Rev.Phil.Psych. (2019) 10:381–400
DOI 10.1007/s13164-017-0335-6

Predicting the Self: Lessons from Schizophrenia

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Published online: 27 April 2017

Abstract Newly developed Bayesian perspectives on schizophrenia hold out the promise that a common underlying mechanism can account for many, if not all, of the positive symptoms of schizophrenia. If this is the case, then understanding how schizophrenic minds go awry could shine light on how healthy minds maintain a sense of self. This article investigates this Bayesian promise by examining whether the approach can indeed account for the difficulties with self-awareness experienced in schizophrenia. While I conclude that it cannot, I nonetheless maintain that understanding how the self breaks down in schizophrenia tells us much about how and why the self functions in normal human circumstances. I proceed first by recounting in some detail a Bayesian interpretation of perception, schizophrenia, and self-awareness, as well as some of the empirical data supporting this interpretation, then by exploring aspects of schizophrenia that this approach leaves out. I conclude by discussing what the "left out" aspects tell us about self-awareness, thereby (I hope) convincing the reader that studying patients with schizophrenia is indeed a useful avenue for understanding awareness of self.

Self-awareness is the kind of awareness that underlies our standard, first-personal attributions of conscious states and actions. It is an awareness–often just in the background – of being an agent who interacts with the world, though that awareness can be quite vague and nascent.[1] Disturbances in self-

[1]Some suggest that we should understand this concept as a "minimal" notion of self, a bare awareness of being embodied (e.g., Gallagher 2000, Blanke and Metzinger, 2009, Metzinger 2013; see also Blanke 2012 [I note that some disagree over whether Metzinger and others offer something a bit richer than a bare awareness of being embodied.]), upon which richer notions of self and consciousness could be built. However, for the purposes of this paper, I am taking self-awareness to be more than this minimal notion; self-awareness also includes reflexivity. It requires some sense that there is an "I" who is having the conscious states or engaging in actions. This would be closer to Tulving's notion of the "autonoetic self" (Tulving 1985).

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awareness can intuitively seem quite strange, for, in its most basic form, it appears to be a fundamental aspect of our conscious experiences. This experience of a blue square is the experience that I am having now; I know this because I am the one having it. And I know it in a raw and immediate way (see Zahavi and Kriegel 2016 for a careful discussion of what this sense of "mine-ness" amounts to in our conscious perceptions). How is it that one could be confused about what the "I" is thinking or perceiving?[2] And yet, it appears that certain mental disorders, like schizophrenia, can give rise to that error quite regularly.

Schizophrenia is not particularly rare – it has a lifetime risk of about 1% (McGrath et al. 2008) – but its constellation of so-called positive and negative symptoms are at once baffling and devastating. In addition to hallucinations, delusions, flat affect, social isolation, and motor impairments, patients suffering from schizophrenia also have markedly impaired first-person awareness[3] (Hur et al. 2014, Parnas et al. 2005, Sass and Parnas 2003; see also Mishara et al. 2016). Investigating these patients and their positive symptoms has been an important avenue in studying the nature of self, for it allows us to see where Nature's joints are, as it were. However, because patients with schizophrenia also suffer from deficits that have nothing to do with self-awareness, it is not clear that they then constitute a good, or even an appropriate, probe for understanding our first-person attributions.

Newly developed Bayesian perspectives on schizophrenia hold out the promise that a common underlying mechanism can account for many, if not all, of the positive symptoms of schizophrenia. If this is the case, then understanding how minds of patients with schizophrenia go awry could shine light on how healthy minds maintain self-awareness. As Andy Clark explains in his new book *Surfing Uncertainty*, Bayesian brains are nothing more than "probabilistic prediction machines" (Clark 2016, p. 167; see also Frith 1997). Perception is a success term in that our brains try "to generate (at multiple spatial and temporal scales) the incoming sensory signal for itself. When … a match is established, we experience a structured … scene" (Clark 2016, p. 14). This process includes predicting what we are doing in our environment and then how the environment responds to and impinges on us. If the Bayesian perspective is correct, then the "I" becomes a construct our brains create to explain and predict our actions in the world – at least according to Clark. By studying how and why these predictions break down, we should learn more about the conditions under which these constructs are successful.

This article investigates this Bayesian promise by examining whether the approach can indeed account for the difficulties with self-awareness experienced in schizophrenia. While I conclude that it cannot, I nonetheless maintain that understanding how self-

[2] I am not going to define here what the "I" is exactly, because my arguments should go through regardless of how one conceives of the self. Even if one considers the self a Humean illusion, it is still an illusion that we use in explaining our own thoughts and behaviors. I myself have previously argued for a narrative conception of self (Hardcastle 1999, 2003a, b; 2008; see also Damasio 1999, Dennett 1992, Flanagan 1996, Gallagher 2000, Hardcastle and Flanagan 1999, Ricoeur 1990/1992, Zahavi 2014) and have described how we can relate difficulties with self-narration to various mental disorders (Hardcastle, 2003a, b; Hardcastle and Flanagan 1999).

