Autistic-like Traits and Positive Schizotypy as Diametric Specializations of the Predictive

Mind

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Abstract

According to the predictive processing framework, only prediction errors (rather than all sensory inputs) are processed by an organism's perceptual system. Prediction errors can be weighted such that errors from more reliable sources will be more influential in updating prior beliefs. It has previously been argued that autism spectrum conditions can be understood as resulting from a predictive processing mechanism in which an inflexibly high weight is given to sensory prediction errors, which results in overfitting their predictive models to the world. Deficits in executive functioning, theory of mind, and central coherence are all argued to flow naturally from this core underlying mechanism. The diametric model of autism and psychosis suggests a simple extension of this hypothesis. If people on the autism spectrum give an inflexibly high weight to sensory input, could it be that people with a predisposition to psychosis (i.e., people high in *positive schizotypy*) give an inflexibly *low* weight to sensory input? In this article I argue that evidence strongly supports this hypothesis. An inflexibly low weight given to sensory input can explain such disparate features of positive schizotypy as increased exploratory behavior, apophenia, hyper-theory of mind, hyper-active imagination, attentional differences, and having idiosyncratic worldviews.

Autistic-like Traits and Positive Schizotypy as Diametric Specializations of the Predictive Mind

William Blake was an 18th to 19th century painter and poet who is often considered the greatest English artist of all time. From his childhood onwards, Blake experienced auditory and visual hallucinations, although he could tell the difference between these experiences and reality. For example, when he was four years old, he saw the face of God “put his head to the window” and when he was about ten years old he saw “a tree filled with angelic wings bespangling every bough like stars” (Blom, 2010, p. 68). William Blake’s visions and hallucinations were not dysfunctional, however, at least if we consider dysfunction to represent the inability to achieve one’s valued goals (DeYoung & Krueger, 2018). His experiences did not cause undue distress and he had a relatively successful career as a printmaker (though his artistic talent was mainly recognized posthumously). Blake’s unusual experiences indicate that he was high in a trait we would now call *positive schizotypy*. Psychosis is often described as a loss of contact with consensus reality (Del Giudice, 2018; Williams, 2012) and schizotypy represents a cluster of traits which predispose to psychosis (Kwapil & Barrantes-Vidal, 2015). Schizotypy is usually thought to have three factors: positive, negative, and disorganized schizotypy (Fossati et al., 2003; Reynolds et al., 2000). Of these three, only negative and disorganized schizotypy are unambiguously associated with dysfunction (Mohr & Claridge, 2015). Positive schizotypy (which is characterized by unusual experiences, magical thinking, and ideas of reference), on the other hand, is often associated with creative and imaginative talent, especially in relation to artistic endeavors (Holt, 2015, 2019; Nettle, 2006). Recently developed models have extended the diametric model of autism and psychosis (Crespi & Badcock, 2008) by suggesting that autistic-like traits and positive schizotypy represent opposite sides of a single underlying

continuum in non-clinical populations (Abu-Akel et al., 2015, 2017, 2018; Crespi et al., 2019; Del Giudice et al., 2010, 2014; Dinsdale et al., 2013). In this paper I will refer to this axis as the *autism-schizotypy continuum*. For convenience, I will refer to people on either side of this continuum as being an ‘autistic type’ or a ‘schizotype’, though it should be understood that there are no clear-cut ‘types’ and that these differences are continuous rather than categorical.

According to these models, everyone falls somewhere on the autism-schizotypy continuum and neither autistic-like traits nor positive schizotypy represent dysfunction. Instead, they are each accompanied by their own sets of cognitive-perceptual strengths and weaknesses. People high in autistic-like traits are detail-oriented (Baron-Cohen et al., 2009), have a focused attentional style which allows them to ignore distractors (Abu-Akel et al., 2017, 2018), have some advantages in sensory-discrimination abilities (Cribb et al., 2016; Mottron et al., 2006; O’Riordan et al., 2001) and have highly developed systemizing skills, allowing them to learn and utilize complicated rules-based systems (Baron-Cohen et al., 2009). People high in positive schizotypy tend to be imaginative and creative (Abu-Akel et al., 2020; Holt, 2015; Stumm & Scott, 2019), have a more diffuse attentional style that allows them to switch their attention more easily (Abu-Akel et al., 2017, 2018), and there is some evidence (reviewed below) that they tend to direct their attention towards highly abstract, ‘big-picture’ concerns rather than focusing on details.

Recently, some authors have put forward the hypothesis that many aspects of autism spectrum disorders (ASD) can be explained by a single underlying mechanism, described in terms of predictive processing accounts of cognitive-perceptual functioning (Palmer et al., 2015, 2017; Van de Cruys et al., 2014, 2017). These authors argue that people with ASD respond differently to prediction errors than neurotypical individuals and that this difference can account for a number of deficits seen in ASD. In particular, it is suggested that people with ASD (and by

extension people high in autistic-like traits) give an inflexibly high weight to sensory prediction errors, making them more prone to overfitting sensory input (Van de Cruys et al., 2014). I will argue in this paper that the diametric model of autism and psychosis suggests a simple extension of this hypothesis. If people high in autistic-like traits give an inflexibly high weight to sensory input, then the diametric model suggests that people high in positive schizotypy should give an inflexibly low weight to sensory input. I will argue that current evidence strongly supports this hypothesis, though this has perhaps been obscured by the fact that most researchers tend to focus on psychosis or schizophrenia (which is highly heterogenous) rather than positive schizotypy (which is more consistent in its presentation and correlates). I will refer to this hypothesis as the precision-weighting of sensory input (PSI) hypothesis. Since multiple authors have previously discussed PSI in relation to autism, my focus in this article will be on positive schizotypy, though I will discuss autistic-like traits in order to compare them with positive schizotypy.

I will structure the article as follows. First, I will briefly summarize the diametric model of autism and psychosis, including its manifestations in non-clinical populations. I will then give a basic description of the predictive processing account of how the mind works, focusing on the role of precision-weighting. Next, the bulk of the article will consist of applying the same mechanism that has been used to explain ASD to the autism-schizotypy continuum more generally, showing how differences in precision-weighting can account for a variety of traits associated with both sides of the continuum, though the main focus will be on positive schizotypy. I will conclude the article with implications for future research.

The Diametric Model of Autism and Psychosis

Autism is a neurodevelopmental disorder characterized by restricted and repetitive behavior, social deficits, and sensory abnormalities (American Psychiatric Association, 2013).

High-functioning autism is often accompanied by impressive systemizing skills, meaning that people with autism are often naturally talented at mastering rules-based systems (e.g., a computer programming language; Baron-Cohen et al., 2009). This systemizing tendency can make them excellent engineers, computer programmers, and hard scientists. Importantly, autistic-like traits exist on a continuum such that many high-functioning people who do not meet criteria for an autism diagnosis can be more or less ‘autistic’. Autistic-like traits in non-clinical populations generally manifest as being detail-oriented, having a restricted imagination, preferring predictable routines, having strong interests in narrow topics, and having strong systemizing skills (Del Giudice, 2018).

