2025), a data-driven natural language processing pipeline designed to extract latent experiential themes from open-ended reports. Interview transcripts were segmented at the sentence level using NLTK sentence tokenization, and each segment was encoded into a high-dimensional semantic embedding using a pre-trained sentence transformer model (Qwen3-Embedding-0.6B). Embeddings were first reduced in dimensionality using Uniform Manifold Approximation and Projection (UMAP; McInnes et al., 2020) with cosine distance prior to clustering. Experiential clusters were then identified using a density-based clustering (HDBSCAN; McInnes et al., 2017), which does not require pre-specification of the number of clusters and allows for variable cluster density. A separate two-dimensional UMAP projection was computed for visualization, in which spatial proximity reflects semantic similarity between report segments.

Cluster labels were generated using a large language model (Meta-Llama-3-8B-Instruct) to identify the invariant structural theme shared across representative text segments and keyword distributions within each cluster. Given that the free-association interviews were conducted in French, reports were first translated into English prior to analysis. This decision was motivated by the fact that the language models used in the pipeline, both for embedding and topic labeling, were primarily trained on English-dominant corpora and are expected to perform more reliably on English-language input. The quality of the translations was verified by a bilingual researcher (native French speaker) who reviewed the translated outputs against the original French transcripts to ensure semantic fidelity. Translation was performed using a locally hosted quantized large language model (Meta-Llama-3-8B-Instruct-GGUF, Q4_K_M quantization; NousResearch) run via llama-cpp-python, ensuring that participant data remained on-premises and were not transmitted to external servers. The model was prompted to translate each report into standard English while correcting spelling and grammar, without altering the meaning, structure, or content of the original text. Inference was run with deterministic settings (temperature = 0, seed = 42) to ensure reproducibility. The translated reports were then processed through the MOSAIC pipeline for embedding, clustering, and topic labeling, all of which were conducted on the English-language translations.

Physiological Analysis. Physiological activity was recorded using the BIOPAC MP160 system (BIOPAC Systems Inc.) with ECG100C, EDA100C, and DA100C amplifiers. All signals (ECG, electrodermal activity, and respiration) were sampled at 2 kHz and acquired via AcqKnowledge v4.4. All preprocessing was conducted in Python using NeuroKit2. Each recording yielded two epochs per participant: a 5-min resting baseline and a 25-min MMGF induction, identified using trigger pulses embedded in the AcqKnowledge files. ECG was collected using disposable adhesive electrodes in a bipolar configuration: the positive electrode on the non-dominant wrist, the negative on the contralateral ankle, and the ground on the ipsilateral ankle. ECG signals were processed using NeuroKit2. R-peaks were detected and iteratively corrected using a Kubios-style algorithm, and RR intervals were screened for physiological plausibility and abrupt interval changes to reduce the influence of detection errors. Heart rate (HR) was computed as the mean beats per minute, and heart rate variability (HRV) was indexed by RMSSD and calculated only from segments with sufficient clean RR intervals.

For electrodermal activity (EDA), two disposable electrodes were wrapped around the index and middle finger of the dominant hand after cleaning the area with water. The electrodes were supported by tape to hold it in place. The EDA signal was decomposed into tonic (skin conductance level, SCL) and phasic components using nk.eda_process to extract tonic EDA (µS). For Respiration (RSP), a respiratory belt connected to the DA100C amplifier recorded thoracic expansion. NeuroKit2's respiration pipeline produced a cleaned waveform and peak series. The primary outcome was respiration rate (breaths per minute). All physiological summaries were processed in R (R Core Team, 2025). For each participant, baseline-corrected deltas were computed for every metric using the induction–baseline difference separately for Red and Green MMGF conditions (e.g., ΔHR = HR Induction - HR Baseline).

Electroencephalography Analysis. EEG was recorded in BrainVision format using a 64-channel cap arranged according to the international 10–20 system. Data were sampled at 500 Hz with online reference preserved as in the original recordings. Files were imported into MNE-Python with preload enabled, and all intermediate steps were saved as FIF files for staged quality control.

Preprocessing followed a minimal, standardized pipeline consistent with recent recommendations for resting-state EEG (Delorme, 2023). Continuous EEG was high-pass filtered at 0.5 Hz. Channels with excessive line noise were identified through visual inspection and by flagging channels whose power in a narrow band around the mains frequency exceeded the mean by four standard deviations. Bad channels were then interpolated using spherical splines. EEG was cropped to the interval between trigger codes 17 and 18 when available; otherwise, no event-based cropping was performed. Afterward, the first drop_first seconds of the remaining continuous recording were discarded. Data were segmented into fixed-length 2-second, non-overlapping epochs without baseline correction. Artifact rejection was performed using Autoreject where thresholds were fit on a subset of epochs and applied to the full dataset. Average re-referencing was applied only when an automated check indicated posterior-reference bias; otherwise, the original reference was retained.

Spectral power was estimated using Welch's method. Power spectral density (PSD) was computed for each epoch and channel across 1–40 Hz, and band-specific power was derived for the α (8–12 Hz) and β (13–30 Hz) ranges. Global band power was defined as the median across channels after channel-level outlier exclusion. In addition, an α/β ratio was calculated per channel and globally as an index of relative band dominance. Final summary variables included per-channel α and β power, global α and β power, and global α/β ratio. Quality control consisted of examining drop logs from Autoreject, reviewing topographies of α and β power, and visually confirming PSD curves from electrodes. All preprocessing and spectral analyses used identical parameters across Red, Green, and Rest conditions to support within-subject comparisons.

To further characterize alpha-band structure, the 8–12 Hz range was subdivided into lower (α1, 8– < 10 Hz) and upper (α2, 10–12 Hz) sub-bands. For each participant, condition, and channel, Welch PSDs were averaged within these sub-bands to obtain α1 and α2 power estimates. A channel-wise α1/α2 ratio was then computed to index the relative dominance of slower versus faster alpha activity. To ensure that global summaries were not driven by residual artifacts, we implemented a robust, context-aware quality control step at the channel level. For each channel, broadband (1–40 Hz) power, α1 power, and α2 power were transformed into robust z-scores using the median and median absolute deviation. Channels were flagged as outliers and excluded from analysis only if they showed extremely elevated broadband power ($z > 4$) in combination with elevated α1 or α2 power ($z > 4$). Global α1 and α2 power values were then defined as the median across the remaining channels, and a corresponding global α1/α2 ratio was calculated. The analysis was run on 32 subjects.

4.4 Results

State and Trait Measures. Participants showed generally typical ranges across all personality and cognitive trait measures (Table B1). Mean dissociative tendencies on the DES-II were low (M = 0.20, SD = 0.13). Big Five scores reflected moderately high Openness (M = 74.21, SD = 13.88) and Agreeableness (M = 66.85, SD = 10.75), with average levels of Conscientiousness (M = 66.94, SD = 12.86), Extraversion (M = 59.61, SD = 12.91), and Neuroticism (M = 56.61, SD = 11.70). Trait absorption (TAS) scores were in the mid–upper range (M = 87.97, SD = 21.53). Visual imagery ability assessed with the VVIQ indicated moderately vivid imagery overall (M = 114.88, SD = 25.84). No extreme outliers were observed.

KSS results show that MMGF did not affect subjective sleepiness (Figure B2). The Karolinska Sleepiness Scale (KSS) was administered before and after each session were analyzed as change scores (ΔKSS = After – Before). A linear mixed-effects model was fit with Condition (Red, Green) and Day (1, 2) as fixed factors and Subject as a random intercept. The model revealed no significant main effects of Condition, $F(1, 61.9) \approx 0.11$, $p = .75$, or Day, $F(1, 61.9) \approx 0.37$, $p = .55$, and no Condition × Day interaction, $F(1, 31.0) \approx 0.04$, $p = .85$. The overall intercept indicated a small, non-significant increase in sleepiness following MMGF (grand mean = +0.83 KSS points, $p = .09$). Estimated marginal means showed near-zero or slightly positive changes across all conditions (Day 1: Red = 0.83 ± 0.48, Green = 1.07 ± 0.53; Day 2: Red = 0.40 ± 0.53, Green = 0.83 ± 0.48). Paired-sample t-tests on day-averaged values confirmed these findings as ΔKSS did not differ between Day 1 and Day 2, $t(32) = 0.62$, $p = .54$, 95 % CI [–0.70, 1.30], and baseline KSS values were comparable across days, $t(32) = 0.55$, $p = .59$. As illustrated in Figure 1, distributions of ΔKSS were centered near zero across both red and green sessions for each day. Together, these results indicate that MMGF exposure did not measurably increase subjective sleepiness, that sleepiness did not differ between red and green light, and that participants did not show cumulative fatigue on Day 2.

Quantitative Phenomenology. Red light MMGF increased complex imagery whereas green light MMGF increased changed meaning of percepts. 33 participants were included in the phenomenological assessment. One participant was excluded for failing to fill out the entire questionnaire. Before conducting analysis between Red- and Green-light MMGF conditions, we assessed whether scores on the 5D-ASC and 11-ASC factors conformed to normality using the Shapiro–Wilk test (Table B3). At the dimensional level of the 5D-ASC, several scales showed clear deviations from normality, including Oceanic Boundlessness ($W = 0.87$, $p = .001$) and Dread of Ego Dissolution ($W = 0.85$, $p < .001$). In contrast, General Altered States Score, Visionary Restructuralization, Auditory Alterations, and Vigilance Reduction exhibited no significant departures from normality ($p = .157$–$.977$). For the 11-ASC factors, most scales violated normality assumptions. Significant deviations were observed for Experience of Unity ($W = 0.89$, $p = .003$), Spiritual Experience ($W = 0.79$, $p < .001$), Blissful State ($W = 0.72$, $p < .001$), Insightfulness ($W = 0.88$, $p = .002$), Impaired Control and Cognition ($W = 0.89$, $p = .004$), Anxiety ($W = 0.81$, $p < .001$), Elementary Imagery ($W = 0.89$, $p = .004$), Audio-Visual Synesthesia ($W = 0.93$, $p = .040$), and

Changed Meaning of Percepts ($W = 0.84$, $p < .001$). Only a small subset, such as Disembodiment ($p = .263$), Complex Imagery ($p = .079$), and several 5D-ASC dimensions, approached or met normality criteria. These results demonstrate that the distribution of scores is frequently non-normal across ASC dimensions, particularly within the 11-ASC factors. Given the prevalence of non-normality, non-parametric paired tests (Wilcoxon signed rank) were used as the primary inferential approach for all analyses.

Confirmatory analyses regarding differences between red and green light MMGF were done first at the dimensional level Visionary Restructuralization scores and then on the factor level on Complex Imagery, Elementary Imagery, Changed Meaning of Percepts, and Audio-Visual Synesthesia scores (Figure 24). A paired Wilcoxon signed-rank test comparing Visionary Restructuralization scores between Red- and Green-light MMGF sessions indicated no significant difference. The test showed no significant within-subject shift ($W = 323$, $p = .453$), and the corresponding effect size was negligible ($r = -0.13$). As only one comparison was performed, the Benjamini–Hochberg–adjusted value was identical ($p_{(BH)} = .453$). Overall, Visionary Restructuralization did not differ reliably between red and green stimulation. Paired Wilcoxon tests were then conducted on factor scores comprised of items belonging to the Visionary Restructuralization dimension of the 5D-ASC questionnaire (i.e., Complex Imagery, Elementary Imagery, Changed Meaning of Percepts, and Audio-Visual Synesthesia). Complex Imagery showed a significant wavelength effect ($W = 375$, $p = .003$, $r = 0.51$), indicating higher scores during Red-light MMGF; this effect remained significant after Benjamini–Hochberg correction ($p_{(BH)} = .008$). Elementary Imagery showed a small, non-significant shift ($W = 328$, $p = .119$, $r = 0.27$), and Audio-Visual Synesthesia showed no detectable wavelength difference ($W = 238$, $p = .665$, $r = 0.00$). Changed Meaning of Percepts revealed a significant negative shift ($W = 84$, $p = .004$, $r = -0.50$), reflecting higher scores under green light; this effect also survived correction ($p_{(BH)}$ = .008).

Green light MMGF increased anxiety and disembodiment. Exploratory analyses were done assessing the general score, every dimension, and every factor of the 5D-ASC questionnaire to test for differences between red and green light MMGF. A series of paired Wilcoxon signed-rank tests were conducted to compare phenomenological responses between red and green light MMGF. BH-corrected p-values (Benjamini-Hochberg) were used to control for multiple comparisons, and effect sizes were calculated as r.

While there were no differences at the general or dimensional level of analysis several differences reached significance at the factor level (Figure B6). For green light MMGF, Disembodiment was significantly higher (W = 108, p(FDR) = .03, r = .48), indicating a moderate-to-large effect as well as Anxiety (W = 96, p(FDR) = .02, r = .517). The early confirmatory findings also reappeared as Changed Meaning of Percepts (Perc_Mean; W = 84, p(FDR) = .02, r = .50) was higher under green light and Complex Imagery (W = 375, p(FDR) = .02, r = .51) was higher under red light. No other dimensions or factors reached significance following BH correction, though several, including Oceanic Boundlessness (W = 161, p(FDR) = .11, r = .37) and Blissful State (W = 147.5, p(FDR) = .23, r = .30), exhibited medium-sized effects. These findings suggest near identical ASC experiences at broader levels of investigation such as the G-ASC and dimensions regardless of light color in MMGF. However, differences at the factor level reveal fine-grained phenomenological profiles elicited by MMGF depending solely on the color of light.

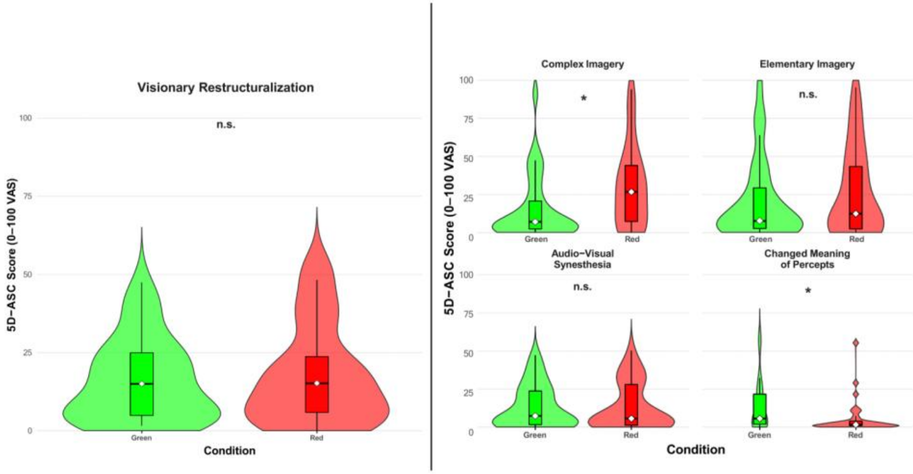

Figure 24. Phenomenological Analysis on the dimension and Visionary Restructuralization and its four factors. Violin plots show within-subject 5D-ASC scores (0–100 VAS) for Visionary Restructuralization (left panel) and for its four constituent 11-ASC visual factors: Complex Imagery, Elementary Imagery, Audio-Visual Synesthesia, and Changed Meaning of Percepts (right panels). A paired Wilcoxon signed-rank test revealed no reliable wavelength effect for Visionary Restructuralization ($W = 323$, $p = .453$, $r = -0.13$). Among the 11-ASC factors, Complex Imagery showed significantly higher scores under Red light ($W = 375$, $p = .003$, $r = 0.51$; $p_{(BH)} = .008$), whereas Changed Meaning of Percepts was significantly higher under Green light ($W = 84$, $p = .004$, $r = -0.50$; $p_{(BH)} = .008$). Elementary Imagery ($W = 328$, $p = .119$, $r = 0.27$) and Audio-Visual Synesthesia ($W = 238$, $p = .665$, $r = 0.00$) showed no significant wavelength differences. Together, these results indicate that wavelength modulates specific components of the Visionary Restructuralization dimension rather than the dimension as a whole.

Qualitative Phenomenology. Applying the MOSAIC approach to the free-association interview transcripts from the red-light and green-light MMGF conditions revealed clear differences in the organization of experiential clusters across conditions. The red-light condition yielded a smaller number of clusters relative to the green-light condition, indicating that participants' reports under red light coalesced into fewer distinct thematic groupings. In contrast, the green-light condition produced a greater number of experiential clusters overall, suggesting a more diverse set of reported phenomena.

As shown in the semantic map for the red-light MMGF condition (Figure 25), the identified clusters were largely mutually exclusive and spatially segregated. Each cluster occupied a distinct region with minimal overlap, indicating that experiential categories under red light were well differentiated from one another. In practical terms, participants' descriptions in the red-light condition tended to fall into a few well-defined domains, with each domain relatively isolated from the others on the map.

By contrast, the semantic map for the green-light MMGF condition (Figure 26) revealed a larger number of clusters with substantial overlap and adjacency. Many clusters were positioned close together or blended into other categories, denoting shared phenomenological content across nominally distinct categories. This overlapping arrangement indicates a more blended and continuous experiential structure under green light stimulation. Rather than segregating into discrete domains, participants' reports in the green-light condition spanned multiple related themes, resulting in clusters with less sharply defined boundaries. Together, these findings indicate that red-light MMGF elicited a more differentiated experiential organization, whereas green-light MMGF elicited a more integrated and overlapping experiential structure.

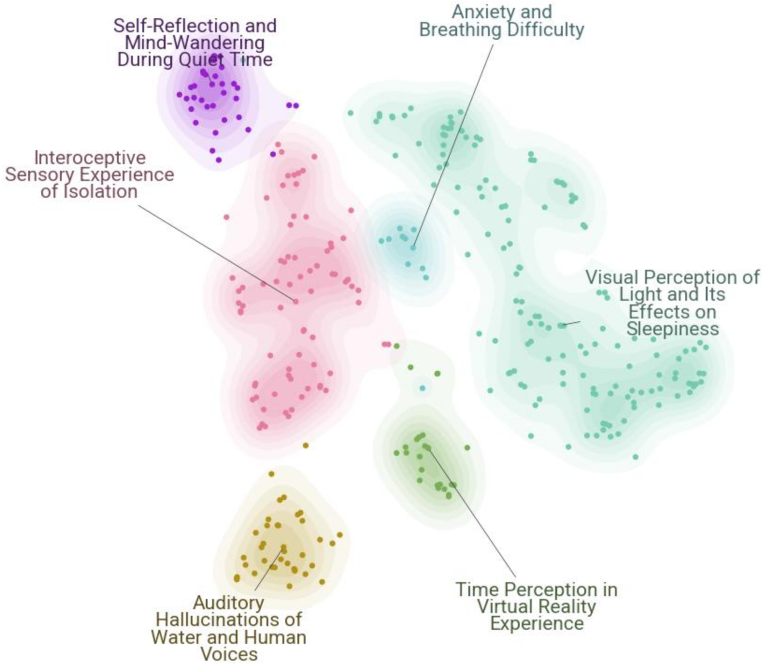

Figure 25. Red Light MMGF Qualitative Topic Representations with Llama 3. Free-association reports were analyzed using the MOSAIC pipeline. Sentence-level report segments were embedded into a high-dimensional semantic space and projected into two dimensions using UMAP. Density-based clustering (HDBSCAN) identified discrete experiential clusters, which are visualized as colored regions with individual report segments shown as points. Cluster labels were generated using a large language model based on representative text segments and keyword distributions. Spatial proximity reflects semantic similarity between report segments. The red-light condition yielded six well-segregated clusters: Self-reflection and mind-wandering during quiet time, interoceptive sensory experience of isolation, anxiety and breathing difficulty, auditory hallucinations of water and human voices, time perception in virtual reality experience, and visual perception of light and it effects of sleepiness.