[3] These disturbances include depersonalization, diminished sense of existing as bodily subject, distortions of first-person perspective, identity confusion, reduced sense of coherence, and confused self-other/self-world boundaries (Parnas et al. 2005).

related properties break down in schizophrenia tells us something about how self-awareness functions in normal human circumstances. I proceed first by recounting in some detail a Bayesian interpretation of perception, schizophrenia, and self-awareness, as well as some of the empirical data supporting this interpretation, then by exploring aspects of schizophrenia that this approach leaves out. I conclude by discussing what the “left out” aspects tell us about self-awareness, thereby (I hope) convincing the reader that studying patients with schizophrenia is indeed a useful avenue for understanding awareness of self.

1 Perceiving the World

Bayesian interpretations of learning and perception are becoming increasingly popular (Shanks 2006).[4] In general, Bayesians (and lots of other theorists as well) hold that our perceptions of the world are formed in part by the context surrounding the incoming stimuli and by how previous experiences (and their contexts) have shaped potential brain responses (Friston 2005a, b; Friston et al. 2006; George and Hawkins 2009; Gregory 1997; Hedges et al. 2011; Mumford 1992; Rao and Ballard 1999; Yellott 1981). The basic idea, which dates back to Helmholtz (1871), is that perception is inferential. Our experiences of events in the world depend on what we expect our experiences to be, which shapes how we interpret incoming sensory stimuli. These interpretations can then alter our future expectations, depending upon how accurate our prior expectations turned out to be.

Sensory stimuli, taken individually and by themselves, are inherently ambiguous. In order to move from this uncertainty to a stable representation of the environment, Bayesians hypothesize that we combine our sensory inputs with our prior knowledge of the world, and the likelihood that our guess about what the sensory information is plus worldly knowledge gives us an accurate prediction about what we are currently perceiving. Doing so allows us to make our best guess about what is happening in the world around us. We can then test that hypothesis by interacting with the world. The results of this test then feed back into our predictions and likelihood estimates.[5]

By and large, the Bayesian framework considers perception as a hierarchical inference process, with more abstract (higher) levels generating expectations and sending them down the cortical hierarchy (a top-down process) toward sensory representation. Meanwhile, sensory evidence climbs up the hierarchy (a bottom-up process) and activates these higher levels representations. In this way, top-down expectations are

[4] I should note that, even though Bayesian approaches are of interest they are still rather controversial. See especially Firestone and Scholl 2016; though see also the 2016 special issue of *Consciousness and Cognition* on cognitive penetration and predictive coding, especially O’Callaghan et al. 2016, and other references following. And, of course, there is a multitude of different ways in which scientists use Bayesian ideas in their theorizing. I am not going to engage in the question of whether Bayesian approaches in general are correct, nor am I going to advocate for any particular version of Bayesianism, but instead I confine myself to the question of whether this type of approach could help us understand problems of self-awareness in schizophrenia.

[5] Bayes’s theorem states that:

$p(\theta|x) = p(x|\theta)p(\theta)/p(x)$.

Relative to perception, we can interpret Bayes’s theorem as: $p(\theta|x)$ is the probability that perception θ is true, given sensory input x; $p(x|\theta)$ is the probability of sensory input x given θ; and $p(\theta)$ is the prior probability of θ before the sensory evidence x has accrued.

constantly updated to account for new sensory evidence, and sensory inputs are influenced by evolving top-down predictions.

One example of how our perceptions are influenced by top-down expectations is the experience of apparent motion (Tse and Cavanagh 2000). For most people, two stationary stimuli rapidly blinking in alternation are perceived as one object in motion. We integrate the two stimuli inputs into a percept of a single thing moving back and forth based on (unconscious) inferences about what these alternating stimuli likely signify (Sigman and Rock 1974). Things move back and forth in our world more often than they wink on and off.

Another example is shown in Fig. 1. Most normally read this sentence as, "We went to the event sponsored by the Women in Philosophy Study Group." However, if you look closely, you will notice that both underlined words in the figure are identical. We interpret the first one as "went," and the second one as "event," because that is what the context of the sentence demands.

Normally, we would learn about our world by using mismatches between our prior expectations and the actual inputs. Over time, as we adjust our expectations based on our errors in prediction, we are able to formulate more precise estimates about the worldly causes of our stimuli inputs. We create models of the world (beliefs) by using prediction error as feedback on our best "guesses" about what our environment contains. Our cognitive goal is always to minimize prediction error about our environment and our interactions in it.

Common examples of the sort of cognitive mismatches described above we probably have all experienced in everyday life include believing there is one more step in the flight of stairs you are ascending, when in fact you have reached the top, or interpreting the train you are sitting on as moving instead of the train next to you moving in the opposite direction. In cases such as these, we experience a moment of startled "perceptual incoherence" (Postmes et al. 2013), in which our world feels decidedly weird before we right our interpretations of it.

