Saggi/Essays

Exploring Precision's Role in Psychosis: Insights From Psychedelics for a 'Quadripartite Model'

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Abstract: The paper examines the connection between the Global Neuronal Workspace Theory of Consciousness (GNW) and Predictive Processing (PP) in understanding psychotic symptoms. The GNW-based account (which I frame as 'tripartite') suggests that an elevated threshold for consciousness, influenced by top-down attention, mediates between neural dysconnectivity and psychosis. However, several interrelated concerns emerge. These include GNW's concentration on inferential processes, its emphasis on information access to consciousness rather than its utilization, and its focus on conscious access while disregarding two-factor models, which, by emphasizing the relevance of both perceptual and cognitive factors in delusions, argue that anomalous perceptual experiences play a significant role in the formation of delusional beliefs. Additionally, the issues of specificity and the persistence of psychotic traits are mentioned. To address these challenges, the paper proposes an incorporation of precision from PP into a four-part model (dysconnectivity, precision/attention, conscious threshold, and psychosis). This enhanced framework is evaluated through recent literature, with a particular focus on research concerning psychedelics and ego dissolution. A sketch of how precision might help address the mentioned issues is outlined. There is still more work to be done to unravel the intricacies of these concerns and to elucidate why impaired precision actually raises the threshold for conscious access.

Keywords: consciousness, precision, psychosis, predictive processing, Global Neuronal Workspace.

1. *Introduction*

This paper delves into the intersection of Global Neuronal Workspace Theory (GNW) and the Predictive Processing (PP) literature (see Section 2) to shed light on the mechanisms underlying psychotic symptoms in schizo-

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ISSN (print) 2532-8255 – ETS
doi: 10.4454/mefisto.7-2.854

phrenia. The relevance of both these theories, as well as of their correlation (cf. Hohwy, 2013, Whyte and Smith, 2021, Alegiani and Marraffa, 2021), and of studies on schizophrenia and psychotic symptomatology has become increasingly pronounced in recent years, as they collectively offer valuable insights into the intricate processes that contribute to the manifestation of symptoms. This growing significance not only advances our comprehension of the condition but also holds promise in paving the way for innovative therapeutic interventions and more effective clinical approaches.

While GNW theory suggests that an elevated threshold for conscious access mediates between neural structural dysconnectivity and psychosis, attributing this elevation to top-down attentional factors, I find noteworthy concerns within this interpretation that call for an expansion of the framework with additional elements and concepts (Section 3). First, there's a concern with the idea that the underlying issue in schizophrenia leading to psychosis is inferential; this is in fact at odds with the dissociation established experimentally between unconscious and conscious processing. Second, there's a concern about the exclusive focus on the access of contents to consciousness within GNW theory; it seems that in psychosis the issues may lie more in how incoming information is utilized in consciousness, rather than in mere access. Third, many established accounts of delusions link them to anomalous perceptual experiences, seemingly inconsistent with GNW's emphasis on conscious access while preserving unconscious processes. These perceptual anomalies are believed to be crucial in both the specificity and persistence of delusions, raising questions about confining the issue to consciousness. Fourth, the claim that limited access to consciousness leads to an overestimation of sensory stimuli that enter consciousness is critiqued, as it fails to acknowledge that underestimation can also occur, as evidenced by studies like Young and Leafhead (1996). To address these challenges, in Section 4 I suggest incorporating the concept of precision from PP into the original tripartite model of dysconnectivity-elevated conscious threshold-psychosis. To support this suggestion, I delve into the role of precision as a critical factor influencing both psychosis and giving rise to experiences resembling *ego dissolution*, mirroring typical psychotic symptoms. The proposal is to extend this framework into a quadripartite model that encompasses dysconnectivity, precision/attention, elevated conscious threshold, and psychosis. This expanded model not only shows potential for resolving the previously mentioned limitations but also enables the convergence of two distinct lines of literature (Section 5). This integration enhances our comprehension of psychosis and facilitates the application of 'parametric variation' (cf. Aimola Davies and Davies, 2009), leading to a more nuanced understanding of psychotic symptomatology.

2. *The Two Theories*

2.1. *Predictive Processing (PP)*

Predictive Processing (PP) stands as a comprehensive theory of brain and cognitive function, asserting that our brains engage in inferential processes throughout our perception and cognition. In the realm of perception, our systems lack direct access to the external environment. Consequently, they must infer the causes behind the sensory stimuli they receive. These causes manifest as hypotheses, subject to evaluation by the brain to predict the cause of the stimulus in question.

Given the absence of a direct, one-to-one correlation between causes and stimuli, the brain navigates life through a continuous process of trial and error, learning from experience. This learning involves the storage of information about the causes of sensory stimuli, allowing the brain to ascribe high probabilities to specific hypotheses when similar stimuli reoccur.

Predictions might turn out to be wrong; or, more precisely, a discrepancy between the selected hypothesis and the actual sensory stimulus might ensue. Such an incongruity results in a prediction error value, that signals that something has failed. According to PP, the main objective of a system is to minimize prediction error signals. To do so, it can either change its models (*perceive*) or intervene in the environment (*act*)[1].

The system achieves this by constructing *hierarchical generative models*, which sketch the intricate relationships between causes and stimuli. These models possess a hierarchical structure, with interwoven relations that guide the system in predicting the causes of encountered stimuli. Such relations comprise a structure where predictions at each level are constrained by input from higher levels, representing broader contextual information, while the prediction errors from lower levels provide feedback about the accuracy of predictions. The system's goal is to construct a predictive architecture that closely tracks the causal-probabilistic relationships between hidden causes and their effects in the environment. This multilevel organization allows the system to capture and model different interactions at various spatial and temporal scales, enhancing its ability to predict the causes of stimuli encountered in the environment.

To illustrate this, consider the scenario of 'hearing' a continuous sound emanating from a neighboring apartment. The sensory stimulus is represented by 'x,' and determining its cause is the task at hand. Given the lack of a strict causal link, one might entertain various hypotheses, ranging from

[1] Later on, these will figure, respectively, as 'perceptual' and 'active' inference.

hallucinations to a live performance by Mozart. Fortunately, through prior learning and model-building, one can select the most probable hypothesis – perhaps identifying the sound as a melody played on a piano by a neighbor. This decision is informed by the stored knowledge that the neighbor is a pianist who regularly plays.

However, if this selected hypothesis turns out to be incorrect (for instance, the piece heard is not in the neighbor's repertoire), a prediction error signal emerges, prompting the need for error minimization. Multiple avenues are available for this purpose: modifying the model (for example, revising the belief that the neighbor always plays her piano), reevaluating the stimulus (e.g., considering characteristics that distinguish it from a live piano), or even contemplating significant changes (such as suspecting that the neighbor has moved or that a deception is in progress). Alternatively, one can take action, such as knocking on the neighbor's door, to verify the source of the sound. These operations are all attempts to minimize prediction errors.