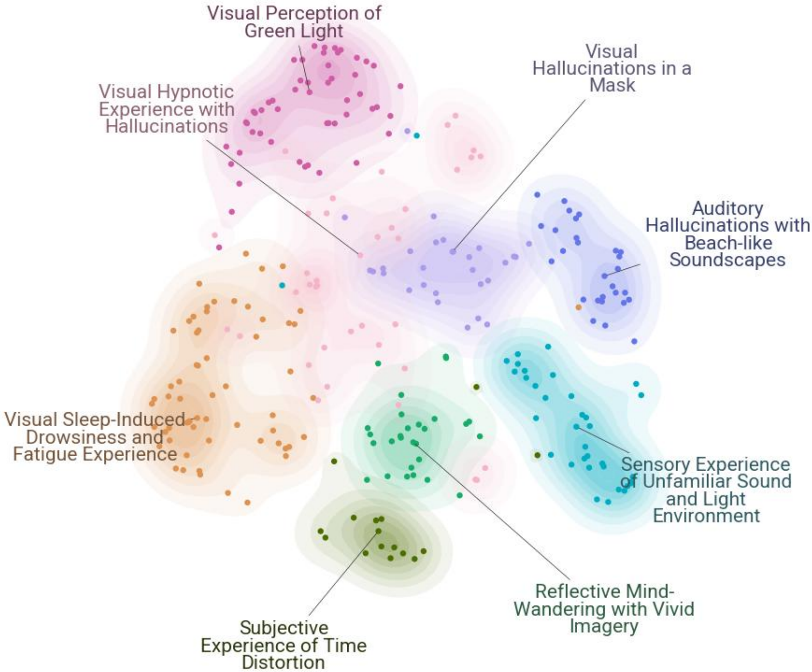

Figure 26. Green Light MMGF Qualitative Topic Representations with Llama 3. Free-association reports were analyzed using the MOSAIC pipeline. Sentence-level report segments were embedded into a high-dimensional semantic space and projected into two dimensions using UMAP. Density-based clustering (HDBSCAN) identified discrete experiential clusters, which are visualized as colored regions with individual report segments shown as points. Cluster labels were generated using a large language model based on representative text segments and keyword distributions. Spatial proximity reflects semantic similarity between report segments. The green-light condition yielded eight, slightly diffuse, clusters: Visual perception of green light, visual hypnotic experience with hallucinations in a mask, visual sleep-induced drowsiness and fatigue experience, subjective experience of time distortion, reflective mind-wandering with vivid imagery, sensory experience of unfamiliar light and sound environment, and auditory hallucinations with beach-like soundscapes.

Physiology. Cardiac analyses revealed a selective decrease in heart rate (HR) under Green-light MMGF. Shapiro–Wilk tests on cardiac paired difference scores indicated non-normality for HRV deltas but not for HR, justifying the use of non-parametric Wilcoxon signed-rank tests for the cardiac analyses (Table B7). Cardiac responses to MMGF were examined using baseline-corrected change scores (Δ = Induction – Baseline) for heart rate (HR) and heart rate variability (HRV; RMSSD), analyzed separately for green and red light conditions (Figure 27; Table B8).

Under Green-light MMGF, HR showed a significant reduction relative to baseline, indicating a reliable slowing of cardiac activity during induction (Md = –1.94 bpm, W = 105, p(FDR) = .03, r = –.48). The confidence interval did not include zero [–2.56, –0.66], and individual change scores showed a downward shift across participants. In contrast, HRV did not differ reliably from baseline under Green light (Md = +2.16 ms, W = 278, p(FDR) = .35, r = .17), with confidence intervals spanning zero.

Under Red-light MMGF, neither HR nor HRV showed significant induction-related changes after correction for multiple comparisons. Although HR tended to decrease numerically (Md = –0.94 bpm), this effect did not reach significance (W = 148 p(FDR) = .16, r = –.32), and its confidence interval included zero [–1.52, 0.21]. HRV likewise showed no reliable change from baseline (Md = –2.16 ms, W = 182, p(FDR) = .35, r = –.19).

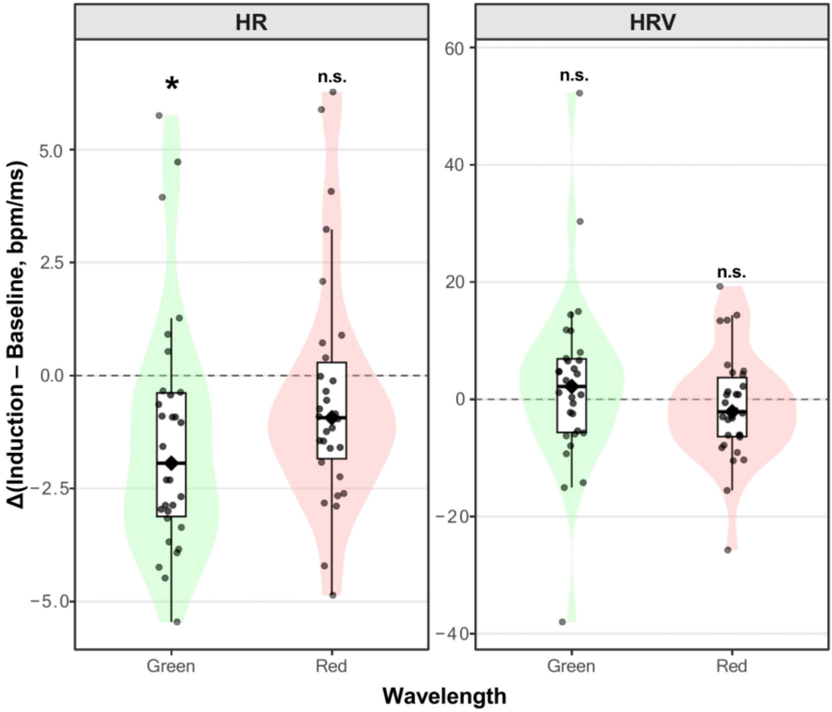

Figure 27. Within wavelength comparison of baseline-corrected cardiac activity under MMGF. Induction-related shifts in heart rate (HR; bpm) and heart rate variability (HRV; RMSSD; ms) were computed as Δ = Induction – Baseline and tested against zero separately for green and red light MMGF using Wilcoxon signed-rank tests. Green light produced a significant decrease in HR relative to baseline (Md = –1.94 bpm; W = 105; p(FDR) = .03; r = –.48), indicating a moderate relaxation response. No other cardiac measures showed significant induction effects after Benjamini–Hochberg correction (Green HRV: Md = +2.16 ms, W = 278, p(FDR) = .35, r = .17; Red HR: Md = –0.94 bpm, W = 148, p(FDR) = .16, r = –.32; Red HRV: Md = –2.16 ms, W = 182, p(FDR) = .35, r = –.19). Across conditions, 95% confidence intervals spanned zero except for Green HR.

To assess whether the observed cardiac slowing generalized to other autonomic indices, baseline-corrected changes in electrodermal activity (EDA) and respiration rate (RSP) were examined and assessed for normality (Table B9 and B10). Neither Green- nor Red-light MMGF produced significant induction-related changes in EDA or respiration after Benjamini–Hochberg correction (all $p(FDR) \geq .44$). Effect sizes were small, and confidence intervals for all measures spanned zero.

HRV changes were selectively associated with Complex Imagery scores under red-light MMGF. Spearman correlations were computed between HRV Δ (RMSSD) and Complex Imagery scores for red and green light MMGF, with BH correction applied. Results show that the higher the complex imagery score the higher one's change in HRV ($\rho = .45$, $p = .013$, $p(FDR) = .026$). This relationship was not observed under green light MMGF ($\rho = -.01$, $p = .95$, $p(FDR) = .95$; Figure 28; Table B12). Further, no such relationship emerged under any light condition for heart rate (HR).

As an explicitly exploratory step, we examined cross-domain associations between physiological and phenomenological changes under each wavelength condition (Figures B13 & B14). Spearman's ρ correlations were computed between deltas in autonomic indices (electrodermal activity [EDA], respiration [RSP], heart rate variability indexed by RMSSD [HRV-RMSSD], and heart rate [HR]) and changes in 5D-ASC measures, including the General Altered States Score (G-ASC), its primary dimensions (Oceanic Boundlessness [OBN], Dread of Ego Dissolution [DED], Visionary Restructuralization [VRS], Auditory Alterations [AA], Vigilance Reduction [VR]), and selected 11-ASC factors such as Audio-Visual Synesthesia (AVS) and Impaired Control and Cognition (ICC). Under both red- and green-light MMGF, a small number of uncorrected correlations reached $p < .05$ (indicated by white dots in the figures); however, none survived Benjamini–Hochberg false-discovery-rate correction. Accordingly, these analyses should be interpreted as hypothesis-generating only and do not provide corrected evidence for robust physiology–phenomenology coupling under either wavelength condition.

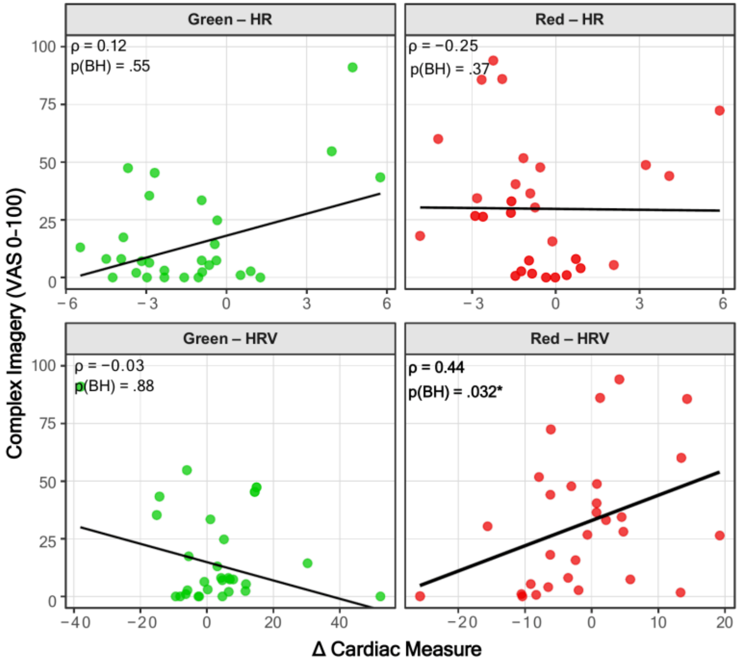

Figure 28. Correlations between cardiac changes and Complex Imagery during MMGF sessions. Scatterplots show correlations between baseline corrected cardiac measures (Heart Rate; HR, and Heart Rate Variability; HRV) and Complex Imagery scores (VAS 0–100) for Green (left panels) and Red (right panels) MMGF sessions. Spearman correlations (ρ) and Benjamini–Hochberg–adjusted p-values are displayed in each panel. HR and HRV correlations were treated as separate test families (2 tests per family). No reliable correlations emerged for HR (Green: ρ = 0.12, p(FDR) = .55; Red: ρ = –0.25, p(FDR) = .37) or for HRV under Green light (ρ = –0.03, p(FDR) = .88). A moderate positive correlation was observed only for HRV under Red light (ρ = 0.44, p(FDR) = .03), indicating that larger HRV increases during Red-light MMGF were associated with stronger Complex Imagery experiences.

An exploratory bootstrapped mediation analysis was conducted to test whether heart rate variability (HRV) mediated the relationship between wavelength of light and complex imagery during MMGF exposure (Figure 29; Table B15). The total effect of wavelength on complex imagery was significant, $c = 14.82$, $\beta = .29$, $p < .05$, indicating a reliable association between wavelength and complex imagery reports. Wavelength did not significantly predict HRV (path a: $a = -3.84$, $\beta = -.15$, $p > .05$), and HRV did not significantly predict complex imagery when controlling for wavelength (path b: $b = -0.13$, $\beta = -.06$, $p > .05$). Consistent with these findings, the bootstrapped indirect effect was small and non-significant ($a \times b = 0.50$, $\beta = .01$), with the percentile confidence interval overlapping zero, indicating no evidence for mediation. The direct effect of wavelength on complex imagery remained significant after accounting for HRV ($c' = 14.32$, $\beta = .28$, $p < .05$). Together, these results indicate that although wavelength reliably influenced complex imagery under MMGF, this relationship was not mediated by HRV.

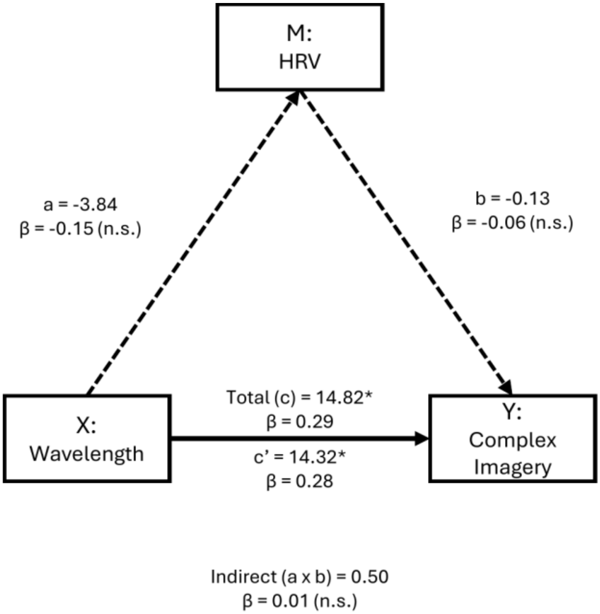

Figure 29. HRV does not mediate the relationship between wavelength of light and complex imagery under MMGF. The model was estimated using 5,000 bootstrap resamples with percentile confidence intervals. Path a (Wavelength → HRV) and path b (HRV → Complex Imagery) were not significant, and the bootstrapped indirect effect (a × b) was small with a confidence interval overlapping zero, indicating no evidence for mediation. The direct effect (c') remained significant, and the total effect (c) was also significant, confirming that wavelength reliably influenced complex imagery but that this relationship was not accounted for by HRV.

EEG. EEG results indicated moderate Bayesian evidence for an increase in global $\alpha1$ power under red light MMGF. Baseline-corrected global EEG power was examined separately for low alpha ($\alpha1$), high alpha ($\alpha2$), and broader frequency bands to assess induction-related changes under red and green light MMGF. All log-transformed deltas ($\Delta\log10$ = Induction − Baseline) satisfied normality assumptions (Shapiro–Wilk tests, all $p \geq .31$), justifying the use of parametric one-sample t-tests (Table B16). Under Green light, neither $\alpha1$ nor $\alpha2$ showed evidence of reliable induction-related modulation (Figure 30; Table B16). Mean changes were small (α1: $\Delta M = +0.06$, +14.9%; α2: $\Delta M = +0.06$, +14.5%), confidence intervals spanned zero, and both frequentist and Bayesian analyses supported the null hypothesis (all $p(FDR) \geq .21$; $d \leq 0.24$; $BF_{10} \leq 0.43$). In contrast, Red light showed evidence consistent with an increase in global α1 power . Low-alpha activity increased by approximately 34% relative to baseline ($\Delta M = +0.13$), yielding a medium-sized effect ($t(31) = 2.62$, $p = .013$, $p(FDR) = .055$, $d = 0.46$) with a positive confidence interval ([0.03, 0.22]). This effect did not survive BH correction, but the magnitude and interval estimate suggest a potentially meaningful upward shift in α1 during Red MMGF.

Due to the threshold p-value and medium effect size of the red light α1 finding, a targeted supplemental Bayesian one-sample t-test was conducted. The posterior distribution for the α1 effect under Red MMGF was sharply displaced from zero relative to the prior, yielding moderate evidence for a non-zero induction effect ($BF_{10} = 3.39$; Figure 31; Table B18). Thus, the observed α1 increase was approximately 3.4 times more likely under a model assuming a genuine induction-related change than under the null model (see Figure 32 for descriptive topography maps).

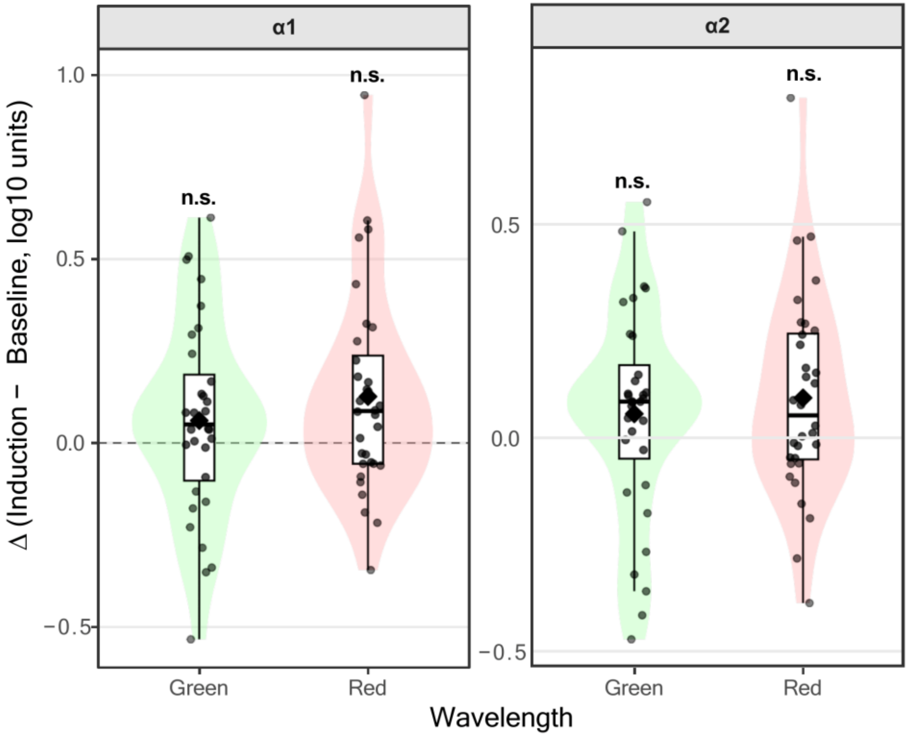

Figure 30. Within wavelength comparison of baseline-corrected alpha band activity under MMGF. Log-transformed baseline-corrected deltas (Δlog10 = Induction – Baseline) were tested against zero using one-sample t-tests for Green and Red MMGF conditions separately. Under Green light, neither α1 nor α2 showed evidence of significant induction-related increases (both $p_{(BH)} \geq .21$; small effect sizes d = 0.23–0.24). Red light produced larger positive shifts in both sub-bands: α1 increased by approximately +34% (ΔM = +0.13, t(31) = 2.62, p = .013, $p_{(BH)}$ = .055, d = 0.46), and α2 by approximately +25% (ΔM = +0.10, t(31) = 2.29, p = .03, $p_{(BH)}$ = .06, d = 0.41). Although neither effect survived correction, the medium-sized α1 increase under Red light indicates a potentially meaningful modulation of low-alpha power during MMGF that warrants further investigation.

