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ORIGINAL RESEARCH

Ecological-enactive account of autism spectrum disorder

Janko Nešić[1]

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Abstract

Autism spectrum disorder (ASD) is a psychopathological condition characterized by persistent deficits in social interaction and communication, and restricted, repetitive patterns of behavior and interests. To build an ecological-enactive account of autism, I propose we should endorse the affordance-based approach of the skilled intentionality framework (SIF). In SIF, embodied cognition is understood as skilled engagement with affordances in the sociomaterial environment of the ecological niche by which an individual tends toward the optimal grip. The human econiche offers a whole landscape of affordances, and situated individuals respond to a field of relevant affordances. An important part of SIF is an ecological-enactive interpretation of the free energy principle and predictive processing. Predictive processing accounts indicate that in ASD too much precision is assigned to prediction errors. Autistic persons depend heavily on current sensory information and less on prior beliefs and cannot attune to stable regularities. To reduce uncertainty, they over-rely on routines, strict habits, and a familiar environment—a predictable ecological niche they construct. I argue that skilled intentionality gives us the framework from which to analyze the autistic field of affordances. Autistic patterns of affordance-related bodily states of action readiness are only sensitive to very specific solicitations in the environment and achieve optimal grip in well-known situations. Autism is to be understood as a disorder of bodily normativity. Taking this approach helps us figure out what neurotypical people can do to attune their environment in order to scaffold the needs of autistic individuals by redesigning the landscape of affordances.

Keywords Autism · Affordances · Ecology · Enactivism · Skilled intentionality · Niche construction

A change in the weather is sufficient to recreate the world and ourselves.

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1 Introduction

Autism spectrum disorder (ASD or simply autism) is a psychopathology (neurodevelopmental disorder) which is characterized by deficits in social interaction and social communication (i.e., deficits in social-emotional reciprocity, nonverbal communicative behaviors) and restricted, repetitive patterns of behavior, interests, or activities (i.e., stereotyped or repetitive motor movements, insistence on sameness, highly restricted, fixated interests, hyper- or hyporeactivity to sensory input) (APA, 2013, p. 50).[1] Leo Kaner, a child psychiatrist of Austrian-Hungarian origin, is usually lauded as the first to name the condition in his 1943 paper. Kaner described a specific pattern of behavior that he observed in a group of 11 children and baptized it "early infantile autism" (from Greek αὐτός meaning *self*).[2] Hans Asperger, an Austrian pediatrician, wrote about older children and adolescents and described "autistic psychopathy" in four boys in 1944. This condition was later called "Asperger syndrome", but the full acknowledgement only came as late as the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-4) (1994). However, recently, it has been pointed out (Sher & Gibson, 2021) that the Soviet-Russian child psychiatrist Grunya Efimovna Sukhareva gave the very first clinical account of autistic children. She published her description of autistic traits of six boys aged between 2 and 14, who spent two years at her 'hospital-school' at the Psychoneurological Department for Children in Moscow, in a German psychiatry and neurology journal in 1926, two decades before Kanner's and Asperger's seminal papers. The boys whose behavior she recounted today would be labeled as "high functioning" autistic individuals (those that have higher IQs and less severe impairments).

Autistic children lack interest in people and the social world but have a peculiar "fascination for objects" (Kanner, 1943). In relation to restricted and repetitive behavior and interests, these behaviors and feelings towards inanimate objects have been observed in autism since Kanner and Asperger,[3] all the way to the DSM-5. These are the types of autistic behavior I will be concerned with in the present article.

Consider a snippet from the case history of a 10-year-old boy Hans R. described by Bosch (1962/1970) that shows the characteristic behavior and relation to objects of autistic children:

> He also showed a particular interest in round or rotatable objects. His mother had noticed this particular predilection in his third year. At home he had filled a box with a very varied collection of wheels, and when visitors were present he

[1] The fifth iteration (DSM-5, 2013) differs from the fourth (DSM-IV-TR, 1994) in that it combines previously separate categories of autistic disorder, Asperger syndrome, pervasive developmental disorder-not otherwise specified (PDD-NOS) and childhood disintegrative disorder—into a single consolidated umbrella diagnosis of autism spectrum disorder.

[2] Viktor Frankl saw autism as a disturbance of affective language and affective contact, and Leo Kanner followed in using these formulations by writing in his famous 1943 paper: "During the interview, there was no kind of affective contact" (Kanner, 1943, p. 229; Bizzari, 2018).

