I overthink—therefore I am not: Altered Sense of Self and Agency in Depersonalisation Disorder

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Abstract:

This paper considers the phenomenology of depersonalisation disorder, in relation to predictive processing and its associated pathophysiology. To do this, we first establish a few mechanistic tenets of predictive processing that are necessary to talk about phenomenal transparency, mental action, and self as subject. We briefly review the important role of 'predicting precision' and how this affords mental action and the loss of phenomenal transparency. We then turn to sensory attenuation and the phenomenal consequences of (pathophysiological) failures to attenuate or modulate sensory precision. We then consider this failure in the context of depersonalisation disorder. The key idea here is that depersonalisation disorder reflects the remarkable capacity to explain perceptual engagement with the world via the hypothesis that "I am an embodied perceiver, but I am not in control of my perception". We suggest that individuals with depersonalisation may believe that 'another agent' is controlling their thoughts, perceptions or actions, while maintaining full insight that the 'other agent' *is* 'me' (the self). Finally, we rehearse the predictions of this formal analysis, with a special focus on the psychophysical and physiological abnormalities that may underwrite the phenomenology of depersonalisation**.**

Keywords: sense of self, agency, sensory attenuation, predictive processing, depersonalisation

Introduction

> *"If I quieten my mind, I can still almost taste the colour and richness of life as I knew it before that point; the feeling of being your own agent of change, the feeling of plotting a course through life, and the sense of expectation". (Ciaunica & Charlton 2018).*

In daily life, our brains constantly receive a cascade of sensory information arising from both inside our bodies and our lived environment. For most of us, most of the time, these experiences seem to be tacitly accompanied by a *sense of self* – a sense of being an (embodied) agent within a world, among but distinct from others (Zahavi 2008, Hohwy 2007; Limanowski and Blankenburg 2013, Seth 2013). Everyday experience also seems to involve experiences *of agency*; namely, the feeling that 'I am in control of my own actions, that I can leverage them to access and change the external world' (Gallagher 2000; Haggard 2017).

Could everyday lived experience ever be any different? Could it be possible for me to constantly endorse the detached viewpoint of an external observer on my own self, body and world? What if I feel like an automaton, or a pilot controlling her own ship from the 'outside'?

Initially described by Dugas in 1898 (Berrios and Sierra 1997), Depersonalisation /Derealisation Disorder (DP/DR) is a condition characterised by profound alterations of one's sense of self (Sierra & David 2011), typically inducing distressing feelings of detachment or estrangement from one's self (depersonalization) and/or one's surroundings (derealisation) (DSM IV-TR fourth edition, text revision 2000)[1]. DP/DR typically co-occurs in association with highly traumatic events or as co-occurring symptoms associated with anxiety, panic, and depression (Hunter et al., 2004).

These dramatic alterations are typically experienced as a 'split' or a 'fracture' between a detached observing agent and an observed self, body and world: "*My perception felt as though it had been drawn back inside my head, almost as though I was looking at the world from the back of my head, and could see the back of my own eye sockets. (…) Essentially, it felt like there was a divorce or fracture between the world and me so that although my body was still in the world, my mind was only an observe*r" (Ciaunica et al. 2020: 6).

The experienced self-split or self-detachment occurs on multiple levels, as it is associated with (a) detachment from one's body or body parts (low-level sensory and bodily aspects of the self); (b) detachment from one's subjective feelings and emotions (experiential aspects);

[1] The other major classificatory system used in contemporary psychiatry is the ICD-10 (International Classification of Diseases, World Health Organisation). While there are some important differences between DSM and ICD, both they largely agree upon the diagnostic criteria for DPD, which are the following: a) persistent symptoms of DP/DR not occurring as part of another disorder or be directly substance-induced; b) the individual should not be suffering from psychosis (which would imply a different diagnosis, such as schizophrenia). DSM adds the criterion c) there should be significant distress and/or functional impairment. This seems appropriate, as otherwise it is hard to argue that the phenomena can usefully be seen as pathological (Medford et al. 2005).

and (c) disconnection from one's personal stories, memories, thoughts and future plans, often described by sufferers as a lack of a narrative or a 'plot' in one's life (see Simeon and Abugel 2006; Sierra 2009; Billon 2016; Ciaunica & Charlton 2018). The overall impact of this 'self-split' makes people feel "not fully real" (Simeon and Abugel 2006; Medford 2012), and living on 'automatic pilot' (Perkins 2021).

The prevalence of DPD is around 1-2% in the general population (Hunter et al. 2004), with onset typically occurring before age 25. Strikingly, feelings of depersonalization are the third most common psychological symptom reported in the general population (after anxiety and low mood), especially among young people (Simeon et al. 2003). Yet its underlying neurocomputational mechanisms, and therefore, the link between biology and phenomenological markers remains poorly understood (see Seth et al., 2011 for an early attempt). As a first step to resolve this problem, we here propose a novel conceptual model of disrupted sense of selfhood and 'self-split' in DPD that draws on the framework of active inference.

Active inference is a process theory that aims to capture the capacity of biological organisms such as human bodies to survive and thrive in volatile environments (Friston et al., 2017). Active inference builds upon the Free Energy Principle (FEP) (Friston 2005) which is a formalisation and extension of the Schrodinger (1956) seminal idea that living organisms avoid entropy, by engaging in self-organisation and by maintaining their homeostasis within optimal limits for survival and potential reproduction (Clark 2013; Hohwy 2013). This approach draws also on von Helmholtz's (2005) seminal idea of how the brain derives perceptual experience from sensory input. Namely: the brain constructs a mental representation of sensory inputs via perceptual inference, whereby prior percepts automatically shape the percept that is generated by the incoming sensory information. This idea has inspired the modern approach of perception as predictive processing (Rao & Ballard 1999; Knill & Pouget 2004; Friston 2005; Clark 2013; Hohwy 2013).