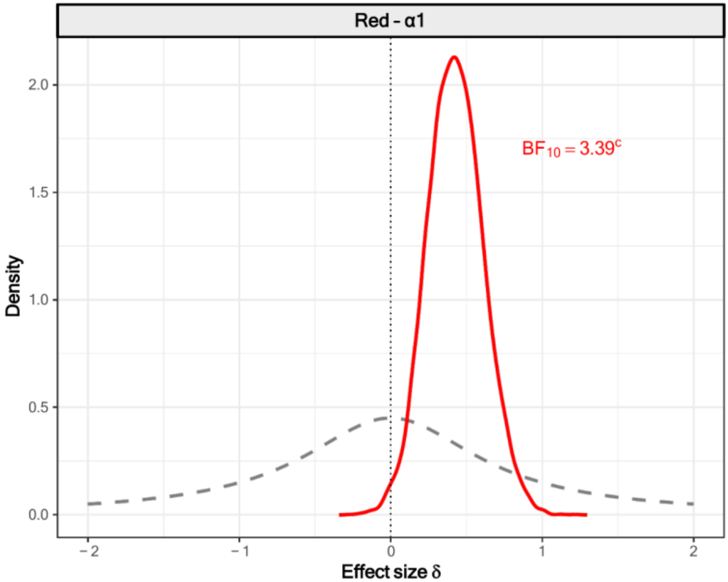

Figure 31. Bayesian estimation of the Red-light α1 effect during MMGF. This plot shows the Bayesian prior (dashed gray) and posterior (solid red) distributions over the standardized effect size δ for baseline-corrected α1 activity under Red MMGF. The prior reflects the default Cauchy (0, 0.707) assumption used in the Bayesian one-sample t-test, expressing initial uncertainty about the magnitude of induction-related change. The posterior is sharply peaked and shifted away from zero, indicating that the observed α1 increases are more consistent with a non-zero effect than with the null hypothesis. The Bayes factor ($BF_{10} = 3.39^c$) quantifies this shift such that the data are approximately 3.4 times more likely under a model assuming a true α1 increase than under a model assuming no change. Superscript ^{c} denotes moderate evidence for a non-zero Δ. Together, the posterior displacement and BF_{10} indicate that Red light produced a reliable induction-related enhancement of α1 power, complementing the medium-sized effect observed in the frequentist analysis.

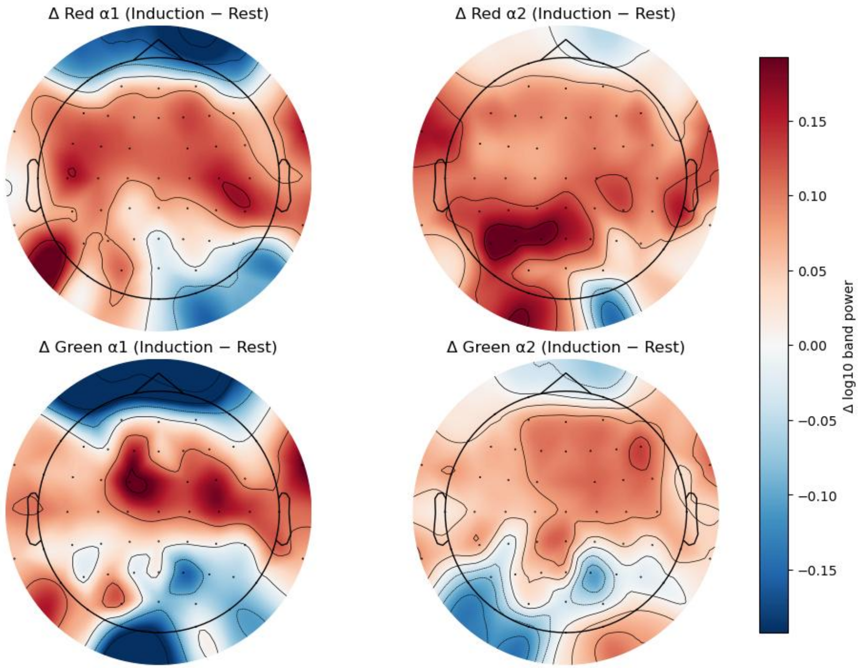

Figure 32. Descriptive scalp topographies of tonic α1 and α2 changes during Red and Green MMGF. Topographic maps depict median baseline-corrected changes in log10-transformed band power (Induction − Rest) for lower alpha (α1, 8–<10 Hz) and upper alpha (α2, 10–12 Hz) under Red and Green light conditions. Baseline maps were computed by pooling both Rest recordings (Day 1 and Day 2) and deriving median channel-wise band power. Induction maps were similarly derived using median channel-wise power across participants. These maps are presented for descriptive visualization only.

For α2, Red light showed a smaller, directionally similar increase ($\Delta M = +0.10$, +24.9%; $d = 0.41$), but evidence was weaker and remained at an anecdotal level ($p(FDR) = .06$; $BF_{10} = 1.82$). To assess whether the observed effect reflected a broadband spectral shift, supplementary analyses examined global Alpha and Beta power. No induction-related changes reached significance for either wavelength (all $p(FDR) \geq .46$; all $d \leq 0.29$), and Bayesian evidence favored the null in all cases ($BF_{10} \leq 0.59$). Confidence intervals consistently included zero.

Exploratory within-wavelength baseline-corrected EEG analyses were first assessed for normality. Shapiro–Wilk tests confirmed that baseline-corrected Δlog10 values did not deviate from normality under either wavelength for alpha or beta power (all $p \geq .24$), justifying the use of parametric one-sample t-tests for the within-wavelength analyses (Table B19). These one sample t-tests indicated indicated no significant induction-related spectral power shifts in either alpha or beta bands under green or red MMGF (Figure B20; Table B21). Although red light showed a numerically larger increase in alpha power ($\Delta M = +0.07$ log10; +18.53%) relative to green light ($\Delta M = +0.04$ log10; +10.13%), one-sample t-tests revealed that no within-condition changes differed significantly from zero after Benjamini–Hochberg correction (all $p(FDR) \geq .46$). Beta power changes were minimal under both wavelengths (green: $\Delta M = +0.00$, +1.15%; red: $\Delta M = +0.02$, +5.05%) and likewise nonsignificant. Across conditions, 95% confidence intervals included zero and effect sizes were small (ds = 0.02–0.29). The distributional patterns shown in the violin plots further illustrate substantial inter-individual variability without consistent group-level shifts in spectral power during induction relative to baseline.

Scatterplots depict Pearson correlations between baseline-corrected α-band power changes (Δlog10; α1, α2) and Complex Imagery scores during Green and Red MMGF sessions (Figure 33; Table B22). No significant associations were observed for either α sub-band under either wavelength (α1: Green $r = .01$, Red $r = .04$; α2: Green $r = -.11$, Red $r = .05$; all $p(FDR) \geq .80$), indicating that α-band power fluctuations do not track imagery intensity.

As an explicitly exploratory analysis, we examined associations between baseline-corrected EEG spectral power changes and phenomenological deltas separately for red- and green-light MMGF (Table B23 & B24). Spearman's ρ correlations were computed between Δlog10 EEG power (induction − baseline) in Alpha, Alpha1, Alpha2, and Beta bands and changes in 5D-ASC measures, including the General Altered States Score (G-ASC), core dimensions (Oceanic Boundlessness [OBN], Dread of Ego Dissolution [DED], Visionary Restructuralization [VRS], Auditory Alterations [AA], Vigilance Reduction [VR]), and 11-ASC factors such as Complex Imagery (CMP), Audio-Visual Synesthesia (AVS), Impaired Control and Cognition (ICC), Anxiety, Unity, Spiritual Experience, Blissful Experience, and Insight. In both wavelength conditions, several correlations reached uncorrected significance ($p < .05$; indicated by white dots in the figures); however, none survived Benjamini–Hochberg false-discovery-rate correction. These findings should therefore be interpreted strictly as hypothesis-generating and do not provide corrected evidence for robust EEG–phenomenology coupling under either red or green light MMGF.

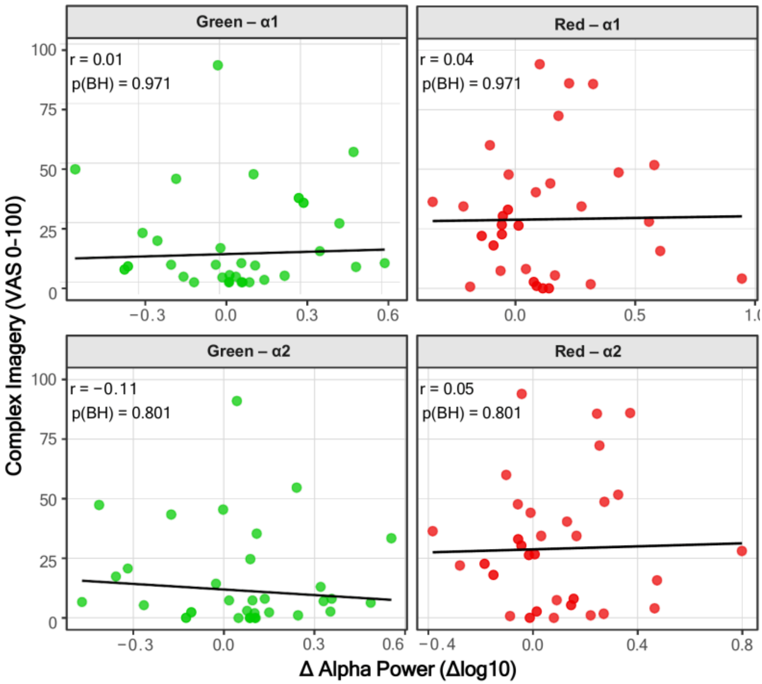

Figure 33. Correlations between α-band power changes and Complex Imagery during MMGF sessions. Scatterplots show the relationship between baseline-corrected changes in α-band spectral power (Δlog10; α1, α2) and Complex Imagery scores (VAS 0–100) for Green (left panels) and Red (right panels) MMGF sessions. Pearson correlations (r) and Benjamini–Hochberg–adjusted p-values are displayed in each panel. α1 and α2 correlations were treated as separate test families (2 tests per family). Across both wavelengths, α1 changes showed no reliable association with Complex Imagery (Green: $r = 0.01$, $p(FDR) = .97$; Red: $r = 0.04$, $p(FDR) = .97$). Similarly, α2 changes were unrelated to imagery intensity (Green: $r = –0.11$, $p(FDR) = .80$; Red: $r = 0.05$, $p(FDR) = .80$). Together, these findings indicate that α-band power fluctuations during MMGF are not meaningfully associated with the strength of induced complex imagery under either wavelength.

An exploratory bootstrapped mediation analysis was conducted to test whether global α1 power mediated the relationship between wavelength of light and complex imagery during MMGF exposure

(Figure 34; Table B25). The total effect of wavelength on complex imagery was significant, $c = 14.97$, $\beta = .30$, $p < .05$, indicating that longer wavelengths were associated with increased complex imagery reports. However, wavelength did not significantly predict global alpha1 power (path a: $a = 0.07$, $\beta = .12$, $p > .05$), and global alpha1 power did not significantly predict complex imagery when controlling for wavelength (path b: $b = 2.04$, $\beta = .02$, $p > .05$). Consistent with these findings, the bootstrapped indirect effect was small and not significant ($a \times b = 0.13$, $\beta = .00$), with the percentile confidence interval overlapping zero, providing no evidence for mediation. The direct effect of wavelength on complex imagery remained significant when accounting for alpha1 power ($c' = 14.83$, $\beta = .30$, $p < .05$). Together, these results indicate that although wavelength reliably influenced complex imagery under MMGF, this relationship was not mediated by global $\alpha 1$ power.

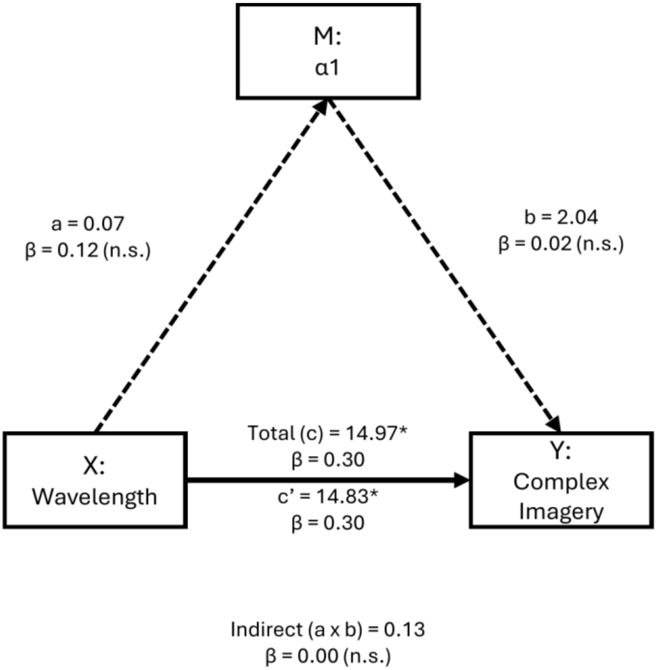

Figure 34. Global α1 does not mediate the relationship between wavelength of light and complex imagery under MMGF. Bootstrapped mediation results for the model Wavelength → α1 → Complex Imagery. The model was estimated using 5,000 bootstrap resamples with percentile confidence intervals. Path a (Wavelength → α1) and path b (α1 → Complex Imagery) were not significant, and the bootstrapped indirect effect (a × b) was small with a confidence interval overlapping zero, indicating no evidence for mediation. The direct effect (c') remained significant, and the total effect (c) was also significant, confirming that wavelength reliably influenced complex imagery but that this relationship was not accounted for by α1 power.

4.5 Review

The present study demonstrates that ASCs produced by MMGF can be systematically modulated by light wavelength to affect the production of complex pseudo-hallucinations. Both red- and green-light MMGF conditions induced a stable, reproducible ASC marked by hallmark Ganzfeld phenomena such as visual and auditory pseudo-hallucinations, time sense distortions, and affective changes. Such findings support Schmidt and Prein's (2019) general claim that the MMGF is a "stably induced" ASC. However, this claim requires some nuance. Previous work from Kübel et al. (2021) demonstrates that simply changing the light color in MMGF can create a different type of ASC, namely that green light promotes a more relaxed state. Our findings add to this by showing that changing the color of light produces further phenomenological divergence. Here, red-light MMGF elicited significantly more complex imagery (i.e., pseudo-hallucinations involving faces and scenes). In contrast, green light MMGF was associated with greater disembodiment and shifts in perceptual meaning.

These condition-specific profiles were further corroborated by natural language patterns in participants' free reports. Using the MOSAIC framework, we found that red-light MMGF reports clustered into a smaller number of distinct thematic groups dominated by imagery-rich content such as visual narratives, symbolic elements, or emotionally vivid scenes. In contrast, green-light MMGF reports formed a greater number of clusters with more semantic overlap, often centering on impressions of perceptual ambiguity, bodily drift, or spatial dissolution. This differential clustering supports the view that red MMGF organizes experience into discrete, content-laden episodes, while green MMGF promotes a more diffuse and introspective experiential field. Together, these results show that red and green MMGF diverge in their quantitative effects on phenomenology as well as how those experiences are shaped, structured, and expressed in language. Such findings can be clinically relevant insofar as converging work across pharmacological and non-pharmacological altered state paradigms indicates that therapeutic outcomes depend not merely on the mechanism of a drug, but on the qualitative features of experience engaged during that state (Yaden & Griffiths, 2021). In this light, it would be interesting to first establish if there is empirical evidence for the clinical efficacy of visual complex imagery (see Garcia-Romeu, 2025; Singer, 1971), then second, to use MMGF as a low-risk and accessible means of eliciting and modulating that complex imagery in a therapeutic context.

Physiological data revealed distinct autonomic profiles for red and green MMGF conditions compared to baseline resting state. Green light induced a significant reduction in heart rate, providing an objective correlate of the subjective relaxation reported by participants and previously described by Kübel et al. (2021). This pattern is consistent with parasympathetic engagement and supports the idea that green MMGF fosters a calm, low-arousal ASC. In contrast, red MMGF showed no significant heart rate change, but complex imagery was positively associated with changes in heart rate variability (HRV). This pattern mirrors prior work linking increased HRV and heart-evoked potential amplitudes to immersive absorption or “flow states” during high-demand tasks, such as video games (Khoshnoud et al., 2022). Similarly, in our red-light condition, elevated HRV may reflect a form of selective flow, that is a quasi-relaxed, immersive physiological mode that specifically supports focused engagement with complex pseudo-hallucinations. While HRV did not mediate the effect of color on imagery, it appears to track the depth of immersion. Overall, green light MMGF appears to promote relaxation through parasympathetic quieting of the heart, while red light MMGF supports a more active form of selective flow marked by general autonomic calm coupled with immersive engagement in complex pseudo-hallucinations. To the best of our knowledge, this study provides one of the first systematic reports of physiological changes under MMGF, extending prior phenomenological work into the autonomic domain.

EEG results showed moderate Bayesian evidence for a selective increase in α1 (8–10 Hz) power under red-light MMGF, suggesting a shift toward a more internally oriented, perceptually gated brain state. This aligns with our primary findings and may help inform part of why red light MMGF increases complex imagery intensity compared to green. This enhancement in α1 power aligns with longstanding views of alpha as an index of cortical inhibition and functional disengagement from external input (Jensen & Mazaheri, 2010; Klimesch et al., 2007). Recent work supports the idea that α1and α2 reflect functionally distinct rhythms as alpha1 is slower, stronger, and more centrally localized, and tends to increase when visual distractors must be suppressed (Rodriguez-Larios et al., 2022). In this context, the increase in α1 under red light MMGF may reflect enhanced inhibition in the absence of meaningful sensory drive, allowing for a more immersive, internally stabilized perceptual mode.

Theoretically, this interpretation builds on neurobiological evidence that red-light MMGF induces functional decoupling between the thalamus and cortex (Schmidt et al., 2020), reducing sensory relay and enabling internally generated percepts. Under such closed gating conditions, cortical networks may shift into endogenous pacing, expressed electrophysiologically as increased α1 power. Our finding of α1 enhancement may thus represent the cortical EEG correlate of the thalamocortical hypoconnectivity observed by Schmidt and colleagues (2020) with both pointing to a state of thalamic gating where internal signals are amplified and then interpreted as hallucinatory percepts.

This stands in marked contrast to the psychedelic drug model of hallucinations. Classic serotonergic psychedelics, such as psilocybin, are associated with suppressed alpha activity (Muthukumaraswamy et al., 2013) and thalamocortical hyperconnectivity (Avram et al., 2021, 2022, 2024), consistent with a breakdown of sensory gating and cortical flooding. Given this information, the prototypical MMGF state observed under red light appears to achieve a superficially similar hallucinatory state through an opposite neurophysiological route, namely thalamocortical hypoconnection (Schmidt et al., 2020) and increases in a subdivision of the alpha band (i.e., $\alpha 1$). Given our result did not pass the frequentist threshold for significance yet yielded a medium effect size and moderate Bayesian evidence, we propose that this finding tentatively extends Schmidt and colleagues (2020) connectivity findings by providing a distinct yet converging electrophysiological marker of closed thalamic gating under red light MMGF, though it needs to be replicated in a larger sample.

This finding also contextualizes previous work on phasic $\alpha 2$ effects under MMGF. Pütz et al. (2006) reported transient increases in $\alpha 2$ (10–12 Hz) just prior to self-reported imagery episodes, along with concurrent drops in $\alpha 1$ and bursts in beta following image formation. These dynamics were tightly time-locked to imagery probes and likely reflect transient, top-down bursts of perceptual generation. Our findings reflect a broader, sustained shift in ongoing alpha dynamics under red light MMGF, independent of time-locked events. However, both effects can co-exist as phasic $\alpha 2$ surges may mark imagery onset, while tonic $\alpha 1$ elevation may reflect the background state of perceptual decoupling that enables such phenomena to emerge. Although tonic $\alpha 1$ was not a direct mediator of the effect of color on complex imagery, it appears to be a promising potential neurobiological correlate of complex pseudo-hallucination production under MMGF.