[3] These were described by both Kanner and Asperger, though interpreted differently; Sukhareva describes it as "'a tendency towards automatism' and that this manifested "as sticking to tasks which had been started and as psychic inflexibility with difficulty in adaptation to novelty" (Sukhareva, 1925; cited in Sher & Gibson, 2021).

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> would always say, 'He wants a wheel.'... But his interest in round or rotatable objects was not just restricted to looking at, handling, or drawing them, for his favorite body movement was also that of spinning round. Rotating played an important part in his rhythmic movements. (Bosch, 1962/1970, pp. 7–8)

In the follow-up examinations, when Hans was between 14 and 16, this was observed:

> "The care which he took over manual work with wood, nails, or paper and the importance he attached to having everything in the flat arranged in a particular way had, if anything, increased. He noticed immediately if his mother moved any of his things and complained about it. He also still retained his liking for wheels. At the time he was collecting watch parts, which he would spend hours twisting back and forth, but he also made drawings of them and cut these out." (Bosch, 1962/1970, p. 13)

What lies at the core of this disorder? There has been a resurgence of interest in philosophical theories of social cognition disturbances in autism spectrum disorder, and a number of models and theories about the nature of autism have been proposed. First came the cognitivist theories, the central coherence model (more attention to details than to global information, Happé, 1999; Happé & Frith, 1996) and the mindblindness theory of Baron-Cohen (1995). The theory of mind position on the psychopathology of autism is that such individuals fail to develop the capacity to mind-read or "mentalize"; they lack the ability to understand mental states and could be called mindblind (Baron-Cohen, 1989; Frith, 2003). There is also the executive function theory (Ozonoff et al., 1991) that autistic individuals do not have control over their actions, as well as the weak central coherence theory (Frith, 2003) regarding the autistic focus on details of information, and problems with integration in perception.

The turn from cognitivist explanations of autism has been taken by phenomenological and 4E approaches to social cognition (Bizzari, 2018; Gallagher, 2004; Gallagher & Varga, 2015; León, 2019; Zahavi, 2005, 2010, 2014; Zahavi & Parnas, 2003). Unlike cognitivist theories, phenomenological theories seek autistic differences already on the pre-reflective level. Those who endorse the phenomenological theories of social cognition maintain that exceptional autistic individuals like Temple Grandine[4] have learned to depend on explicit mentalizing and inferring from social cues and rule-based knowledge about the behavior of others because they lack a "social sense" and certain capacities of primary intersubjectivity (sense of *being-with-others* provided by intercorporeality, Fuchs, 2020, pp. 330–331; Zahavi, 2014). Fuchs's phenomenological and enactive theory (2015, 2020) understands autism as a disturbance of intercorporeality and interaffectivity. What lacks is affective attunement, pre-reflective understanding, and engagement with other people. Similarly, ASD was characterized by impairments in connecting to the emotions of others (León, 2019).[5]

[4] Temple Grandin is a highly intelligent, high-functioning autistic woman who has a PhD in animal science and has published more than 200 scientific articles and autobiographical accounts on her experiences with autism.

[5] Peter Hobson argued that thinking and feeling are deeply related, and that self-conscious affectivity helps constitute the concept of self (Hobson, 1990). In autism, the abilities for social-emotional relatedness are severely limited (e.g., being unable to identify with the attitudes of others), and this seems to be the source of later deficits in creative symbolic thinking and self-reflective awareness (Hobson, 2018).

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In her enactivist account, De Jaegher (2013) argues that ASD involves different forms of participatory sense-making.[6] Maiese (2021) sees autism as entailing maladaptive, disordered patterns of sense-making. Predictive coding/processing explanations have also been proposed (Pellicano & Burr, 2012, hypothesizing weak priors in autism; Van de Cruys et al., 2014). Bolis et al., (2017, the dialectical misattunement hypothesis[7]) and Schilbach (2016) argue for second-person neuropsychiatry and neuroscience and have built second-person models of autism that are a synthesis of predictive processing and enactivism. Enactivist/extended approaches to autism are a recent addition to this literature (ASD persons suffer from "style blindness", Krueger, 2021; Krueger & Maiese, 2018).