In the context of PP, it is crucial to stress the significance of having a guiding compass for inferential operations. In the event of a prediction error, a system must first assess its reliability, including both its *precision* and its accuracy. Notably, on PP, "precision processing [...] map[s] on to attention" (Hohwy, 2012: 6), in the sense that attention is precision optimization[2] (see e.g., Feldman and Friston, 2010). A system must be capable of evaluating the legitimacy of the prediction error, both, so to say, 'vertically' (focusing on the error itself using *first-order precision*) and 'horizontally' (considering the context and employing *second-order precision*). Is the prediction error variable? Can we trust the conditions under which it arises? For instance, if, in the previous scenario, your sibling was in another room playing loud drums, you might suspect that the error signal could be due to noisy environmental factors. Conversely, if you were wearing headphones and listening to something else, your inferential abilities might be compromised. In such cases, the error signal would likely be considered unreliable, and no intervention, neither on the stored models nor in the environment, would be necessary. In other words, no learning process would ensue.

2.2. *The Global Neuronal Workspace Theory of Consciousness (GNW)*

According to the Global Neuronal Workspace (GNW) model, which has evolved over decades of theoretical development, beginning with Baars' cog-

[2] This optimization involves, in the case of perceptual inference for example, giving more significance to the learning signal from the world for units anticipating precision, particularly in perceptual inference. Conversely, in the processing of units anticipating high imprecision, top-down expectations exert greater influence on perception.

nitive theory of a 'global workspace' in 1989, building upon the contributions of Shallice and Posner and culminating in Dehaene, Changeux and collaborators' immense work, consciousness fundamentally involves a stimulus gaining entry into a finite-capacity global neurocognitive workspace. This global workspace serves as a central stage where the stimulus, which would otherwise remain confined within specific, localized brain systems, can be effectively broadcast to a broad spectrum of executive, conceptual, and emotional processes. The underlying architecture of this workspace is established through long-range connections among various cortical regions, with a notable concentration in prefrontal, parieto-temporal, and cingulate associative cortices, as well as their thalamo-cortical loops.

Alongside characterizing a stimulus as conscious, GNW distinguishes between two alternative states in which a stimulus can engage with the workspace: it can exist as either subliminal or preconscious. This categorization is instrumental in comprehending the intricate dynamics involved in achieving conscious access. A stimulus is classified as subliminal when it triggers a very subtle level of activation, yet this activation tends to be weak and rapidly fades away (as exemplified by Dehaene et al. in 2006). On the other hand, a stimulus is considered preconscious when its activation is relatively robust and extends to specific brain regions, such as sensorimotor areas. Nevertheless, despite this heightened activation, such a stimulus fails to gain conscious access because attention is not directed towards it, preventing it from being globally ignited or effectively amplified. This brief analysis underscores the significance of attentional amplification within this framework: for a stimulus to surpass the threshold for conscious access, it necessitates undergoing attentional amplification.

3. *Psychosis and the Threshold for Conscious Access on GNW*

3.1. *The Issue with Top-Down Attention*

Psychosis is often defined by a common theme centered around difficulties in perceiving reality accurately or a breakdown in a person's sense of self. In essence, it comprises two primary features: hallucinations and delusions. Hallucinations involve experiencing perceptual stimuli when there is no actual external or physical trigger for them. Delusions, on the other hand, are persistent false beliefs. These beliefs are not grounded in reality and remain unshaken even when confronted with clear and undeniable evidence that contradicts them.

While I will explicitly reference 'schizophrenia' and psychosis in this paper, it is crucial to recognize the complexity of the topic, including the intricate distinctions pertaining to schizophrenia, even though I will not delve into them in this specific discussion. As Arciniegas (2015) pointed out, for instance, the DSM-5 itself has represented a departure from portraying schizophrenia as the primary psychotic disorder and instead situates it within a spectrum of psychotic disorders. Symptoms within this spectrum encompass hallucinations, delusions, disordered thinking, markedly disorganized or unusual physical behavior (including catatonia), and negative symptoms.

In the following discussion, I will delve into the works of Berkovitch and colleagues (2017; 2018; 2021; 2022). In contrast to an alternative perspective attributing the primary challenges of schizophrenia to bottom-up factors, Berkovitch and colleagues (2017) firmly adhere to the 'top-down interpretation.' According to this viewpoint, they argue that individuals with schizophrenia may indeed show impairments in explicit cognitive processing, explicit recollection, and explicit emotion classification. Additionally, they may experience delays in conscious perception, both in visual masking and inattentional blindness during experimental setups. They also maintain that these individuals exhibit intact unconscious elaboration (ivi: 879). For instance, subliminal priming in number processing remains unaffected, as does the unconscious elaboration in emotional and semantic priming[3].

The focus on top-down processing in schizophrenia is confirmed in experiments such as that presented in Berkovitch and colleagues (2018)[4]. There, the researchers conducted an experiment involving patients with schizophrenia and control subjects. Their goal was to explore how top-down attention affects the perception of visual stimuli. During the experiment, both groups were shown brief visual stimuli (specifically, numbers) followed by masks.

[3] These findings are further confirmed and corroborated by other research, such as Grandgenevre et al. (2015).

[4] It must be acknowledged that the experiments conducted by Berkovitch and colleagues commonly interpret the emergence of the P3 wave in ERP data as associated with conscious perception. This statement must be handled with care, for it is not without controversy. First off, a similar wave, which appears at a later stage, has been detected through MEG (van Aalderen-Smeets et al., 2006). Second, an earlier negative event (variably called N2, N3, or even "visual awareness negativity" [VAN]) peaking at ~260 ms and with a total duration of ~200 ms is also often observed when contrasting conscious to unconscious stimuli (Eklund and Wiens, 2018; Koivisto and Revonsuo, 2010; Pitts et al., 2012, 2014). VAN has been suggested as the earliest electrophysiological correlate of visual awareness (Koivisto and Grassini, 2016), and this claim has been corroborated by magnetoencephalography (MEG) (Andersen et al., 2016). It remains unclear whether P3 is correlated with awareness (Salti et al., 2012), post-perceptual processes (Andersen et al., 2016; Koivisto et al., 2016), or both. In many experiments, the N2 simply precedes the P3b (which figures as another way of referring to P3, cf. Pitts et al., 2012: 346), and their succession may index the spread of global ignition as reflected in intracranial and MEG signals. However, the two waves occasionally dissociate. Most importantly, only the N2 remains under conditions where the stimuli are task-irrelevant yet reported to be consciously perceived (Pitts et al., 2012, 2014).

The participants had two tasks: in one, they were instructed to concentrate on the numbers, while in the other, they needed to focus on the colors surrounding a fixation cross. Throughout these tasks, the researchers closely monitored the brain responses of the participants, specifically through ERPs (event-related potentials). The key findings of the study revealed that when participants concentrated on the numbers, there were observable changes in their ERPs. These changes were indicative of conscious perception. However, in the unattended condition, these changes diminished or disappeared. Of particular significance, in patients with schizophrenia, the research revealed a noteworthy observation: their ability to consciously perceive stimuli appeared to be impaired. This observation implied that conscious perception is a step-by-step process that heavily relies on the allocation of attention. The researchers concluded that *the challenge in schizophrenia is closely tied to difficulties in top-down attention* rather than any issues with early perceptual processing. In simpler terms, the 'basic' information processing functions remain intact in patients, but their capacity to focus attention is noticeably affected.