Several models of psychosis and schizophrenia have used this sort of Bayesian-type perspective to explain hallucinations and delusions (the positive symptoms of schizophrenia). These models generally hypothesize that psychosis occurs when mismatches between prior expectations and incoming stimuli are not fed back up the system to correct posterior expectations or when prior expectations are not sent downstream to inform stimuli interpretations. So, for example, patients with schizophrenia are less likely to perceive the illusion of apparent motion described above, which indicates that they rely less on inferences in perception than controls (Sanders et al. 2013). (I do not know how they might read the sentence in Fig. 1, though Rothbaum et al. 1979 suggests that they would have difficulty interpreting it.) Interestingly, they are able to trace the presumed path of the illusory motion if prompted, which suggests that the higher-level inferences are there, but they are not being integrated into

Fig. 1 Ambiguous sentence

perceptual content.[6] From a Bayesian perspective, one would say that these patients place greater relative confidence in the incoming stimuli and less in any top-down inferences or interpretations (Adams et al. 2013; Corlett et al. 2010).

A biologically plausible way of explaining how this change in confidence level might occur in schizophrenia is to hypothesize an excitatory-inhibitory disequilibrium in the brain's hierarchically structured neural circuits.[7] In this case, instead of making only one prior prediction for each sensory input pattern, these brains could start propagating sensory inputs and sensory predictions in a "circle." As a consequence, they could start interpreting prior beliefs as occurrant sensory inputs and sensory inputs as prior beliefs (Jardi and Deneve 2013). If the imbalance causes sensory inputs to reverberate while prior beliefs do not, then one would prioritize the inputs over expectations (Notredame et al. 2014).

A different way of looking at these phenomena is that patients with schizophrenia have problems with the global organization or the "Gestalt" of a set of sensory inputs (either over time or across space).[8] We can see this sort of difficulty in patients' decreased susceptibility to the hollow-mask illusion, a visual illusion of the appearance of a normal convex face instead of implausible concave face stimuli (Emrich 1989; Gregory 1973; Notredame et al. 2014; Schneider et al. 2002). Because they rely less on top-down, conceptually driven, strategies (Fletcher and Frith 2009; Garety et al. 1991; Hemsley 1992), their experiences are largely uninformed by their predictions of what is in the world around them, such as convex faces instead of concave ones. They cannot use their theoretical models of the world to interpret incoming stimuli correctly, which means that they perceive concave face stimuli as being concave, instead of being convex, as normal controls would (Hemsley 1994, 2005).

My only point here is that Bayesian models suggest that patients with schizophrenia relate sensory inputs to prior expectations sub-optimally. This impairment leads them to experience the world differently from healthy controls, as well as have more difficulty in predicting their world than healthy controls. And there are some robust brain data that support these very broad claims.

Event-related potential (ERP) brain data confirm patients' difficulties in predicting their environment. In general, averaged EEG recordings from normal subjects show a positive ERP deflection approximately 300 msec after stimulus input (the "P300" response) when they are confronted with an "oddball" or surprising event. Patients with schizophrenia do not show this effect. More than a hundred replications and extensions of a reduced P300 waveform in patients with schizophrenia have been published since the effect was first described (Ford et al. 2010). It is likely the most reproduced neuropsychological effect in all of schizophrenia research (Bramon et al.

[6] We see similar impairments in action sequencing in patients with schizophrenia (Delevoye-Turrell et al., 2007, 2012, Jorgens-Kosterman et al., 2001). Giersch et al. (2016) argues that the timing difficulties in both action and perception are likely due to a common mechanism.

[7] This model has been linked to abnormalities in the glutamate and GABA systems in patients with schizophrenia (Adams et al. 2013, Corlett et al. 2010, Giersch et al. 2016, Notredame et al. 2014, Seymour et al. 2013).

[8] This inability to use associated information in schizophrenia appears to start quite early in sensory processing. For example, Seymour et al. 2013 have shown that contextual modulation to visual orientation information in V1 (primary visual cortex) is significantly reduced in patients.

2004). That patients have an attenuated P300 response to surprising stimuli tells us that they have difficulties processing relevant context for incoming stimuli, for one needs context in order to determine unexpectedness.

When subjects are aware of context as set up by local probabilities, they will expect a certain event to occur. When it does not, the unmet expectancy elicits the P300 response. This effect occurs even when what the subjects have learned to expect is an infrequent event (Ford et al. 2010). For example, if they have repeatedly heard four of the same sequences of tones, which are directly followed by a different sequence, then when they hear three sequences of the original same tones, they then expect one more sequence of same to be followed by a sequence of different. If the same tones occur for the fifth time, a P300 response is produced, even though the tones themselves in the fifth repeat are not unusual. They are, however, unexpected, given the local context.