A detailed account of the ecological aspects of autistic disturbances is still missing in the literature. In addition, I think that an integrative account of autism is much needed at this point. It will bring all these diverse aspects of ASD together and do justice to the experience of autism. The account I develop helps us connect two aspects of autism (two core types of deficits) found in the current DSM-5 diagnostic criteria: social and non-social (how they relate to persons and objects). Current theories of autism usually give explanations only to certain deficits, like social and cognitive ones or repetitive behavior. An integrative account I propose can show how social, cognitive and communication deficits hang together with the differences in phenomenology, embodiment and situatedness of autistic people and, thus, provide a multidimensional explanation. The account offers not just a detailed explanation of mechanisms behind differences in both social and non-social domains and how they are connected but also gives ways in which we can understand those differences in more detail and depth, which can lead to the development of more precise diagnostic criteria. The phenomenology of autism is mostly left out, even in the DSM-5. This account highlights and analyzes previously philosophically unexplored aspects of autistic situatedness while at the same time connecting them to predictive processing problems and phenomenological differences through ecological-enactive terms (such as the bodily normativity and field of relevant affordances).[8]

I find that the *ecological-enactive framework* has the synthetizing power required for the task. Thus, I will present an ecological-enactive account of ASD. The remainder of the paper consists of five sections. Following what was said in the Introduction, in Sect. 2, I urge for a closer philosophical look at the ecological aspects of the autistic spectrum disorder, on the different ways autistic persons relate to their environment. Section 3 introduces and outlines the skilled intentionality framework (SIF) from which I propose to view ASD. This framework brings along with it an affordance-based perspective that synthesizes ecological and enactive approaches to cognition with phenomenology and neuroscientific theories. Section 4 highlights the predictive

[6] Living beings are actively searching, and engaging the environment for affordances, trying to make sense of it through moving, they enact their world through *sense-making* (Varela et al., 1991; Di Paolo, 2009). *Participatory sense-making* comes from social interactions and relations with other human beings in the shared human reality which is "*interenacted*" (Fuchs, 2018, pp. 26–27; De Jaegher & Di Paolo, 2007).

[7] In this hypothesis, authors integrate predictive processing with intersubjective approaches and understand ASD as "a cumulative interpersonal mismatch of prediction and interaction styles… with the world and others across multiple timescales" (Bolis et al., 2021, p. 223).

[8] I am thankful to the anonymous reviewer for pointing out that this needs to be made explicit.

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processing (PP) framework, in coalition with the free energy principle (FEP), as part of skilled intentionality. SIF boasts an ecological and enactive construal of both predictive processing and the free-energy principle. I show how health and well-being are understood in the ecological-enactive interpretation of PP and FEP. I will then employ various PP theories of ASD to sketch the particular ways in which the precision estimation differs in autistics and how this entails their peculiar niche construction. Section 5 is dedicated to bringing the findings of such PP theories of autism to bear in the SIF and working out a detailed ecological-enactive account of autistic differences in terms of affordances that includes the autistic lived experience. Finally, tentative suggestions for therapy and inclusion are given in Sect. 6.

2 Integrative framework for ASD: the skilled intentionality

In this paper, I want to hone this aspect of autistic impairments and offer an ecological-enactive account of autism. Highlighting the enactive and ecological perspective on autism could further improve our understanding of the disorder, make diagnostics better and more precise, and finally, enable the designing of more inclusive environments for ASD persons.

The ecological and enactive framework that I want to focus on is the *skilled intentionality framework* or the SIF (Rietveld et al., 2018).[9] I will argue that the skilled intentionality framework should be endorsed to build an integrative, ecological-enactive account of ASD. The potency of this framework lies in the fact that it connects complementary findings from a significant number of scientific disciplines—neurodynamic, ecological, affective, and phenomenological levels of analysis of cognition (all aspects of the self-organizing system "brain–body–landscape of affordances.", both individual and environmental). SIF connects a number of disciplines: ecological psychology (landscape of affordances; Chemero, 2009; Gibson, 1979; Heft, 2001), phenomenology (selective openness to and relevance of affordances, optimal grip), emotion psychology (states of action-readiness along the lines of Frijda, 2007), and embodied neurodynamics (self-organizing affordance-related states of action-readiness). I will explain in the following the key concepts of the framework: landscape and field of affordances, solicitations, optimal grip, etc., that will be applied to ASD later.