The predictive processing framework has been recently heralded as a powerful conceptual toolbox for examining how alterations in low-level bodily sensory processes could drive the emergence of high-level mental symptoms in various psychiatric conditions (see Heinz and Schlagenhauf 2010; Corlett and Fletcher 2015 for reviews). Within this framework, it has been suggested that DPD symptoms may be explained via pathologically imprecise interoceptive signalling – the perception of visceral signals (Craig 2002) – which consequently fails to update higher-level beliefs and thus perpetuates a sense of 'unrealness' (Seth et al. 2011). More recently, impaired self-related affective processing has been advocated as core feature od DPD symptoms (Gerrans, 2018).

In this paper we propose an account of DPD symptoms in terms of aberrant somatosensory attenuation, and consequent 'split' in the sense of agentive control over one's own perceptions and actions. Two intertwined key ideas underlie our proposal.

First, self-organising living beings such as humans need to move and take action in the world in order to ensure their survival and interact with others. However, as we will see shortly, in order to successfully prepare and engage in perception and action 'out there" in the world, the human brain needs to be able to attenuate and process self-related information 'transparently', in the background.

Second, disrupted somatosensory attenuation may lead to aberrant self-focus, i.e., enhanced attentional bias towards one's own perceptions and actions. Alterations in the ability to 'forget' about the self and optimally perceive, engage and act in the world may further lead to increased reflexivity or 'hyper-reflexivity' (Parnas & Sass, 2003; Fuchs 2005; Ciaunica et al. 2020). At the phenomenological level, this seems to be captured neatly by feelings of being trapped simultaneously in one's head (overthinking) and outside one's body (disembodiment) (Ciaunica et al. 2021). Disconnection from one's body may also explain the sensations of being unreal (Simeon & Abugel, 2006; Sierra 2009; Ciaunica & Charlton, 2018), and navigating through the world surrounded by a 'pane of glass', 'experiential airbag' or 'opaque veil' interposed between one's self, body and the world.

If our hypotheses are correct, the sense of presence and realness in the world may depend on a bias towards over-thinking and hyper-reflexivity, offsetting diminished body-related processing. Perhaps paradoxically for a syndrome "depersonalisation", this unbalance may entail an abnormal elevation of higher-order self-related processing, rather than a 'loss' of the sense of self.

We unpack these hypotheses below as follows. In section 1 we briefly introduce the notions of somatosensory attenuation and transparent self-models. We then move in section 2 to present the active inference conceptual toolbox and its relation to the sense of self and the sense of agency over one's actions. Sections 3 and 4 develop and motivate the claim that disrupted sensory attenuation and aberrant self-focus may trigger a 'split' in the sense of agentive control over one's own perceptions and actions in DPD. And how this is intimately related to the attentional augmentation and attenuation of sensory precision in the setting of active inference. Section 5 connects these claims with the phenomenology of depersonalisation symptoms focusing on phenomenal transparency and qualitative experience. We conclude with a non-exhaustive list of testable predictions that our hypotheses imply. We also suggest some potential therapeutical implications of our approach that could usefully be explored, with the aim of improving the day-to-day life of people experiencing this distressing condition.

§ 1 The Importance of 'Self-Forgetting': Somatosensory Attenuation and the Transparent Self

1.1 Somatosensory attenuation

When picking a ripe cherry from a tree—to borrow an example from Limanowski and colleagues (2020)—we seem to be quite sensitive to the feel of the cherry, as we touch and grasp it. Yet we are almost insensitive to the feelings of our arm and eye movements while reaching the cherry, despite the fact these signals are essential in ensuring we successfully pick the ripe cherry, and not the green one next to it. Somatosensation (from 'soma' (body) + sensation) is an umbrella term referring to processing of tactile, thermic, proprioceptive inputs and pain signals through neural receptors in the skin. In our example, somatosensory

information would include a set of signals about both the tactile perception of the cherry (softness, humidity, etc.) and the perception of one's body in space and movement (position of fingers, kinaesthetic trajectory of the arm, etc.).

Seminal studies illustrated that we automatically anticipate the sensory effects of self-initiated actions (Wolpert & Kawato 1998), which explains why people typically cannot tickle themselves (Blakemore et al., 1998). There is mounting psychophysiological and brain imaging evidence for this requisite attenuation of somatosensation during and prior to action is typically accompanied by a decrease in the primary somatosensory cortex responses (Bays et al. 2005; Voss et al. 2006; Palmer et al. 2016)[2]. These findings suggest that sensory attenuation plays a key permissive role in action-initiation (Brown, Adams et al. 2013, Hughes, Desantis et al. 2013, Parees, Brown et al. 2014, Oestreich, Mifsud et al. 2015, Zeller, Litvak et al. 2015, Bhatt, Bowen et al. 2016).

Importantly, somatosensory attenuation is key for building multisensory bodily-self representations, especially when sensory signals from multiple sensory modalities are conflicting (Paton, Hohwy et al. 2012, Zeller, Litvak et al. 2015, Limanowski and Friston 2020). It has been argued that attenuation of self-generated inputs gives rise to the feeling that one is in control of one's own actions, or the sense of agency (Gallagher 2002; Leptourgos & Corlett 2020). Thus, it has been proposed that somatosensory attenuation (Haggard, 2017), and, generally, the comparison of predicted and actual somatosensory feedback underpins the distinction between oneself and the world (Frith et al., 2000; Blakemore and Frith, 2003; Fletcher and Frith, 2009); and specifically, self-other distinction (Haggard, 2017). While the relationship between sensory attenuation and the sense of agency is complex (Seth et al., 2012), it has been shown that agency over movements that generate sensation may be necessary for sensory attenuation (Desantis et al. 2012; Gentsch & Schutz-Bosback 2011).

Summing up so far: in order to establish where the self ends, and the world/other begins, the brain needs to maintain a fine balance between the inferences concerning the external and internal causes of sensory information.