Patients with schizophrenia do not exhibit a P300 response in these conditions either. That they do show normal P300s to isolated sounds occurring with long inter-stimulus intervals (such that there is no context for developing an expectation of their occurrence) (Ford 1999, Shelley et al. 1996) suggests that these patients are indeed failing to use local context to predict local events (see also Ford et al. 2004 for similar results using a Go-No Go paradigm). In short, patients with schizophrenia cannot discern that something is unlikely to happen using evidence that it is unlikely to happen.

As a result, we can see that the mismatch or prediction violation effects in patients with schizophrenia are not failures to detect surprising stimuli, which is what they would normally index, but instead are failures to detect or predict *unsurprising* stimuli (Adams et al. 2013). Failing to predict incoming stimuli means that everything becomes surprising – nothing is singled out as being unusual because everything is strange (Kapur 2003; see also Adams et al. 2013, Whitford et al. 2012).

Norma McDonald, who had schizophrenia, describes her sudden fascination with the details of world around her as her mental illness worsened:

> It was as if parts of my brain "awoke" which had been dormant, and I became interested in a wide assortment of people, events, places, and ideas which normally would make no impression on me. …I made no attempt to understand what was happening, but felt that there was some overwhelming significance in all this…, and I felt that I was duty-bound to ponder on each of these new interests, and the more I pondered the worse it became. The walk of a stranger on the street could be a "sign" to me which I must interpret. Every face in the windows of a passing streetcar would be engraved on my mind, all of them concentrating on me and trying to pass me some sort of message.
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> MacDonald (1960, p. 218)

Clark describes this effect as a disturbance in the generation of bottom-up prediction errors. Persistent prediction errors signal to the person receiving them that their causes are important events in world. These "highly weighted 'false errors'" (Clark 2016, p. 80) force revisions in the person's model of the world, even as that model does little to inform future predictions. Patients then compensate with decreased confidence in their sensory inputs, which leads to more mistakes in their inferences regarding the structure of environment. Moreover, there is no way for system to assess its own reliability "for precision-weighting on prediction error already reflects systemic estimations of the reliability … of signals at every level of processing" (Clark 2016, p. 201; see also see also Hohwy 2013, p. 47). As a result, the patients' perceptual incoherence is on going, and they continually struggle to make sense of their world. Unlike normal interactions, in which instances of perceptual incoherence are fairly quickly righted, persons with schizophrenia must live in a world in which at best faint expectations are regularly being thwarted.

These types of errors entail that the world would be perceived and experienced very differently than with a fully functioning Bayesian learning system (see, e.g., Gray et al. 1991). It is not at all surprising that with such errors, what would otherwise normally be perceived as irrelevant background information could suddenly take on special salience and would therefore capture attention and require an explanation for its newly discovered importance (Fletcher and Frith 2009; Friston 2005a, 2005b; Freedman 1974; Kapur 2003; McGhie and Chapman 1961; Young 2008). To manage this dissonance, patients create sensory surrogates to help support their redrawn interpretations and predictions in order to figure out what is "wrong" in the world (Horga et al. 2014; Wilkinson 2014). These then generate false perceptions, or hallucinations, which reinforce their erroneous model of world in a "coherent and mutually supportive cycle. … False inferences spiral and feed back on themselves" (Clark 2016, p. 80).

As Fletcher and Frith (2009) comment, "The repeated occurrence of the faulty signal in essence may render the world baffling and unreliable, providing even greater challenges to the sufferer's explanatory models. The resultant inferences become limited in their richness and bizarreness only by the boundaries of the individual's imagination" (p. 56). In addition to hallucinations, incorrectly interpreted sensory stimuli can change beliefs about the environment so much that patients develop severely mistaken worldviews (Fletcher and Frith 2009; Pally 2005, 2007). They experience things that are not there and then create a false model of the world to explain the things that they are experiencing. Because these beliefs are in effect detached from stimuli inputs from the actual environment, it becomes quite difficult to amass any data that might demonstrate their falsity.[9] They are delusions, in other words.

One well-known example of how patients develop different beliefs about the world than controls is through their tendency to jump to conclusions (Garety et al. 1991; see also Joyce et al. 2013): they see patterns in the world that are not there (or at least that the rest of us cannot see) and they maintain their beliefs in those patterns, come what may. In a common experimental paradigm, patients or subjects are confronted with two urns, each of which contains red balls and blue balls. One urn contains about 80% red balls and the other about 80% blue balls. Balls are removed one at a time from one of the urns and the patient or subject has to decide which of the two urns had been selected. Patients with schizophrenia make their decisions on the basis of less evidence and are more convinced of their conclusions – even despite additional balls being

[9] In contrast, circular inference approaches would say that top-down expectations reverberate more than bottom-up stimuli, thereby leading to the inability of stimuli inputs to correct predictions about the world (Notredame et al. 2014). See also Schmack et al. 2016 for new imaging evidence in support of a predictive signaling approach to explaining for delusions.

drawn from the urn – than control subjects (Bentall et al. 1991; Warman 2008; Woodward et al. 2008). It is not hard to see how such patients could assume false things to be true and hold onto these false beliefs despite disconfirming evidence. Just as with delusions, patients are unable to use stimuli inputs to correct top-down expectations about their world.