3.2. *Attention and Connectivity*

Impairments in conscious access, as posited by the Global Neuronal Workspace (GNW) framework, are suggested to be linked to disruptions in long-range connectivity essential for conscious perception. Both classic studies like Sergent et al. (2005) and Del Cul et al. (2007) and more recent ones like van Vugt et al. (2018) underscore the crucial role of this connectivity in conscious perception.

Berkovitch et al. (2018) sought to experimentally test this hypothesis. Using MRI-based tractography, the research aimed to explore the neural underpinnings of an elevated threshold for conscious access. Note, further, that these findings nicely dovetail with the subsequent sections of this paper, since the impaired long-range synchrony of gamma bands is counted as underlying binding (a key phenomenon in integrative processes) in sensory processing.

Previous research noted that individuals with schizophrenia exhibit not only impairments in conscious access but also discontinuities in cerebral structures. These structural changes include alterations in fractional anisotropy, indicating insufficiently myelinated fiber tracts, particularly in the prefrontal cortex and cingulum (Berkovitch et al., 2021: 514).

To investigate these neural structure alterations, the researchers employed diffusion tensor imaging (DTI). This method is based on the idea that the structure of neural matter, including axon structure and myelination status, can constrain water molecules. If water molecules diffuse freely, the structure is isotropic; if they exhibit directionality, the structure is anisotropic. Altered anisotropy in brain tissue may signify anomalies in neural structure, affecting neural connectivity.

Berkovitch and colleagues (2021) evaluated patients with schizophrenia, patients with bipolar disorder (with and without psychotic traits), and control subjects in terms of their consciousness threshold using a visual masking paradigm. Concurrently, they measured neural connectivity using DTI and generalized fractional anisotropy (gFA) on seven cortical bundles, including those implementing the global workspace. The study revealed a negative correlation between mean gFA of specific bundles (IFOF, CLF, and the corpus callosum) and the threshold for conscious access. In simpler terms, higher anisotropy was associated with an increased capacity for conscious perception. Thus, lower thresholds for conscious access were linked to higher anisotropy (Berkovitch, 2018: 81).

Consistent with earlier findings, the visual masking experiment used to gauge the consciousness threshold indicated that individuals with psychotic traits (both those with schizophrenia and bipolar disorder) had a notably higher threshold for conscious access in comparison to control subjects and bipolar patients without psychotic symptoms. Regarding anatomical connectivity, the study revealed a negative correlation between the mean gFA (a measure of anisotropy) of the IFOF (both right and left), CLF (both right and left), and the corpus callosum. In simple terms, this means that a higher degree of anisotropy is associated with an increased capacity for conscious perception. So, the lower the threshold (i.e., the better the ability to consciously perceive), the higher the anisotropy, which aligns with the previous indication about the coherence of water molecule directionality in DTI.

3.3. *The Tripartite Model: Dysconnectivity, Elevated Threshold, and Psychosis. Correlation and Mediation*

The observations presented above led the authors to make further interesting considerations. The experimenters there, recall, noticed both that patients with *psychotic* traits presented an increased *threshold for conscious access*, and that those same patients exhibited *altered anisotropy* (i.e., gFA, cf. Sarrazin et al., 2014). The relationship between these three key elements has been further examined. Such assessment has been conducted by Berkovitch et al. (2021) in a ‘threestep model’ suited for investigating this tripartite relationship. Very importantly, not only did the researchers detect a correlation between high conscious threshold, psychosis, and dysconnectivity in neural tissue, but identified the occurrence of a mediation: dysconnectivity raises the consciousness threshold, which, in turn, fosters psychotic symptoms.

This conclusion is drawn from a comprehensive mediation analysis (ivi: 517). Mediation analysis is a statistical framework that allows researchers to explore the mechanisms underlying observed relationships between variables. In this case, the researchers formulated a hypothesis that dysconnectivity (measured by gFA) would be associated with an elevated threshold for conscious access, and that this elevated threshold, in turn, would be related to the presence of psychotic symptoms. To substantiate this hypothesis, the study employed several statistical methods. First, they ran linear models to assess the relationship between gFA and psychotic symptoms, discovering that the effect was significant for certain brain bundles (CLFs and corpus callosum) but not for others. The study also identified a significant correlation between masking threshold and gFA for all three bundles, establishing a connection between the mediator (masking threshold) and the independent variable (gFA). The mediation analysis showed that the correlation between decreased mean gFA and psychotic symptoms was indeed mediated by the elevated masking threshold for these specific brain bundles. As a result, when masking threshold was included as a covariate in the linear model, the direct effect of gFA on psychotic symptoms became statistically non-significant. This statistical evidence led to the conclusion that, at least within the context of these particular brain regions, the effect of reduced gFA on psychotic symptoms is exclusively explained by its influence on the threshold for conscious access.

3.3.1. *The Limitations of the Model*

At first glance, these observations align well with the idea that an elevated threshold for conscious access could lead to a restriction on the information available to individuals with schizophrenia. This notion lends support to the prevailing interpretation, which identifies *deficient inferential processing* as the central problem in this condition, as proposed by researchers of various perspectives, including those both within and outside the predictive framework, such as Fletcher and Frith (2009), Adams et al. (2013), Powers et al. (2017), and Sterzer et al. (2018). Furthermore, this proposal offers a compelling explanation for how an elevated conscious threshold could lead to psychosis. In general, the inferential interpretation involves critical factors, such as a significant limitation on the information available to the individual, resulting in an imbalance between prior beliefs and actual sensory inputs. It's worth noting that, while this concept shows promise, the precise details require further refinement and development.

One first, more general and architectural[5] question is how the issue can be both *inferential* and *circumscribed* to conscious access simultaneously. Berkovitch and colleagues, for instance, do make reference to the PP framework in their work. Indeed, the latter would postulate that all cognitive processing operates inferentially, from the perceptual right up to the full-blown 'cognitive' levels of elaboration, by virtue of its unificatory posture (for related issues on the matter, see Alegiani and Marraffa, 2021). Thus, if the issue involves inferential processes in general, it should affect all levels of cognitive elaboration, not just conscious access, given that inference plays a fundamental role across all cognition. To put it differently, if the ingredients of our inferential operations are consistent throughout the cognitive system, as PP asserts, then it becomes perplexing how intact unconscious processing can coexist with impaired conscious access.

Second, in the case of delusions, patients often confront counterevidence at a conscious level. The problem seems to lie not in the evidence reaching conscious access but rather in the disruption of inferential[6] processes based on this evidence. For instance, when people close to a delusional individual present counterevidence, the individual remains aware of this information. The challenge lies in the individual's inability to effectively incorporate this counterevidence into their conscious inferential processes. This aspect needs more clarity in the literature. When we discuss an elevated conscious threshold, we refer to information that either doesn't reach consciousness or experiences delayed access. In many instances, though, patients do consciously acknowledge information that could help dispel their delusional beliefs. The issue isn't solely about conscious access, but about how effectively individuals *use* this information. It appears that while useful pieces of counterevidence are consciously perceived by the delusional individual, they struggle to integrate this information effectively with their pre-existing beliefs. Consequently, the issue may not be exclusively about conscious access, as suggested in the referred to studies.