The study faced several limitations. First, given local constraints the study was run on a French-speaking population which forced us to use a non-validated French version of the 5D-ASC. Second, the phenomenological contrasts did not have a true control group as the study was designed to capture red and green contrasts in phenomenology. While we collected 5D-ASC white light MMGF data (pseudo-control), such data would be confounded by order effects, and by extension, novelty effects and so it was not analyzed.

Third, while the sample size properly detected phenomenological effects in light contrasts, as our power analysis indicated, it is also clear that the study is underpowered in properly detecting group differences in neurophysiological activity. Particularly with EEG measures, our frequentist approach was challenged by a threshold level p-value and a medium effect size in Cohen's d. This illustrates that the effect was likely real but underpowered to cross the frequentist threshold of significance. This necessitated the Bayesian supplemental analysis on alpha1 changes in the red-light condition, providing moderate evidence for a real effect. Future research should consider increasing the sample size if confirmatory hypotheses are about cortical activity under MMGF as effects are likely meaningful, but subtle, given the nature of the induction.

Fourth, MOSAIC qualitative interpretation could be slightly blurry due to the English translation of the labels. To best protect the primacy of subjective experience, we tested only native French speakers who underwent a French free association interview and had their audio transcribed in French. Then the MOSAIC procedure clustered the French terms but then converted the labels in English for publication and presentation purposes. Together with our use of a non-validated French 5D-ASC, this study should be replicated in English speaking samples.

Looking forward, future work has the opportunity to study blue light MMGF which was omitted from this study. Given that red and green light primarily engage L- and M-cones, which dominate the human retina and exhibit substantial neural overlap (Purves et al., 2001), they represent ideal starting points for probing cone-specific contributions to ASC induction. In contrast, the sparse distribution and distinct pathways of S-cones may underlie blue light's underrepresentation in Ganzfeld research and therefore inform how sustained exposure to short wavelengths of light affects MMGF phenomenology (Mahabadi & Al Khalili, 2025).

Beyond spectral level analyses, future work would benefit from greater use of time-domain and event-related approaches to both EEG and physiology. The present study focused on tonic, baseline-corrected changes averaged across the induction period, which is well suited for detecting global state shifts but is insensitive to the temporal microdynamics of MMGF experience. Prior work suggests that MMGF-induced imagery and perceptual restructuring unfold in a punctuated, event-like manner, with transient neural changes preceding or accompanying the emergence of complex pseudo-hallucinations (Pistolas et al., 2025b; Pütz et al., 2006). Future studies could therefore leverage time-locked analyses aligned to subjective reports, button presses, or experimentally defined markers to examine phasic cortical dynamics and autonomic responses to both replicate prior EEG work and extend such findings into the physiological domain.

Lastly, the exact effect of what auditory homogenization (i.e., static white noise) adds to the MMGF experience has not been directly tested. It has been suggested that visual homogenization is more central to the overall phenomenology of MMGF states, but MMGF has yet to be directly compared to a strict visual Ganzfeld within-subjects, under matched conditions. Such findings could help inform quantitatively why auditory homogenization is used over auditory deprivation (e.g., noise cancelling headphones) in the MMGF set up.

4.6 Transition

Chapter 4 demonstrated that MMGF is a tunable induction method capable of modulating complex imagery by changing the color of light. This provides an initial proof-of-concept for phenomenological engineering, as specific features of the experience can be modulated through the manipulation of induction parameters.

One question remains however: whether the phenomenological features modulated by the tuned MMGF induction correspond to those elicited by a pharmacological induction. Since both the proposition of Core Features (Chapter 1) and its formalization into the meta-structure of the ASC Phenomenon Space (Chapter 2) imply that features of ASC experience are not tied to a single method of induction, it becomes important to examine whether specific axes of this space, for example complex imagery, exhibit equivalence across methods. Such an investigation provides provisional evidence that these features are not strictly bound by a particular domain of induction method (e.g., pharmacological versus non-pharmacological).

This distinction is critical for the broader framework of phenomenological engineering because if specific dimensions of experience can be reproduced across fundamentally different induction methods, then they reflect more generalizable targets that can be probed and modulated through a variety of means. This has direct implication for the scope of clinical application, as it motivates the expansion from psychedelic-assisted psychotherapy to ASC-psychotherapeutics where non-pharmacological induction methods are also given clinical consideration. Chapter 5 informs this question by providing a cross-study comparison of the phenomenological data between psilocybin and MMGF.

V

Psilocybin and Multi-Modal Ganzfeld: Equivalence of Experience?

This chapter is based on:

Fort, L., D., Ramaekers, J., & Demertzi, A. Red-Light Multimodal Ganzfeld Elicits Equivalent Complex Imagery to Moderate-Dose Psilocybin: A Cross Study Comparison (in prep).

See Appendix C for author role

5.1 Introduction

ASCs characterized by changes in subjective experiences that differ from the normal waking state and are typically recognized by the experiencer, and in some cases inferred by external observers (see Chapter 1). These changes span multiple dimensions of experience such as perception and imagery, control and cognition, and emotion (Fort et al., 2025). In experimental and clinical research, pharmacological inductions of ASCs particularly with classic psychedelics such as psilocybin, are often treated as the most effective means of eliciting these dimensions of experience, as such states reliably produce large effects on global measures of ASC phenomenology. This has led to an implicit bias where drug-induced ASCs are taken as phenomenological benchmarks (see Fort et al. 2026 in press). This pharmacocentric bias can shift non-pharmacological induction methods out of the clinical research picture, such as in the case of questionnaire development, synthesis, and refinement (see Stocker et al., 2025; Studerus et al., 2010; Yaden et al., 2024). As a result, research directly testing parity between pharmacologically induced ASCs and their non-pharmacological counterparts is still underdeveloped; however, it is generally understood that pharmacologically induced ASCs, particularly the serotonergic psychedelics, are more intense, longer lasting, and less controllable (Cardeña, 2025). Recent research has demonstrated some comparisons between these two domains of induction in both meditation (Kallio-Mannila et al., 2025) and hypnosis (Cardeña, 2005, 2025) through qualitative analysis. However, quantitative work directly testing for equivalence between induction methods on dimensions/factors of interest is less available.

One phenomenological feature of interest is complex imagery, which refers to vivid, internally generated visual scenes with semantic or emotional content, rather than simple perceptual distortions. Complex imagery has long been recognized as a fundamental mode of cognition, playing a role in emotional processing, symbolic meaning-making, and imaginative simulation, particularly in therapeutic contexts (Singer, 1971). In psychedelic research, complex imagery is a prominent component of subjective experience and has recently been emphasized as a potentially relevant target for clinical outcomes psychedelic-assisted psychotherapy (Garcia-Romeu, 2025). At the same time, complex imagery is not unique to pharmacological inductions of ASCs as it has also been reported under non-pharmacological inductions such as sensory flooding (Amaya et al., 2023a; Bartossek et al., 2021), sensory homogenization (Hubbard & Langford, 1986; Kübel et al., 2021; Pistolas et al., 2025a; Schmidt & Prein, 2019; Wackermann et al., 2008), sensory deprivation (Mason & Brady, 2009; Zubek, 1969) and trance states (Gosseries et al., 2024). This makes complex imagery a theoretically informative test case for examining whether specific phenomenological features can reach equivalent levels across pharmacological and non-pharmacological induction methods, despite differences in overall ASC intensity. Prior work has suggested potential overlap between pharmacological and non-pharmacological induction methods on imagery-related dimensions, based on descriptive and visual cross-study comparisons of questionnaire profiles (Bartossek et al., 2021). However, these observations have not been evaluated using statistical frameworks designed to test phenomenological equivalence.

In the present cross-study comparison, we test feature-level comparability of Complex Imagery across pharmacological and non-pharmacological induction methods by comparing subjective reports elicited by moderate-dose psilocybin and a red light, white noise multimodal Ganzfeld (MMGF). MMGF provides a well-characterized, low-risk non-pharmacological induction known to elicit imagery-rich ASCs in some individuals, while remaining broadly safe and practically compatible with pharmacological induced ASCs. Using the Five Dimensions of Altered States of Consciousness (5D-ASC) Rating Scale (Dittrich, 1998), we focus on the Complex Imagery factor provided by its 11-ASC scoring scheme (Studerus et al., 2010) and apply a non-parametric equivalence testing method as explained by Meier (2010) to compare the two induction methods.

5.2 Method

See Chapter 3 and Chapter 4 for information on participants, designs, and measures.

5.3 Data Analysis

Full 5D-ASC and 11-ASC phenomenological profiles were computed for each induction method and examined using descriptive visualizations (radar plots) alongside statistical comparisons across factors. Based on statistical analysis, dimensions and/or factors showing minimal differences between induction methods were identified as candidates for equivalence testing, with our specific focus remaining on Complex Imagery. As a contrast case, the Blissful State factor was additionally examined to assess whether the equivalence testing procedure appropriately rejected equivalence for a factor showing clear separation between induction methods.

All analyses were conducted to compare phenomenological outcomes between psilocybin and MMGF. We employed an equivalence testing framework to assess whether the observed differences between the induction methods were sufficiently small to support claims of statistical equivalence. In contrast to conventional NHST, equivalence testing is specifically defined to determine whether two conditions can be considered practically equivalent within predefined bounds of negligible difference (Meier, 2010). This approach is therefore well suited to the present research question, which concerns whether specific phenomenological features may reach comparable levels across induction methods despite differences in overall ASC intensity.

Equivalence testing was implemented using a non-parametric approach following Meier (2010). For each factor of interest, pairwise differences were computed between all observations from the psilocybin and MMGF datasets (psilocybin – MMGF), yielding a full set of cross-condition difference scores (21 x 33 = 693). These pairwise differences were used to construct an empirical cumulative distribution function (ECDF), with the difference score on the x-axis and the cumulative proportion of comparisons on the y-axis. Per Meier (2010), the 50th percentile of the ECDF was taken as the estimate of the typical (median) difference between induction methods, and the plausible median range [Z_L, Z_U] was defined by the first pairwise difference values immediately below and above the 50th percentile.

Equivalence bounds (±Δ) were specified a priori as a smallest effect size of interest (SESOI) expressed in raw questionnaire units (0-100 VAS). To define a phenomenologically meaningful equivalence margin on the 0–100 VAS of the 5D-ASC, we reasoned about what magnitude of difference would plausibly constitute a meaningful change in subjective experience. As a reference point, we considered the structure of the Hallucination Rating Scale (HRS; Strassman, 2005), which assesses hallucinatory experience on a coarse 0–4 categorical scale. By design, each unit step on the HRS reflects a qualitatively distinct experiential category, implying that differences smaller than one category are not intended to represent meaningfully distinct experiences. When expressed on a 0–100 scale, a single categorical step on the HRS corresponds approximately to 25 VAS points. We therefore selected an equivalence bound of ±9 VAS points, corresponding to substantially less than one categorical step. This margin represents a conservative estimate of the smallest phenomenological difference likely to be experienced as meaningful, thereby biasing the test against concluding equivalence unless differences are minimal. Phenomenological equivalence was concluded when the entire plausible median range [Z_L, Z_U] lay within the predefined equivalence bounds, indicating that the typical difference between induction methods was smaller than a minimally perceptible change. If any portion of the plausible median interval extended beyond these bounds, equivalence was rejected. This procedure was applied to the Complex Imagery factor identified as both a theoretically relevant target and candidate for equivalence, and to the Blissful State factor as a contrast case.

5.4 Results

To evaluate whether parametric assumptions were met, the distribution of Complex Imagery scores was assessed separately for the psilocybin and MMGF conditions. Shapiro–Wilk tests indicated that psilocybin scores did not significantly deviate from normality ($W = 0.93$, $p = .13$), whereas MMGF scores showed a significant deviation from normality ($W = 0.90$, $p = .006$). Visual inspection of quantile–quantile plots and histograms were consistent with these results (Figure 1). Given this violation of normality assumptions, subsequent analyses were conducted using non-parametric statistical methods/

Mann–Whitney U tests were conducted to compare phenomenological scores between psilocybin and MMGF across the 5D-ASC dimensions and 11-ASC factors (Table 3).

Scale	Measure	W	p (FDR)	Cliff's δ
5D-ASC	General Altered States Score	137.0	.001***	−0.605
	Oceanic Boundlessness	111.0	< .001***	−0.680
	Dread of Ego Dissolution	279.0	.307	−0.195
	Visionary Restructuralization	108.5	< .001***	−0.687
	Auditory Alterations	293.5	.427	−0.153
	Vigilance Reduction	390.5	.440	0.127
11-ASC	Experience of Unity	177.5	.005**	−0.488
	Spiritual Experience	197.5	.014*	−0.430
	Blissful State	138.5	.001***	−0.600
	Insightfulness	153.0	.001***	−0.558
	Disembodiment	296.5	.430	−0.144
	Impaired Control and Cognition	301.5	.440	−0.130
	Anxiety	248.5	.129	−0.283
	Complex Imagery	277.5	.307	−0.199
	Elementary Imagery	167.0	.003**	−0.518
	Audio-Visual Synesthesia	70.0	< .001***	−0.798
	Changed Meaning of Percepts	78.0	< .001***	−0.775

Table 3. Mann Whitney U NHST Results. Moderate-dose psilocybin induced significantly more intense experiences overall (G-ASC) particularly in Oceanic Boundlessness and Visionary Restructuralization dimensions. Several factors (e.g., Experience of Unity, Spiritual Experience, Blissful State, and Elementary Imagery) also showed significantly higher scores under psilocybin. Differences could not be found (supplemented with small effect sizes) in some dimensions (e.g., Dread of Ego Dissolution) and factors (e.g., Complex Imagery).

Consistent with prior work, moderate-dose psilocybin elicited significantly greater overall altered-state intensity, as reflected by higher General Altered State Scores (G-ASC; pFDR = .001, δ = −0.61; Figure 35).

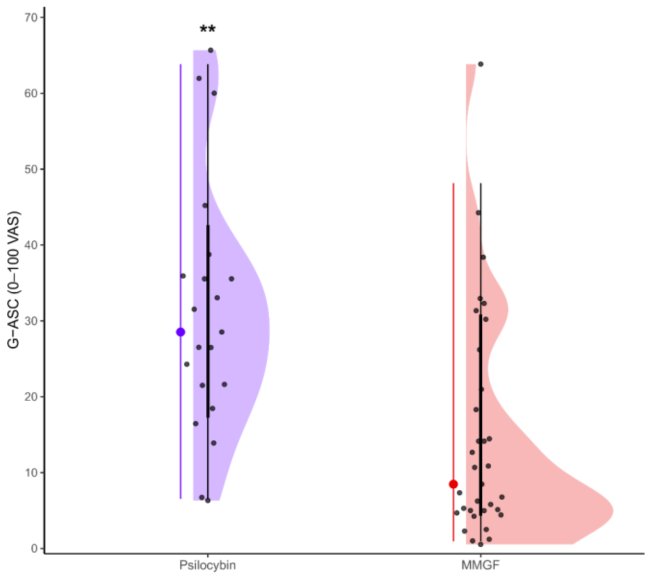

Figure 35. *General altered states intensity under psilocybin and MMGF*. Violin plots with overlaid individual data points show distributions of the General Altered State Score (G-ASC; 0–100 VAS) of the 5D-ASC for the psilocybin condition (purple) and the multimodal Ganzfeld (MMGF) condition (red). Central tendency and dispersion are indicated by the median (black line) and interquartile range. Psilocybin elicited significantly higher overall altered-state intensity than MMGF (Mann–Whitney U = 137, pFDR = .001, Cliff's δ = −0.61). Negative values of Cliff's δ indicate higher scores under psilocybin. Asterisks denote FDR-corrected significance (** p < .01).

At the dimensional level, psilocybin also produced significantly higher scores on Oceanic Boundlessness ($pFDR < .001$, $\delta = -0.68$) and Visionary Restructuralization ($pFDR < .001$, $\delta = -0.69$; Figure 36A).

At the factor level, several phenomenological features showed significantly higher scores under psilocybin, including Experience of Unity, Spiritual Experience, Blissful State, Insightfulness, Elementary Imagery, Audio-Visual Synesthesia, and Changed Meaning of Percepts (all $pFDR \leq .014$), with corresponding effect sizes in the moderate to large range ($|\delta| = 0.43–0.80$; Figure 36B).

In contrast, no significant differences were observed for several dimensions and factors, including Dread of Ego Dissolution, Auditory Alterations, Vigilance Reduction, Disembodiment, Impaired Control and Cognition, and Complex Imagery (all $pFDR \geq .129$). These non-significant comparisons were accompanied by small effect sizes ($|\delta| \leq 0.28$), indicating minimal separation between induction methods on these features. Together, these results confirm robust global and dimension-level differences favoring psilocybin, while also identifying specific phenomenological factors, most notably Complex Imagery, for which group differences were minimal, motivating subsequent equivalence testing.

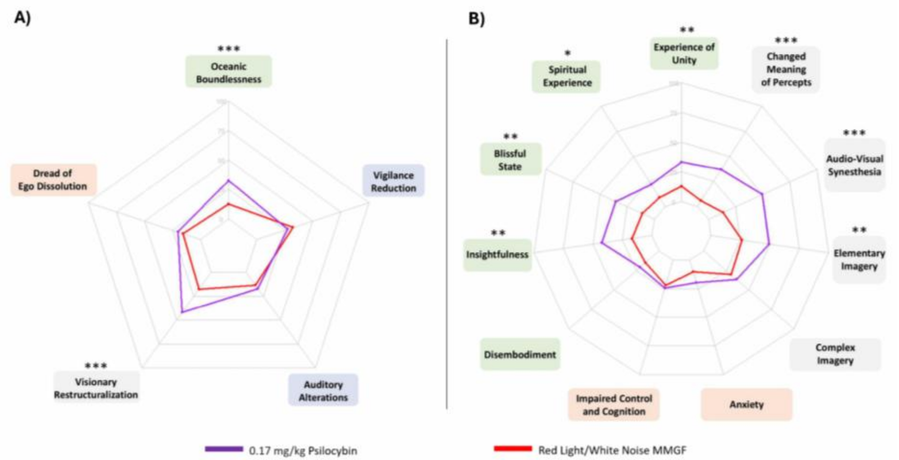

Figure 36. *Dimension and factor level phenomenological patterns for psilocybin and MMGF*. **(A)** Radar plot showing mean scores on the five dimensions of the 5-Dimensions of Altered States of Consciousness (5D-ASC). **(B)** Radar plot showing mean scores on the eleven factors of the 11-ASC scoring scheme. Psilocybin is shown in purple and multimodal Ganzfeld (MMGF) in red. Axes represent normalized 0–100 VAS scores. Asterisks denote significant between-group differences based on Mann–Whitney U tests with FDR correction (* p < .05, ** p < .01, *** p < .001). Negative Cliff's delta values indicate higher scores under psilocybin. Factors without asterisks did not differ significantly between induction methods.