These false perceptions, interpretations, and beliefs extend to experiences of self-awareness as well. As mentioned above, disorders of self form a primary component of the symptomatology for schizophrenia. Patients are challenged in seeing themselves as the authors of their thoughts and behaviors, or even in experiencing themselves as a continuous and unique agent who exists across time. They often feel as though other beings are controlling them, which is likely them misattributing their own thoughts and actions to someone or something else. Their sense of self and of agential capacities are diminished as the world around them and its causal powers seems to grow in comparison. Allow me to explain.

All animals have mechanisms that permit them to suppress incoming stimuli resulting from their own motor actions, implicitly tagging them as being their own (cf., Crapse and Sommer 2008; Curio et al. 2000; Houde et al. 2002; Martikainen et al. 2005; Ford et al. 2007a, b; see also Shergill et al. 2003).[10] Among other things, this allows us to predict our own behaviors precisely, which reinforces our sense of authorship and control over personal activities. We can measure this effect in humans through an attenuated auditory N100 ERP response to personally generated speech as compared to other generated speech sounds (Ford et al. 2007a, b). Patients with schizophrenia, however, lack this response, which suggests that they are unable to predict their own speech sounds when they talk (Ford and Mathalon 2012). One consequence of this failure is that patients can interpret the surprising speech sounds as coming from something other than themselves.[11]

Consider, for example, Peter Chadwick's description of his faltering sense of self-control as he succumbed to increasingly paranoid delusions:

> I sat in my room thinking that somehow it felt as if there was a black hole in my mind. Then … then the record "Black is black" which was in the charts at the time, came on the radio. Yet another confirmatory synchronistic event, as if by magic, from the radio…. "Obviously" there was indeed an Organisation of technological experts, informed by past enemies, the neighbours and maybe by newspaper personnel, out to monitor and predict my thoughts and then send in replies by the radio.
>
> (Chadwick 1993, pp. 247-248)

[10] I note that not all Bayesian models take into account the mechanisms believed to be behind self-monitoring: efference copies of motor commands and corollary discharges from expected sensory. For example, Pickering and Clark's (2014) Auxiliary Forward Model explicitly relies on these mechanisms to compute sensory consequences, while their Integral Forward Model does not. Wilkinson (2015) offers reasons to accept the IFM over the AFM, especially in explaining psychotic symptoms. Given the brain's tendency toward functional redundancy, I do not see why it could not exploit both models in trying to predict its world.

[11] Langland-Hassan (2016) argues that we can fail to recognize speech as our own without needing the full Bayesian apparatus of comparing predicted stimuli to actual stimuli.

Instead of feeling he was generating his own thoughts, he perceived his mind as a void, while an external group anticipated his thoughts and sent evidence that they were doing so via the radio. As he explains later in his article, this outside group was attempting to "reform" him, which they fail in doing. Their only recourse was to "induce" him to kill himself (p. 248), which he then tried to do by walking in front of a bus, as instructed by what seemed to be external commands:

> A man came out of a side office, turned round and said back to the manager who was in there, "So he's got to do it by bus then?!" "Yes!" came the reply. … That was indeed how I had to do it. Everything, even trivia, had so much meaning. … [P]retty well everything said around me at that time seemed at least "relevant." This strengthened and confirmed the idea that "everyone is against me" even more. How else could it all be "relevant?"
>
> (Chadwick 1993, p. 249)

In virtue of not being able to predict incoming stimuli from their local environment, patients with schizophrenia not only are continuously surprised by what is going on around them, but these events take on additional significance. Their brains try to make sense of the confusing world by creating new models of it, though they cannot effectively use those models to now predict what is likely to happen. So they create new models to account for the new surprises, and on it goes, into an unhappy cognitive spiral that results in false perceptions as well as entrenched false beliefs. These false perceptions and false beliefs extend to themselves as well. Patients with schizophrenia cannot predict their own actions in the world any more than they can predict the actions of any other. As a consequence, they feel controlled by external sources as their awareness of self as a nexus of causal power diminishes.

We use our predictions of incoming stimuli to hypothesize the existence of an external world of mid-sized objects with particular attributes. We use the same predictions to hypothesize the existence of inner thoughts that perhaps comprise a "self" or an "I" which correlates with acts upon the world in predictable ways, and we can predict those ways based on our "reasons" for acting, which in turn are based upon our beliefs about or models of the world at large. When these predictions break down, our hypotheses about our outer and our inner worlds do as well. In this manner, a Bayesian perspective on schizophrenia can tell us something about how self-awareness operates in all of us: we become aware of a self qua active agent as we predict our own behavior successfully.

2 Remembering the Self

A Bayesian approach does seem to account for the positive symptoms of schizophrenia. However, there are additional cognitive challenges which patients with schizophrenia exhibit, beyond correctly managing perceptual errors. In particular, patients with schizophrenia have problems with memory and affect, both of which impinge significantly on experiences of self-awareness, and neither of which pure Bayesianism can easily account for.