Third, a particularly intricate point that warrants attention is that Berkovitch and colleagues' work insists that the issues in psychosis lie in conscious processing, while many pieces of influential literature in cognitive psychiatry

[5] With the term 'architectural' I intend to consider the general structure through which we examine delusions. In this context, particularly when meaning to conjoin PP and GNW, there's a conflict between viewing cognition as inferential and the possibility of an impairment being restricted to a single cognitive process. Indeed, PP is characterized by a 'fractal-like' approach to cognitive processing: thus, the idea that inferential processing is disrupted in one point of cognition but is intact in others poses a significant challenge within this framework.

[6] This term here must not be taken as referring to predictive processing, but to reasoning through cause and consequence more in general. Basically, it points to the 'simple' process of drawing conclusions from premises we habitually perform in the course of our lives.

frequently associate psychotic traits with perceptual processing as well. For instance, influential explanations of delusions often incorporate a "first factor" in the development of delusional thoughts that revolves around perceptual features. For example, let's consider the case of a friend who strongly believes that her partner is an impostor (Capgras delusion; Capgras and ReboulLachaux, 1923). Many authoritative interpretations, such as Aimola Davies and Davies (2009) and Stone and Young (1997), propose a dual-sided explanation: on the one hand, the belief arises from an anomalous perceptual experience (the "first factor"), while on the other, the individual persists in maintaining the belief despite counterevidence (the "second factor"). This suggests that the issue not only pertains to the belief system, which can be located within the realm of consciousness, but also to the perceptual sphere. The challenge here lies in reconciling this involvement of perception with the centrality of conscious access emphasized in Berkovitch et al.'s (2021) interpretation.

One way to address this challenge is to suggest that the threshold for consciousness, while mediating between global functional connectivity alterations and psychosis, may not be the exclusive locus of the issue. Instead, it could be that the problem is also present in the realm of perception, and the threshold serves as a means through which these impairments manifest as psychosis. While this may seem like a promising solution, it appears to be at odds with Berkovitch and colleagues' findings. They emphasize the dissociation between intact unconscious systems and impaired conscious access.

Alongside presenting the three-step model where dysconnectivity disrupts conscious access, ultimately leading to psychotic symptoms, they also argue that an elevated threshold for conscious access significantly reduces the amount of information entering consciousness, leading to distorted interpretations and a disproportionate emphasis on the limited sensory inputs reaching consciousness. Moreover, preserved unconscious processing may continue to guide behavior implicitly, fostering delusional constructs disconnected from the external world. These references substantiate the direct link between an elevated conscious access threshold and psychotic traits, making it unlikely that the suggested solution can fully explain the phenomenon. Note that this third problem, combined with insights drawn from PP, reinforces the first problem mentioned (the inferential issue). If the issue indeed lies in inferential processing, it should manifest at all levels of cognitive elaboration, not just in conscious access.

Fourth, a challenge arises when considering the reduction of information entering consciousness. Berkovitch and colleagues' referred to account, in fact, points to a consequent overestimation of the reduced sensory stimuli that make it into consciousness. Why is there an overestimation of such contents, rather than an overestimation of established beliefs, akin to cognitive conservatism (cf. Fodor, 1987; Stone and Young, 1997)? In many cases of psychosis, subjects often resist incoming evidence rather than overestimating it. This resistance suggests that sensory contents may be underestimated by the individual, while delusional hypotheses are persistently maintained.

For instance, in the case of a patient with Cotard delusion (see e.g., Young and Leafhead, 1996), who believes she is dead, the individual dismisses counterevidence such as feeling her heart beat or experiencing temperature changes, suggesting that the issue extends beyond conscious access. In some instances, sensory counterevidence that is consciously experienced has no impact on delusional beliefs. Hence, the problem does not seem to be restricted to conscious access but involves the individual's ability to process and integrate this information correctly at a conscious level.

4. *The Parametric Variations: Precision*

In light of the above, the existing explanation for the origins of psychotic traits, which primarily focuses on the threshold for conscious access, appears to be in need of further refinement. To address this, I propose an intriguing hypothesis that considers the concept of *parametric variation* (as hinted at by Aimola Davies and Davies, 2009[7]). In general terms, parametric variation involves the idea of exploring how changing specific parameters or factors can affect a system or condition.

Applied to psychiatry and more specifically to psychosis, the general idea is that while psychosis in its manifestations (hallucinations and delusions) is definitely heterogeneous, these variations and specific traits can be seen as outcomes of adjusting parameters within a unified framework.

I suggest that *alterations in precision* might be the driving force behind this parametric variation. This notion aligns with the idea that individuals with schizophrenia may experience impairments in top-down attention. Notably, recall, precision and attention are equated on PP, thus underscoring the potential value of this hypothesis in exploring the intricate underpinnings of psychotic traits.

In addition to the four issues mentioned earlier, it's essential to recognize that hallucinations and delusions exhibit a range of characteristics that cannot be fully accounted for by merely raising the threshold for conscious access. Two distinct features are particularly evident. For instance, consider the *specificity* and *persistence* of these symptoms. Individuals with schizophrenia

[7] While Aimola Davies and Davies themselves do not delve into parametric variation, they point to its potential in providing a unified explanatory framework within psychiatry. Their perspective takes into account the inherent heterogeneity within the field.

tend to eliminate some of their false beliefs, but there is a subset of these beliefs that they do not eradicate. The specificity is evident in the circumscribed nature of these beliefs, while the persistence is characterized by the fact that, unlike other erroneous beliefs, these particular beliefs remain intact in individuals with schizophrenia. The same principle applies to hallucinations: they revolve around specific experiences, and it is these particular experiences that tend to recur over time.

These considerations lead to the suggestion that the elevation of the threshold for conscious access should be further elaborated to accommodate parametric variation, allowing to account for specific and variable manifestations of psychotic traits. In this vein, then, precision/attention would add a new dimension to the understanding of these phenomena.

Expanding upon the tripartite model, I suggest including precision/attention as a pivotal component that mediates the relationship between dysconnectivity and the elevation of the threshold for conscious access.

4.1. *Proof in Ego-Dissolution*

To substantiate these discoveries, it becomes essential to delve into the PP literature regarding precision and its connection to psychosis. While the interplay between these two factors has frequently been observed (e.g., Adams et al., 2013; Sterzer et al., 2018) it's noteworthy that recent and intriguing findings have emerged. This fresh line of research is primarily founded on the exploration of psychedelics. These substances are often referred to as 'psychotomimetic'[8] because their effects closely mirror those of psychosis. Further, psychedelics have become a further path to explore, not only because their intake in controlled settings allows us to experimentally investigate the features of psychosis, but also because their molecular structure, as well as their interactions with neurotransmitters, allows us to accelerate therapeutic solutions (Letheby, 2021). Studies involving psychedelics specifically explore the concept of ego-dissolution, shedding light on the crucial role that precision plays in the onset and characteristics of psychotic symptoms.

To gain deeper insights into the phenomenon of ego-dissolution and the centrality of precision, an examination of the intact functioning of the 'ego'

[8] It is worth mentioning that, even though psychedelic substances induce the occurrence of 'psychotic' symptoms, it is also true that they are able to replicate other symptoms of schizophrenia as well – this tying the knot between schizophrenia and disintegration even more strongly. For example, ketamine replicates both positive and negative symptoms; its principal mechanism of action (NMDA receptor antagonist) appears to reproduce, from a molecular perspective, traits of schizophrenia's pathophysiology (see Rajpal et al., 2022; McCutcheon et al., 2020). LSD, in turn, is an antagonist of serotonin receptors which are strongly associated with the symptoms of early schizophrenia – such as "ego disorders, affective changes, loosened associations and perceptual alterations" (Vollenweider et al., 1998).

becomes essential. It must be noted that these studies confirm the key role of *integration* in schizophrenia's symptomatology[9].