Equivalence testing was first applied to the Complex Imagery factor, which showed minimal separation between induction methods in the NHST analysis. Pairwise differences were computed between all psilocybin and MMGF observations ($21 \times 33 = 693$ comparisons) and summarized using an ECDF. The median pairwise difference was close to zero, with the plausible median range defined by the two adjacent order statistics bracketing the 50th percentile [$Z_L = 6.33$, $Z_U = 6.67$]. Using a predefined equivalence margin of ±9 VAS points, the entire plausible median range lay fully within the equivalence bounds (Figure 37), indicating phenomenological equivalence between psilocybin and MMGF on Complex Imagery. This conclusion converged with conventional NHST results, which showed no significant difference between conditions (Mann–Whitney $U = 277.5$, $p_{FDR} = .307$) and a small effect size (Cliff's $\delta = -0.20$). Together, these findings indicate that, despite large global differences in altered-state intensity, Complex Imagery reached comparable levels across pharmacological and non-pharmacological induction methods.

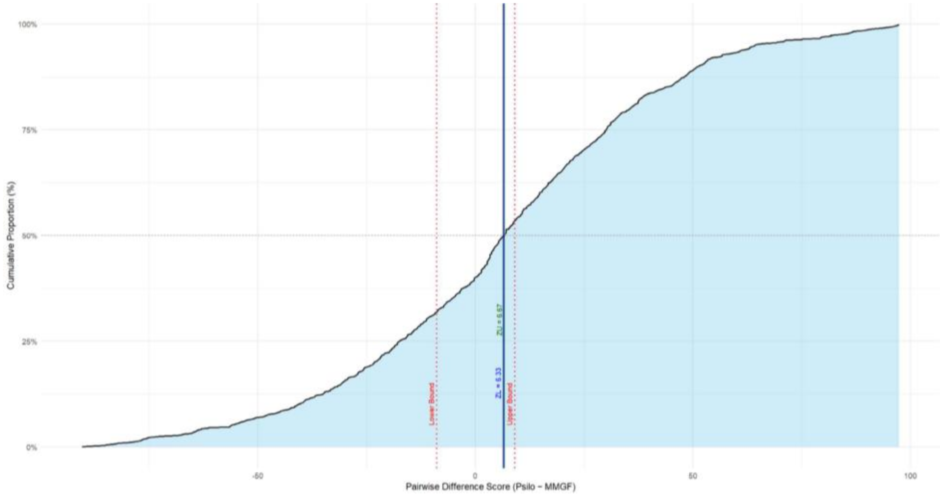

Figure 37. *Phenomenological equivalence in complex imagery scores between moderate-dose psilocybin and MMGF*. Empirical cumulative distribution function (ECDF) of all pairwise Complex Imagery difference scores (psilocybin − MMGF; 0–100 VAS; n = 693). The solid curve shows the cumulative proportion of pairwise differences. The horizontal dashed line marks the 50th percentile of the distribution. The plausible median range is defined by the last difference score below the 50th percentile (Z_L = 6.33; blue line) and the first difference score above the 50th percentile (Z_U = 6.67; green line). Red dotted vertical lines indicate the predefined equivalence bounds (±9 VAS points). Because the entire plausible median range lies within these bounds, phenomenological equivalence between psilocybin and MMGF is supported for Complex Imagery.

To evaluate the specificity of the non-parametric equivalence procedure, a contrast analysis was conducted on the Blissful State factor, for which conventional analyses indicated clear separation between induction methods. Consistent with this expectation, psilocybin elicited substantially higher Blissful State scores than MMGF (Mann–Whitney $U = 138.5$, $p_{FDR} = .001$, Cliff's $\delta = -0.60$). Applying Meier's (2010) equivalence framework to the same data, all 693 pairwise difference scores (psilocybin − MMGF) were used to construct an ECDF. The plausible median range, defined by the two adjacent order statistics bracketing the 50th percentile, was [$Z_L = 24.33$, $Z_U = 24.67$]. Using the same predefined equivalence margin of ±9 VAS points, the entire plausible median range lay well outside the equivalence bounds, leading to rejection of phenomenological equivalence for Blissful State (Figure 38). This result converges with NHST and effect-size findings and serves as a proof-of-concept demonstration that the equivalence testing procedure appropriately distinguishes between phenomenological features that are comparable across induction methods and those that are clearly distinct.

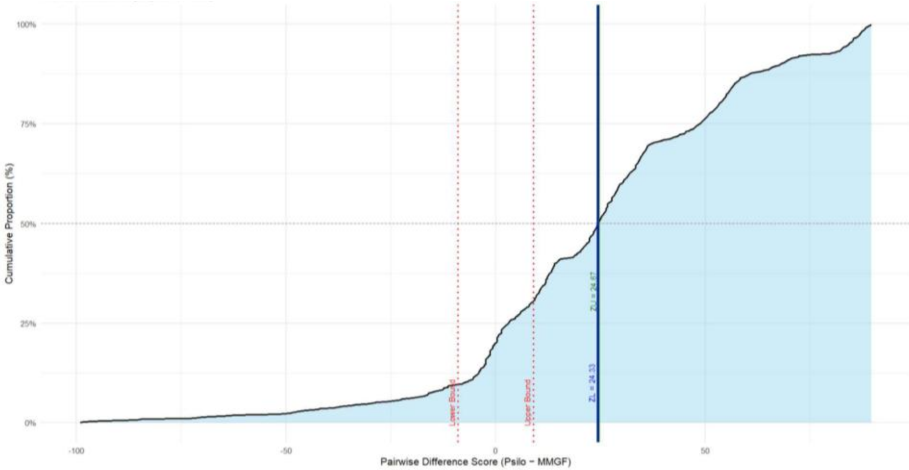

Figure 38. *Lack of evidence for phenomenological equivalence in blissful state scores between moderate-dose psilocybin and MMGF*. Empirical cumulative distribution function (ECDF) of all pairwise Blissful State difference scores between psilocybin and MMGF (psilocybin − MMGF; 21 × 33 = 693 comparisons). The solid curve shows the cumulative proportion of differences as a function of raw score (0–100 VAS). The horizontal dashed line marks the 50th percentile. The plausible median range is defined by the two adjacent order statistics bracketing this percentile (Z_L = 24.33, Z_U = 24.67; blue and green vertical lines). Red dashed vertical lines indicate the predefined equivalence bounds (±9 VAS). Because the entire plausible median range lies outside the equivalence bounds, phenomenological equivalence is rejected for Blissful State, consistent with NHST results indicating higher Blissful State under psilocybin.

5.5 Review

The present cross-study comparison examined whether Complex Imagery scores were statically equivalent across a pharmacological (moderate-dose psilocybin) and a non-pharmacological (MMGF) ASC induction method despite significant differences in overall state intensity. Consistent with prior ASC research, moderate-dose psilocybin produced substantially higher global altered state intensity and elevated scores across multiple dimensions of subjective experience compared to MMGF. However, as analysis shifted from global differences to dimension level differences and to factor level differences, scores on certain factor scores between the two induction methods aligned. Using a non-parametric equivalence testing framework, Complex Imagery was shown to be statistically equivalent between moderate-dose psilocybin and red-light, white-noise MMGF with the entire plausible median difference falling within a conservative, a priori equivalence margin. This finding converged with conventional non-significant NHST results and small effect sizes, while a contrast analysis on the Blissful State factor scores appropriately rejected equivalence. Together, these results demonstrate that large differences in overall ASC intensity do not rule out statistically equivalent levels of finer-grained experience (i.e., factors) and provide statistical support to the comparability of complex imagery generation between moderate-dose psilocybin and red-light, white noise MMGF.

This finding has important implications for how ASC induction methods are compared and interpreted. In much of the ASC literature, pharmacologically induced states, particularly those produced by serotonergic psychedelics, function as implicit reference points for changed subjective experience. For example, the 11-ASC scoring scheme can be criticized for pharmacocentric bias (i.e., omission of non-pharmacological datasets from the factor analysis), a bias which was later replicated with the Revised Three-Dimensional Altered States of Consciousness scale (Fort et al., 2026 in press; Stocker et al., 2025). This creates cascading effects on the architecture of the ASC field itself by distorting both how we define ASCs and which dimensions of experience are considered relevant (see Fort et al., in press). Such choices are motivated by the field's drug-dominant history (Carhart-Harris & Goodwin, 2017) and emerging work showing psychedelics as more subjectively intense than non-pharmacologically induced ASCs such as hypnosis (Cardeña, 2025) and meditation (Kallio-Mannila et al., 2025). Other studies have implicitly stated that psychedelic drug level phenomenology is the benchmark for evaluating non-pharmacologically induced ASCs, such as those researching stroboscopic light stimulation (Bartossek et al., 2021) and breathwork (Havenith et al., 2024),

Beyond challenging implicit pharmacocentric assumptions, the present findings directly inform whether non-pharmacological induction methods can meaningfully approximate pharmacologically induced methods on specific phenomenological dimensions/factors of experience. The present results provide formal statistical support for factor-level parity between moderate-dose psilocybin and red light, white noise MMGF demonstrating that Complex Imagery scores can reach equivalent levels under a low-risk MMGF session despite an overall weaker subjective intensity.

This has practical implications for how ASC induction methods are selected and combined. Rather than treating pharmacological and non-pharmacological approaches as mutually exclusive, this factor-level equivalence supports a more modular view of ASC inductions, in which methods can be combined across the primary classification domain of pharmacological and non-pharmacological (see Fort et al., 2025 for a review of method-based classification schemes). These "hybrid" ASCs can be designed to selectively target specific dimensions/factors of experience given prior knowledge of their phenomenological patterns generally elicited by each induction method separately (i.e., what we refer to here as phenomenological engineering). In this context, MMGF may not function as a weaker approximation of overall psychedelic experience, but as a complementary induction that may contribute meaningfully to complex imagery generation while minimizing dose-dependent safety risks associated with drug intake. However, the concept of hybrid-induction ASCs is far from novel, though phenomenological engineering may offer a clearer end goal. Historically, pharmacological and non-pharmacological induction methods have been tested in a hybrid manner such as in the case of hypnodelic work of the 1960s and 1970s (Lemercier & Terhune, 2018; Levine & Ludwig, 1966). While this work sharply declined after the 1970 Controlled Substance Act

(Carhart-Harris & Goodwin, 2017), it is already continuing such as in the combination of psilocybin and meditation (Griffiths et al., 2018). At present, this cross-study comparison demonstrates the importance of testing for dimension/factor level equivalence instead of assuming pharmacological primacy across the board. The results of this work may also support the eventual combination of psilocybin and MMGF given their similarities in evoking potentially clinically relevant Complex Imagery.

Several limitations should be acknowledged when interpreting the present findings. First, language issues regarding the 5D-ASC persist (see Section 4.10). Second, the comparison was conducted across two independently collected datasets that differed in experimental context. The psilocybin data was acquired during MRI scanning, whereas the MMGF sessions took place in a reclined medical bed outside the scanner. These environmental differences likely influenced aspects of comfort, bodily awareness, and affective tone, and may partially account for group differences observed in factors such as Anxiety, Disembodiment, and Impaired Control and Cognition. In contrast, Complex Imagery is less readily explained by contextual or bodily constraints because it primarily reflects internally generated visual experience rather than responses to the immediate physical environment.

Third, the psilocybin dataset included participants who had previous experience with a psychedelic drug, while the MMGF dataset did not screen for this. If expectancy effects were at play, then one would expect the psilocybin complex imagery score to be artificially inflated which would change the conclusion from red-light MMGF may produce equivalent intensity of complex imagery to red-light MMGF may produce more intense complex imagery than moderate-dose psilocybin. Both conclusions are equally interesting for motivating future work.

An important methodical strength of the present cross-study comparison is that expectancy effects were minimized in both datasets.

The psilocybin study employed a double-blind design, and the MMGF study withheld information about the hallucinatory nature of the induction until after the study was completed. This reduces the likelihood that observed similarities in Complex Imagery scores reflect demand characteristics across induction methods.

Future work should test if the present Complex Imagery equivalence findings hold within a single, prospectively designed study in which the two inductions are directly compared under matched experimental conditions. This would allow equivalence testing to be applied without cross-study differences in environment and assessment context. Building on this, future studies could test whether combining MMGF with psilocybin produces additive, dampening, or null effects on Complex Imagery. Such findings could have implications for how induction methods are designed and implemented in psychedelic-assisted psychotherapy through amplifying potentially relevant features, such as Complex Imagery.

5.6 Transition

Chapter 5 provides preliminary evidence of equivalence of experience on certain subjective factors across induction method domains despite differences in overall subjective intensity. While these results demonstrate that phenomenological patterns can be measured and compared meaningfully in a shared space via the 5D-ASC, it does not provide a basis of intentional design of experience. The findings of Chapter 5 therefore invite a larger question in the context of this thesis, namely how can insights into equivalence be translated into the selective modulation of clinically relevant experiences? Addressing this question requires synthesizing the conceptual and empirical work of Chapters 1 through 5 into a forward-facing, preliminary framework in which theory informs measurement, and measurement, in turn, informs practice.

VI

Phenomenological Engineering & ASC-Psychotherapeutics

6.1 Thesis in Review

Throughout the work presented in this thesis, a consistent trajectory emerges, namely that altered states of consciousness (ASCs) can be understood as structured, multidimensional patterns of experience that lend themselves to systematic mapping (Chapters 1-2), comparison across induction methods (Chapters 3-5), and selective modulation through controlled manipulation of induction parameters (Chapter 4). Together, these findings support the notion of understanding ASCs as patterns within a shared phenomenological space.

In this view, ASC science can be thought to operate within an ASC Phenomenon Space, a provisional meta-structure that integrates three nested levels (Chapter 2). First, definitional boundaries establish what qualifies as an ASC (outer boundary). Second, candidate invariant dimensions, such as the Core Features (Chapter 1), define the structured axes along which such states vary (inner boundary). Third, these dimensions give rise to state-space representations in which individual experiences can be located, compared, and analyzed. Here, the state-space is manifested in either two-dimensional (radar plots) or three-dimensional (dynamic trajectories) visualization space.[17] This framework allows various ASCs to be compared in a common coordinate system across induction methods while explicitly nesting them within the confines of phenomenon operationalization (i.e., what is and what is not an ASC) and candidate dimensions for an invariant structure

[17] Note the difference between dimensions of visualization space and dimensions of phenomenological experience. Visualization space refers to low-dimensional geometric projections e.g., 2D radar plots or 3D trajectories (see Timmermann et al., 2023) used for interpretability. Phenomenological dimensions refer to features of the experience that researchers aim to measure.

of ASC phenomenology (i.e., the inner boundary represented by the Core Features as an example).

Importantly, the Core Features and the ASC Phenomenon Space work best when understood as treating ASCs as patterns of phenomenology in n-dimensional space where the number of dimensions in the inner boundary structures the resulting state space. Using the Core Features as a worked example in the ASC Phenomenon Space, the inner boundary of that space would result in an eight-dimensional state-space representation because there are eight Core Features comprising the inner boundary. When viewed as such, one can more easily and confidently evaluate which features of the experience located in the inner boundary are clinically relevant independent of the method used to elicit them. Building on this, Chapter 4 provides initial evidence that one can tune parameters of the induction method (i.e., color of light) to selectively modulate certain features of the ASC experience (e.g., complex imagery), specifically in multi-modal Ganzfeld (MMGF). Chapter 5 then shows that such features of the experience, namely complex imagery, are not unique to one induction method and can show meaningful equivalence despite vast differences in overall ASC intensity.

Together, these findings establish that ASC phenomenology can be structured, measured, modulated, and potentially reproduced to the degree of statistical equivalence across different domains of induction methods. The trajectory of this thesis therefore moves toward construction via the concept of phenomenological engineering understood as the deliberate design, tuning, and application of ASC induction methods based on their prototypical phenomenological patterns such that clinically or experimentally relevant dimensions of experience are targeted for maximal elicitation or modulation.

Central to the idea of phenomenological engineering is a rejection of epiphenomenalism, namely the view that conscious experience is merely a causally inert byproduct of underlying physical processes (Robinson, 2010). In contrast, phenomenological engineering assumes that subjective experience plays a functional role, particularly in the context of therapeutic change. Within psychedelic-assisted psychotherapy (PAP), and more broadly ASC-psychotherapeutics, clinical outcomes are not mediated directly by molecular or neural changes alone, but by the exposure to certain features of experience those changes bring about. As such, phenomenology becomes one of the most proximal and, in conjunction with therapeutic process (e.g., the therapeutic alliance), one of the more primary steps in reaching positive therapeutic outcomes.

This framing sets the stage for the remainder of Chapter 6, which aims to be forward-facing in the discussion of what the work of this thesis means and some speculation on how it can be used. The following sections will work to develop phenomenological engineering in the context of the thesis by clarifying the role of ASC phenomenology within a pragmatic hierarchy of explanation, examining the experiential mediators of therapeutic outcomes, and ultimately suggesting a provisional model of phenomenological engineering to be refined and formalized later.

6.2 Phenomenological Primacy via Jamesian Pragmatism

Throughout the thesis, a Jamesian pragmatic perspective has been adopted in interpreting neurophysiological data in relation to phenomenological findings. This section aims to briefly explain one way of understanding biological and phenomenological data in the context of clinical utility. Beginning with William James' *Pragmatism*:

“The whole function of philosophy ought to be to find out what definite difference it will make to you and me…at definite instants of our life…” (James, 1906/1921, p. 50).

This principle provides a criterion for evaluating explanatory levels in the study of ASCs. Here, the value of any given level is determined by the extent to which it produces a meaningful difference in outcome. Rather than treating molecular, neural, large-scale body/brain dynamical, and phenomenological accounts as equally primary, a Jamesian pragmatic approach evaluates each in terms of its contribution to the target of interest. This thesis makes it a point to continually raise the importance of studying ASCs for their clinical potential, both pharmacologically and non-pharmacologically induced. Therefore, for the purposes of applying the perspective to this thesis, the target of interest will focus on the therapeutic outcome.

From this standpoint, the study of ASCs in relation to clinical outcome is best understood where neurophysiological correlates are subordinate to phenomenological experience based on their lack of direct actionability. For example, in Chapter 3 work is shown that associates the neurobiological space of transition probabilities between clustered connectivity states with the phenomenological space of the 5D-ASC under moderate-dose psilocybin. According to Jamesian pragmatism, such neurobiological detail does not provide a direct basis for intervention within typical clinical settings. However, the phenomenological findings that emerged, namely the prominence of the Oceanic Boundlessness dimension and the associative strength of its Unity factor, under the drug can be immediately actionable to a clinician as they know they may want to continue to use psilocybin at a moderate-dose if it was inducing clinically relevant egotropic experiences.

Simply put, variables that do not increase the capacity to produce, guide, or stabilize clinical outcome in ASC-psychotherapeutics remain descriptively useful but operationally secondary to phenomenology. They contribute to our overall understanding, but not necessarily to our ability to control and shape experience for the goal of therapeutic efficacy.

This reordering of primacy helps set the conceptual foundation for phenomenological engineering which is developed in the remainder of this chapter. If phenomenology is the level at which interventions exert their effects, and if different induction methods can converge on shared phenomenological features, then these features can be treated as targets for modulation. The task then is to identify which features of a prototypical phenomenological pattern of any given induction are clinically relevant and how tuning the parameters of that given induction can reliably engage those features. In this way, the emphasis of Jamesian pragmatism on practical consequences leads directly to the concept of phenomenological engineering, wherein ASCs can ideally be designed to maximize the elicitation of clinically relevant features of experience.