In addition to causing failure in predicting the world, schizophrenia also appears be an illness of memory (Tamminga 2013). This conjecture is born out by structural, functional, and molecular pathologies identified in the hippocampus in patients with schizophrenia (Tamminga et al. 2010), as well as significant deficits in all aspects of episodic and working memory (Forbes et al. 2009). Impaired memory could help explain why patients make erroneous associations among concepts and perceptions, fail to use local contextual information in making decisions, and appear to discount temporally distant salient events relative to more recent ones. It could also help explain why their self-awareness is diminished. To put this in Bayesian terms, one might say that in addition to difficulties with making and using predictions, the ability to access the models that individuals with schizophrenia develop is additionally diminished or disordered. Bayesian theoretical approaches, however, generally assume accessing predictive models to be an unproblematic step in cognition, if they see it as a separate step at all.

Conceptual evidence that one might use to make decisions seems to be unavailable to the mind of persons with schizophrenia (cf., Joyce et al. 2013). Bethany Yeiser, prior to receiving any treatment her mental illness, describes her mind as "a thick cloud: … It is like I just found out a close friend died, and the shock never went away…[And] the recognition that my mind is altered makes no difference. My mind is a cloud. It prevents me from studying or working a job. I cannot concentrate" (Yeiser 2014, p. 86). As a result, despite being a college student, she spends her days sitting on a bench in a park instead of attending classes, trying to think: "I must have come to this park bench sometime in the morning. Now it is mid-afternoon, and … I am still sitting here… I am just trying to think about my childhood" (p. 125).[12]

Abnormalities in prefrontal cortex processing play a significant role in the episodic memory and retrieval impairments we see in patients with schizophrenia (Achim and Lepage 2005, Leavitt and Goldberg 2009, Ragland et al. 2009, Ranganath et al. 2008). In particular, attenuated functioning in the dorsolateral region of the prefrontal cortex, which is associated with the organization and monitoring of specific goals and their contexts, seems to be a problem (MacDonald and Carter 2003, Ragland et al. 2015). Patients with schizophrenia can perform close or identical to controls when cognitive control demands are low, but when control demands increase (e.g, by the command to remember only goal-relevant stimuli but to ignore the non-relevant stimuli), patients begin to struggle (Ragland et al. 2015; see also Joyce et al. 2013). Patients' performance goes down and they start to make mistakes when they have to adjust mentally to changing environmental demands. At the same time, the activity levels in their dorsolateral prefrontal cortex are reduced and its connections with the medial temporal lobe are weaker (Meyer-Lindenberg et al. 2005, Wolf et al. 2007). Easy memory tasks (recalling a simple but specific personal fact) become hard, and hard ones (recalling that fact in order to solve a problem) become impossible.

Similarly, a recent meta-analysis of putative implicit memory impairments in patients with schizophrenia indicated that patients showed greater impairments in conceptual priming tasks (e.g., generating category exemplars) than in perceptual priming tasks (e.g., completing word-fragments), and that tasks that required patients to encode the conceptual properties of a stimulus resulted in much greater deficits than in control

[12] In Bethany's case, after receiving appropriate medication, her positive symptoms abated and her capacity for retrieving and cognitively manipulating memories returned.

subjects (Spataro et al., 2016). These results indicate that patients with schizophrenia have difficulty with conceptual processes, both at the level of stimulus encoding and at the level of memory retrieval. ERP studies bear out this idea, for they indicate that patients with schizophrenia exhibit a hypoactivation of related concepts following a category prime, relative to normal controls (Guillem et al. 2001; Kiang et al. 2007; 2012; Matsuoka et al. 1999; Matsumoto et al. 2001). Implicit priming effects that involve conceptualization have also been localized to the frontal cortex (Henson 2003), which, as just discussed, is undersized with abnormal connections to other areas in the brain in patients with schizophrenia (Kubicki et al. 2007; Mechelli et al. 2007).

These results could explain patients' inability to exploit related information (as represented by, for example, category labels used to generate exemplars) that bias response selection in conceptual decision-making (Cohen and Servan-Schreiber 1992). In other words, it is hard to make decisions, such as whether to get up off a bench in order to find food. It is hard to conceptualize the problem, much less develop an appropriate solution. Consequently, it is difficult to be aware of self-needs – like food, hygiene, or shelter – and to act on those needs. As Bethany explains, though she was homeless and sleeping outdoors in the elements, with no possessions or means of support, she "felt provided for and happy" (Yeiser 2014, p. 145). Even though she was experiencing painful hallucinations of being stabbed in the back with a knife and she was constantly being harassed by a choir of voices whose commands she could not resist, she still thought that "life is beautiful" (p. 144).