To do this, I shall first refer to how the 'self' actually works on PP, attempting then to show how the link between precision and psychosis is secured in these studies.

The purpose of this section, as a reminder, is to reinforce the idea that precision plays a pivotal role in the emergence of psychosis, thus providing substance to the construction of a quadripartite model. Precision, in fact, acts as the mechanism that furnishes the intricate details that an explanation centered solely on raising the threshold for conscious access cannot fully explain.

4.1.1. *What it's Like to be a Self on PP*

Since that of "self" is a rather elusive term, it must be made clear how, upon this reading, this concept must be understood. The notion of "self" can be defined as either a dynamic process or as an "entity", whether it's stable or fragile, that springs from a process (think, for instance, of the Jamesian notion of "self", 1890), or in terms of continuity in time (think of Locke, 1690/1694, where the notions of "self" and of personal identity are firmly interwoven[10]). I shall consider the self here on its Jamesian interpretation: the self is the product of a "fundamental sense of unity" we tend to through *integrative* operations. The self as a subject (an "I"), then, exhibits a proces-

[9] It must be noted that the literature is not unanimous on this point. A consistent quantity of the literature, in fact, invokes caution in the juxtaposition between schizophrenia and psychedelics (e.g., Friesen, 2022): even though the latter may help us understand that the impairments involved not only in the case of self-modeling but of psychosis in general are strongly tied to those of binding – which are indeed disrupted in the case of psychedelic drug use –, it is also true that differences between the two – that is, schizophrenia and psychedelics – exist. One example of this line of thought is Rajpal et al. (2022). The authors provide substance to this distinction from two different angles: one neurobiological, the other computational-functional (i.e., in terms of differences regarding Bayesian inference in predictive processing). With these two different approaches in mind, the authors uncovered that, while in general the symptoms of both schizophrenia and psychedelic drug consumption can be explained concerning a "strengthening of sensory information over prior beliefs", the processes that trigger this state of affairs are qualitatively different: computationally, in the case of drugs, it is a reduction of the precision weighting of the priors that takes place; in the case of schizophrenia, the precision of sensory inputs increases. Neurologically, both cases instantiate an increased signal diversity and complexity, but while drugs entail a reduced information flow, schizophrenia shows an increased information flow.

[10] Locke explicitly talks about the "self" when dealing with personal identity. There, he investigates the latter in terms of the concept of "person", which ultimately is a thinking, intelligent being that is able to consider itself one and the same through time and space. Further, "consciousness always accompanies thinking, and it is that which makes every one to be what he calls *self*, and thereby distinguishes himself from all other thinking things, in this alone consists *personal identity*" (Locke, 1694/1999: 319; emphases added).

sual nature; the self as an object of reflection (the "Me") is the product of this "*self-ing*" process (see Mc Adams, 1997 and, e.g., Marraffa and Vistarini, 2019: 3). James's account further articulates self-consciousness in terms of identity: "self-consciousness is a self-describing, an identity forming, which is a unifying, integrative, synthesizing process" (Chiaradonna and Marraffa, 2018: 52).

In this vein, it could be claimed that, by and large, the notion of "self" can be here correlated to that of "identity". In brief, the terms we commonly associate with "identity" – i.e.,what makes us "who we are" through time, what "pulls us together" – are deeply ingrained within the concept of "self" on PP. It appears that, within this framework, the "self" can be understood as a *hierarchical model*, and the elements we attribute our identity to are essentially the higher-level components of this model. Thus, when I explain how a "self" is formed, I am also touching upon the aspects that contribute to shaping our identity – those enduring components that are overarching and form the core of who we think we are.

In the realm of PP, this sense of unity is constructed by the system as it strives to minimize prediction errors. In essence, the self can be seen as a hierarchical generative model that the system constructs to exist. In this regard, one of the most relevant perspectives on the self has been put in place by Hohwy and Michael (2017). On their account, the self is a hierarchical model that encompasses different levels of abstraction and inclusion, just like any other model we employ (see Gładziejewski, 2016).

In this vein, not only is, for instance, the body one of the many causes interacting with the world, but its representation, too, is just one of the many represented causes in the models used to minimize error (Hohwy and Michael, 2017: 367-368).

In making explicit how the self-model is made, the authors note how it is hierarchically structured:

1) At the lower levels are those regularities involving the body, the temporal scale of which is fast.
2) At a higher (intermediate) level are medium-term correlations (in term of days or months).
3) At the highest levels, we find established regularities such as character traits.

A compelling illustration of how different levels interact can be seen in our meteorological monitoring model (ibid). In this model, there are multiple layers of information. At a lower spatiotemporal level, I might come across a weather forecast in the newspaper indicating rain, prompting me to grab an umbrella before heading out. This immediate response to the weather forecast also updates my broader understanding of the seasons. For instance, if I've observed this rainy pattern consistently over the past month, I might conclude that the current season, say Spring, is very rainy. Consequently, I may infer that it's wise to keep an umbrella in my backpack throughout the season. This type of information processing occurs because the system's goal is not just to minimize prediction error in the short term but in the long run (Friston, 2010).

This example is a very simple sketch of how a model is built on PP.

Using this example to illustrate the concept in the context of the self, we can draw a parallel: daily information about the weather stands to the body as the seasons stand to the overarching aspects of the self. To put it in a relatable context, imagine that every day at 6 p.m., you find yourself heading to the fridge with a desire for beer. Over time, this habit not only informs you that you have a preference for beer but also that, at that specific moment, you possess the intentional mental state of desiring beer. Importantly, both the fact that you are a beer lover and the fact that you have a desire for beer on that occasion are included in the generative model of your self, but at a high, deep level. Such acquisitions, in fact, are deeper both spatially and temporally than the fact that a particular moment you are moving your body toward the fridge (which is, in fact, a low-level piece of information).

However, there is a subtle yet crucial distinction between the 'season example' and the 'beer example.' While we can acknowledge the similarities between models of the self and other models, a unique aspect of self-models becomes evident: when we construct a model of ourselves, we are essentially modeling our own model. We perceive ourselves only through the model we have created, similar to how we perceive any other object through our model for it. This self-modeling process is circular in nature. On one hand, it involves perceptual inference, where we refine our self-model by adjusting it based on incoming sensory data. However, this adjustment process is carried out through active inference. In simpler terms, we build and update our self-model through perceptual inference, aligning the model with new data. Yet, this incoming data is, in turn, shaped by our actions. As a result, perceptual and active inference continually interact in a circular manner, shaping and structuring the self-model.

This circularity further goes to show, together with Hohwy and Michael's general account of the self, how we ultimately "pull ourselves together", both within and between levels. Crucially, integration is the premise of keeping a coherent model of our bodies, our medium-term features and traits, and our long-term qualities and objectives.