In the SIF, which brings together the embodied, enactive and ecological programmes, cognition has been understood as skilled engagement with different

[9] There are not many ecological approaches to psychopathology. Another interesting approach to the ecological side of psychopathological disorders has been advocated by Thomas Fuchs (2007, 2019). He draws from both the phenomenology of the lived body (Merleau-Ponty, 1945/2002) and ecological psychology (Gibson, 1979), bringing concepts like the *phenomenal field* and *lived space* (permeated by *field forces*, towards affordances/valences of the environment). The lived space of a person is its ecological niche (feedback cycles of "responded activity"). The ecological niche can be considered a segment of the environment that is complementary to the dispositions of the individual—objects living and nonliving, with which an individual interacts (Fuchs, 2007, p. 42; 2019, p. 3). The econiche offers different affordances (possibilities for action). Fuchs applied these concepts to psychopathology and psychotherapy in order to institute an ecological approach to psychic disorders and ecological psychotherapy.

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affordances (possibilities for action) in the sociomaterial environment of the ecological niche by which an individual tends toward the optimal grip. Part of SIF is an ecological-enactive interpretation of the free energy principle and predictive processing (Bruineberg & Rietveld, 2014). Predictive processing accounts indicate that in ASD, too much precision is assigned to prediction errors (Van Constant et al., 2018a, 2018b; de Cruys et al., 2014; Miller et al., 2022). I will put all of these together toward a better understanding of ASD.

According to SIF, embodied cognition (both higher and lower forms[10]) is skilled engagement with multiple affordances offered by the sociomaterial environment in the context of the human ecological niche." (Rietveld et al., 2018, p. 49), where affordances are understood as possibilities for action that are provided by the environment. Members of the same species are situated within the same ecological niche, e.g., the human ecological niche. Human econiche is a rich *landscape of affordances*. These affordances correspond to the abilities available in a particular *form of life*.[11] Skilled intentionality is thus the skilled responsiveness to a landscape of affordances (essentially relational). It is selective engagement with affordances simultaneously in a concrete situation. The landscape contains all the affordances that are available to a form of life in general (humans).[12] This landscape is fundamentally social. Now, a *field of affordances* can be distinguished from the landscape, and it "reflects the multiplicity of inviting possibilities for action for an individual in a concrete situation" (Rietveld et al., 2018, p. 52; de Haan, 2020, p. 218; de Haan et al., 2013). The field of affordances is an individual "subset" of the whole landscape of affordances.

The creators of the SIF introduce several novel phenomenological concepts. First, solicitations are the affordances that are inviting to a situated individual and generate bodily states of action readiness (Rietveld et al., 2018, p. 52). There is a pre-reflective, experiential dimension to them. The field of relevant affordances is the field of solicitations. Phenomenologically, this responsiveness to many solicitations simultaneously is designated as the "tendency toward optimal grip on a field of relevant affordances".

The central phenomenological concept is that of the *optimal grip* and comes from Merleau-Ponty's philosophy of life. All living beings have an inherent disequilibrium within the individual-environment system (Merleau-Ponty, 1968/2003). There is a fundamental lack that motivates "compensatory activity" (Merleau-Ponty, 1968/2003, p. 149; Rietveld, 2008, Ch. 7). This disequilibrium is experienced as an "affective tension". To understand the optimal grip, consider the famous Merleau-Ponty's example of moving closer to a painting in an art gallery to get to the *optimal* distance from which it is best viewed Merleau-Ponty (1945/2002). That is why the living animal is always selectively open to the landscape of affordances and responsive to relevant affordances (Bruineberg & Rietveld, 2014). Organisms always tend toward an optimal grip in the dynamic coupling of body and world. The individual has to be responsive to solicitations to improve their situation. The core of the SIF can be stated thus: "skilled intentionality means reducing disequilibrium by moving toward an optimal

[10] SIF research program plan is to understand social interaction in terms of skilled intentionality.

[11] Rietveld and Kiverstein (2014) follow the Wittgensteinian (1953) notion of affordances. With the form of life, they refer both to the kind of animal (with an ecological niche) and to the sociocultural practices. A form of life is expressed in the stable patterns of behavior of a particular species.

[12] So, their human econiche is broader than the niche Fuchs has in mind (as cited in footnote 8).

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grip on multiple relevant affordances simultaneously, that is, on a *field of relevant affordances*" (Rietveld et al., 2018, p. 45).