Psychosis is often described as a loss of contact with consensus reality. People who are in the throes of psychosis can experience delusions (strange and unlikely beliefs which are held with unshakable confidence), hallucinations (perceptions which do not appear to have any apparent correspondence with reality), and a loss of coherence in their thought patterns or speech (Del Giudice, 2018). The PSI hypothesis, however, is not primarily meant to explain acute psychosis. There is a cluster of personality traits associated with a predisposition to psychosis called schizotypy and the PSI hypothesis is primarily meant to explain the cognitive, perceptual, and behavioral correlates of *positive schizotypy* (which is a specific factor of schizotypy) rather than acute psychosis. Acute psychosis and delusion-formation may not have a straight-forward relationship to the PSI hypothesis and a full discussion of precision-weighting in relation to psychosis will be reserved for a future paper. Schizotypy is usually described as having three factors: positive schizotypy, negative schizotypy, and disorganized schizotypy. Positive schizotypy is characterized by magical thinking (e.g., ascribing supernatural causes to events), ideas of reference (e.g., the idea that seemingly random events have personal significance),

unusual experiences (often described as mystical or paranormal), and is often associated with increased creativity and imagination (Mohr & Claridge, 2015; Raine, 1991). Negative schizotypy is characterized by anhedonia (loss of motivation and interest in normally pleasurable activities) and social isolation (Raine, 1991). Disorganized schizotypy is characterized by odd thoughts and behaviors (Debbané & Barrantes-Vidal, 2015).

Crespi and Badcock (2008) first presented the hypothesis that autism and psychosis represent the dysfunctional manifestations of opposite ends of a single continuum which is genetically mediated by differential expression of paternally and maternally expressed genes (i.e., genomic imprinting). They amassed a large body of data to support this hypothesis, including evidence for opposite tendencies in gene expression, growth patterns, and cognition (Crespi & Badcock, 2008). More recent research has used the diametric model to study autistic-like and schizotypal traits as they manifest in non-clinical, healthy populations (Abu-Akel et al., 2015, 2017, 2018, 2020; Del Giudice et al., 2010, 2014). According to these models, severe autism and schizophrenia represent extreme and dysfunctional manifestations on either end of the autism-schizotypy continuum, but the continuum itself is not associated with dysfunction since there are high-functioning people on both ends of the continuum. Of the three schizotypy dimension mentioned above, it is only positive schizotypy which has diametric relations with autistic-like traits (Del Giudice et al., 2014; Dinsdale et al., 2013). A careful reading of the literature will show that negative schizotypy often has diametric associations with positive schizotypy, and this may be due to its being confounded with autistic-like traits (Del Giudice et al., 2014; Del Giudice, 2018). Therefore, I want to make clear that what I will be referring to as the autism-schizotypy continuum for the rest of this paper is characterized primarily by non-social autistic-like traits on one end and positive schizotypy on the other. To reiterate (since this

is a constant source of confusion when discussing this topic), neither end of the continuum is necessarily dysfunctional. Each side of the continuum has its own set of strengths and weaknesses (e.g., systemizing ability with autistic-like traits and imagination with positive schizotypy). If the diametric model is correct, everyone falls somewhere along this spectrum. Thus, the hypothesis presented in this paper is not primarily meant to explain mental illness or dysfunction, but to elucidate the primary cognitive-perceptual difference along an axis of individual differences in non-clinical populations.

The Predictive Mind

Classic theories of sensory processing view the brain as a passive, stimulus-driven, machine-like processor. Predictive processing, on the other hand, views the brain as actively ‘predicting’ and constructing reality (A. Clark, 2013b, 2016; Friston, 2010; Hohwy, 2013). Predictive processing suggests that instead of processing all sensory input, the perceptual system only processes prediction errors. In this view, the mind is arranged in a hierarchy of predictions, with higher levels predicting the input they will receive from the level below and passing prediction errors up to the next level of the hierarchy (Badcock et al., 2019; Kiebel et al., 2008). Prediction errors from lower levels of the hierarchy cause higher levels to adapt so as to reduce the discrepancy between prediction and prediction error. The hierarchy is arranged according to spatio-temporal level of abstraction, with lower levels dealing with more concrete and short-term aspects of sensori-motor functioning while higher level predictions cover larger spatio-temporal distances (A. Clark, 2016; Kiebel et al., 2008). This process of prediction error minimization can be cast in terms of Bayes’ rule, with higher level predictions acting as priors for lower level processing and the posterior being calculated by combining the likelihood (bottom-up input) with the prior (top-down prediction) (see A. Clark, 2016, Appendix 1).

Action in Predictive Processing

There are two ways to minimize prediction error in the predictive processing framework. In the first place, an organism can change its predictions in order to bring them into closer alignment with the world (A. Clark, 2016; Hohwy, 2013). This is often called *perception*, though it should be noted that this process also applies to higher cognitive functions which we wouldn't normally associate with perception. The other way to reduce prediction error is to change one's sensory input to bring it more into alignment with predictions, which is called *action*. One way to use action is for *utility*, or to bring about a desired state (Hohwy, 2020). For example, if I 'predict' (i.e., *desire* in this case) that I will eat a muffin, I can minimize prediction error by taking the action of seeking out and consuming a muffin. Action can also be used for *epistemic value* to reduce uncertainty about beliefs (Hohwy, 2020). For example, if I want to know whether the muffin is fit for consumption, I may use action to move the muffin around in order to check for mold or contamination on all sides. The use of action to reduce prediction error is referred to as *active inference* (Adams, Shipp, et al., 2013; Friston et al., 2017). Thus, rolling cycles of perception and action function to reduce prediction errors at all levels of the processing hierarchy (A. Clark, 2016). High-precision proprioceptive predictions (i.e., high confidence predictions about the future state of one's body) are considered the equivalent of goals or desires (A. Clark, 2020; Shipp et al., 2013; Yon et al., 2019). Values can be considered highly abstract goals (e.g., if one places a moral value on 'integrity', this should affect behavior at all times and places). Thus, the predictive processing framework subsumes beliefs, goals, desires, and values under the broader category of 'prediction' (A. Clark, 2017; Yon et al., 2020).

Attention in Predictive Processing

In order to account for noise (i.e., irrelevant information) in the sensory input, an organism can adjust the amount of weight it gives to sensory prediction errors (H. Feldman & Friston, 2010). The amount of weight given to sensory prediction errors determines how much effect they have on updating priors. Highly weighted sensory prediction errors have a larger effect on updating prior beliefs. If the current environment contains a lot of noise or randomness, the organism may be better off giving less weight to sensory prediction errors, which means that only relatively large prediction errors (which are more likely to be signal than noise) will have a major effect on updating predictions (A. Clark, 2016; Hohwy, 2013). For example, when driving at night on a foggy stretch of highway, one may want to lower the weight given to sensory input since the sensory input will be less reliable. If, however, the environment is orderly and predictable with a high signal-to-noise ratio, then it makes sense to give more weight to sensory prediction errors, allowing them to have a greater effect on updating top-down predictions. However, giving too much weight to bottom-up inputs can result in *overfitting*, which means that learning becomes so precise that it cannot be generalized to new contexts (J. Feldman, 2013). On the other hand, giving too little weight to bottom-up input can result in *underfitting*. In data analysis, underfitting occurs when strong assumptions are brought to bear on the data, such that the data is made to fit the assumptions rather than vice-versa. In perception or cognition, this would be the equivalent of relying too much on top-down predictive models and not enough on bottom-up input, which in the extreme may result in hallucinations or delusions (Adams, Stephan, et al., 2013; Teufel et al., 2015). Figure 1 provides a visual representation of overfitting and underfitting in a data-analysis context, which will serve as a useful analogy later in the paper for understanding some cognitive-perceptual differences along the autism-schizotypy continuum.