It is difficult for purely Bayesian approach to account for these phenomena, since the capacity to build models of the world is presumed, not explained. While Bayesians may be correct and a failure in being able to predict the world can account for much of the positive symptoms of schizophrenia, that is not the full story. Impairments in working memory mean that patients cannot hold enough information in front of themselves, as it were, to formulate action plans, even misguided ones. They cannot reflect on their needs or desires, except with great difficulty, because they cannot manage complex thoughts. Though they may try, they cannot easily connect their own past to their present situation, nor can they project themselves into possible future.

Importantly, we use our memories not only to help us understand the world around us, but also to as a way to anchor our current activities in a narrative history that makes sense of our current behavior. In other words, when episodic and working memory are severely impaired, we can lose our sense of an "I" existing across time. At the limit, the world becomes a series of blinkered moments.[13] Without a robust sense of the self as a continuously existing agent across time, self-awareness is necessarily diminished.

3 Feeling the Self

Even though schizophrenia is widely regarded as a neurocognitive disorder (e.g., Andreasen 1999; Elvevag and Goldberg; 2000, Frith 1992; Green 1998; Minzenberg

[13] We can see the most extreme examples of this loss of self-narrative in patients with amnesia, especially those who have both retrospective and prospective memory loss. They feel as though they are just waking up for the first time, in the midst of a life, but without any experiences to anchor or give meaning to their present. (See discussion in Hardcastle 2008.)

et al. 2002), affective responses are quite dysfunctional in patients with schizophrenia as well. Though the psychotic symptoms of schizophrenia are the most striking, reduced affect, apathy, and anhedonia are among its most pervasive indicators – and they are strongly linked to the social difficulties from which many patients with schizophrenia suffer (Aleman and Kahn 2005). The emotional disturbances seen in patients with schizophrenia include reduced facial and verbal expressions, an inability to identify personal feelings or the bodily sensations of arousal, and difficulty describing feelings to others. That these symptoms often precede the hallucinations and delusions by several years is telling and suggest that they comprise a core feature of schizophrenia (Aleman and Kahn 2005).

Emotional dysfunction was seen as an indicator of schizophrenia from the earliest days of research on mental disorders (Bleuler 1911; Kraepelin 1919). However, from then until only very recently, the emotional difficulties were primarily taken to be a reaction to the cognitive dysfunction associated with schizophrenia and not as a primary symptom. Indeed, the DSM-IV-R (American Psychiatric Association 2000), DSM-5 (American Psychiatric Association 2013), and ICD-10 (World Health Organization 1992) all consider schizophrenia to be a "non-affective" psychosis, unlike, for example, bipolar disorder.

Most of the research on affective processing in schizophrenia tests patients' abilities to recognize emotional facial expressions in others, and most of the data from this research indicates that patients do indeed have difficulty recognizing emotional facial expressions in others, especially for the negative emotions (Edwards et al. 2002, Kohler et al. 2003; Mandal et al. 1998; Scholten et al. 2005; Whittaker et al. 2001). These difficulties in patients are notably worse than their abilities to discriminate age, race, or other emotionally-neutral facial attributes (Habel et al. 2000; Mandal et al. 1998; Novic et al. 1984), which suggests that affective processing itself is disturbed in schizophrenia, in addition to the well-documented and more global cognitive deficits. So far as I can tell, no Bayesian accounts would predict worse affective facial discrimination over other facial attributes in patients with schizophrenia. There appear to be additional difficulties with affective processing, over and above other predictive challenges.

We know that damage to the amygdala results in deficits in recognizing a variety of emotional facial expressions (and in social perception in general), even though general emotional experiences can remain intact (Aggleton and Shaw 1996). Structural imaging clearly shows reduced volume or density of the amygdala in patients with schizophrenia (Harrison 1999; Hulshoff Pol et al. 2001; Nelson et al. 1998; Shayegan and Stahl, 2005; Shenton et al. 2001; Wright et al. 2000), which aligns with data on the behavioral impacts of amygdala lesions. A review of both structural and functional imaging studies of the amygdala in patients with schizophrenia reveals that its activity is reduced with respect to emotional stimuli in comparison to neutral stimuli (Andrew et al., 1999; Phillips et al. 1999; Schneider et al. 1998; Takahashi et al. 2004; Taylor et al. 2002; Williams et al. 2004).

However, baseline amygdala activity is also increased in patients relative to controls (Aleman and Kahn 2005). This increased baseline activity could be related to patients' heightened vigilance and increased anxiety. It also suggests that the alleged reduced activity with respect to emotional stimuli is nothing more than an artifact of subtracting the over-activity of neutral material from a normal reaction to emotional stimuli (Potvin et al. 2016). Indeed, Rauch et al. (2010) have found increased amygdala activity to masked facial emotions when followed by consciously perceived neutral faces (Rauch et al. 2010). In short, it appears that patients with schizophrenia exhibit emotional hyperresponsiveness to most stimuli, even though their responses are not valenced in the same way as the rest of us.