1.2 The Transparent Pre-Reflective Self

There is in increasingly influential perspective, in both philosophy and cognitive neuroscience, proposing that our bodily self anchors all our feelings, perceptions, emotions, thoughts and actions into a unitary whole, and thereby plays a central role in structuring a minimal or pre-reflective sense of self. (Merleau-Ponty 1962; Gallagher 2000; Damasio 2000; Sass and Parnas 2003; Metzinger 2004; Zahavi 2005; Ciaunica and Fotopoulou 2017; Friston 2018; Seth & Tsakiris 2018). A comprehensive review of this rich literature—on the different facets of the selfhood—lies beyond the scope of this paper (see Gallagher 2013; Quin et al. 2020 for reviews).

In what follows, we build upon the notion of pre-reflective self-consciousness as an intrinsically non-*objectifying* form of self-awareness. This form of self-awareness is thought to pervade and constitute every conscious experience without requiring introspection or

[2] At higher levels of the somatosensory hierarchy, it is not clear whether an attention or an enhancement of ascending sensory information may be at work. It has been proposed that these higher-level regions are the best candidates for an implementation of action-dependent weighting of self-generated versus externally caused somatosensory components (e.g., Edwards, et al. 2012; Parees et al. 2014).

reflection (Zahavi 2005). The key idea is that any experience directed towards an object implies a pre-reflective self-awareness that makes my experiences immediately and tacitly given as *mine* (Zahavi 2005). This first-personal 'givenness' of all experience may be regarded as general medium integrating bodily sensations, movements and thoughts, within which specific modes of intentional consciousness are articulated: "This basic and foundational medium can be called sense of self or "mineness" (Fuchs 2015: 325).

As Sartre proposed, pre-reflective self-consciousness should not be regarded as an extra layer added to the on-going experience; rather it essentially constitutes the very mode of being of *any* conscious experience: "This self-consciousness we ought to consider not as a new consciousness, but as the only mode of existence which is possible for a consciousness of something" (Sartre 1943, 20 [1956, liv]). In Sartre's view, necessarily, any conscious experience *is* a self-conscious experience (Legrand 2006).

Interestingly, the phenomenological view—according to which every experience has necessarily and tacitly an experience of selfhood underwriting it—echoes recent trends in mind and brain research stipulating that our perceptions, cognitions and actions are geared towards self-preservation (Panksepp, 1998; Northoff & Panksepp, 2008; Barrett & Simmons 2015;Ciaunica & Fotopoulou 2017; Seth & Tsakiris, 2018; Azzalini et al. 2019). By maintaining and regulating the physiological needs and integrity of the organism (the human body), perceptual and sensory awareness at the most basic sensory level is inherently "selfish" (Seth & Tsakiris, 2018; Ciaunica & Crucianelli, 2019; Seth, 2021).

Now, a self-organising system such as the human body is most intimately acquainted with *self*-related signals. This means that the problem the brain has to solve is often "not which sensory evidence to *emphasise*, but which to *attenuate* "(Parr et al. 2018)" (Limanowski & Friston 2020:8, original italics) in order to optimally act in the world. This means that the most basic parts of the self-model are unique, in the sense that they are "necessarily transparent" (Limanowski & Friston 2018: 5). The idea of phenomenal transparency (cf. Metzinger 2003) can roughly be described as follows: a transparent (mental) representation is associated with an experience of unmediated access to the representational object (e.g., the world); conversely, an opaque representation can be grasped as being 'constructed' and, therefore, potentially *unreal*.

Crucially, this idea can be applied not only to our perception of the external world, but also to self-models: "just as a transparent world-model grants the experience of being in immediate touch with the world, a transparent phenomenal self-model...affords the experience of being in immediate relation to a self" (Metzinger, 2003; Limanowski & Friston 2018, p. 2.). In what follows, we call this basic default-mode of self-processing 'transparent self-modelling'; and we will discuss how disruptions of this process may be linked to the phenomenology of DPD (Fuchs 2005; Ciaunica et al. 2020).

In the next section, we revisit the phenomena of sensory attention and somatosensory attenuation in formal terms by appealing to predictive processing and the active inference framework. First, we rehearse the key concepts of 'self-model', 'precision' and 'precision weighting' and review suggestions that aberrant precision control may disrupt the ability to infer accurate self- and world models in various conditions. We then turn to the case of DPD (section 4) and suggest that aberrant precision estimation—biased towards ego-centric priors—means that the luxury of transparently processing self-models is denied. In other words, failures of somatosensory attenuation and consequent abnormal percepts—and

beliefs—may underwrite aberrant self-model in DPD. This may lead to a disruption of agentive control over both (sensory attention) perception and (sensory attenuation) action, triggering abnormal perceptions, and consequent aberrant beliefs of self-detachment. We turn to this discussion now.

§2 Predicting (Im)Precision: Getting the Bodily Self Balance Right

Recent work in mind and brain sciences argues that the basic pre-reflective experience of being a self is the result of an ongoing predictive process within a generative model that is centred on the embodied organism (Seth 2013; Apps & Tsakiris 2014; Limanowski & Blankenburg 2013; Limanowski and Friston 2018, 2020). The experience of a self is thus linked to an inferential hierarchy; the key idea being that embodied agents act as self-evidencing systems in the game of maximizing evidence for their self-model as they minimise prediction errors (Hohwy 2016).

Self- and world-modelling is organised in a dynamic and hierarchical fashion. Prior beliefs[3] about the self and world generate predictions that are conveyed by the top-down (backward) connections to lower hierarchical levels. Bottom-up (forward connections) return predictions errors to update prior beliefs — into posterior beliefs — until prediction errors are explained away by ensuing belief updating. In a hierarchical setting, this enables sensory input at the lowest level of the hierarchy to be assimilated through prediction. Posterior beliefs are hypotheses concerning the causes of sensory input at any hierarchical level that therefore rest on (1) *prior beliefs* about the self and world and (2) *current sensory evidence* gathered from a volatile and ever-changing environment.