Figure 1.*A Visual Representation of Overfitting and Underfitting*

Note. Giving too much weight to sensory input can lead to overfitting while giving too little can lead to underfitting. Finding the right balance can allow a cognitive agent to find the true pattern underlying noisy sensory input.

In a nutshell, the relative ‘weight’ given to select sensory prediction errors is the predictive processing account of attention (H. Feldman & Friston, 2010). This is called *precision-weighting* because it reflects (in part) implicit assumptions about the reliability (i.e., the precision or inverse variance) of incoming sensory data (H. Feldman & Friston, 2010). It’s important to understand, however, that precision-weighting is about more than the signal-to-noise ratio of sensory input. Adjusting the precision-weighting of sensory input will also vary the impact of sensory signals according to their task-salience and their estimated value in relation to reducing prediction error (A. Clark, 2017). Thus, precision-weighting is adjusted based on how *relevant* a sensory input is to one’s current predictions (desires, beliefs, etc.). For example, if I were to be looking for my car in a parking lot, the estimated precision of signal elements that are relevant to finding my car (e.g., gray color, Nissan insignia, etc.) would be increased (A. Clark, 2017).

Giving an inflexibly high precision-weighting to sensory prediction errors means that even relatively small errors will be used to update priors, while an inflexibly low weight means that the perceptual system will mainly utilize only large errors to update priors. Optimally, this weighting will be adjusted based on the signal-to-noise ratio of the environment. In other words, it will be adjusted based on top-down predictions about how precise the sensory input in the current environment is. Noisy, chaotic environments call for low weight on sensory prediction errors while stable, predictable environments call for a high weight (A. Clark, 2016; J. Feldman, 2013).

What's at the Top of the Hierarchy?

Most research conducted under the predictive processing framework focuses on relatively low-level issues concerning perception, sensation, and motor control (A. Clark, 2016; Hohwy, 2013), although there are theoretical accounts of higher-level cognition under predictive processing (Gilead et al., 2020; Pezzulo, 2017; Pezzulo et al., 2018; Pezzulo & Castelfranchi, 2009). For the purpose of evaluating the PSI hypothesis in relation to the diametric model, we must consider how higher cognitive functions (e.g., scientific and philosophical theorizing, religious cognition) operate according to the same predictive architecture as low-level sensation and perception. Higher levels of the processing hierarchy are occupied by more abstract predictions, meaning that they cover larger spatio-temporal distances. It will be important for the present hypothesis to consider what kinds of predictions occupy the highest levels of abstraction in the processing hierarchy. Here I want to propose that the highest levels of abstraction will often manifest in what Taves and colleagues (2018) refer to as the “Big Questions” that make up a *worldview*. These are questions like “what exists?”, “how do I know what’s true?”, and “what is good and bad?”, asked in the most general possible sense. The Big Questions are necessarily the

most abstract because they apply to *all situations* at *all times*. Everything a person comes into contact with may be considered as real or unreal, as true or false, and as good or bad. As such, whether our answers to the Big Questions are implicit (i.e., unconscious) or explicit, they necessarily reside at the highest levels of abstraction in the processing hierarchy. All organisms must have answers to these questions, though outside of humans these answers (e.g., food is good; predators are bad) will usually be implicit rather than explicit (Taves et al., 2018).

Throughout much of human history, explicit answers to the Big Questions have tended to take on a mythological or religious format, most often in the form of a narrative (Bouizegarene et al., 2020; Hirsh et al., 2013; Peterson, 1999; Peterson & Flanders, 2002). More recently, philosophy and science have attempted to provide answers to the Big Questions. No matter what format they are in (mythological, philosophical, or scientific), people are highly motivated to protect the abstract beliefs and values which make up their worldviews (Brandt & Crawford, 2020; Goplen & Plant, 2015; Peterson & Flanders, 2002; Hirsh et al., 2012). We know this intuitively, since sensory information which violates the belief that you have a dentist appointment today (a relatively low-level belief) is not nearly as distressing as sensory information which violates the notion that you're a good person (if your goal is to be a good person), that God exists (if you believe in God), or that the world is a just and fair place (if you believe in a just world). As worldview violations are so distressing, people will often go to great lengths to protect their worldviews (see Van De Cruys, 2017 for a similar view in relation to predictive processing). This may involve rigidly clinging to high-level beliefs despite evidence against them (Peterson & Flanders, 2002). It may also involve suppressing, slandering, avoiding, or aggressing against people who hold alternative worldviews (Brandt & Crawford, 2020; Goplen & Plant, 2015; Peterson & Flanders, 2002). People are motivated to protect their highly

abstract beliefs and values because uncertainty about the Big Questions is *a much bigger problem* from a practical perspective than uncertainty about lower-level, more concrete issues (Hirsh, 2012; Hirsh et al., 2012). In particular, “the dissolution of these more abstract goals has broader implications than the loss of simple behavioral goals, so the concomitant increase of psychological entropy is greater and more widespread” (Hirsh et al., 2012, p. 6). Worldview questions shape the trajectory of one’s entire life, so if they are called into question this can necessitate a dramatic re-organization of one’s goals, values, and even perceptions.

Predictive Processing in ASD

Multiple previous papers have proposed that an inflexibly high weight is given to sensory prediction errors in ASD (Lawson et al., 2014; Palmer et al., 2017; Van de Cruys et al., 2014, 2017). These authors suggest that many aspects of autism, including social deficits, sensory overload, and systemizing abilities can be explained by this relatively simple mechanism. Van de Cruys and colleagues (2014, 2017) call this hypothesis HIPPEA (High, Inflexible Precision of Prediction Errors in Autism). In a nutshell, HIPPEA posits that:

Indiscriminately high precision will mean that unrepeated, accidental variations in the input receive disproportionate weight. This in turn prevents abstract representations to be formed, because matching will continue on a more specific level, closer to the input.

Indiscriminately high precision also induces superfluous learning, leading to narrowly defined, lower-level predictions, and incomplete hierarchical models. (Van de Cruys et al., 2014, p. 5).

Because the person with ASD is constantly trying to use small prediction errors to update their priors, it’s likely that many of the errors they try to resolve are not particularly informative (meaning that they mainly represent noise). Prediction matching in relation to noisy error signals

remains at lower levels of the hierarchy rather than propagating up it to affect high-level priors. As an analogy, if a fire department with limited resources is receiving so many calls that they are constantly away putting out fires, they will never have the time or resources to formulate abstract ideas about why there are so many fires in the first place. Although this hypothetical fire department may not be able to formulate high-level abstract ideas about why so many fires are occurring, their time spent putting out these fires may result in them becoming really efficient at doing so, in the same way that autistic-like traits are associated with increased systemizing (i.e., mastering rules-based systems like a computer programming language) and certain sensory-discrimination abilities like absolute pitch-discrimination (Stanutz et al., 2014), neither of which require the use of high-level abstractions (Van de Cruys et al., 2014).

Autistic-like traits are also associated with a preference for routine and predictable environments. Why might high PSI result in this tendency? In what is essentially a tautology, predictable environments do not generate as many prediction errors. In other words, predictable environments do not require the autistic person's perceptual system to be constantly "putting out fires" which will make them more efficient at solving whatever problems they are currently dealing with. Given that prediction errors are often accompanied by an increase in anxiety (J. A. Gray & McNaughton, 2003; Hirsh et al., 2012), seeking out predictable environments would be an effective way to reduce this anxiety for people with ASD.