6.3 PAP and ASC-Psychotherapeutics

Psychedelic-assisted psychotherapy (PAP) refers to the practice of novel therapies incorporating psychedelic drugs to treat a wide range of mental health disorders (Marseille et al., 2022). Empirical evidence indicates that PAP shows promise in treating a variety of mental health disorders including anxiety and depressive disorders (Muttoni et al., 2019; Chmiel & Rybakowski, 2026), as well as end-of-life distress (Cohorst & Kajonius, 2026), eating disorders (Cuerva et al., 2024), cluster headaches (Im & Sandoe, 2025), obsessive-compulsive disorder (Collins, 2024), attention-deficit/hyperactivity disorder (Chmiel et al., 2026), and post-traumatic stress disorder (Henner et al., 2022). Emerging evidence further suggests potential efficacy in treating addiction disorders such as those involving tobacco (Spoelstra et al., 2024), opioids (Pulido-Saavedra et al., 2025), and alcohol (Calleja-Conde et al., 2022).

Evidence increasingly suggests that specific features of the acute psychedelic experience predict enduring clinical outcomes, even when controlling for overall drug intensity (Yaden & Griffiths, 2021). In particular, features of the ASC experience such as Oceanic Boundlessness (Roseman et al., 2017), emotional breakthrough, and mystical experience (Roseman et al., 2019) were shown as predictors of therapeutic outcome. Further, mystical experience has been identified as a significant mediator of outcome in PAP, specifically with psilocybin (Griffiths et al., 2008; Griffiths et al., 2016; Ross et al., 2016).

Together, this suggests that experience is not epiphenomenal in PAP, but rather a predictive and mediating variable in its outcome and efficacy. This centrality of experience supports why pharmacological primacy was previously made explicit as the aims of the thesis remain on how presented work can translate into psychotherapeutic application. It is worthwhile to note that while there have been large studies on PAP, with some showing these predictive and mediating effects of phenomenology, non-pharmacological induction methods of ASCs are not without their clinical merit as shown by work on floatation-restricted environmental stimulation therapy (Floatation-REST; Feinstein et al., 2018a; Feinstein et al., 2018b; Garland et al., 2024) and meditation (Krisanaprakornkit et al., 2006; Saeed et al., 2019). As such, we will shift from PAP to ASC-psychotherapeutics so that the clinical potential of non-pharmacological ASC induction methods can be included, studied, and compared alongside their pharmacological counterparts within a shared phenomenological space.

Since empirical work regarding ASC-psychotherapeutics suggests clinically relevant outcomes are mediated by specific features of the ASC experience, then the goal becomes to reliably engage and modulate those features. This frames the task of ASC research, in the context of ASC-psychotherapeutics, to map the territory precisely enough to return there with intention. In the final section of this discussion, I will suggest the provisional idea of phenomenological engineering as a means to approach this task.

6.4 Phenomenological Engineering

It is at this point in the thesis that we move from classification and characterization to the possibility of construction. If ASCs can be described within a shared phenomenological space (Chapters 1 and 2), compared across induction methods (Chapters 3, 4, and 5), and selectively modulated through parameter-level manipulation (Chapter 4), the next step is to determine how such states can be deliberately engineered. This introduces the concept of phenomenological engineering defined here as the systematic design of ASC induction methods based on their prototypical phenomenological patterns. The development of phenomenological engineering can be thought to happen in three stages: precision phenomenology, phenomenological targeting, and phenomenological engineering itself. Together, these stages form a translational pipeline linking theoretical structure to clinical application.

The first stage, precision phenomenology, concerns the rigorous identification and refinement of invariant dimensions of ASC subjective experience. As outlined throughout this thesis, various classification schemes of ASCs have attempted to distill the essential phenomenological components of ASCs (see Chapter 1). Precision phenomenology is then the end result of conceptual, a priori state-based classification extended into the empirical realm by its associated measurement tool.

For example, the Etiology-Independent Structures of ASCs proposed by Dittrich was a conceptual framework aimed at refining a shared phenomenological space which was then extended empirically by various measurement tools (e.g., the 5D-ASC). In this sense, for an a priori conceptual framework to move toward precision phenomenology, it must extend into psychometrics so that candidate dimensions can be revised with data. This was done by Dittrich with the APZ, OAV, and 5D-ASC questionnaires and Pekala with different versions of the Phenomenology of Consciousness Inventory. Conversely, researchers like Charles Tart, for example, did not extend his Subsystems of ASCs into a psychometric tool, evidencing that some state-based classifications never cross into the empirical realm.

Therefore, precision phenomenology can be seen as aligning theory with measurement such that conceptually solid dimensions reappear across the history of the field and that these same dimensions are then psychometrically supported by data in the questionnaire construction process. Ideally, precision phenomenology leaves us with stable, recurring dimensions that can be defended conceptually and empirically such that we have a shared, etiology-independent space to compare the prototypical phenomenological patterns of various induction methods. Simply put, precision phenomenology concerns making the best map for the territory.[18]

Once the map is made and defensible on both conceptual and empirical grounds, the second stage of phenomenological targeting becomes possible. Here, the goal is to identify which dimensions of experience are most strongly associated with clinically relevant outcomes. Previously reviewed empirical work suggests that features of the ASC experience such as emotional breakthrough, oceanic boundlessness, and/or mystical experience are predictive of, or mediate, the therapeutic outcome. While these are established phenomenological targets of clinical interest, recall that they are constrained by their measurement tools and their biases. Failure to address or account for these would lead to "imprecise" phenomenology and require a return to Stage 1.

For example, constructs such as the mystical experience are derived from specific questionnaires with their own unique psychometric development histories and contexts. As a result, these may reflect biased representations of the broader phenomenological space, rather than invariant dimensions of ASC experience. In essence, this means that clinically relevant features are only as precise as the conceptual structure and empirical measurement tools used to define them. This is made explicit in the ASC Phenomenon Space

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[18] It is useful to briefly invoke the map-territory distinction, often attributed to Alfred Korzybski who emphasized that the map is not the territory (i.e., our representations of the thing are not the thing itself; Korzybski, 1933/2023). In the present context, attempts at structuring a shared invariant phenomenological space should be seen as creating better maps of the territory. Here, it is understood that because all models and representations are provisional (James, 1906/1921), we can never access the true structure of ASC experience (i.e., the territory) but we can aim for and develop better maps of that structure.

via the nested nature of the outer and inner boundaries alongside the resulting state space representation.

These concerns have been discussed in Chapter 2, particularly in relation to potential pharmacocentric bias within the 5D-ASC via its 11-ASC refinement. Addressing such limitations reflects the iterative nature of scientific progress. Accordingly, a return to Stage 1 is a necessary step toward developing next-generation conceptual structures and associated measurement tools that more accurately capture invariant dimensions of ASC experience. The creation of a next-generation ASC instrument that adheres to the basic idea of precision phenomenology could therefore continue to support and clarify existing clinical targets (e.g., mystical experience and its issue of operationalization, see Mosurinjohn et al., 2023), or possibly, reveal new features of experience with clinical potential.

The final stage of phenomenological engineering is its application. Here, aggregated data across induction methods (i.e., prototypical phenomenological patterns) and data on trait-level individual differences regarding the ASC experience[19] are used to design interventions and select participants to maximize the probability of eliciting the features of experience identified by phenomenological targeting (Stage 2). This is an inherently probabilistic process as the same induction method on the same person does not always produce identical experiences. This variability is addressed in reviewing prototypical phenomenological patterns (i.e., which patterns of experience tend to most emerge with a given induction).

[19] One prominent trait difference across individuals in ASCs regards absorption. It reappears often such that people who have higher trait levels of absorption tend to have more intense ASC experiences (Glicksohn & Avnon, 1997; Lifshitz et al., 2019; Pekala et al., 1985).

By identifying these prototypical patterns as well as the role of trait-level differences regarding ASC experiences, ASCs can be preferentially modulated for clinical purposes.

For example, consider the case of complex visual imagery, a feature of ASC experience discussed at length in this thesis. First, proper mapping of the ASC Phenomenon Space (i.e., precision phenomenology, Stage 1) would need to occur such that complex visual imagery emerges as a conceptually and empirically defensible feature of experience. This involves having a strong enough outer boundary (i.e., what is and what is not an ASC) to defend the emergence of a feasible inner boundary and resulting state-space. Once that occurs, a series of studies and/or clinical trials using the questionnaire that emerged from Stage 1 need to establish that complex imagery is somehow relevant in therapeutic outcome (e.g., reduction in depression scores), ideally as a predictor or mediator (i.e., phenomenological targeting/Stage 2; see Figure 39).

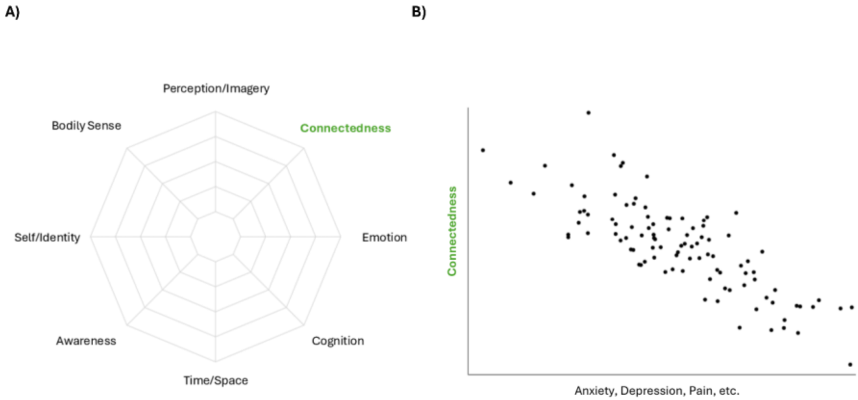

Figure 39. *Precision Phenomenology and Phenomenological Targeting.* (A). Precision phenomenology. A radar plot representing a hypothetical eight-dimensional structure of ASC experience (e.g., perception/imagery, bodily sense, connectedness, etc.). This space is assumed to be conceptually defensible (i.e., dimensions seem plausible with degrees of recurrence across history) and empirically defensible (i.e., empirical refinement regarding its associated questionnaire has already occurred). A) illustrates the ideal state-space where axes of experience are invariant and etiology-independent. (B) Phenomenological Targeting. An illustrative example identifying a clinically relevant dimension of the hypothetical eight-dimensional space shown in (A). Here, variation in score along the feature of interest (e.g., connectedness) is shown in relation to clinical assessment scores, such as those relating to depression, anxiety, and/or pain inventories. Here, it is shown that as the Connectedness score increases, the score on those clinical assessments decreases, establishing some semblance of clinical relevance. After this has been established, Connectedness is colored green to signal it has been determined a clinically relevant target. Together (A) and (B) form the foundation of the eventual engineering of experience.

After clinical relevance is discovered for complex imagery in this hypothetical, trait level associations with complex imagery intensity and the prototypical phenomenological patterns of induction methods biased toward complex imagery generation would be consulted. From there, proper engineering could begin.

Chapter 4 of this thesis already established that a non-pharmacological induction method, MMGF, can preferentially amplify complex imagery generation by simply changing the color of light. Therefore, if a clinician wanted to maximize the probability of a patient experiencing intense complex imagery for therapeutic benefit, red-light MMGF would be an option. This of course extends to pharmacological inductions as well. If complex imagery were the aim, clinicians would have to decide which substance to use. Given a recent meta-analysis, evidence suggests that LSD produces more intense complex visual imagery than psilocybin which should bias the practicing clinician toward choosing LSD over psilocybin for their sessions in this hypothetical (Shinozuka et al., 2024).

One should also keep in mind that induction methods are not always mutually exclusive, especially across domains (e.g., pharmacological and non-pharmacological inductions). This means that a phenomenological engineer may be interested in testing hybrid-induction[20] methods given the low-risk options of non-pharmacological induction methods such as MMGF.

As an interesting example, Chapter 5 showed statistical equivalence between moderate-dose psilocybin and red light MMGF which invites the question of combining them to test whether MMGF would increase or decrease complex imagery scores, or whether it would have an effect at all. Such findings would directly inform the goals of phenomenological engineering in this hypothetical such that one moves closer to an induction

[20] The term hybrid-induction refers to the combination of ASC induction methods across the primary domain of classification, meaning pharmacologically and non-pharmacologically induced (see Section 1.2.2 and Induction-Domain schemes).

method that maximizes the probability of intense complex imagery elicitation.

Taken together, the system developed in the conclusion of this thesis attempts to translate the theory of conceptual frameworks and carry them through to clinical application. First, through precision phenomenology, specific features of a defensible shared phenomenological space can be derived from a properly mapped ASC Phenomenon Space. Second, phenomenological targeting aims to justify their elicitation and modulation through establishing clinical relevance regarding desired therapeutic outcomes. Lastly, induction methods can be systematically selected, combined, and tuned to engage phenomenological targeting through maximizing the probability of modulating a given feature in phenomenological engineering. This preliminary proposal moves the thesis' aim from historical classification through empirical characterization and toward state construction such that it suggests a forward-facing orientation for the current work. Simply put, the ability of ASCs to heal lies in the structure of their underlying phenomenology and it is then the task of the phenomenological engineer to provide the toolbox.

Appendix A: Classification Term Coding (Chapter 1)

A list of all the extracted terms and how they were coded, based on conceptual meaning, for word cloud clustering.

1. **Perception and Imagery Cluster:**
    1. Perceptual Distortions (Ludwig – perception1)
    2. Changes in Perception (Farthing – perception2)
    3. Altered Perception (Pekala – perception3)
    4. Input-Processing (Tart – sensory1)
    5. Sensory Dynamics (Vaitl – sensory2)
    6. Auditory Alterations (Dittrich – auditory1)
    7. Exteroception (Tart – exteroception1)
    8. Visual Imagery (Pekala – visual1/imagery1)
    9. Audio-Visual Synesthesia (Studerus – synesthesia1/auditory2/visual2)
    10. Imagery and Fantasy (Farthing – imagery2/fantasy1)
    11. Amount of Imagery (Pekala – amount1)
    12. Vividness of Imagery (Pekala – vividness1)
    13. Elementary Imagery (Studerus – imagery3/elemetary1)
    14. Complex Imagery (Studerus – imagery4/complex1)
    15. Changed Meaning of Percepts (Studerus – perception4/meaning1)
2. **Bodily Sense Cluster:**
    1. Body Image Change (Ludwig – body1/image1)
    2. Changed Body Image (Farthing – body2/image2)
    3. Altered Body Image (Pekala -body3/image3)
    4. Arousal (Pekala – tension1)
    5. Body Image (Metzner – body4/image4)
    6. Disembodiment (Studerus – disembodiment1)
    7. Interoception (Tart – interoception1)
    8. Motor output (Tart – proprioception1)
3. **Self-Boundary Cluster:**

1. Sense of Personal Identity (Farthing – identity1/sense1)
2. Identity/Ego (Wilber – identity2/ego1)
3. Sense of Self/Identity (Metzner – self1/identity2)
4. Unity, Internal, External (Pahnke – unity1/internal1/external1)
5. Experience of Unity (Studerus – unity2)
6. Objectivity and Reality (Pahnke – boundary1)
7. Social Perception (Tart – boundary2/social1)
8. Environmental Perception (Tart – boundary3/environment1)
9. Transcendence of Space (Pahnke – space1/transcendence1)
10. Sense of Space (Metzner – space2/sense2)
11. Self-Awareness (Vaitl – self2/awareness1)

4. **Mystical Significance Cluster:**
   1. Change in Meaning or Significance (Ludwig – meaning1/significance1)
   2. Changes in Meaning or Significance of Experiences (Farthing – meaning2/significance2)
   3. Insightfulness (Studerus – insight1)
   4. Ineffability (Pahnke – ineffable1)
   5. Sense of the Ineffable (Pahnke – ineffable2)
   6. Paradoxicality (Pahnke – paradoxical1)
   7. Sacredness (Pahnke – sacredness1)
   8. Varieties of Transpersonal Experiences (Grof – mystical1)
   9. Mystical (Pahnke – mystical2)
   10. Satori States (Lilly – mystical3)
   11. A-E Level (Leary – mystical4)
   12. Mind Level (Wilber – mystical5)
   13. Spiritual Experience (Studerus – spiritual1)
   14. Rejuvenation (Ludwig – significance3)

15. Altered Meaning (Pekala – meaning3, awe1, sacredness2, reverence1)

5. **Arousal Cluster:**
    1. Activation (Vaitl – activation1)
    2. Vigilance Reduction (Dittrich – vigilance1)
    3. Changes in Arousal (Farthing – arousal1)
    4. Ergotropic Arousal (Fischer – hyper1/arousal2)
    5. Trophotropic Arousal (Fischer -hypo1/arousal3)
    6. Arousal (Metzner – arousal4)
    7. Altered State of Awareness (Pekala – alertness1)
6. **Time Sense Cluster:**
    1. Time Sense (Tart – time1/sense1)
    2. Disturbed Time Sense (Ludwig – time2/sense2)
    3. Altered Time Sense (Pekala – time3/sense3)
    4. Changed Time Experience (Farthing – time4/experience1)
    5. Subjective Time (Berkovich-Ohana/Glicksohn – time5/subjective1)
    6. Time (Paoletti/Ben-Soussan – time6)
    7. Sense of Time (Metzner – time7/sense5)
    8. Transcendence of Time (Pahnke – time8/transcendence1)
7. **Emotion Cluster:**
    1. Positive Mood (MEQ – mood1/positive1)
    2. Positive Affect (Pekala – affect1/positive2)
    3. Joy (Pekala – bliss1)
    4. Hedonia (Metzner – bliss2)
    5. Sexual Excitement (Pekala – sex1)
    6. Love (Pekala – love1)
    7. Blissful State (Studerus – bliss3)
    8. Emotional Valence (Lilly – emotion1)
    9. Emotional Expression (Ludwig – emotion2/expression1)

10. Emotional Feeling/Expression + (Farthing – emotion3/expression2)
11. Emotion (Berkovich-Ohana/Glicksohn – emotion4)
12. Emotion (Paoletti/Ben-Soussan - emotion5)
13. Negative Affect (Pekala – affect2/negative1)
14. Anger (Pekala – anger1)
15. Sadness (Pekala – sadness1)
16. Fear (Pekala – anxiety1)
17. Anxiety (Studerus – anxiety2)

8. **Control and Cognition Cluster:**
    1. Alterations in Thinking (Ludwig – cogntion4)
    2. High Level Thought Processes (Farthing – cognition5)
    3. Thinking/Attitude (Metzner – cognition6/attitude1)
    4. Changes in Attention (Farthing – attention1)
    5. Inward Attention (Pekala – attention2)
    6. Absorption (Pekala – attention3)
    7. Changes in Memory (Farthing – memory1)
    8. Memory (Pekala – memory2)
    9. Memory (Tart – memory3)
    10. Cognitive Processing (Tart – cognition1)
    11. Rationality (Pekala – rationality1)
    12. Impairment of Cognition (Studerus – cognition2)
    13. Impairment of Control (Studerus – control1)
    14. Loss of Control (Ludwig – control2)
    15. Changes in Self-Control (Farthing – control3)
    16. Self-Control (Vaitl – control4)
    17. Self-Determination (Paoletti/Ben-Soussan – control5)
    18. Self-Awareness (Pekala -awareness1)
    19. Volitional Control (Pekala-control6)
    20. Hyper-suggestibility (Ludwig – suggestibility1)
    21. Changes in Suggestibility (Farthing – suggestibility2)

22. Changes in Inner Speech (Farthing – speech1)
23. Internal Dialogue (Pekala – speech2)
24. Awareness Span (Vaitl – awareness2)
25. Awareness (BerkovichOhana/Glicksohn – awareness3)
26. Evaluation and Cognitive Processing (Tart – cognition3)
27. Attitude and Behavior (Pahkne – attitude2/behavior1)

Appendix B: Supplemental Figures (Chapter 4)

Trait Measures

Measure	*Mean*	*SD*
DES-II (%)	0.20	0.13
Openness	74.21	13.88
Conscientiousness	66.94	12.86
Extraversion	59.61	12.91
Agreeableness	66.85	10.75
Neuroticism	56.61	11.7
TAS (Absorption)	87.97	21.53
VVIQ Total	114.88	25.84
Age (years)	33.24	13.78
Sex	**n (%)**	
Male	15 (45.5%)	
Female	18 (54.5%)	

Table B1. Trait Data. Means and standard deviations are reported for all continuous measures, including dissociation (DES-II), Big Five personality dimensions, trait absorption (TAS), visual imagery vividness (VVIQ), and age. Sex is reported as raw counts with corresponding percentages. All measures reflect baseline trait characteristics of the final sample (N = 33).