Further idea of this precarious maintenance that makes the self is conveyed by Letheby and Gerrans (2017). While many elements of their account are in line with Hohwy and Michael's and adhere to the broader principles of PP, several key differences emerge. Both approaches acknowledge that the mind treats the self in a similar manner as it does other objects, constructing and integrating a hierarchy where higher-level models address features at lower levels, ultimately forming the entirety of objects we perceive.

However, a significant divergence emerges: the primary point of disagreement centers on the notion that nothing, not even a self-model (as proposed by Hohwy and Michael), can be considered the self. It seems as though Letheby and Gerrans take the concept of reducing the solidity of the self, which is present in Hohwy and Michael's work, to its utmost consequences.

In doing so, they put binding at center stage. They say (2017: 2): "the mechanisms involved model the self as a heuristic, a way of making information 'sticky', rather than as a way of tracking the fluctuating cognitive fortunes of an actual entity". Then, I dare say, the difference between Hohwy and Michael and Letheby and Gerrans could be thus summarized: while the former conceive the self as '*something*' that is – very provisionally – stuck together, the latter conceive the self as the *glue* that – here, too, precariously – keeps a flux of continuously changing information together. *Both, glaringly, entail integration, and in a very strong and fundamental way*. Regardless of how radically one's stance with regard to the fragmentation of the self is, *integration* remains a pivotal phenomenon.

To get an idea of this latter point, I shall briefly focus on one of these levels, the lowest, "bodily" one, that serves as a basis for the other ones.

4.1.2. *The lowest level: the body*

The self, in line with the foregoing, arises from the body and is shaped by sensory integration. To explore fundamental aspects of the bodily self, experiments on body ownership (Schlicht, 2018) have been utilized. These experiments appear to unveil more fundamental insights than the intricate concept of bodily awareness (cf. Tsakiris, 2010).

A prominent experiment in this context is the "rubber hand illusion," introduced by Botvinick and Cohen (1998). In this experiment, one of the subject's hands is concealed, and a rubber hand is positioned in its place. Both the hidden hand and the rubber hand are simultaneously stimulated. Consequently, the subject observes the simulated touch on the rubber hand while feeling the corresponding sensation on their hidden hand. Due to the synchronous timing of these sensations, the subject concludes that the rubber hand is, in fact, their own (Tsakiris and Haggard, 2005).

This illusion is described in terms of a disruption of a process of "intermodal matching"[11] between what is seen and what is felt. This disruption results in a phenomenon known as proprioceptive drift, where the subject's

[11] This expression, intuitively, refers to the correlation (integration, indeed) between stimuli coming from different modalities.

perception of their body's location shifts. Significantly, the illusion is induced by manipulating the correlations between multisensory signals. When these correlations are altered or disrupted, it becomes evident that *assembling* multisensory information is crucial in shaping one's sense of body ownership.

In sum, not only does the exposure to certain signals of a perceptual nature change the sense of ownership relative to one's body but the self itself could be said to be built by signals from disparate sensory systems, thus corroborating the idea that the latter is not a preexisting substratum to which all those signals are attached.

Once sensory integration has taken place (though note that this is an ongoing process), the components that 'make up my body' are probabilistically treated: what I come to identify as 'my body' is nothing more than that set of data having the highest probability of being 'me'.

What prompts us to categorize specific aspects of our experiences as "body parts" is the observation that they trigger numerous sensory systems, particularly those related to the somatosensory[12] domain. Take the example of a hand: the brain learns to establish a connection between a particular visual stimulus and a corresponding sensory input. This learning process leads us to perceive the hand as the source of these visual and proprioceptive[13] inputs. It's worth noting how this recognition of the hand involves the integration of multiple sensory modalities.

The sense of "this is my hand" that's ingrained in an individual's brain is a result of the association formed when they observe an object making contact with their hand, and they simultaneously experience a proprioceptive sensation. In the context of the rubber hand illusion, the process of updating this internal representation occurs when sensory information is inconsistent. In this case, the update relies on the visual information about the body's expected position, rather than information from proprioception or interoception.

What makes this experiment particularly impactful is that it demonstrates that an individual's mental representations of their own body can indeed change and adapt when multisensory experiences deviate from their expected patterns. This reveals how our understanding of our own bodies can be dynamically altered based on sensory discrepancies.

The rubber hand illusion presents an unusual combination of sensory circumstances that can be best explained by the brain incorporating another object into one's self-perception. The updated model of the self incorporates

[12] This term is employed to refer to sensory systems more in general. It includes the proprioceptive, the exteroceptive, and the interoceptive.

[13] Proprioception equates to the ability to perceive stimuli from the body regarding position, movement, and balance. Even if one is blindfolded, they proprioceptively know if their arm is over their head or along their body.

corrections for prediction errors arising from proprioceptive inputs, aligning their sources with the observed location of the visible body or body part. As a result of this update, the predictions are consistent with the visual inputs, giving greater importance to the location information conveyed by sight over proprioception. In essence, sight "hijacks" proprioception (Gallagher, 2012: 144) and triggers a revision of the self-body model.

Furthermore, research has shown physiological changes in the real hand during the illusory experience, such as a decrease in temperature (Hohwy and Paton, 2010). These results indicate a shift in the perception that the actual limb is a part of oneself, pointing to a reduction in the degree to which the real limb is considered an integral aspect of the self during the illusion. This implies a downsizing in the consideration that the real limb may be part of the self.

This observation is particularly significant because it underscores how the body represents a fragile, probabilistic model that heavily relies on sensory associations. In addition to these insights, it's important to acknowledge that, in line with long-standing theories advocating for a "constructive" and *integrative* approach to the self, PP also supports a robustly "interactionist" perspective regarding the expansion of the self. In other words, PP aligns with the idea that the self is continuously constructed and expanded, akin to the incremental building of a structure, with each new "brick" representing a development in this ongoing process.

These observations hold particular relevance for the concept of precision, as precision plays a crucial role in integration and binding processes (as in, e.g., Spratling, 2008). Therefore, if the core issue in psychotic traits revolves around integration, and precision is a fundamental factor in these integrative processes, this line of reasoning further substantiates the idea that precision is a pivotal factor in the development of psychosis.

4.1.3. *What it's Like to Ego-Dissolve*

The upshot of the binding and integrative resources at play even in the most basic levels of construction of ourselves is self-awareness. The latter ultimately lies in the experience we "report in terms of awareness of being a unified persisting entity: the same person at a time and over time" (Gerrans, 2015: 2). In recent years, phenomena occurring at the level of self-awareness – such as episodes of alteration of this experience – have begun to appear as privileged windows to look through to further explore our integrative processes. In addition to this, since such phenomena are incredibly present in schizophrenia's symptomatology – in psychosis, specifically – it has become more and more evident that the latter is a clear example of the alteration of these integrative capacities. As mentioned earlier, psychedelic substances have become a supplementary tool of exploration: the latter have proved able to replicate the alterations presented in schizophrenia. Namely, the phenomenon of alteration of integrative processes visible both in schizophrenia and in psychedelic intake is termed 'ego-dissolution' (Milliére, 2017). To put it in a metaphorically forceful way: when we 'dis-integrate', what happens is we 'ego-dissolve'.