Autism and Culture

People with ASD are relatively poor at picking up on high-level statistical regularities in complex situations (Van de Cruys et al., 2014, 2017). In particular, their inability to distinguish signal from noise in complex environments will make it hard for them to pick up on the relevant information that they ought to pay attention to. In mild (i.e., non-clinical) cases, however, this

need not concern them too much as there is a ready-made solution to this problem. The problem of knowing what to attend to in our complex, ever-changing environments can be outsourced to *culture* (Ramstead et al., 2016; Veissière et al., 2019). Culture provides a “scaffolding” (Ramstead et al., 2016) by which individuals can learn what to attend to in a complex environment. Culture in this view consists of “regimes of attention” that direct us towards relevant endeavors (Ramstead et al., 2016). What this means is that people embedded in a culture don’t have to figure everything out for themselves. Through their engagement with parents, schools, churches, books, etc., people are presented with relevant ‘affordances’ (i.e., functionally meaningful properties of the environment) which preclude them from having to figure out what to do all on their own. These affordances may include career paths and lifestyles which constrain the types of goals and values that a person may consider worthy of their attention. Van De Cruys and colleagues (2014) have said that individuals with autism must “rely much more on the scaffolding provided by caregivers, explicitly guiding progression from simple to more naturalistic situations” (p. 653). My contention here is that this notion be extended such that people high in autistic-like traits (not only those with diagnosable ASD) rely more not only on caregivers, but the culture at large (Ramstead et al., 2016) to provide a developmental scaffolding that can facilitate the adoption of functional high-level priors (i.e., beliefs, values, and goals).

Furthermore, people can have linguistically mediated high-level abstractions “installed” for them directly by cultural productions (e.g., one can adopt high-level priors through engagement with education systems, churches, books, etc.; Bengio, 2012; Veissière et al., 2019). If this view is correct, people high in autistic-like traits may not necessarily have impoverished high-level priors, as would be suggested by HIPPEA (Van de Cruys et al., 2014, 2017). Instead,

their high-level beliefs and values will tend to be more conventional and less idiosyncratic, having been adopted from the set of beliefs and values on offer by their culture rather than being constructed from the bottom up based on their own experience. Indeed, I will argue that there is ample evidence to suggest that people with high positive schizotypy show the exact opposite tendency, tending to have idiosyncratic high-level beliefs and values which are highly responsive to their own sensory input, for better or for worse.

Positive Schizotypy and Hierarchical Predictive Processing

Inflexibly high PSI provides a plausible explanation for many of the deficits and strengths associated with autism and autistic-like traits. As discussed above, the diametric model posits that autistic-like traits and positive schizotypy are diametrical in nature. The diametric model therefore lends itself to a straight-forward hypothesis. Might positive schizotypy be explainable in terms of an inflexibly *low* weight given to sensory input? That is the hypothesis I will be exploring in the rest of this paper, though I will continue to discuss autistic-like traits in order to compare them with positive schizotypy. In the following sections I explore how diametric phenotypes associated with the autism-schizotypy continuum can be explained according to the PSI hypothesis.

Top Down vs. Bottom Up

If positive schizotypy is related to an inflexibly low PSI, this necessarily means that there will be a greater top-down influence of priors on perception (A. Clark, 2016; Hohwy, 2013). This is because the weight given to prediction errors is always relative, so that if less weight is given to sensory input, more weight must be given to top-down priors (Hohwy, 2013). There is empirical evidence suggesting that positive schizotypy and autistic-like traits are diametrically related to top-down vs. bottom-up influences on cognition and perception. For example, Crespi

and Dinsdale (2019) review evidence for diametric susceptibility to the rubber hand illusion. The rubber hand illusion involves stroking a visible rubber hand at the same time as the participant's real hand is being stroked in a similar way. If the rubber hand is positioned in front of the participant while the real hand is hidden to the side, this often gives rise to the feeling that the rubber hand belongs to the participant. Hohwy (2013) suggests that the illusion works because of the top-down prior belief that systemically related properties (e.g., seeing a hand being stroked and feeling your own hand being stroked) are very likely to be causally related (e.g., the hand you see being stroked is caused by the same force as the feeling that your hand is being stroked). Thus, susceptibility to the illusion will be facilitated by a relative over-weighting of top-down priors, while decreased susceptibility will be facilitated by over-weighting of bottom-up sensory input. As would be expected based on the PSI hypothesis, positive schizotypy is associated with increased susceptibility to the illusion while autistic-like traits are associated with decreased susceptibility (Crespi & Dinsdale, 2019). Relatedly, one set of studies found that, in early psychosis and among individuals at risk for psychosis, there was a relative advantage in using prior knowledge to discriminate between ambiguous images, indicating a greater influence of top-down priors (Teufel et al., 2015). Importantly, both of these papers present evidence that schizotypy or psychosis-risk is associated with an increased top-down influence in addition to psychosis *per se*. This is important because there is some heterogeneity in the literature on psychosis or schizophrenia, with some studies showing increased bottom-up influence (Sterzer et al., 2018), especially among chronic schizophrenia patients (King et al., 2017). Antipsychotic medication and heterogeneity within schizophrenia have the potential to confound the relationship between top-down influence and psychosis, making it beneficial to focus research on positive schizotypy in addition to schizophrenia as such.

Mentalizing

Both autistic-like traits and positive schizotypy have been associated with impaired theory of mind abilities (i.e., the ability to infer other people's intentions and mental states), but for very different reasons (Crespi, 2016; Crespi & Badcock, 2008; Crespi & Go, 2015). Autism and autistic-like traits are associated with hypo-mentalizing, meaning that there is *under-attribution* of mental states to other people (Abu-Akel et al., 2015; Baron-Cohen, 2000).

Psychosis and positive schizotypy are associated with hyper-mentalizing, meaning that there is *over-attribution* of mental states to other people (Abu-Akel et al., 2015; Crespi & Badcock, 2008; Wastler & Lenzenweger, 2019). In the predictive processing framework, mentalizing is thought to result from high-level predictive models about behavior (Koster-Hale & Saxe, 2013). Hypo-mentalizing in autism is thought to result from the inability to form high-level abstract models because of an inflexibly high PSI (Van de Cruys et al., 2014). The over-reliance of the schizotype on top-down predictions due to an inflexibly *low* PSI would therefore result in the opposite tendency of hyper-mentalizing. In this view, hyper-mentalizing consists of the over-utilization of top-down predictive models and the under-utilization of bottom-up sensory input to determine the causes of other people's behavior.

Imagination

Autism is associated with a deficit in imaginative abilities (Craig & Baron-Cohen, 1999; Crespi et al., 2016). In the predictive processing framework, imagination can be thought of as the use of predictive models “off-line” (A. Clark, 2013a). That is, to imagine something is to simulate what would happen ‘as if’ events unfolded in a certain way according to our high-level models. Indeed, one might even imagine what would happen if certain aspects of the model were changed and then run *that* (the altered model) as a simulation (e.g., what would the world be like

if the Germans won WW2?). How might this sort of imaginative simulation work in a predictive processing framework? Let's take a very simple example, one which was given by A. Clark (2013a). How might one imagine reaching for a cup?