In updating the self- and world-models in order to optimally adapt within a dynamic and potentially threatening world, much depends on the '*precision*' of the prior prediction and the sensory prediction error induced by sensations. Prior beliefs and sensory data are represented as probability distributions with (a) mean value (expectations) and (b) precision (inverse variance). Now, if prediction errors are based on precise sensory data and relatively imprecise prior beliefs, the mean of the posterior will be closer to the mean of the sensory data. By contrast, if sensory information is deemed imprecise, posterior beliefs will be much closer to prior beliefs. This means that predictions of precision—or predictions of predictability—can have a profound effect on hierarchical belief updating in the brain.

The literature on self-models defined through a predictive processing and active inference lens is too vast to summarize here. For the purpose of this paper it suffices to retain the key idea that in updating one's self- and world-models, much depends on the relative precision of expectations versus sensory evidence. Fine-tuning the weighting of prior beliefs and sensory evidence is often called *precision weighting*, which translates to selectively attending to (or ignoring) particular sources of evidence. Note that precision control has a fundamental role in

[3] The terms 'prior beliefs', 'expectations', 'predictions' are used here interchangeably.

the construction of self-representations. The challenge that an adaptive living organism faces is to 'decide on the fly' whether the weight of the balance—the 'gain' of the updating process— as afforded to the (a) sensory evidence from various modalities or (b) to the prior beliefs (or expectations) that have to explain these multimodal data.

In a nutshell, self-modelling in active inference relies on the getting the balance between sensory evidence and prior (model) precision right.

Precision weighting has been linked to attention[4] as the process of affording precision to (i.e., placing confidence in) certain aspects of the sensorium (Feldman and Friston 2010; Hohwy 2019). The other side of this coin is the attenuation of sensory precision that undergirds sensory attenuation. This selective dis-attention may be a crucial faculty that enables us to ignore sensory evidence that we have not acted, when we think we are acting. This transient suspension of attention to the consequences of action enables reflexes to realise our predicted (i.e., intended) actions in both motor and autonomic domains. Crucially for our thesis, increasing sensory precision entails a reduction of sensory attenuation, which is especially prescient when modelling oneself. As Limanowski & Friston put the point: "The temporary attenuation of the precision of sensory "self-evidence" – which is necessary to entertain an alternative (and yet counterfactual, c.f., Seth 2014) hypothesis about myself – is effectively a form of "self-attenuation" (2020: 10).

The idea that aberrant precision control disrupts the ability to infer accurate self- and world models—thereby triggering abnormal perceptions and beliefs—has been linked to various conditions[5] (see Heinz and Schlagenhauf 2010; Corlett and Fletcher 2015; Friston 2017, Sterzer, Adams et al. 2018, Smith, Lane et al. 2019). For example, it has been suggested that prior knowledge about the world is under-emphasized relative to incoming sensory information in patients with autistic spectrum condition (ASC). The primary source of these alterations however remains an open question: some authors argue for attenuated priors (Karaminis et al., 2016; Pellicano and Burr, 2012a; 2012b; Powell et al., 2016), while others argue for aberrant sensory precision (Karvelis et al., 2018; Lawson et al., 2014; Palmer et al., 2017; Brock, 2012; Van de Cruys et al., 2013).

A recent study suggested that apathy—a pathological lack of motivation to initiate purposeful actions—results from imprecise prior beliefs about the consequences of action (Hezemans et al. 2020:8). The authors found that higher traits of apathy were associated with lower precision of prior beliefs about action outcomes and suggested that a loss of prior precision leads to an impairment of goal-directed behaviour (cf. Friston et al., 2010, 2014).

In a similar vein, depression has been linked to a shift in the (precision of) prior beliefs about self-efficacy, as a consequence of prolonged interoceptive surprise (Stephan et al., 2016; Barrett et al. 2016; Badcock et al. 2017). In this view, fatigue[6] might initially represent an adaptive response to unexpected sensory input about metabolic states or bodily integrity (i.e.,

[4] Recent work has significantly broadened the concept of attention in order to take into account inner bodily states (interoception) as well as dynamic brain-body coupling (Allen et al. 2019; Quadt et al. 2018).
[5] In typical individuals, sensory attenuation is correlated with the level of delusional beliefs (Teufel et al., 2010). For example, a recent study probed the use of prior knowledge to perceive the gist versus the details of ambiguous images in a healthy population with varying degrees of hallucination and delusion proneness (Davies et al. 2017).
[6] This model of fatigue and depression is separable from the model of apathy mentioned above, as individual differences in behaviour are accounted for by variation in the prior mean or prior precision, respectively (Stephan & Mathys, 2014).

dyshomeostasis), in the sense that it promotes passivity and rest, while chronic dyshomeostasis leads to a generalized belief of lack of control, as in "learned helplessness" (Stephan et al., 2016). Crucially, disrupted precision balance has been related to disorders of selfhood such as psychosis and schizophrenia. For example, psychosis has been linked to a decreased precision in the encoding of prior beliefs relative to the sensory evidence (c.f., a failure of sensory attenuation), thereby engendering maladaptive inferences (Corlett et al 2006, Corlett et al 2007, Corlett et al 2009, Fletcher & Frith 2009; Sterzer et al. 2018).

The proposal here is that the fine-grained predictive model of the moment-to-moment changes in sensory input—that are expected on the basis of one's own planned movement— usually attenuate the sensory consequences of action. This enables us to ignore the fact that we are not moving prior to the execution of a movement. If this sensory attenuation fails, the inability to ignore the sensory consequences of self-made acts may result in a false attribution of agency: i.e., 'you did that, not me' (Synofzik et al 2010, Voss et al 2010). Thus, the sensory consequences of one's own actions generate unattenuated prediction errors that are read as evidence by the brain that this was not one's own agentic movement (Sterger et al. 2018). Indeed, a common feature of dissociative disorders of selfhood—such as psychosis and schizophrenia—is a perceived loss of agency: e.g., one's actions and thoughts are experienced as controlled by external agents, the so-called passivity phenomena (Waters & Badcock 2010). This hypothesis is supported by several lines of evidence. For example, psychosis has been associated with a greater resistance to visual illusions—which rely on prior beliefs for their effects—and a failure to attenuate sensory consequences of self-generated actions (see Adams et al. 2013 and Notredame et al. 2014).[7]