Strangely, less research has focused on the actual emotional experiences of patients with schizophrenia. This is especially odd because it appears that while patients demonstrate less emotional expression than controls, their internal emotional experiences of every day life are both more intense and more negative (see also Myin-Germeys et al. 2000). At the same time, their emotional reactions are not the same as controls; they fail to interpret scary stimuli as such (Edwards et al. 2001) and tend to see ambiguous or neutral stimuli as threatening (Cohen and Minor 2010 Phillips et al. 2000; Potvin et al. 2016). And, of course, patients' hallucinations and delusions can often be quite disturbing (Freeman et al. 2001; Nayani and David 1996). In short, while patients have difficulty perceiving emotions in others around them and in expressing their own feelings, they also have more, and more negative, subjective emotional experiences with greater affective arousal (Llerena et al. 2012).

Importantly, abnormalities in processing the valence of stimuli severely impacts social behavior (Sheyegan and Stahl 2005), for it means that patients with schizophrenia cannot make appropriate sense of things and other people in the world around them (Fiske 1993). They might interpret a compliment as an expression of disgust, for example. It is entirely likely that problems interpreting emotional stimuli feed into the cognitive deficits seen in patients with schizophrenia (Kee et al. 2003), as well as into their own judgments about self: they come to believe that they are worthy of disgust, for example, and not of a compliment. And because working memory is impaired, they cannot think clearly about whether such a self-interpretation might be correct.

These misinterpretations, perhaps, can be accounted for using a Bayesian approach. Patients with schizophrenia could be misinterpreting their own bodily responses to the world, just as they misinterpret their perceptual inputs (cf. Seth 2013). However, it is when emotions connect with memory that Bayesian accounts break down. In particular, patients with schizophrenia have difficulty anticipating pleasures (Kring and Caponigro 2010; Kring and Elis 2013). Of course, impaired episodic and working memory would prevent a person from being able to anticipate a future pleasure. Without being able to establish memories of pleasant events, it is difficult to anticipate any happiness in engaging in the same activities again (D'Argembeau et al. 2008).

Moreover, in articulating the future, patients use fewer descriptions of personal experiences; fewer references to self, others, or emotions; and are less detailed (Raffard et al. 2013; Painter and Kring 2016). To envision a personal future requires that individuals can "flexibly extract, recombine, and reassemble" events from remembered past experiences (Schacter and Addis 2007, p. 778; see also Buckner and Carroll 2007, Painter and Kring 2016; Schacter et al. 2007; Szpunar 2010). Because persons with schizophrenia have problems recounting autobiographical memories, their accounts are less coherent, less linear, and less relevant to a prompt, especially when urged to describe an emotionally charged memory, compared to controls (Docherty et al. 1998; Docherty and Hebert 1997; Gruber and Kring 2008; Raffard et al. 2010). And indeed they reference their past less when describing their future than controls, which could also explain why their prospections appear less rich (Painter and Kring 2016).

Being unable to effectively access personal and emotionally charged memories has important implications for our sense of self over time. Not only do our affective memories help inform our day-to-day decisions as well as our long-term planning (Herbener 2008), but they also tell us about the sort of person we are. For example, I am the sort of person who likes strawberries but not blackberries; I miss my children now that they have grown up and moved away. My sense of self as a stable constellation of consistent reactions and feelings would be greatly disturbed if I lost my ability to access my memories of how I react to the world affectively. I would not be able to be aware of myself as one thing existing across time; rather, I would be anchored only to the present and my affective reactions to it.

I have argued elsewhere and at length (Hardcastle 2008) that personal memories and emotions are fundamental to having a self and to one's sense of self. My only point here is that deficits in both in patients with schizophrenia impact their self-awareness. One's awareness of self indeed becomes twisted if one can no longer successfully anticipate one's actions and behaviors, as the Bayesians do suggest (see also Nelson et al. 2014a, b). At the least, one's sense of self-control is diminished. However, by not being able to think clearly or to project the past into the future effectively, one's self-awareness is further diminished (see also Mishara et al. 2014). One's inner world becomes limited to a narrow present window, where demands of self are harder to recognize. Bayesians have more difficulty accounting for these types of deficits in self-awareness.

Schizophrenia is multi-faceted and complex. So is self-awareness. But by pulling apart schizophrenia's various strands, we can learn more about how each of them affect how our self is constructed, what we need in order to be aware of a self, and how we respond to it. Perhaps a Bayesian approach can tell us much about how the mind breaks down in schizophrenia, but it does not tell us everything. And we need the everything in order to fully appreciate how the self falls apart in this illness. And appreciating the many ways in which the self is disturbed in schizophrenia helps us to understand the many dimensions that go into creating a self in the first place.[14]

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[14] Many thanks are due to two anonymous referees whose detailed comments and thoughtful suggestions turned a mediocre essay into something better. I am truly grateful. An earlier version of this essay was presented at the Embodied Awareness conference sponsored by the Taft Humanities Center, University of Cincinnati. Audience comments made this a stronger work as well. This work was sponsored by a grant from the Templeton Foundation as part of the University of Cambridge New Directions in the Study of Mind project.

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