The proposal is that the brain, in order to simulate future unfoldings, must mute the weighting on select aspects of the proprioceptive prediction error signal. Suppose this is done while simultaneously entering a high-level neural state whose rough-and-ready folk-psychological gloss might be something like "I reach for the cup." Motor action, on the [predictive processing] account, is entrained by proprioceptive expectations and cannot here ensue. But all the other intertwined elements in the generative model remain poised to act in the usual way. The result should be a "mental simulation" of the reach and hence an appreciation of its most likely consequences. Such mental simulations provide an appealing way of smoothing the path from basic forms of embodied response to abilities of planning, deliberation, and "off-line reflection" ... (A. Clark, 2013a, p. 2).

According to Clark, in order to imagine reaching for a cup one must lower the precision-weighting of proprioceptive information (which is a subset of sensory input). If it's the case that autism is associated with an inflexibly high PSI, this provides a neat and plausible account for why people high in autistic-like traits have imaginative deficits. With inflexibly high PSI, it becomes near-impossible to run "off-line" simulations (i.e., to use one's imagination).

Conversely, there is a robust and reliable finding of high positive schizotypy among artists compared to non-artists (Holt, 2015, 2019). Furthermore, positive schizotypy has been associated with better divergent thinking abilities, which was measured by the ability to imagine novel uses for everyday items (Abu-Akel et al., 2020). Given these results and given that the defining feature of most artists is their well-developed imagination, it's fair to say that positive

schizotypy is associated (all else being equal) with a hyper-active imagination (Crespi et al., 2016). There's also evidence that artists high in positive schizotypy spend an inordinate amount of time detached from here-and-now reality (i.e., day-dreaming; Holt, 2019). As discussed above, the predictive processing account according to A. Clark (2013a) posits that imagination is facilitated by a lowering of proprioceptive precision-weighting. If positive schizotypy is associated with chronic inflexibly low PSI, then the person high in positive schizotypy is more likely to spend an inordinate amount of time running 'simulations' in their own imagination (i.e., imagining or day-dreaming), as the evidence suggests (Holt, 2019). With sufficiently low PSI, these off-line simulations may even occur involuntarily, as with people like William Blake (described in the introduction) or Carl Jung (described below). Visual perception in predictive processing has been described as a 'controlled hallucination' with top-down priors acting as the 'hallucination' and bottom-up error correction acting as the 'control' (A. Clark, 2016). With inflexibly low PSI, the top-down 'hallucinations' may be given undue importance in perception, resulting in the kind of involuntary perceptual hallucinations experienced by people like William Blake and Carl Jung.

High-level Tinkering

In autism, inflexibly high PSI means that prediction matching tends to take place at relatively low levels of the processing hierarchy (Van de Cruys et al., 2014, 2017). Inflexibly low PSI with positive schizotypy would have the opposite effect. Because the schizotype is, on average, handling fewer sensory prediction errors than the autistic type (because they only pay attention to the large errors and ignore the smaller ones), prediction errors will tend to propagate farther up the processing hierarchy, affecting values, goals, and beliefs at higher levels of abstraction. Given that prediction errors tend to propagate farther up the perceptual hierarchy for

people with high positive schizotypy, their over-active imagination is likely to involve running ‘simulations’ that involve high-level priors. William Blake is a good example, since his art and poetry was almost always concerned with religious and metaphysical ideas (which, as discussed previously, are likely to occupy the highest levels of abstraction in the processing hierarchy). The proclivity for people high in positive schizotypy to ‘tinker’ with their high-level beliefs and values may result in their having highly idiosyncratic worldviews. Evidence for this hypothesis is discussed in the following section.

Idiosyncratic Worldviews

Which cognitive abilities underlie the ability to construct an explicit worldview? According to Taves and colleagues (2018), these are: 1) theory of mind, 2) self-reflection, 3) mental time travel, 4) narrative synthesis, and 5) symbolic representation. It should come as no surprise, given the PSI hypothesis, that most or all of these abilities are at a deficit in autism. Autism is associated with theory of mind deficits (Baron-Cohen, 2000; McCauley et al., 2019), diminished self-reflection (Lind, 2010; Philippi & Koenigs, 2014), impaired episodic memory and episodic future thinking (i.e., mental time travel; Lind et al., 2014; Lind & Bowler, 2010; Terrett et al., 2013; Desautay et al., 2020), impaired narrative synthesis abilities (Baixauli et al., 2016) and impairments in the ability to engage in symbolic play (Baron-Cohen, 1987). I take all of this as support for the idea that, instead of constructing their own idiosyncratic worldviews, people high in autistic-like traits are more likely to adopt a conventional, culturally provided worldview (which may include the modern scientific worldview).

While the autistic type may rely more on culturally inherited high-level belief systems, the schizotype’s proclivity for tinkering with their high-level priors may lead them to construct relatively idiosyncratic high-level belief systems. In our own culture, this could manifest as

having odd or (seemingly) unlikely beliefs about high-level causes. This may include beliefs in the paranormal, idiosyncratic religious beliefs (e.g., being “spiritual but not religious”), or believing conspiracy theories, all of which are associated with positive schizotypy (Dagnall et al., 2015; Hart & Graether, 2018; Hergovich et al., 2008; March & Springer, 2019; Willard & Norenzayan, 2017). Intelligence is likely to play a large role in this process. While the less sophisticated schizotype may fall prey to magical thinking, unlikely conspiracy theories, etc., the more intelligent schizotype may produce strikingly original and useful high-level belief systems. Consider the life’s work of the Swiss psychologist Carl Gustav Jung, for example. Jung was a highly intelligent and imaginative person who constructed a system of thought which (whatever one’s opinion of its validity may be) has inspired a great deal of subsequent historical, scientific, and philosophical theorizing (Dunne, 2015; Peterson, 1999). Jung’s system was highly concerned with religious and metaphysical questions, as the PSI hypothesis would predict if Jung was high in positive schizotypy (Jung, 1979). He regarded the religious aspects of his work to be of primary importance (Dunne, 2015). Of importance for the PSI hypothesis, early in his career Jung had what has been called a “spiritual crisis” in which he claimed to have conversed with demons, deities, bird-girls, and other strange entities (Ellenberger, 1970; Lane, 2010), which were presumably (and hopefully) the products of his own hyper-active imagination. At least some of these voices were experienced involuntarily (Ellenberger, 1970). As with William Blake, these experiences would result in a high score on most ‘unusual experiences’ measures of positive schizotypy. Jung’s experience was not technically considered a psychosis, however, since he was able to carry on with his normal life and clinical practice even while having these experiences (Ellenberger, 1970).

Furthermore, there is evidence to suggest that people high in schizotypy who grew up in a religious family are *less religious* than others who grew up religious, while people high in schizotypy who grew up in a non-religious family are *more religious* than others who grew up outside of a religious milieu (Hanel et al., 2019). In other words, people high in positive schizotypy do not conform to the high-level religious beliefs and values of those around them, for better or for worse.