Additionally, a significant body of work found that sensory attenuation is also reduced in schizophrenia, yet another dissociative condition (Blakemore et al. 2000; Brown et al. 2013; Shergill et al. 2005; Fletcher & Frith 2009). More specifically, this deficit transpires to be a failure of sensory attenuation that can be attributed to aberrant precision control that confounds inference about the causes of self-generated sensations (Brown, Adams et al. 2013, Parees, Brown et al. 2014, Oestreich, Mifsud et al. 2015). Failures of sensory attenuation mean that the quantitative percepts of schizophrenic people can be less malleable and more veridical than controls; hence, their characteristic resistance to illusory phenomena. A key symptom of schizophrenia is aberrant perception of agency (Frith 2005) with the delusion that one's actions are controlled by others. This has been linked to deficits in the patients' generative model (Frith, 2005), and an inability to retune their model to elude cognitive deficits and psychiatric symptoms (Kilteni et al. 2019).

In the remainder of this paper, we suggest that aberrant (pathophysiological) precision control underwrites a failure of sensory attenuation in DPD, which precludes the processing of self-generated sensations 'transparently' in the background. We show how these disruptions may lead to feelings of 'overthinking', hyper-reflexivity, opacity and consequent lack of presence in the world or 'realness' of one's experiences.

[7] There is also debate over the question whether a loss of prior precision (e.g., prefrontal hypoconnectivity) and gain in sensory precision (e.g., sensory hyperconnectivity) may indeed be two separate factors in the illness (see Sterzer et al. 2018).

§3 Over-inferencing the Self – From aberrant precision control to self-opacity and hyper-reflexivity

3.1 Splitting the I, me and my self - disrupted agentive control in depersonalisation

Hitherto, we have seen that sensory attenuation may underwrite a feeling that one is in control of one's perceptions and actions (i.e., feelings of agency): 'I infer that I am the agent of these sensed actions' because any evidence to the contrary is attenuated. Failures of sensory attenuation may therefore disrupt the sense of agency over the perceived consequences of action. Indeed, if significant deviation from the predicted sensory consequences of my actions occurs—or sensory evidence is unattenuated before the consequences are sensed—then the most plausible explanation for the system may be that 'I am not in control of my actions', but 'some other agent is'.

The basic claim here is that in depersonalisation, individuals may also feel as though someone else is controlling their thoughts, perceptions, or actions, while maintaining the metacognitive insight that the 'other agent' or stranger *is* '*me*' (myself). To put it simply, depersonalisation may be seen as a type of 'passivity phenomenon'. If my perceived bodily sensations depart from my expectations all the time, I could start believing that they are not mine: c.f., delusions of control. However, if I were able to downregulate my confidence in my own expectations (i.e., a form of metacognition), I could maintain a higher-level belief that I am still in control of my sensations, even though it does not feel like that.

If this is so, then DPD may reflect the remarkable capacity to explain perceptual and active engagement with the world with two mutually exclusive but equally plausible hypotheses. (1) First, a hypothesis that the best explanation for all the evidence at hand is that "I am an embodied perceiver, and I am in control of my perceptual inference". (2) The alternative hypothesis is that "I am an embodied perceiver, but I am not in control of my perceptual processing". These permit a dissociation between controlled perception and the agency of that control.

This aberrant self-modelling is accounted for by the hypothesis that the self has a split agentive control over itself. The self-model's simplest explanation for this disruption is that "I am no longer in control of my perceptions and actions", but some other 'self' or agent is[8]. However, at the same time, the full insight that that other 'self' is *my* 'self' remains intact. This fits nicely with self-reports of depersonalisation as being on 'automatic pilot' (Perkins 2021) or like an "the captain of a ship". The captain can observe his crew, navigating through some space of affordances, but he is not actually 'doing' anything. An 'external self' or 'stranger' is perceived as doing it, while the agent maintains the full insight that this 'self' is *my* 'self'.

[8] For example, psychosis, the subject may 'buy into' this explanation and may believe that another agent is controlling their thoughts, percepts, or actions (passivity phenomena).

Crucially, while there is a significant overlap of dissociative symptoms between depersonalisation and psychosis (Sass et al. 2013), it is important to stress that reality testing remains intact in DPD. As one individual with DPD strikingly puts the point: "*I feel like a robot, like I am listening to someone else talking, like I am looking at myself from the outside, but it is not another voice or body - it is mine, it is me, it just doesn't feel like it."* (Baker et al., 2003). Or: "*When I'm having an episode of depersonalisation, it feels more like I'm watching myself doing things, but I'm not present for it. I'm witnessing myself… I 'know' I'm in control, but I'm not 'feeling' in control*" (cited in Perkins 2021:44). People experiencing DPD are not delusional, and they remain acutely aware that their self-split and self-detachment is a subjective phenomenon, and not objective reality. At the phenomenological level, the agentive self-split can be experienced as the sudden realisation that one is viewing oneself and the world 'from the backstage', through a camera when the lens is broken or obscured by raindrops. The content of visual information has not changed but one suddenly appreciates that the agent of visual foraging is the cameraman and not oneself.

3.2 From altered transparent self-modelling to hyper-reflexivity and self-opacity

Here, we hypothesise that alterations at the basic, low-level of self-related sensory processing are key to the pathophysiology of DPD. Phenomenologically these alterations necessarily led to a loss of transparency of one's basic pre-reflective sense of self. This may lead to an enhanced compensatory metacognitive self-processing or 'hyper-reflexivity' (Sass & Parnas 2003; Fuchs 2005; Ciaunica et al. 2020) accompanied paradoxically by a diminished sense of self. This paradox may be explained by the fact that our sense of self is an open-ended process, constantly fuelled and transformed via dynamic exchanges with the physical and social world. Limited exchanges with others and feelings of being 'cut off' the outer world may lead not only to overly ruminative inner workings, but also to feelings of being 'cut off' from oneself (Ciaunica et al. 2021).