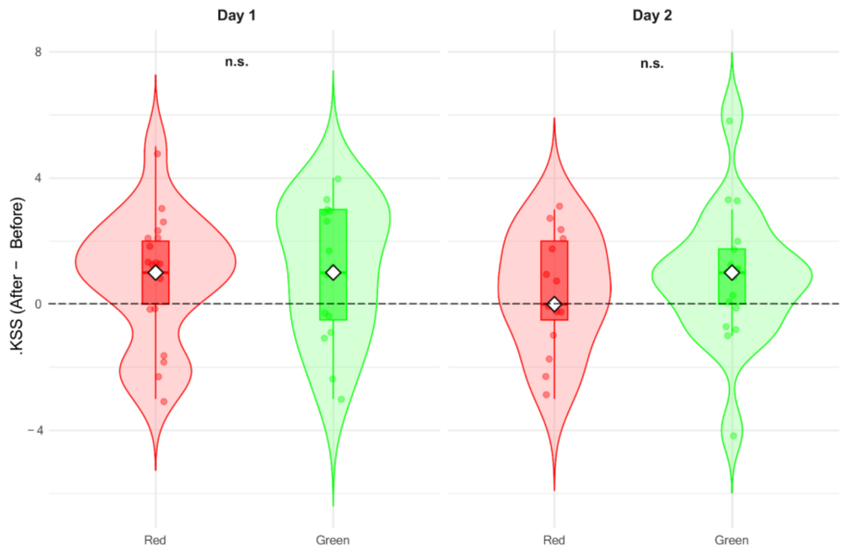

Figure B2. No measurable effect of MMGF on subjective sleepiness. Across both experimental days, no significant differences in subjective sleepiness (ΔKSS = After – Before) were observed between red-light and green-light MMGF sessions. Violin plots display the distribution, median (white diamond), and interquartile range (box) of change scores for each light condition on Day 1 and Day 2. The dashed horizontal line marks the zero-change baseline. All comparisons were nonsignificant, indicating that MMGF exposure did not measurably alter subjective sleepiness across days or light conditions.

	Variable	W	p
	General Altered States Score	0.96	.340
5D-ASC	**Oceanic Boundlessness**	**0.87**	**.001**
	Dread of Ego Dissolution	**0.85**	**<.001**
	Visionary Restructuralization	0.97	.396
	Auditory Alterations	0.95	.157
	Vigilance Reduction	0.99	.977
11-ASC	**Experience of Unity**	**0.89**	**.003**
	Spiritual Experience	**0.79**	**<.001**
	Blissful State	**0.72**	**<.001**
	Insightfulness	**0.88**	**.002**
	Disembodiment	0.96	.263
	Impaired Control and Cognition	**0.89**	**.004**
	Anxiety	**0.81**	**<.001**
	Complex Imagery	0.94	.079
	Elementary Imagery	**0.89**	**.004**
	Audio-Visual Synesthesia	0.93	.040
	Changed Meaning of Percepts	**0.84**	**<.001**

Table B3. Normality Tests - Phenomenology. Shapiro–Wilk tests were applied to 5D-ASC scores to evaluate the assumption of normality prior to inferential testing. Several dimensions showed significant deviations from normality, most notably Oceanic Boundlessness, Dread of Ego Dissolution, and multiple 11-ASC factors (e.g., Spiritual Experience, Blissful State, Anxiety, Elementary Imagery, Changed Meaning of Percepts), supporting the use of non-parametric paired comparisons in the main analyses. W statistics and associated p-values are reported for each dimension.

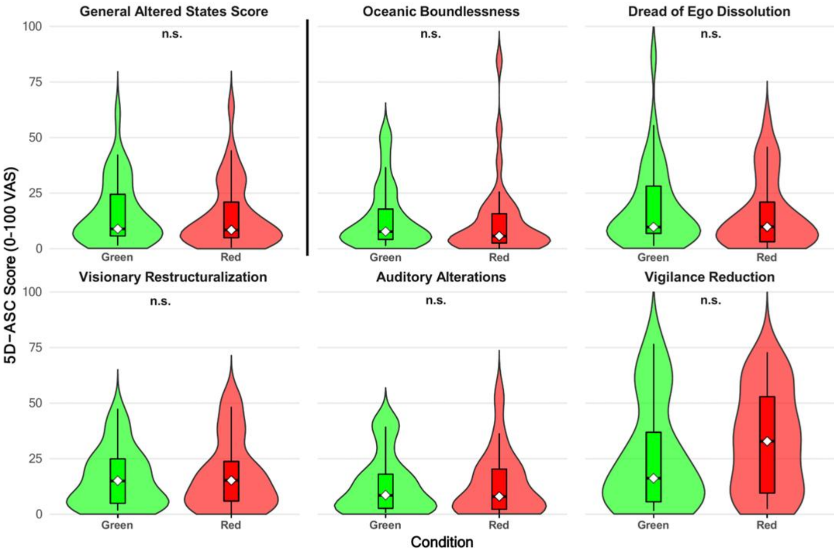

Figure B4. General and Dimensional Level Analysis of 5D-ASC Scores under MMGF. Violin plots display the distribution, median (white diamond), and interquartile range (box) of subjective experience scores across the General Altered States Score (G-ASC) and the five 5D-ASC dimensions (Oceanic Boundlessness, Dread of Ego Dissolution, Visionary Restructuralization, Auditory Alterations, Vigilance Reduction). A thick black line separates the general (G-ASC) from the dimensional (5D-ASC) levels. All comparisons were nonsignificant.

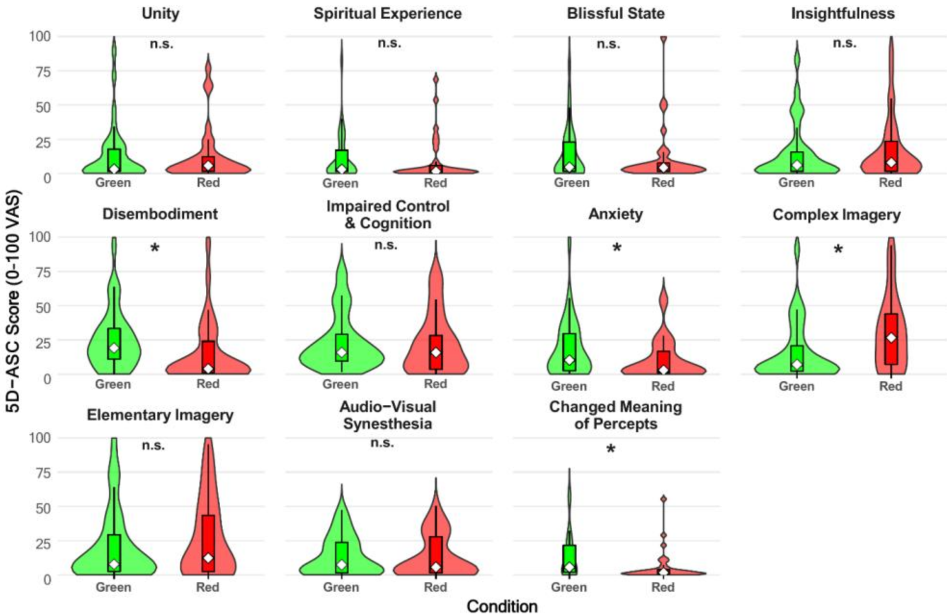

Figure B5. Factor Level Analysis of 5D-ASC Scores under MMGF. Violin plots depict the distribution, median (white diamond), and interquartile range (box) for the 11-ASC factors. Asterisks indicate factors showing significant differences between wavelengths (p < .05, paired Wilcoxon tests, FDR-corrected). Disembodiment, Anxiety, and Changed Meaning of Percepts scores were higher in green and Complex Imagery scores were higher in red. All other comparisons were nonsignificant.

	Variable	W	p	p(FDR)	r
	General Altered States Score	215	.245	.417	-0.20
5D-ASC	Oceanic Boundlessness	161	.033	.114	-0.37
	Dread of Ego Dissolution	197	.138	.293	-0.26
	Visionary Restructuralization	323	.453	.550	-0.13
	Auditory Alterations	253	.844	.844	-0.03
	Vigilance Reduction	360	.158	.299	0.25
11-ASC	Experience of Unity	173	.710	.754	0.00
	Spiritual Experience	156.5	.295	.425	0.00
	Blissful State	147.5	.082	.233	-0.30
	Insightfulness	249	.300	.425	0.00
	Disembodiment	**108**	**.006**	**.027**	**-0.48**
	Impaired Control and Cognition	229	.362	.474	-0.16
	Anxiety	**96**	**.003**	**.023**	**-0.52**
	Complex Imagery	**375**	**.003**	**.023**	**0.51**
	Elementary Imagery	328	.119	.290	0.27
	Audio-Visual Synesthesia	238	.665	.754	0.00
	Changed Meaning of Percepts	**84**	**.004**	**.023**	**-0.50**

Table B6. Phenomenological comparisons between red and green light MMGF conditions on the 5-Dimensional Altered States of Consciousness (5D-ASC) Rating Scale. Wilcoxon signed-rank tests were conducted to compare phenomenological responses between red and green light MMGF at the general (G-ASC), dimensional (5D-ASC), and factor (11-ASC) levels. Reported are the Wilcoxon test statistic (W), Benjamini–Hochberg–adjusted p-values (pBH), and effect sizes (r). No differences emerged at the general or dimensional levels. At the factor level, significant differences were observed in green light MMGF for Disembodiment, Anxiety, and Changed Meaning of Percepts, with red light MMGF showing significant differences in Complex Imagery. All of these significant differences show moderate-to-large effect sizes.

Wavelength	DV (Δlog10)	W	p
Green	**HR**	**0.91**	**.014**
Green	**HRV**	**0.89**	**.006**
Red	**HR**	**0.91**	**.012**
Red	HRV	0.97	.514

Table B7. *Within wavelength normality of cardiac deltas.* Shapiro–Wilk tests were performed on the paired difference scores for each physiological measure to assess normality. Reported are the Shapiro–W statistic and corresponding p values. Only HRV (RMSSD) significantly deviated from normality (p = .009), justifying the use of non-parametric paired Wilcoxon signed-rank tests for subsequent group-level comparisons.

Wavelength	**DV**	**Median Δ**	**W**	**p**	**p (BH)**	**95% CI of Δ**	**r**
Green	HR	−1.94	105	.010	.030	[−2.56, −0.66]	−0.48
	HRV	2.16	278	.350	.350	[−2.27, 5.90]	0.17
Red	HR	−0.94	148	.080	.160	[−1.52, 0.21]	−0.32
	HRV	−2.16	182	.300	.350	[−4.77, 1.84]	−0.19

Table B8. *Within wavelength nonparametric comparisons of cardiac deltas.* Within-wavelength nonparametric comparisons of cardiac deltas (Induction – Baseline) for heart rate (HR) and heart rate variability (HRV; RMSSD). Wilcoxon signed-rank tests were applied separately for Green and Red light sessions. Under Green light, HR showed a small but consistent reduction from baseline, with the median decrease reaching significance before and after BH correction, whereas HRV exhibited no reliable change. Under Red light, neither HR nor HRV differed significantly from baseline after correction, and confidence intervals for both measures spanned zero. Effect sizes were small to moderate across all comparisons.

Wavelength	DV	W	p
Green	EDA	0.97	.47
Green	RSP	0.96	.29
Red	EDA	0.96	.35
Red	RSP	0.94	.08

Table B9. *Within wavelength normality of EDA and RSP Deltas.* Shapiro–Wilk tests of normality for within-wavelength difference scores in electrodermal activity (EDA) and respiration (RSP). W values and associated p-values are reported for each physiological measure.

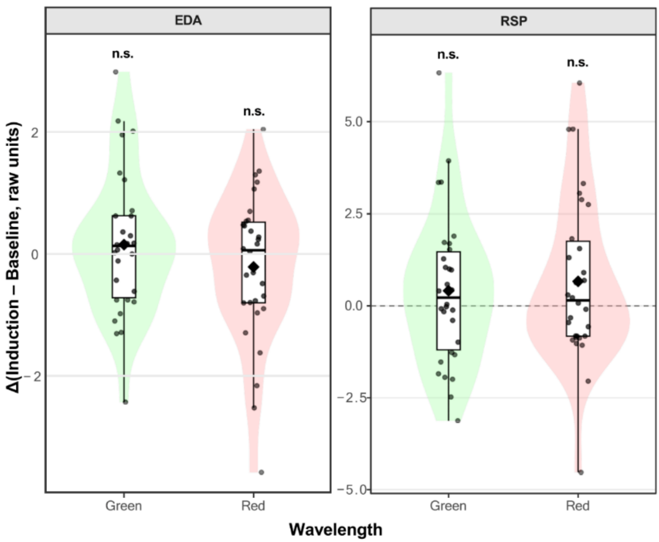

Figure B10. *Within wavelength normality of EDA and RSP Deltas.* Within-wavelength changes in electrodermal activity (EDA; left) and respiration (RSP; right) during green and red MMGF sessions relative to baseline. Violin plots display the distribution of individual difference scores (Δ = induction − baseline), with embedded boxplots showing medians and interquartile ranges. Points represent individual participants. No significant within-wavelength effects were observed (all $p > .05$).

Wavelength	DV	Mean Δ	t	p	p (BH)	95% CI of Δ	Cohen's d
Green	EDA	0.17	0.78	.440	.440	[−0.27, 0.60]	0.14
	RSP	0.41	1.08	.290	.440	[−0.37, 1.18]	0.20
Red	EDA	−0.20	−0.89	.380	.440	[−0.66, 0.26]	−0.16
	RSP	0.66	1.61	.120	.440	[−0.18, 1.50]	0.29

Table B11. *Within wavelength nonparametric comparisons of EDA and RSP deltas.* Within-wavelength changes in electrodermal activity (EDA) and respiration (RSP) during green and red MMGF sessions relative to baseline. Values represent mean difference scores (Δ = induction − baseline). Statistics reflect paired-samples *t*-tests with Benjamini–Hochberg (BH)–adjusted *p*-values. 95% confidence intervals of the mean difference and Cohen's *d* are reported.

Wavelength	DV	ρ	p	p (BH)
Green	HR	0.12	.550	.550
	HRV	−0.03	.880	.880
Red	HR	−0.25	.180	.370
	HRV	0.44	.020	.030

Table B12. Spearman correlations (ρ) between baseline-corrected cardiac changes (Δ) and Complex Imagery scores during green and red MMGF sessions. Benjamini–Hochberg (BH) correction was applied within cardiac measures. A significant positive association was observed between HRV changes and imagery intensity during red light (ρ = .44, p(FDR) = .03).

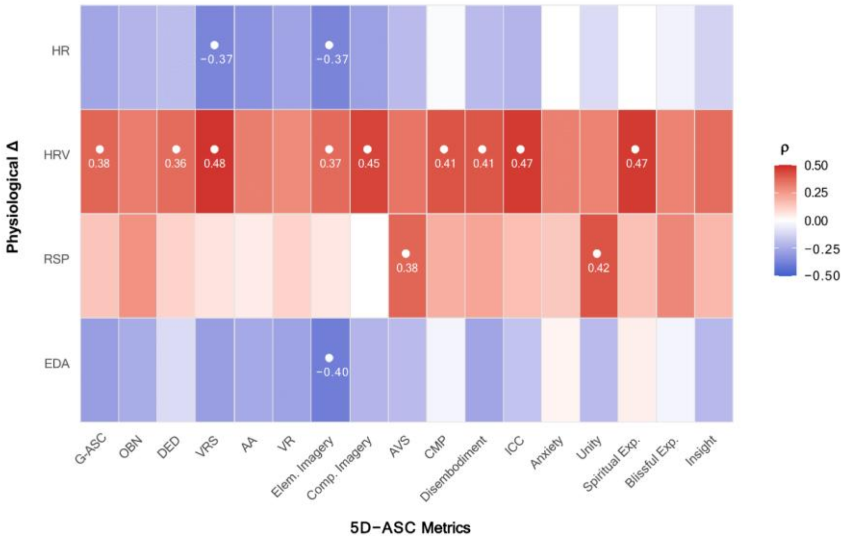

Figure B13. Exploratory correlations between physiological and phenomenological deltas under red light multi-modal Ganzfeld (MMGF). Spearman's ρ correlations were computed between changes in physiological measures (electrodermal activity [EDA], respiration [RSP], heart rate variability [HRV-RMSSD], and heart rate [HR]) and changes in 5D-ASC phenomenological scores (General Altered States Score [G-ASC]), dimensions (Oceanic Boundlessness [OBN], Dread of Ego Dissolution [DED], Visionary Restructuralization [VRS], Auditory Alterations [AA], and Vigilance Reduction [VR]), with 11-ASC factors such as Audio-Visual Synesthesia [AVS] and Impaired Control and Cognition [ICC]). White dots and numerical labels indicate uncorrected correlations reaching $p < .05$. No correlations survived Benjamini–Hochberg false-discovery-rate (FDR) correction.

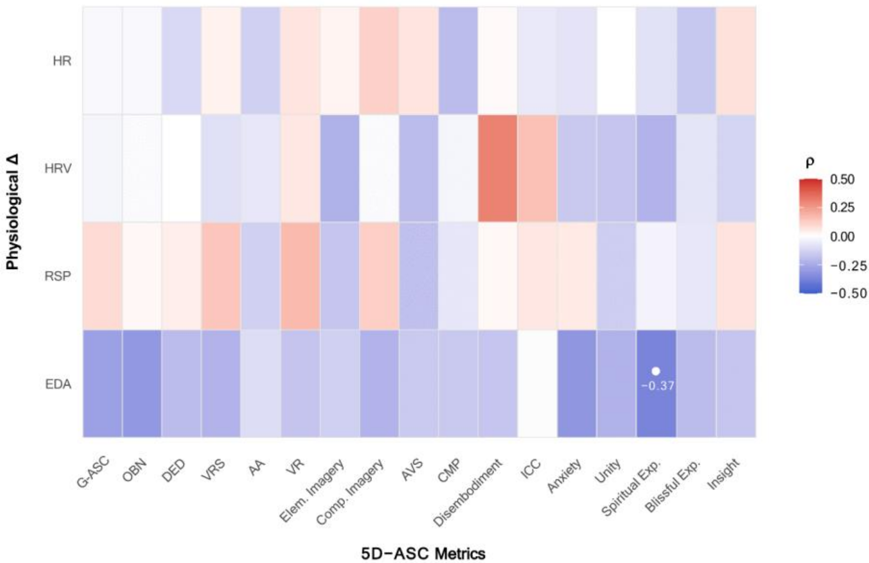

Figure B14. Exploratory correlations between physiological and phenomenological deltas under green light multi-modal Ganzfeld (MMGF). Spearman's ρ correlations were computed between changes in physiological measures (electrodermal activity [EDA], respiration [RSP], heart rate variability [HRV-RMSSD], and heart rate [HR]) and changes in 5D-ASC phenomenological scores (General Altered States Score [G-ASC]), dimensions (Oceanic Boundlessness [OBN], Dread of Ego Dissolution [DED], Visionary Restructuralization [VRS], Auditory Alterations [AA], and Vigilance Reduction [VR]), with 11-ASC factors such as Audio-Visual Synesthesia [AVS] and Impaired Control and Cognition [ICC]). White dots and numerical labels indicate uncorrected correlations reaching $p < .05$. No correlations survived Benjamini–Hochberg false-discovery-rate correction.