Self-awareness is a product of the intricate, multi-level integrative processes within the 'self.' Ego dissolution, as an alteration of self-awareness, signifies a simultaneous change in these integrating processes. Schizophrenia encompasses such symptomatology. Notably, psychedelics replicate this phenomenon, both at the lower sensory, hallucinogenic level, and at higher levels, where effects encompass changes in emotion, thinking (including creativity and insight), altered perspectives, and shifts in attention, salience, meaningfulness, and the quality of consciousness itself (paraphrasing Letheby, 2021: 46). Collectively, these lines of reasoning lend further support to the idea that schizophrenia involves an impairment in integration, and conversely, that typical self-awareness results from these binding processes. Further, psychedelics, in light of their more recent reappraisal (see Letheby, 2021; Stoliker et al., 2022; Kałużna, 2022), might be employed to further look into the core of this symptomatology.

Considering this literature, the connection between disintegration and precision becomes explicitly evident through two key points.

First, Letheby and Gerrans (2017) have interestingly noted that the disruption of integration observed in ego dissolution, rather than suppressing conscious experience, actually *intensifies* it: subjects experience objects they would not typically consider and are more prone to have unfiltered experiences. This goes to show that integration, by linking salience and experience together – that is, by making us experience what is salient, and by making us consider salient what is functional to our preservation – ultimately constrains our experience. Ego dissolution, in this sense, would essentially be the experience of cognition stripped of the models of the self, that is, cognition unbounded by integration (cf. Stoliker et al., 2022). Empirical evidence has supported this hypothesis: Sapienza et al. (2023) signaled a global decrease in functional connectivity, highlighting the disintegration of preserved functional circuits and a concurrent increase in overall connectivity in the brain. This finding, in effect, nicely dovetails with the suggestion that an impairment in integration couples with a concomitant intensification of conscious experience.

Stoliker et al. (2022), in particular, tied the notion of 'disintegration' with that of 'desegregation' (Stoliker et al., 2022), where the latter phenomenon has been seen to positively correlate with ego dissolution (Tagliazzucchi et al., 2016). Specifically (Stoliker et al., 2022: 6):

"Desegregation describes the abundant deviation of connectivity from functional pathways – or decreased modularity[14] in brain networks and regions – and is an effect cited in reference to an increased complexity […] Desegregation in cortical communities may relate the richness of psychedelic phenomenological experience which differs from other altered self-dissolving states of consciousness […] that may relate to the complexity of a self-generative model."

Second, one very notable point, I think, concerns *serotonin*. The so-called 'serotonin hypothesis' is one of the various theories put together to frame schizophrenia with reference to neurotransmitter alterations (see Stahl, 2018). Considering this particular model, though, a few interesting elements surface. One starting point is that Letheby (2021) has particularly focused on this specific neurotransmitter as one target of psychedelics. His focus is mainly therapeutic[15], but what emerges is that psychedelic substances, by dampening the stringency of our tight self-models, actually alter serotonin. The narrative could be described in the following way: psychedelics have the capacity to modify binding processes, which means they alter the stringency with which our self-models are constructed and can induce phenomena such as ego dissolution. This alteration by psychedelics is closely tied to the impact on serotonin levels. In turn, this connection reveals that serotonin plays a significant role in shaping binding processes. Furthermore, fascinating connections exist. For instance, existing literature suggests that serotonin is the neurotransmitter responsible for encoding precision. This perspective enriches our understanding of how serotonin is involved in regulating and influencing the precision of self-models (e.g., Carhart-Harris and Friston, 2019; Yon and Frith, 2021). This observation can be seen as a confirmation that precision plays a key role in the manifestation of psychotic symptoms in schizophrenia.

A significant connection can be drawn from the previous analysis: serotonin affects both binding and precision. The dampening of precision through psychedelics, resulting in ego dissolution, highlights the close relationship between integration and precision, underscoring the impairment in precision modulation in individuals with schizophrenia. This, remember, further corroborates the suggestion that the shortcomings of the tripartite model should be dealt with by inserting the notion of precision into the picture.

[14] The term 'modularity' here is referred to the fact that functional pathways are not separated from one another, and everything comes to be entangled, albeit in a flexible and mutable way.

[15] Letheby (2021) proposes a positive view of this perspective. The underlying idea is that if the tightness of the links encompassed by our self-models is highly reduced, we can effectively intervene on those models and change them: in short, they are more prone to being revised. To make a simplistic example of a scenario as such, a person affected by depression, who has a very negative representation of herself, through the fraying of her self-model right up at its higher levels, can more easily intervene on it and restructure it, ideally refurbishing it with positive information.

5. *Putting all this to work: further developments*

Although the various problems posed above (cf. Subsection 3.3.1) are far from being solved, I shall here elaborate on them briefly.

Recall, in the context of understanding psychosis, one intriguing challenge is the apparent *selectivity* of the issues related to inference and conscious access. It may seem counterintuitive that if inference processes are impaired, these issues would only manifest at the level of conscious access. This problem requires further exploration and could be approached from two different perspectives for clarification.

One way to address this problem is by considering that the impaired inferential processes are not exclusive to conscious access but rather have a pervasive impact on the entire cognitive system. This perspective suggests that the issues stemming from impaired precision influence all levels of cognitive processing, from the most fundamental sensory perception to higher-order cognitive functions. In this view, conscious access might be the point where these issues become most apparent, given that it represents the culmination of these problems. Conscious processing is where the *consequences* of these pervasive issues are most noticeable.

Another perspective to consider is that the issues related to inference and precision are indeed pervasive throughout the cognitive system, but they become more pronounced when it comes to conscious access. Conscious access, in this context, acts as a bottleneck where the competition between different sources of information and the integration of prior beliefs and incoming evidence is most evident.

Consciousness is where the effects of deficient precision are amplified, leading to the overemphasis of prior beliefs at the expense of incoming evidence. This heightened competition and selection process, determined by top-down attention, increases the consequences of these issues, making them most evident at the level of conscious experience.

In sum, this perspective suggests that the entire cognitive system may be affected by these issues, but it is in conscious access where the impact is most notable.

The second challenge I highlighted when investigating psychosis pertains to the *utilization* of information within the realm of conscious access. The problem extends beyond the mere question of what reaches the conscious mind; it delves into the critical issue of how this information is employed.

One potential solution focuses on the concept of "use" in the context of higher-level information within the hierarchy. This information plays a key role in determining the effect of incoming data as it interacts with conscious access.

In this context, the question becomes not just about the *quantity* of information that emerges into conscious awareness but also the *quality* of its use. The way higher-level beliefs guide the processing of this information is crucial. If these beliefs[16] are rigid and resistant to updating, they can hinder the proper integration of new data. Conversely, flexible and adaptive higher-level beliefs can ensure a more accurate and contextually appropriate interpretation of incoming information[17]. These considerations highlight the need to examine not only the entry point of information into conscious access but also the cognitive "filters" through which this information is processed and evaluated, and, consequently, put to use.

The third worry in this exploration of psychosis revolves around the contribution, for example in the onset of delusions, of *anomalies* in *perceptual* experiences. Within this context, then, it is observed that issues in sensory perception significantly contribute to the development of psychotic experiences (e.g., Stone and Young, 1997; Coltheart, 2007; McKay, 2012). Why, then, focus exclusively on the threshold for conscious access? Precision, as observed all along, could help solve the matter.