As we saw earlier, in neurotypical people, given that self-modelling is the most basic and pervasive processing, the problem that the brain has to solve is often "not which sensory evidence to *emphasise*, but which to *attenuate*" (Parr et al. 2018)" (Limanowksi & Friston 2020:8, original italics). In an atypical population such as DPD, an individual's inability to attenuate self-related information may lead to an exaggerated emphasis on metacognitive, modes of self-awareness. At the experiential level, this process may correspond to what phenomenologists call 'self-objectification' (Sass & Parnas 2003; Fuchs 2005). By allocating extra resources to the processing of its own model, the self treats itself as an object to be controlled and 'grasped'—much like the cherry in the example above—and thereby destroys the inherent 'transparency' of one's sense of self. Hence, the agent may experience herself less as a subject of an experience and more like an object of an experience.

One could see this as a loss of phenomenal transparency, not concerning the contents of perception, but regarding the normally transparent control of sensory attenuation and ensuing attention. The 'I' becomes overly self-aware and 'stands in the way'—so to speak—between the agent and its own bodily self and surroundings. An example may help make this point clearer: think of an experienced tennis player that in the middle of a game voluntarily enhances her awareness that it is 'I' generating the percepts and actions entailed by playing. Such an overt metacognitive self-awareness will significantly impact the quality of her playing: by allocating resources to the metacognitive self-awareness of an 'I' at the centre of one's perceptions and actions, the tennis player disrupts the transparency of one's basic sense

of self. These alterations may account for the simultaneous diminished sense of self (the self-as-subject of an experience) and enhanced metacognitive self-awareness (the self-as-object of an experience) over one's perceptions and actions: "*I feel sometimes that it's not me who sees the things I see in a way. I know it's me, but it feels like my consciousness is somewhere else, as if I'm not experiencing the things I see*" (Værnes et al. 2018: 202).

In becoming aware of self- and world-modelling itself as a process being controlled by a 'self', the latter is perceived simultaneously as being (a) an 'other' external agent; and (b) *my* internal self. The self-modelling process becomes attended, or 'opaque'. An important corollary of having alternative self-models in play is that one immediately introduces uncertainty about which model is fit for purpose in explaining the sensory data. The capacity to entertain uncertainty about 'what sort of self I am', may also explain the stress and negative effective valence associated with depersonalisation. This follows from the fact that all the available evidence suggests that negatively valanced experiences and stress can be traced back to a loss of confidence or certainty in representations of how to engage actively with the world (Badcock, Davey et al. 2017, Peters, McEwen et al. 2017). In one sense, perhaps the most fundamental sort of stress would be associated with the existential uncertainty about "the sort of me that I am".

To use the (metaphorical) example: the loss of transparency occurs when one realises one is looking through a window because the glass has broken. Furthermore, the system's inability to process transparently self-related information (to 'attenuate' or 'dis-attend' the self), may trigger compensatory attempts to respond by over self-attending and hyper-reflexivity (Parnas and Sass 2003; Fuchs 2005) via enhanced self-scrutinization and self-monitoring strategies.

For example, an enhanced tendency towards obsessional self-checking of one's internal states has been consistently reported by DPD patients (Torch 1978; Hunter et al. 2003, 2004; Medford et al. 2005; Simeon & Abugel 2006; Ciaunica, Pienkos et al. 2021). 'How do I feel now?', 'Who am I', 'Why do I feel the way I feel?': these existential, philosophical questions on the nature of the 'mind', 'self', 'existence' and 'reality' are very common in DPD, who are often drawn to ruminative and over-intellectualization of their inner workings. Patients' attention is monopolized by the strangeness of one's internal states, triggering simultaneously inner turmoil and non-responsiveness to external world (Hunter et al. 2003).

Some sixty years before Dugas, Zeller reported five patients who complained about "a total lack of feelings, as if they were dead ... they claimed they could think clearly, and properly about everything, but the essential was lacking even in their thoughts ..." (Zeller, 1838, trans. in Berrios and Sierra, 1997). As an individual experiencing DPD strikingly puts it : "*I don't have any emotions - it makes me so unhappy"* (Medford 2012). As Medford notes, this may seem self-contradictory, but on further questioning, the patient explained that he experienced considerable *inner* turmoil, related to his experience of being altered and 'not himself', but felt little or no emotional response to *external* events or other people.

This description fits with a report described by Ackner in 1954, where he notes increased responsiveness for anxiety of internal origin, whereas that of external origin is reduced (quoted in Medford 2012). It has been suggested that DPD may be related to a form of *pathological attentional bias* and atypical multisensory integration of self-related information, in which

aberrant salience is misattributed either to internal (interoceptive) bodily signals or external (exteroceptive) information (Hunter et al. 2003; Medford 2012; Sass et al. 2013).

Interestingly, these observations are in line with previous work showing that passivity symptoms can be linked to an altered sense of agency in schizophrenia patients. For example, a stronger self-attribution bias—individuals' misperception of a limb as being their own (Farrer et al. 2003; Tsakiris et al. 2005)—has been found in schizophrenia (Daprati et al. 1997; Franck et al. 2001).

§4 Mechanisms behind failures of sensory attenuation in depersonalisation

The specific mechanism behind a failure of sensory attenuation in DPD is currently an open question. Here, we hypothesize that a core mechanism involves imbalanced precision weighting towards self-priors, leading to the inability to flexibly update the self- and world-models as new information is accumulated. These disruptions may be linked with an aberrant higher precision allocated to internal milieu (e.g., interoceptive) signals, resulting in enhanced self-focus and inability to attenuate self-induced stimulation and actions. A detailed mathematical description of aberrant self-modelling in DPD is beyond the scope of this paper and will explored in future work (Authors et al., in prep. See Fig 1.).