Path	Unstandardized Estimate	Bootstrapped SE	95% Bootstrap CI	Standardized Estimate
a	−3.84	3.36	[−10.56, 2.61]	−0.15
b	−0.13	0.42	[−0.78, 0.87]	−0.06
c′ (Direct)	14.32	7.26	[0.78, 29.15]	0.28
Indirect (a × b)	0.50	1.84	[−4.54, 3.03]	0.01
c (Total)	14.82	6.62	[1.74, 27.48]	0.29

Table B15. Bootstrapped mediation results for the model Wavelength → HRV → Complex Imagery. The model was estimated using 5,000 bootstrap resamples with percentile confidence intervals. Path a (Wavelength → HRV) and path b (HRV → Complex Imagery) were not significant, and the bootstrapped indirect effect (a × b) was small with a confidence interval overlapping zero, indicating no evidence for mediation. The direct effect (c′) remained significant, and the total effect (c) was also significant, confirming that wavelength reliably influenced complex imagery but that this relationship was not accounted for by HRV.

Wavelength	***DV (Δlog10)***	***W***	***p***
Green	Alpha1	0.98	.84
Green	Alpha2	0.96	.31
Red	Alpha1	0.93	.05
Red	Alpha2	0.97	.41

Table B16. *Normality of EEG Deltas (Red - Green) for Alpha1 and Alpha2.* Shapiro–Wilk tests were performed on log10-transformed baseline-corrected deltas (Δ = Induction – Baseline) separately for Green- and Red-light MMGF conditions. Under Green light, all measures showed clear evidence of normality. Under Red light, the distributions likewise showed no indication of non-normality. Because normality was satisfied across all wavelength–measure combinations, parametric one-sample t-tests were used for the exploratory within-wavelength analyses.

Wavelength	**Band**	**Mean Δ (log10)**	**Mean % Change**	**t**	**p**	**p (BH)**	**95% CI of Δ (log10)**	**Cohen's d**
Green	Alpha1	0.06	14.88%	1.29	.210	.210	[−0.04, 0.16]	0.23
	Alpha2	0.06	14.53%	1.35	.190	.210	[−0.03, 0.15]	0.24
Red	Alpha1	0.13	33.76%	2.62	.013	.055	[0.03, 0.22]	0.46
	Alpha2	0.10	24.92%	2.29	.030	.060	[0.01, 0.18]	0.41

Table B17. *Within wavelength comparison of baseline-corrected EEG activity in the alpha band under Red and Green MMGF.* One-sample t-tests were conducted on log10-transformed within-subject baseline-corrected changes (Δ = Induction – Baseline), analyzed separately for Green- and Red-light sessions. In the Green-light condition, neither Alpha1 nor Alpha2 exhibited meaningful changes from baseline (all p(FDR) ≥ .21). In contrast, Red light elicited a moderate increase in Alpha1 power (mean Δ = 0.13; ≈34% above baseline; d = 0.46), which was statistically significant prior to correction (p = .013) and trend-level after Benjamini–Hochberg adjustment (p(FDR) = .055). Alpha2 showed a smaller but directionally similar pattern (≈25% increase; uncorrected p = .03; p(FDR) = .09).

Wavelength	*DV*	*BF_{10}*	*BF_{01}*	*$log(BF_{10})$*
Green	Alpha1	0.40[a]	2.50	−0.92
Green	Alpha2	0.43[a]	2.32	−0.84
Red	**Alpha1**	**3.39[c]**	**0.30**	**1.22**
Red	Alpha2	1.82[b]	0.55	0.60

Table B18. Bayesian analysis of within-wavelength effects for baseline corrected alpha band activity under MMGF. Bayes factors (BF_{10}) quantify evidence for a non-zero induction–baseline change ($\Delta \neq 0$). Values below 1 ([a]) indicate that the data more strongly support the null model ($\Delta = 0$), values between 1 and 3 ([b]) reflect only anecdotal evidence for an effect, and values greater than 3 ([c]) provide moderate evidence for a non-zero change. Consistent with this scale, both Green conditions showed BF_{10} values below 1 (0.40[a] and 0.43[a]), supporting the absence of reliable baseline–induction shifts. For Red, Alpha1 showed moderate evidence for an increase (BF_{10} = 3.39[c]), whereas Alpha2 showed only anecdotal evidence for change (BF_{10} = 1.82[b]).

Wavelength	*DV (Δlog10)*	*W*	*p*
Green	Alpha	0.97	.53
Green	Beta	0.98	.79
Red	Alpha	0.96	.24
Red	Beta	0.97	.59

Table B19. *Normality of EEG Deltas for Alpha and Beta.* Shapiro–Wilk tests were performed on log10-transformed baseline-corrected deltas (Δ = Induction – Baseline) separately for Green- and Red-light MMGF conditions. Under Green light Alpha and Beta showed clear evidence of normality. Under Red light, the distributions likewise showed no indication of non-normality (all $p \geq .79$). Because normality was satisfied across all wavelength–measure combinations, parametric one-sample t-tests were used for the within-wavelength analyses.

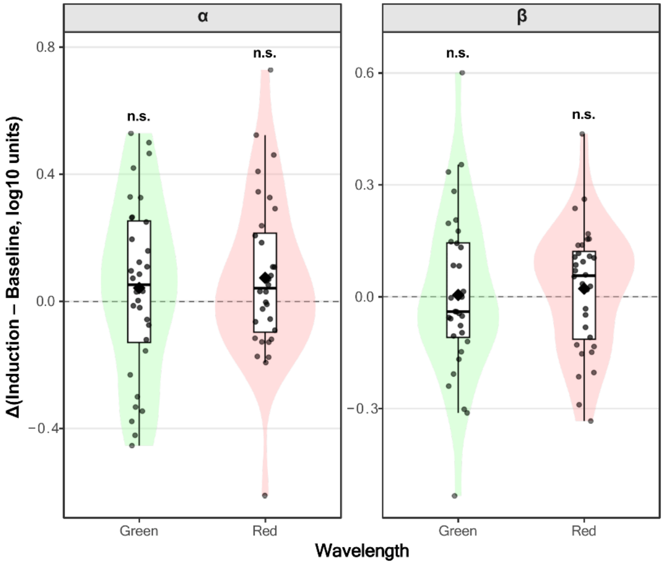

Figure B20. *Within wavelength baseline corrected EEG changes (Δ log10) for Alpha and Beta.* Within-wavelength changes in log-transformed spectral power (Δlog10 = induction − baseline) for the alpha (left) and beta (right) bands during green and red MMGF sessions. Violin plots depict the distribution of individual difference scores, with embedded boxplots showing medians and interquartile ranges; points represent individual participants. Although red light showed a numerically larger increase in alpha power (Mean Δ = 0.07; 18.53%) relative to green (Mean Δ = 0.04; 10.13%), no significant within-wavelength changes were observed after Benjamini–Hochberg correction (all p(FDR) ≥ .46).

Wavelength	Band	Mean Δ (log10)	Mean % Change	t	p	p (BH)	95% CI of Δ (log10)	Cohen's d
Green	Alpha	0.04	10.13%	0.86	.390	.640	[−0.06, 0.14]	0.15
	Beta	0.00	1.15%	0.13	.900	.900	[−0.08, 0.09]	0.02
Red	Alpha	0.07	18.53%	1.63	.110	.460	[−0.02, 0.17]	0.29
	Beta	0.02	5.05%	0.72	.480	.640	[−0.04, 0.08]	0.13

Table B21. *Within wavelength baseline corrected EEG changes (Δ log10) for Alpha and Beta.* Log-transformed induction-related spectral shifts (Δlog10 = Induction – Baseline) are shown for Alpha and Beta ratio under Green and Red light separately. One-sample t-tests assessed whether within-condition changes differed from zero. Green-light MMGF showed no significant induction-related increases for any measure (Alpha: ΔM = +0.04, +10.13%, $t(31) = 0.86$, $p = .39$, $d = 0.15$; Beta: ΔM = +0.00, +1.15%, $t(31) = 0.13$, $p = .90$, $d = 0.02$; Ratio: nonsignificant, not shown in the table; all $p_{(BH)} = .64–.90$). Under Red-light MMGF, no measure reached significance either (Alpha: ΔM = +0.07, +18.53%, $t(31) = 1.63$, $p = .11$, $d = 0.29$; Beta: ΔM = +0.02, +5.05%, $t(31) = 0.72$, $p = .48$, $d = 0.13$). Across both wavelengths, 95% confidence intervals included zero, and effect sizes were small.

Wavelength	Band	r	p	p (BH)
Green	Alpha1	0.01	.970	.970
	Alpha2	−0.11	.560	.800
Red	Alpha1	0.04	.850	.970
	Alpha2	0.05	.800	.800

Table B22. Pearson correlations between baseline-corrected changes in alpha sub-band power (Δlog10; Alpha1 and Alpha2) and Complex Imagery scores during green and red MMGF sessions. Benjamini–Hochberg (BH) correction was applied within each alpha sub-band. No significant associations were observed (all $p(FDR) \geq .80$).

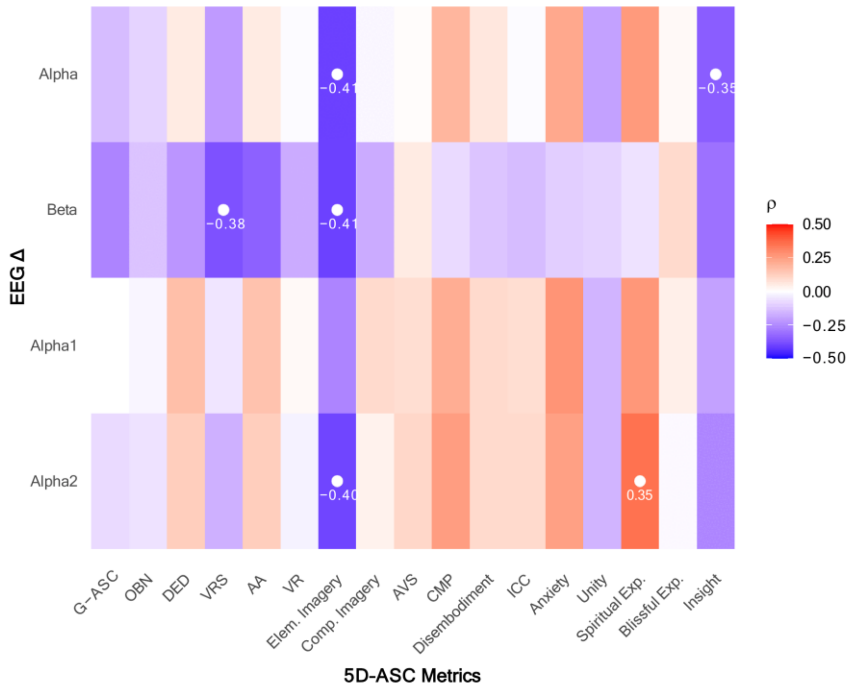

Figure B23. Exploratory correlations between baseline-corrected EEG power changes and phenomenological deltas under red light multi-modal Ganzfeld (MMGF). Spearman's ρ correlations were computed between changes in EEG spectral power (Alpha, Beta, Alpha1, and Alpha2; Δlog10 = induction − baseline) and changes in 5D-ASC phenomenological scores, including the General Altered States Score (G-ASC), dimensions (Oceanic Boundlessness [OBN], Dread of Ego Dissolution [DED], Visionary Restructuralization [VRS], Auditory Alterations [AA], and Vigilance Reduction [VR]), and 11-ASC factors (e.g., Complex Imagery [CMP], Audio-Visual Synaesthesia [AVS], Impaired Control and Cognition [ICC], Anxiety, Unity, Spiritual Experience, Blissful Experience, Insight). White dots and numerical labels indicate uncorrected correlations reaching $p < .05$. No correlations survived Benjamini–Hochberg false-discovery-rate correction.

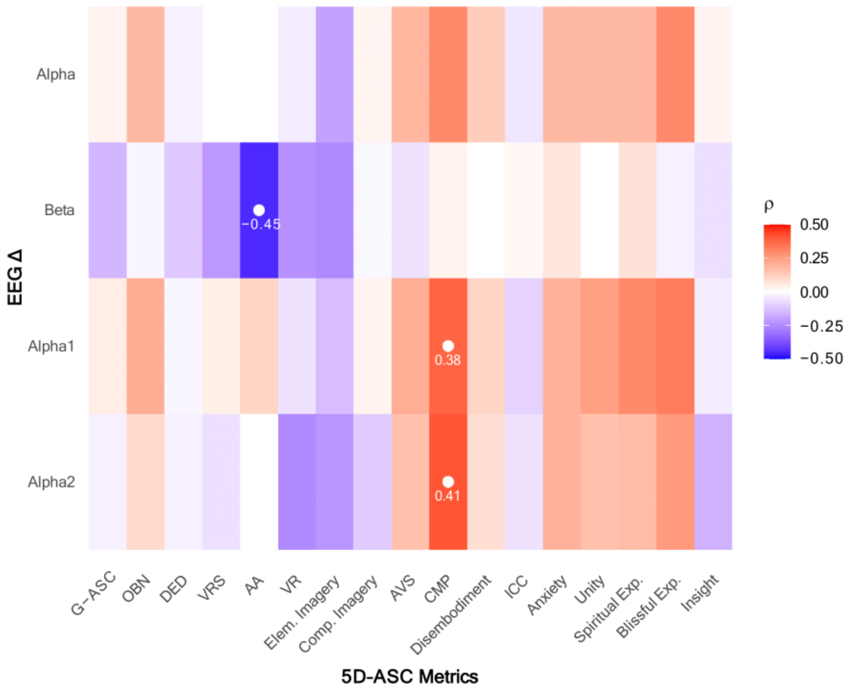

Figure B24. Exploratory correlations between baseline-corrected EEG power changes and phenomenological deltas under green light multi-modal Ganzfeld (MMGF). Spearman's ρ correlations were computed between changes in EEG spectral power (Alpha, Beta, Alpha1, and Alpha2; Δlog10 = induction − baseline) and changes in 5D-ASC phenomenological scores, including the General Altered States Score (G-ASC), dimensions (Oceanic Boundlessness [OBN], Dread of Ego Dissolution [DED], Visionary Restructuralization [VRS], Auditory Alterations [AA], and Vigilance Reduction [VR]), and 11-ASC factors (e.g., Complex Imagery [CMP], Audio-Visual Synesthesia [AVS], Impaired Control and Cognition [ICC], Anxiety, Unity, Spiritual Experience, Blissful Experience, Insight). White dots and numerical labels indicate uncorrected correlations reaching $p < .05$. No correlations survived Benjamini–Hochberg false-discovery-rate correction.

Path	Unstandardized Estimate	Bootstrapped SE	95% Bootstrap CI	Standardized Estimate
a	0.07	0.07	[−0.06, 0.20]	0.12
b	2.04	10.53	[−15.56, 25.54]	0.02
c′ (Direct)	14.83	6.04	[3.21, 26.75]	0.30
Indirect (a × b)	0.13	0.89	[−2.03, 1.82]	0.00
c (Total)	14.97	6.08	[3.12, 26.86]	0.30

Table B25. Bootstrapped mediation results for the model Wavelength → Global Alpha1 → Complex Imagery. The model was estimated using 5,000 bootstrap resamples with percentile confidence intervals. Path a (Wavelength → Alpha1) and path b (Alpha1 → Complex Imagery) were not significant, and the bootstrapped indirect effect (a × b) was small with a confidence interval overlapping zero, indicating no evidence for mediation. The direct effect (c′) remained significant, and the total effect (c) was also significant, confirming that wavelength reliably influenced complex imagery but that this relationship was not accounted for by Alpha1 power.

Appendix C: CRediT Authorship Statements

Chapter 1

Classification Schemes of Altered States of Consciousness

Larry Douglas Fort: Conceptualization, Investigation, Writing - Original Draft, Writing - Review & Editing, Software, Visualization.

Cyril Costines: Writing - Review & Editing.

Marc Wittmann: Writing - Review & Editing.

Athena Demertzi: Funding acquisition, Resources, Writing - Review and Editing, Funding acquisition

Timo Torsten Schmidt: Writing – Original Draft, Project management, Supervision, Conceptualization, Writing - Reviewing/Editing, Visualization.

Clarifying Classification Approaches to Altered States of Consciousness

Timo Torsten Schmidt: Project management, Supervision, Conceptualization, Writing - Original Draft, Writing - Reviewing/Editing.

Larry Douglas Fort: Conceptualization, Writing - Original Draft, Writing - Review & Editing.

Chapter 2

Toward an Invariant Structure of Altered States Phenomenology: Rethinking Subjective Measures for Clinical Application

Larry Douglas Fort: Conceptualization, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization.

Marc Wittmann: Resources, Writing - Review & Editing.

David Bryce Yaden: Conceptualization, Supervision, Writing - Review & Editing.

Athena Demertzi: Resources, Writing - Review and Editing.

Chapter 3

Dynamic Functional Hyperconnectivity After Psilocybin Intake is Primarily Associated with Oceanic Boundlessness

Sepehr Mortaheb: Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Data Curation, Software, Formal Analysis, Validation.

Larry Douglas Fort: Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Software, Formal Analysis.

Natasha Leigh Mason: Investigation, Conceptualization, Supervision, Writing - Review & Editing, Methodology.

Pablo Mallaroni: Investigation, Writing - Review and Editing, Methodology.

Johannes Gerardus Ramaekers: Conceptualization, Methodology, Writing - Review and Editing.

Athena Demertzi: Supervision, Resources, Funding Acquisition, Conceptualization, Writing - Review and Editing, Data Curation.

Chapter 4

Red Light Selectively Amplifies Complex Imagery in the Multi-Modal Ganzfeld: A Phenomenological and Neurophysiological Investigation

Larry Douglas Fort: Funding Acquisition, Conceptualization, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Data Curation, Software, Formal Analysis, Validation, Methodology.

Romy Beauté: Writing - Review & Editing, Visualization, Software, Formal Analysis.

Marc Wittmann: Resources, Writing - Review & Editing.

Athena Demertzi: Funding Acquisition, Resources, Supervision, Writing - Review and Editing, Data Curation.

Chapter 5

Red Light Selectively Amplifies Complex Imagery in the Multi-Modal Ganzfeld: A Phenomenological and Neurophysiological Investigation

Larry Douglas Fort: Funding Acquisition, Conceptualization, Investigation, Writing - Original Draft, Writing - Review & Editing, Visualization, Data Curation, Software, Formal Analysis, Validation, Methodology.

Johannes Gerardus Ramaekers: Writing - Review and Editing.

Athena Demertzi: Supervision, Resources, Funding Acquisition, Conceptualization, Writing - Review and Editing, Data Curation.

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