The view that positive schizotypy is associated with high-level tinkering is also consistent with the finding that autistic-like traits and positive schizotypy have diametric relations with spirituality and the “search for meaning” (Crespi et al., 2019; Farias, Underwood, et al., 2013; Willard & Norenzayan, 2017). According to some theories, the subjective sense of *meaning* is experienced when there is coherence between top-down beliefs or goals and bottom-up perceptions (Inzlicht et al., 2011). This coherence reduces anxiety by giving rise to the feeling that the world is an orderly, controlled place that we can understand and explain (Inzlicht et al., 2011; Peterson, 1999; Peterson & Flanders, 2002) and by reducing conflict between competing beliefs and goals (Hirsh, 2012; Hirsh et al., 2012; Proulx & Inzlicht, 2012). In this view, there may be at least two strategies by which somebody can find meaning. In the first place, one can adopt the high-level meaning-making structures on offer by their culture. In this case, there would be no need to continually seek out meaning. Adopting culturally inherited high-level beliefs and values will provide at least some sense of coherence. As alluded to above, and as the evidence suggests (Crespi et al., 2019), this strategy is more likely to be taken up by people high in autistic-like traits. On the other hand, one can forego the culturally inherited meaning-making structures and seek to construct one’s own idiosyncratic high-level beliefs and values from the bottom up. In this case, one might be on a continual “quest” for meaning, and the evidence

suggests that people high in positive schizotypy tends towards this strategy (Crespi et al., 2019; Willard & Norenzayan, 2017). Given that autistic-like traits tend to be associated with atheism (K. Clark & Visuri, 2019; Norenzayan et al., 2012), though multiple studies do not find this link (Crespi et al., 2019; Maij et al., 2017; Reddish et al., 2016), it's important to note that in modern Western culture, belief in 'science' may play this meaning-making role, as evidenced by the fact that belief in science increases in the face of stress and existential anxiety (Farias, Newheiser, et al., 2013). In sum, there is no need to be on a "search for meaning" if one adopts the high-level (meaning-making) beliefs and values on offer by the culture. That positive schizotypy is associated with being "spiritual but not religious" and with being on a search for meaning indicates that people high in this trait tend to search for their own, idiosyncratic high-level beliefs and values, foregoing the adoption of culturally mediated belief systems, regardless of whether those belief systems are religious or scientific in nature.

Attention

The kind of attention we pay to the world is a fundamental determinant of our experience in it (McGilchrist, 2009). Attentional differences between people high in autistic-like traits compared to positive schizotypy may therefore have profound downstream consequences. Abu-Akel and colleagues (Abu-Akel et al., 2017, 2018) found diametric effects of autistic-like traits and positive schizotypy on attentional style. People high in autistic-like traits did better on a task in which they were required to ignore a salient non-task distractor, but they did worse on a task in which they were required to shift their attention to a salient non-task event (Abu-Akel et al., 2018). The opposite tendency was found for people high in positive schizotypy. The autistic type was thus found to have a *focused* attention style. They are able to focus on the task at hand, blocking out distractors. This kind of attention, however, means that they will be likely to miss

out on some relevant events in their periphery and be less able to quickly switch their attention when necessary. People high in positive schizotypy have a more open, diffuse kind of attention. They are not able to ignore salient distractors like the autistic type, which is disadvantageous if the situation calls for focused, laser-like attention. They are, however, able to switch their attention more easily if something new and unexpected happens on the periphery (Abu-Akel et al., 2018).

This may seem like a strange finding in light of the PSI hypothesis. If the autistic type's perceptual system is being constantly bombarded by small prediction errors, wouldn't that make them more distractible rather than less? Conversely, if the schizotype's flow of sensory information is attenuated (since their perceptual system only deems relatively large prediction errors important), wouldn't that facilitate their ability to focus on the task at hand? The answer to these questions is 'no', but it will take some unpacking to understand why. The autistic type's perceptual system *is* being bombarded by precise prediction errors, but they will quickly learn (and this learning almost certainly takes place outside of conscious awareness) that most of that sensory input is *noise*. That is, the autistic type will learn that most of the prediction-errors that their perceptual system initially deems as important are actually irresolvable and are better off being ignored. In a relatively chaotic environment, the autistic type person is better off ignoring distractors because they have learned that *most distractions are mere noise*.

The schizotype, on the other hand, has learned (again, this learning is probably not conscious) the exact opposite. According to the PSI hypothesis, their perceptual system does not utilize prediction errors to update priors unless the errors are relatively large. Thus, a prediction error deemed important by the schizotype's perceptual system is more likely to be signal than noise. For this reason, they are less likely to ignore any extant prediction errors. If a distractor

presents itself to them, they have learned to *assume* that it is relevant (i.e., a large prediction error) and that they should redirect their attention to it. Again, this attentional style ought to work great for noisy, chaotic environments. Their perceptual system essentially filters out all the low-level noise and only presents them with the relatively large prediction errors, which are more likely to be signal than noise. However, in a stable, predictable environment with a high signal-to-noise ratio, they are likely to ignore relevant details (i.e., small prediction errors).

A common metaphor for understanding how attention works is as a spotlight (A. Clark, 2016), and this metaphor will allow for an alternative description of the attentional difference described above. Because the autistic type is utilizing even small prediction errors, their attention is highly detail-oriented. However, this detail-oriented style means that if they do not ignore everything outside of a certain range, they would be unable to focus on the task at hand. Using the spotlight metaphor, the autistic type's spotlight would have a narrow beam, but the picture it creates would be very high-resolution (i.e., detailed). This is consistent with the empirical finding of a sharper distribution of spatial attention in autism leading to a detail-oriented, narrow type of attention that authors have described as “tunnel vision” (Robertson et al., 2013; Song et al., 2015). According to the PSI hypothesis, the schizotype only utilizes relatively large prediction errors, meaning that their attention is not as detail-oriented. However, this attentional style will allow them to have a broader spotlight, covering a larger area. Their spotlight would have a broad beam, but the picture it creates would be relatively low-resolution (i.e., coarse-grained). The Big Five trait Openness to Experience is associated with positive schizotypy (Blain et al., 2020; Del Giudice et al., 2014) and people high in Openness have been found to have a broader distribution of spatial attention, opposite to the narrow distribution associated with ASD (Wilson et al., 2016).

A Tale of Two Fire Departments

An analogy may serve to clarify the argument in the previous section. To use the fire department analogy once again, the attentional difference between the autistic type and the schizotype can be described as such: There are two fire departments in two different cities (we'll call them fire departments A and B). In these cities there are small, medium, and large fires. When these departments receive a call about a fire, they are *not* told whether the fire is small, medium, or large. They are only told that there's a fire at a certain location. Fire department A has told the citizens of its city to call them for any size fire, whether small, medium, or large. Fire department B has told the citizens of its city to call them *only* for large fires and not to call them for small and medium fires. Which of these department's strategies works best? In a situation where there are only a small number of fires to put out, fire department A's strategy works best. Fire department A will put out all the fires while fire department B will not be notified about the small and medium fires (thus, fire department B will ignore the *details* of the situation). But what if most of the city catches fire at the same time? The fire departments, having limited resources, must choose wisely regarding which fires they will put out. In this scenario, fire department B has an advantage. It will not receive calls about small and medium fires, and so will be able to seek out only the most *relevant* fires, the large ones. Fire department A will receive calls about all the fires and will not have any *a priori* means for differentiating between small, medium, or large fires. In this situation, fire department A will waste resources attending to small and medium fires when it should be attending only to large ones. Fire department A, of course, represents the perceptual system of the autistic type. In a relatively orderly, predictable environment (with a small number of fires), this system works best. In a

chaotic environment (with many fires of differing sizes), the schizotype's perceptual system (i.e., fire department B) works best.