Proponents of SIF defend an ecological-enactive *model of disability* (Toro et al., 2020), which emphasizes the role of a pragmatically structured sociomaterial environment in constraining and enabling behavior. This model, contrary to medical and social models, focuses on the experience of the lived body of the disabled person. The ecological-enactive approach follows Canguilhem's (1991/2015) analysis of health and illness to make a distinction between "normal" and "pathological" embodiment.[13] Toro et al. emphasize that the concept of bodily normativity is very close to the contemporary enactivist notion of *sense-making* and is inspired by the work of Canguilhem and Merleau-Ponty. It refers to "the organism's evaluative capacity" that guides the organism on how to behave in order to attune to the environment to "achieve dynamic" stability (Toro et al., 2020, p. 6). A healthy person can institute new norms in new situations, and a pathologically embodied cannot adapt to change (2020, p. 8). Canguilhem writes: "more than normal—that is, adapted to the environment and its demands—but normative, capable of following new norms of life" (Canguilhem, 1991, p. 200). Being healthy means being "more than normal", adopting new norms of bodily normativity to reach dynamic stability in novel situations.

3 Predictive processing and skilled intentionality

3.1 Predictive processing and free energy in SIF

Skilled intentionality framework encompasses the so-called "free energy principle" (FEP or free energy framework) (Friston, 2010, 2011), an "ecological-enactive interpretation of FEP" (Bruineberg & Rietveld, 2014; Bruineberg et al., 2018). Proponents of SIF see the free energy principle as arguing that the brain is a part of a larger coupled system with the environment that, on the basis of its coupling, is constantly reducing misattunement with the environment. There is an inherent tendency toward an optimal grip on a field of relevant affordances. According to SIF this is in connection to the reduction of disequilibrium in the dynamical system "brain–body–landscape of affordances". Through the organism's minimization of free-energy, the brain's internal dynamics are normally adequately attuned to the external dynamics of the environment." (Bruineberg et al., 2018, p. 2440).

FEP promises to be a unifying theory of biological and cognitive sciences. An organism maintains its organization as an adaptive living system by way of minimizing its information-theoretic free-energy in interactions with its environment (Friston & Stephan, 2007) The minimization is achieved by predicting sensory input or by changing the environment to match what is predicted (*perceptual* and *active inference*, two ways to bring models and the world closer). This is how an organism attunes to its ecological niche. Bruineberg et al. emphasize that FEP is a unifying framework for

[13] As pointed out by Georges Canguilhem, although some conditions are pathological by common standards, they are experienced and understood as normal by the person who has the condition. Experiential life is norm-instituting or normalizing, and so the pathological is not just something lacking norm, but that which institutes its own normality (Canguilhem, 1991).

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self-organizing living systems, and predictive coding/processing is about the neural functioning of the brain. Although they usually come together as a package (the free-energy principle is combined with Bayesian predictive-coding by Friston himself), Bruineberg et al. argue they should not be conflated (Bruineberg et al., 2018, p. 2419).

Predictive processing (*prediction-error minimization*) is a theory of the brain and its cognitive functions (Clark, 2013; Friston, 2010; Hohwy, 2014). It has recently been used as a theoretical framework for studying mental illness in computational psychiatry. The predictive brain tries to minimize prediction-errors that result from (mis)matching between top-down predictions and bottom-up sensory information. Brain instantiates a hierarchical probabilistic model of the environment called the *generative model*. An agent gives more or less precision to either prior beliefs or current sensory evidence (prediction errors) depending on how reliable (or "precise") they estimate each to be. Perceptual and active inference should not be distinct strategies for minimizing prediction-error, but as "parts of a single process of readying the organism to act in such a way as to improve its" (Bruineberg et al., 2018, p. 2430).

Bruineberg et al. show that, contrary to the orthodox Helmholtzian picture that Hohwy and Clark assume, the brain is not an exemplary scientist and that this understanding of perception is incompatible with predictive coding under the free-energy principle. The Helmholtzian interpretation of the anticipating brain postulates a strict border separating the organism from the environment. This conflicts with the free energy principle in which the brain is within a larger coupled system with the environment. Bruineberg et al. argue that such internalist and representationalist interpretation is not supported and that an enactivist and ecological interpretation should be endorsed instead. Active inference of FEP is incompatible with *unconscious inference,* which is at the centre of the Helmholtzian view.[14] The structure of the generative model does not have to be representational. The generative model does not provide representation but guides interaction with the environment to make a healthy brain-body-environment system possible. In Bruineberg et al.'s non-representational interpretation, the generative model is viewed as a dynamical system of (patterns of action-readiness; a multiplicity of simultaneous and coupled) states of *action-readiness* that are sensitive to environmental affordances (selective openness) accessible in the landscape of affordances (Bruineberg et al., 2018, pp. 2439–2440) (it is "a system of multiple interacting states of action–readiness" 2018, p. 242). The states of action-readiness shape the prominence of solicitations in the environment and allow tending towards the optimal grip.