Precision, in essence, acts as a 'filtering' mechanism, and when it is impaired, a crucial breakdown occurs. Although precision sure is pervasive on PP, if we are to employ it within the tripartite model presented in this work, then we must suggest that it is in its 'top-down' component that the issue really stands, so that it is in the selection for conscious access based on contextual, high-level information that the impairment is all the more manifest. Nonetheless, PP appears to give us the tools to postulate that an impairment in precision's top-down component can reverberate in perceptual modelling. This is also useful, as we shall see, for the 'specificity' of psychotic traits. It is no wonder that this is one of the toughest nuts to crack in this integration between the tools of PP and the posture of GNW (see Alegiani and Marraffa, 2021, for a few observations on this point). When precision is impaired, the brain struggles to discern between meaningful, contextually relevant sensory data and random, irrelevant sensory noise. The result is an indiscriminate treatment of sensory information, with even erroneous data receiving excessive importance. This indiscriminate processing, influenced by prior beliefs and expectations, leads to the formation of distorted perceptual models. These models serve as the brain's internal representation of the

[16] I am aware of the care that is required in employing a term as such, especially in the context of PP. I shall not delve here into the debate concerning representations and their nature within this framework, as it is incredibly vast and complex.

[17] In predictive processing, a key process involves finding the right balance between the flexibility and rigidity of higher-level priors to avoid under-constraining incoming information, as exemplified in ego-dissolution.

external world. In the context of psychosis, these models become distorted, causing sensory experiences to be inaccurately interpreted, resulting in altered perceptions. Importantly, it is probable to imagine, on PP, that these altered perceptions, originating from issues within the model, including the top-down level of precision evaluation, can simulate perceptual anomalies. This observation is crucial for understanding accounts of psychosis, where anomalous perceptions have oftentimes been presented as 'starting points' for the condition. It might be postulated that these perceptual anomalies are the result rather than the origin of psychosis, as the issue start at higher levels, to then reverberate perceptually and manifest, in fact, at the conscious level of cognition.

The fourth issue presented above concerns the theme of underestimation of incoming evidence, which is emphasised by Berkovitch and colleagues themselves. In all truth, seemingly, it's not a matter of overestimating what gains conscious access but rather a tendency to dismiss incoming information, even when it is relevant. Inizio modulo

One potential solution to this problem focuses on the concept of *rigid* high-level priors within the hierarchical generative models. It is in fact quite intuitive that if these high-level priors become resistant to change, they can play a key role in explaining the mechanism behind the dismissal of incoming information. In sum, the rigid high-level priors orient the interpretation of incoming information. When they are inflexible, they might lead to the outright dismissal of data that contradicts or challenges the web pre-existing beliefs[18]. This can result in the exclusion of relevant information from consciousness.

In line with the foregoing, this process, systematically reiterated, impacts not just conscious access, but the entire cognitive system, thus leading to the persistence of erroneous beliefs and the reinforcement of delusional thinking.

One of the other issues mentioned above focused on the persistence of psychotic traits. Once a delusion is fixed, it is resilient to change. On this point, I find Corlett and colleagues' (2009) focus on memory reconsolidation particularly informing: here, delusions, for example, are seen as forms of memory that resit correction due to impaired precision. Delusions in psychotic states occur in the context of a noisy nervous system striving to construct and maintain a robust set of priors. The heightened noise levels result in more cycles of reactivation and subsequent reconsolidation, leading to the development of a peculiar and 'dysfunctional' set of expectancies about the world. These learned expectations, which are highly resistant to sensory input, form the basis for the persistence of delusional beliefs. In the context of memory reconsolidation, delusions, considered a type of memory, are challenging to correct due to precision impairment. The "transition from a salient episodic experience to a habitual belief about the world" (Corlett et

[18] This sure reminds us of "conservatism" (Stone and Young, 1997).

al., 2009: 5) relies on systems responsible for encoding the salience of events, tightly interwoven with learning and memory processes. In fact, interventions directed at these systems can yield memories as enduring as those established through repeated real-world experiences. Thus, discrepancies in prediction error values stemming from issues related to precision can swiftly lead to the shaping of distorted prior beliefs.

The last challenge proposed here consists in understanding the *specificity* of psychotic traits. The latter might lie in the role of perceptual processing in fabricating hierarchical models. This consideration becomes especially relevant in light of the suggestion that the primary point of these challenges is at higher levels of processing, culminating in their manifestation at the conscious level. Once again, we can focus on precision: on PP, the latter assumes a central role in guiding how the brain evaluates the reliability of sensory inputs. When precision is impaired, the brain faces the difficult task of distinguishing between meaningful sensory information and random noise, which encompasses data from perceptual systems. As anomalous prediction errors accumulate, the brain attempts to construct a coherent model of the world that can effectively accommodate these unusual experiences. This accommodation often involves intervening at the level of expectations regarding sensory stimuli, which primarily occurs at higher levels of cognitive elaboration. In this process, erroneous beliefs arise, exhibiting a *duality* that is both specific and situated at higher levels of cognitive processing. These beliefs possess a specificity that pertains to the individuality of psychotic traits, while also being intimately tied to the cognitive elaboration that characterizes higher-order information processing.

One last nut to crack involves a contradiction that the reader might have already noticed: until now, I have referenced to the stiffness of higher-level information in the onset of psychosis. However, the section on ego-dissolution has pointed to a relaxation of priors and expectations[19]. This contradiction might perhaps be tackled by delving into the concept of precision and its flexibility within the model. The case of ego-dissolution might highlight a different facet of precision's influence: precision purports parametric variation to the model, recall. While precision typically reinforces prior beliefs, making them resistant to change, it can also, under certain conditions, permit the relaxation of these priors. This flexibility in precision, when functionally gauged, helps the brain adjust its beliefs to encompass a wider range of experiences and sensory inputs. Precision, in sum, is not solely about rigid beliefs but also encompasses the capacity for belief relaxation. This understanding points out the necessity for model adaptability, as well as the dynamic nature of

[19] The relationship between lower and higher-level components cognition in ego-dissolution is the object of discussion; for two examples, see Carhart-Harris and Friston (2019) and Corlett et al. (2016).

precision in shaping our perception and understanding of the world. It also aligns with the idea that precision can grant parametric variation to the model of psychosis, impacting priors in ways that may involve both relaxation and increased rigidity, depending on the context and conditions.

6. *Conclusion*

The primary aim of this paper was to draw attention to specific concerns within Berkovitch and colleagues' GNW-based account of psychosis (e.g., Berkovitch et al., 2021). I proposed that integrating the concept of precision, derived from Predictive Processing (PP), could potentially address these concerns and enrich the existing tripartite model.

After briefly reviewing the two theories, I elucidated the core tenets of the target GNW-based account to lay the groundwork for the following discussion on precision. While the literature has previously highlighted precision's role in psychosis, I referenced to a quite novel perspective by exploring its connection to ego-dissolution, particularly within the context of psychedelic experiences, as a means to emphasize its relevance to understanding psychotic traits.

In light of this foundation, we put forward some preliminary solutions for further exploration and development, focusing on how precision could serve to mitigate the identified shortcomings. This paper contributes to the ongoing discourse on psychosis, offering a promising avenue for future research and a potential bridge between GNW and PP.

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