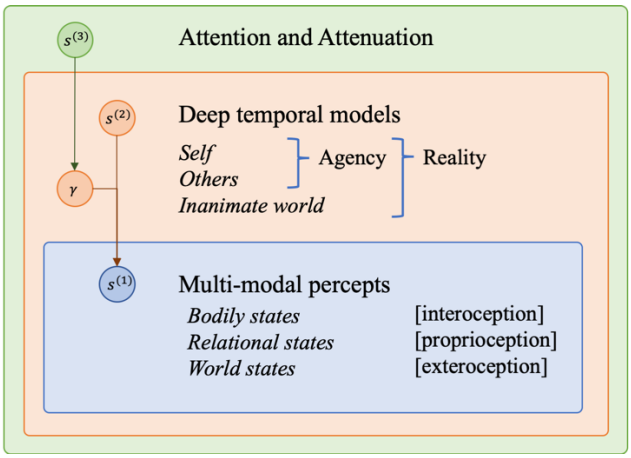

Figure 1. This simplified generative model illustrates the inferential process of explaining *multi-modal percepts* ($s^{(1)}$; blue) in terms of *deep temporal models* ($s^{(2)}$; orange) for which the precisions γ are set by higher-level states of *attention and attenuation* ($s^{(3)}$; green). Self and Others are models of agency (or intuitive psychology), which often exhibit large degrees of overlap (Friston & Frith, 2015), while one's model of the inanimate world is governed by intuitive physics (see Ullman et al., 2017). The highest level performs Bayesian model selection to guide inferences about which combination of the deep temporal models (Friston et al., 2017) provides the best explanation of the multi-modal percepts of one's body (interoception; Seth et al. 2013; Allen et al., 2019), world

(exteroception; Parr et al., 2019). For a computational implementation of Bayesian filtering with multiple internal models, see the work by Isomura, Parr, & Friston (2019). Such models are temporally deep in the sense that they involve Bayesian inference on multiple time scales (Ramstead, Badcock, & Friston, 2018; Hesp et al., 2020): observations in 'real-time' inform beliefs about lower-level parameters (intermediate time scales), which in turn allow for updating beliefs about higher-level parameters (successively larger time scales).

Adaptive behaviour depends on optimal balance between top-down and bottom-up driven attention over self- and world-induced sensory signals. The hypothesis that DPD seems to be imbalanced towards bottom-up modes is supported by evidence suggesting a stronger impact of exogenous attention and underlying neuronal abnormalities in these pathways in DPD (Corbetta & Shulman 2002; Simeon et al. 2000). Empirical support for this disrupted bodily sensory processing comes from studies that demonstrate disrupted physiological responses in patients with DPD, compared to healthy participants (Sierra et al., 2002; Dewe et al., 2018; Owens et al., 2015). Another study found altered attentional functioning at early sensory stages in depersonalisation but not in anxiety-and depression-matched patients (Schabinger et al. 2018). DPD has also been linked to disrupted activity in neuronal regions underlying somatic processing (Lemche, Brammer, et al., 2013; Medford et al., 2016) and the vestibular system (Jáuregui Renaud, 2015), which is responsible for providing information about the body's position in space (Ferrè & Haggard, 2016). Also, Farmer and colleagues (2020) used the visual remapping of touch (VRT) paradigm to explore self-bias in visual–tactile integration in non-clinical participants reporting high and low levels of depersonalisation experiences. They found disrupted integration of tactile and visual representations of the bodily self in those experiencing high levels of depersonalisation and argued that disruptions in multisensory perception of the self may underlie the phenomenology of depersonalisation.

It has been proposed that DPD may be related to abnormal activation in the posterior parietal cortex, an area important for body ownership (Ehrsson et al., 2005; Ionta et al., 2011). Furthermore, differences in the processing of signals from inside the body have also been reported in DPD (Sedeno et al., 2014; Schulz et al., 2015). (Though see Lush et al, 2020, and Lush, 2021 for alternative explanations of ownership results, and discussion of potential confounds created by demand characteristics.)

The core mechanistic pathophysiology of aberrant precision weighting underlies a number of specific hypotheses connecting this mechanism to the phenomenology of DPD.

First, a failure to attenuate interoceptive and exteroceptive self-related sensory signals would lead to an increase in interoceptive sensitivity and accuracy, to the detriment of a balanced and optimal coupling between signals coming from inside and outside one's body, which is considered to be a key component of bodily self-consciousness (Park & Blanke 2009). This may also transcend into the exteroceptive domain. For example, we anticipate that DPD correlates positively with over-sensitivity to visual and auditory sensory self-related signals (e.g. seeing one's face in a mirror, or hearing one's voice on a recorder). These alterations may trigger sub-optimal behaviours, which may lead to inhibitory, uncanny effects. As one patient with DPD puts it: "*The loss of the sense of self is a constantly perturbing experience. Looking at my face in the mirror feels like an uncomfortable staring contest with a total stranger*" (Perkins 2021:41). Intriguingly, these sensations of self-estrangement seem to be closely linked with feelings of disembodiment and detachment from the reality: "*I look in the mirror and it doesn't feel like myself I'm looking at. It's like I'm floating, not actually*

experiencing the world, and slowly fading away into nothing. It's like I'm on autopilot in somebody's else body" (Perkins 2021 :198) (see also Simeon and Abugel 2006; Sierra 2009).

Second, given that aberrant somatosensory attenuation may lead to hyper-reflexivity and over-intellectualisation of one's experiences, we predict that people with high level of depersonalisation will report to feel closer to their 'former' or 'normal' self during their dreams (Gillmeister & Ciaunica, in prep). This is because in their awake life, over-mentalization fuels abnormally their self-models, preventing them to feel fully in touch or immersed in their daily lives. By contrast, this hyper-reflexivity is diminished during the non-awake life, which should lead to an increase of their transparent self-modelling and consequent feelings of being again in touch with their 'old' self.