Now, imagine that these two departments are in the midst of putting out a particularly large and important fire. While putting out this large fire, department A receives a call about a new fire at a different location. What should they do? Since most of their calls end up being about small-to-medium sized fires, they would be better off ignoring the new call and focusing on the problem at hand. In the same situation, however, fire department B ought to have a different strategy. When they receive a call, they know that it is a large fire, worthy of their attentional resources. They should be more willing to devote resources to the new fire. This analogy can explain how differences in PSI would lead to the attentional differences found between people high in autistic-like traits and high in positive schizotypy. When a salient distractor presents itself to the autistic type, they must *assume* (perhaps unconsciously) that it's irrelevant because their perceptual system is constantly bombarding them with small and unimportant prediction errors. Thus, the autistic type must have a relatively narrow attentional scope in order to utilize their highly detail-oriented attention style. On the other hand, because only relatively large prediction errors are registered by the schizotype's perceptual system, they must *assume* that salient distractors are relevant and worthy of their attention. The schizotype's attentional scope will be broader because their perceptual system ignores small details. Neither of these assumptions (about whether to ignore extant prediction errors) are necessarily wrong. Which assumption will work better simply depends on the signal-to-noise ratio in the current environment. Others have argued that inflexibly high PSI in autism may reflect the implicit assumption of a stable, predictable environment (Palmer et al., 2017). My contention is that inflexibly low PSI with positive schizotypy reflects the opposite assumption of a chaotic,

unpredictable environment and that attentional differences along the autism-schizotypy continuum reflect these implicit assumptions.

Latent Inhibition

Thus, when an anomaly is registered by the autistic type's perceptual system, they are more likely to ignore or suppress it so that they can focus on the task(s) at hand (Abu-Akel et al., 2017, 2018). The schizotype, on the other hand, is more likely to pay attention to the anomaly — to deem it as real and worthy of their attentional resources. This more open attentional style is similar (if not equivalent) to the phenomenon of *low latent inhibition*. Latent inhibition is the capacity or tendency to screen from conscious awareness information which has been previously deemed irrelevant (Carson, 2010; Lubow & Kaplan, 2005; Lubow & Weiner, 2010). High latent inhibition will allow the person to focus on the task at hand by quickly learning to ignore all sensory input that is irrelevant to the current task. Low latent inhibition, on the other hand, will result in a more diffuse attentional style, in which sensory input that is not particularly relevant to the task at hand will still draw one's conscious attention. Low latent inhibition has been associated with both positive schizotypy (Carson, 2018; N. S. Gray et al., 2002; Kumari & Ettinger, 2010) and creativity (Carson, 2018; Carson et al., 2003). Intelligence is an important moderating factor here, with high IQ facilitating creativity and serving as a protective factor against psychopathology for those with low latent inhibition (Carson et al., 2003). One study has found that people with ASD exhibit increased latent inhibition, which the authors refer to as “learned irrelevance” rather than latent inhibition (Maes et al., 2011).

Apophenia

Apophenia is defined as the predisposition to false positives (i.e., perceiving random patterns as meaningful) and is thought to be a core feature of positive schizotypy (Blain et al.,

2020; Brugger & Graves, 1997; DeYoung et al., 2012; Fyfe et al., 2008). The PSI hypothesis can account for this predisposition to false positives for the same reason that positive schizotypy is associated with a diffuse attentional style. As discussed above, the PSI hypothesis suggests that the schizotype's perceptual system only registers relatively large deviations from its predictions. Because the schizotype's perceptual system normally filters out low-level noise, the schizotype has learned to assume that sensory input mainly represents *signal* rather than *noise*. In a situation in which sensory input is nothing but noise, the schizotype may still be working under the top-down assumption that its sensory input represents signal, and will therefore try to impose some order onto the noise, resulting in false positives. While some deficits associated with ASD have been characterized as a result of *overfitting* sensory input (Van de Cruys et al., 2013), apophenia can be considered a result of *underfitting* sensory input. In data analysis, underfitting occurs when strong top-down assumptions are brought to bear on the data. Indeed, Pasquinelli (2019) has argued that underfitting is the equivalent of apophenia in machine learning:

If apophenia is the human tendency to perceive meaningful patterns in random data, underfitting is a sort of machine apophenia. Machine apophenia happens if a statistical model sees a pattern that is not there, that is, if it reads noise as similar to an existing pattern. (p. 11)

Similarly, because of the greater effect of top-down assumptions on the schizotype's perception, they can end up seeing meaningful patterns in pure noise (Blain et al., 2020). Of course, this bias towards pattern detection will be useful if there *is* a hidden signal to be found in a relatively noisy pattern. On the other hand, because the autistic type's perceptual system is more likely to pick up on noise (due to inflexibly high PSI), they have learned to assume that when faced with unpredictable, chaotic situations much of their sensory input is noise rather than

signal. As such, they should be less likely to attempt to impose order on random patterns, and therefore less likely to exhibit apophenia or false positives.

Systemizing

ASD and autistic-like traits are associated with greater proficiency at mastering rules-based systems (Baron-Cohen et al., 2009). However, there has been little research looking at the relationship between systemizing and positive schizotypy. One relevant study split participants into high and low positive schizotypy groups, finding that people in the high positive schizotypy group scored lower on the systemizing quotient (Russell-Smith et al., 2013). However, the effect barely failed to reach conventional levels of statistical significance (calculating the p-value based on the reported statistics produces a value of .06), likely because of the low power due to small sample size ($n = 20$ per group). Another study used principal components analysis and found that, in a sample of female undergraduates, systemizing loaded negatively on a factor that included psychosis-related traits (e.g., paranoia, thought insertion, strange experiences) and empathizing (Brosnan et al., 2010). This finding indicates that positive schizotypy is associated with low systemizing in this population.

The PSI hypothesis can be used to understand why autistic-like traits and positive schizotypy would have opposite relationships with systemizing ability. By giving a relatively high weight to sensory input, people with high autistic-like traits may be prone to overfitting sensory input, incorporating noise into their predictive models (Van de Cruys et al., 2014). However, in a truly lawful, rules-based system, *there is no noise* to be incorporated. A given input produces the same output every time, meaning that overfitting is simply not an issue. When dealing with a rules-based system, the highly precise cognitive-perceptual style afforded by

giving a high weight to sensory input will facilitate the ability to pick up on highly complex but low-noise patterns.

People high in positive schizotypy, however, may tend to *underfit* their predictive models when confronted with highly complex, low-noise input. In trying to understand rules-based systems, the greater influence of top-down priors may lead people high in positive schizotypy to impose simplifying assumptions onto the input, which will result in them missing out on important details and treating signal as if it's noise. Figure 2 provides a simplified visual representation of how differences in the weight given to sensory input, and thus differences in the influence of top-down assumptions (in this example, the top-down assumption is that a linear model best fits the data), could result in differences in the ability to pick up on highly complex but low noise patterns.

Figure 2.

Differences in the Weight Given to Sensory Input Lead to Differences in Systemizing Ability

Giving a high weight to sensory input will result in fitting one's predictive models very precisely to sensory input, affording systemizing abilities.

Giving a low weight to sensory input will result in underfitting complex sensory input, resulting in a lesser ability to understand complex systems.

Note. Differences in the weight given to sensory input along the autism-schizotypy continuum result in differences in the ability to understand complex, rules-based systems.

Exploration-Exploitation

Deciding whether to exploit current opportunities or search for new ones through exploration is a fundamental trade-off facing all organisms. Another way to put this is that there is a trade-off between following a current plan in operation and being distracted by an emergent opportunity (Carver & Scheier, 1998). If an organism is too flexible (i.e., exploratory) it will be easily distracted and never get anything done. If an organism is too focused on current goals, however, it will fail to recognize both emergent opportunities and emergent problems (Carver & Scheier, 1998). In this section I review evidence suggesting that the schizotypal type tends to be more exploratory than the autistic type and explain how this tendency towards exploration can be understood according to the PSI hypothesis. In addition to the findings reviewed above, Del Giudice and colleagues (2014) also found that the autism-schizotypy variable was correlated with the Big Five traits of Openness and Extraversion, but not with other Big Five traits (Del Giudice et al., 2014). Higher scores on the autism-schizotypy variable indicate higher positive schizotypy, so these findings indicate that the schizotypal type tends to be higher in Openness and Extraversion. Additionally, Barrantes-Vidal and colleagues (2010) performed a cluster analysis on a measure of schizotypy in a sample of college students and found that the high positive schizotypy group also had elevated levels of Openness and Extraversion (in addition to Neuroticism). Together, Openness and Extraversion form a higher-order factor of the Big Five called Plasticity (DeYoung et al., 2002; Digman, 1997). Plasticity has been characterized as “the general tendency towards exploration” (DeYoung, 2015, p. 15), indicating that the schizotypal type is, on average, more exploratory than the autistic type. Del Giudice and colleagues (2014) also found that positive schizotypy was related to sensation-seeking, which is another indicator of exploratory tendency (DeYoung, 2013). Del Giudice and colleagues’ (2014) findings are not the

only indicator of differences in exploratory tendency along the autism-schizotypy continuum. As discussed in a previous section, schizotypy (and especially positive schizotypy) is associated with reduced latent inhibition (Carson, 2018; N. S. Gray et al., 2002; Kumari & Ettinger, 2010) and one small study has found abnormally high latent inhibition to be associated with ASD (Maes et al., 2011). Reduced latent inhibition is also associated with increased Plasticity (Peterson et al., 2002; Peterson & Carson, 2000), indicating that reduced latent inhibition is related to a general exploratory tendency. As further evidence, Andersen and colleagues (2021) recently predicted and found in a pre-registered study that positive schizotypy is associated with increased intentions and desires to migrate. This prediction was based on evidence for increased exploration associated with positive schizotypy.

Increased exploration associated with positive schizotypy can be understood according to the PSI hypothesis. Because the perceptual system of the schizotype only utilizes relatively large deviations from its predictions in updating priors (meaning that these prediction errors are more likely to be signal than noise), the schizotype ought to be more willing to explore the causes of deviations from sensory predictions since larger prediction errors represent larger potential information gains (DeYoung, 2013). As Kiverstein and colleagues (2019) put it, “a large but resolvable error signal informs the agent that the environment offers the opportunity to resolve uncertainty” thus making “epistemic action” (i.e., exploration) an attractive option (p. 2857). In other words, because the schizotype essentially ignores small prediction errors, any prediction errors large enough to be noticed by them ought to be worth exploring. This increased exploration may come with a grave risk, however, as Peterson (2011) has suggested that “the perceptual, cognitive, emotional, and behavioural aberrations of psychosis—schizophrenic or

manic—can be productively regarded as illnesses of the process of creative exploration” (p. 130).

Van de Cruys and colleagues (2014) argue that the inflexibly high weight given to sensory prediction errors in ASD will result in decreased exploration. Because people with ASD and high autistic-like traits treat all or most prediction errors as if they are important, they have a hard time seeing where the greatest information gains can be had. As such, they will tend to linger on previously learned/explored stimuli. The restricted and narrow interests associated with high autistic-like traits are likely a result of this decreased exploratory tendency (Del Giudice, 2018). Of course, this reduced exploration also has an upside, as people high in autistic-like traits are more likely to be competent specialists precisely because they aren’t as likely to be distracted by different opportunities.

In sum, differences in exploratory behavior along the autism-schizotypy continuum as evidenced by measured differences in personality traits are explainable in terms of the PSI hypothesis. If people high in positive schizotypy only pay attention to relatively large prediction errors, this would plausibly lead to an increased proclivity to explore in order to determine the causes of these errors since larger errors represent larger potential information gains.

Discussion

The primary purpose of this paper was to convey the idea that differences in the way sensory input is weighted can potentially explain a wide array of features on both sides of the autism-schizotypy continuum. Differences along the autism-schizotypy continuum in top-down vs. bottom-up influences on perception, mentalizing, imagination, worldview formation, attention, detail-orientation, systemizing, apophenia, and exploration may all be explicable according to this relatively simple mechanism. The PSI hypothesis implies that autistic-like traits

represent a specialization for orderly, predictable environments while positive schizotypy represents a specialization for chaotic, unpredictable environments. If true, this hypothesis has implications that go beyond clinical work. It would mean that there is an identifiable continuum of individual differences in both clinical and non-clinical populations characterized by people who give a relatively high weight to sensory input on one side (associated with autistic-like traits) and people who give a relatively low weight to sensory input on the other side (associated with positive schizotypy). Identifying a continuum like this would help to advance our knowledge of the cognitive and neural underpinnings of individual differences in all populations. Future empirical tests will determine whether the PSI hypothesis holds up to scrutiny and can be usefully applied to facilitate a deeper understanding of the autism-schizotypy continuum and the study of individual differences more generally.

For example, one of the most interesting implications of the PSI hypothesis is the difference in worldview formation that is expected to occur along the autism-schizotypy continuum. While it is well-established that positive schizotypy is associated with having unconventional and/or idiosyncratic worldviews, there is little published evidence regarding the opposite finding with autism. Holding relevant factors like IQ constant, are autistic-like traits associated with a *reduced* propensity to believe in extra-terrestrial encounters, conspiracy theories, extra-sensory perception, etc.? That is what would be expected based on the PSI hypothesis. Additionally, it is surprising how little research there is on systemizing and positive schizotypy. Indeed, based on the PSI hypothesis and the diametric model in general we would strongly expect for positive schizotypy to be associated with a reduced systemizing tendency when controlling for relevant factors like IQ. In the section on systemizing, I discussed the only two studies about this that I am aware of and while the evidence is suggestive, it is weak and

inconclusive. There is also a need for more empirical research on differences in attention along the autism-schizotypy continuum. Attentional differences associated with autism have been studied extensively, but Abu-Akel and colleagues (2017, 2018) studies are the only ones that compare the attention style of people high in autistic-like traits with people high in positive schizotypy. An interesting direction for future research may be to compare differences in the scope of attention (e.g., Wilson et al., 2016) along the autism-schizotypy continuum. These are not the only areas with potential for future research. The diametric model of autism and psychosis is relatively new and the PSI hypothesis provides a basis for making precise predictions about cognitive-perceptual differences in a variety of domains along the autism-schizotypy continuum in non-clinical populations. Furthermore, research on the autism-schizotypy continuum may prove useful for discovering the physiological/neurological basis for individual differences in the relative weight given to sensory input (e.g., Lawson et al., 2017). Much of the current research being done on these topics focuses on autism and schizophrenia in clinical settings. As I discussed earlier, schizophrenia is highly heterogenous and the results of many studies are potentially confounded by the use of anti-psychotic medication. For these reasons, discovering the cognitive, perceptual, and physiological bases underlying the diametric model may require devoting more resources to the study of autistic-like traits and positive schizotypy as they manifest in non-clinical populations.

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