We also anticipate that people with high-levels of depersonalisation experiences will show a modulation of the magnitude of self-prioritization of self-associated bodily (avatar faces) versus abstract stimuli (geometrical shapes) in the sequential matching task (Woźniak, Kourtis, Knoblich, 2018; Woźniak, Hohwy, 2021). Specifically, we predict that depersonalisation individuals will show less of the self-prioritization effect than the typical controls in the self-associated *bodily* task (avatar faces). However, they will perform equally as the typical controls in the self-associated *abstract* task (geometrical shapes) (Woźniak et al. in prep). This is due to the fact that processing and integrations of bodily-related signals is impaired in DPD, while the processing of mentalistic (abstract) self-related processing is enhanced (hyperreflexivity). Along the same lines, we predict that activities involving high level and abstract cognitive abilities (e.g., participating in e-meetings via digital platforms such as Zoom, Skype, playing computer game, etc.) will be positively correlated with higher levels of depersonalisation. By contrast, more basic and 'humble', body- and movement-based abilities (e.g., manual workings, physical exercise, etc.) will be positively correlated with low levels of depersonalisation (Ciaunica et al. in prep). Again, experimental tests of these ideas will have to be careful to exclude potential confounding effects of demand characteristics.

Finally, one would anticipate that people with depersonalisation disorder should show failures of sensory attenuation. In other words, they will show reduced psychophysical and electrophysiological response differentials to stimuli caused by self and other, in relation to typical controls. They will also show a different pattern of responsiveness regarding affective touch. From previous literature, gently stroking the skin at a medium velocity (3-10m/s, Löken et al., 2009) activates a special subclass of receptors that code for pleasant touch. We predict that people with high levels of depersonalisation experiences will rate affective touch experiences as significantly less pleasant and less vivid than the typical controls (Ciaunica et al. in prep). As above, demand characteristics would again have to be controlled for, or ruled out, in experimental tests.

Notice that all of these predictions relate to the primary pathophysiology that may underwrite depersonalisation disorder, not the phenomenology (given appropriate control conditions, especially regarding potential confounds due to demand characteristics). At the phenomenological level, these observations point to a stance of self-objectification (Sass & Parnas 2003; Fuchs 2005; Ciaunica et al. 2020), underpinned mechanistically by atypical self-modelling due to aberrant precision control and failures of sensory attenuation in DPD.

Crucially, unlike in the case of psychosis, in DPD the meta-awareness state 'It is I who experiences this split" remains intact, which may explain why the depersonalisation patients don't 'buy' into the self-detachment story itself, and remain dramatically aware of the subjective nature of the experienced split (i.e., reality testing intact). This intact awareness may explain why "the distressing complaints of patients with depersonalization do not seem to be accompanied by observable changes in behavior" (Sierra 2009:132). It is crucial however to better understand the experience of depersonalization because, as one person with DPD strikingly puts it "*a disorder that makes you feel invisible, is invisible in society*" (Perkins 2021:193).

Conclusion

In this paper, we have examined some potential mechanisms behind an atypical sense of self and sense of agency in Depersonalisation Disorder (DPD), a condition in which people experience a 'split' or detachment from oneself, one's body and the world. We built upon the idea that somatosensory attenuation is typically accompanied by a feeling that one is in control of one's perceptions and actions (i.e., feelings of agency). Consequently, failures of somatosensory attenuation may disrupt the sense of agency over one's perceptions and actions in dissociative disorders such as psychosis, whereby the individual may believe that another agent is controlling their thoughts, perceptions or actions (i.e., passivity phenomena). By contrast, in depersonalisation we suggested that individuals may believe 'another agent' is controlling their thoughts, perceptions or actions, while maintaining full insight that the 'other agent' *is* 'me' (the self).

We have proposed that atypical self-modelling—underpinned by aberrant precision control and sub-optimal sensory attenuation—disrupts the *transparency* of basic, pre-reflective forms of self-awareness in Depersonalisation Disorder. Failures of somatosensory attenuation and consequent abnormal percepts and beliefs may lead, in turn, to self-opacity. Ensuing subjective feelings of 'losing touch' with oneself, body and the world may occur (Simeon & Abugel, 2006; Ciaunica & Charlton, 2018). This split may be responsible for the both the sense (a) self-detachment, of looking to oneself from the outside, from the "back of one's eye sockets"; and (b) unrealness, often and strikingly reported by DPD patients as 'having a pane of glass' or 'veil' interposed between one's self, body and the world (Simeon & Abugel, 2006; Ciaunica & Charlton, 2018).

If our argument is correct, then future research could usefully assess whether active multisensory engagements with the world and others via body-based, dynamic proximal (tactile and olfactory) interactions enhance the sense of self, realness and presence in people with DPD. We hypothesise that close and dynamic physical and synchronous interactions with their environment will make DPD people feel more present in their bodies, and less 'trapped' in their minds. This is because, paradoxically, in order to get closer to one's self, one needs to feel safe enough to be able to 'forget' oneself, and to focus instead on (inter)acting with the world and others, via proximal multisensory interactions (Ciaunica et al. 2021).

The emphasis thus needs to be placed on what connects us to ourselves and reality, as opposed to what separates us from it. As Ratcliffe insightfully notes: "talk of feeling detached from body and world might best express an all-pervasive feeling of estrangement but, importantly, that feeling is *itself* a way of experiencing the body-world relationship and so one has not actually escaped from body and world at all" (2008:131). We must thus use this fundamental openness to the world as a powerful tool to repair the 'lost' connectedness to oneself. For example, by training people to repair and adjust the overweighted balance towards the inner mentalistic self, by actively and dynamically engaging with their close sensory environment via their bodily self.

This observation is supported by self-reports from DPD individuals indicating that their dissociative experiences usually trigger distressing existential questions about the nature of their 'self', of the reality and the meaning of the existence itself. This existential questioning is, in most of the cases, overwhelming, and impeded the individual to simply 'be there' and enjoy life and experiences directly, as they unfold. As a recovering DPD patient strikingly expresses it:

> "*It came the moment where I realised that I was fully inhabiting every moment of my life, and that I couldn't induce a feeling of depersonalisation if I tried. That was a moment of such indescribable joy, and it's a memory that I try to hang on to when things get tough. I remember sitting at my tiny kitchen table in my studio flat, and not feeling the need to achieve or function or engage. I sat at the kitchen table for over an hour, just being. Just living"* (Ciaunica & Charlton 2018).

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