The generative model prepares the agent for actions that improve the grip on affordances in a particular situation. States of action-readiness are states of the organism that, according to sensory states and skills/capacities, make it ready to attain a grip on the situation (Bruineberg & Rietveld, 2014; Bruineberg et al., 2018, p. 2421). In a typically developing organism that develops its skills, the generative model becomes more (attuned) to the relevant affordances of the changing environment (growing openness). With their concept of the tendency towards an optimal grip, Bayesian notions of precision and uncertainty are reinterpreted as constrained by the free energy principle.

[14] One of the anonymous reviewers has remarked that Helmholtz, in all likelihood, would have been congenial with an enactivist interpretation of unconscious inference, especially when one takes into account his careful considerations of active vision. I thank the reviewer for this comment.

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3.2 Healthy attunement

In predictive processing, mental health is understood in terms of the goodness of the agent's generative model. In SIF's non-representational interpretation, the generative model is viewed as a multiplicity of simultaneous and coupled states of action-readiness sensitive to some affordances (selective openness) accessible in the landscape of affordances (Bruineberg et al., 2018). According to the predictive processing framework, we find abnormal beliefs about the world in psychopathology because agents use "suboptimal generative models" (Miller et al., 2022, p. 17).

Now, this needs to be qualified because, technically, there are no suboptimal models from a Bayesian perspective (due to the complete class theorem). Suboptimal here reduces to some prior beliefs within a generative model that are not suitable for the current situation, niche or world-generating sensations. In the case of autism, the priors in question are priors over the precision afforded sensations. Nevertheless, a failure of active inference may lead to aberrant learning and, eventually, generative models, in the wider sense, that are not fit for purpose.[15] To be more precise, it is the agent's behavior that is suboptimal or maladaptive "suboptimal modes of engaging with their environment".[16] I will explain in what ways autistic behavior diverges from healthy attunement in connection to bodily normativity in Sect. 5.

It is argued that *metastable attunement* (Bruineberg et al., 2021; Miller et al., 2022) provides conditions for well-being because agents that balance between order and disorder, known and unknown (to the edge of criticality, attain a balance between stability and instability, they are open, ready to seek new ways, skills. Metastable attunement is a notion that is grounded in ecological dynamics and phenomenology. There is a positive or negative *felt* character of affect if the agent is doing better or worse than expected at error reduction. This dynamical state of being metastably poised is what they call the state of "metastable attunement".[17]

"Such an agent will continually make progress in learning, growing and broadening their field of relevant affordances, which will, in turn, increase their confidence in managing unexpected volatility as it arises over the whole of their lives." (Miller et al., 2022, p. 24). This way, the generative model develops and can optimally manage environmental volatility in the long run. Management of volatility is crucial to maintaining a state of well-being of the organism.

Abnormal beliefs can come from *aberrant precision estimation* (Miller et al., 2022, p. 18). Giving too much or too little precision to prediction errors results in abnormal beliefs and a suboptimal generative model. In the case of autism, it is hypothesized that too much precision is assigned to prediction errors and sensory perturbations. Let us discuss in detail the exact way in which autistic generative models are suboptimal.

[15] I thank the anonymous reviewer for pointing out that this needs to be qualified.

[16] Here are two quotes that clarify suboptimality. Schwartenbeck et al. say: "In short, characterising the generative model underlying suboptimal behavior provides a principled approach to understanding the origins of maladaptive behavior as well as the diverse computational phenotypes that present similar 'symptoms'" (2015, p. 116). Corlett and Fletcher point out that: "Psychiatric illness and distress might be considered in terms of a failure to achieve this optimum interaction, and the challenge faced by computational psychiatry is to identify and quantify this suboptimal state" (2014, p. 401).

[17] Recall what being healthy means in terms of bodily normativity, as explained at the end of Sect. 3.

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4 Predictive processing in ASD: precisely situated individuals

4.1 Prediction error minimization in ASD

Predictive processing accounts of ASD point to problems in estimating precision (Pellicano & Burr, 2012; Van de Cruys et al., 2014). In this disorder, "too much precision is given to prediction errors relative to prior predictions", it is claimed, and autistic persons depend heavily on current sensory information and less on prior beliefs (Miller et al., 2022). Autistics give too much weight to novel sensory evidence and cannot attune to stable regularities (Karvelis, et al., 2018; Kirchhoff & Kiverstein, 2020; Lawson et al., 2014; Palmer et al., 2017).

According to the HIPPEA ("high and inflexible estimation of precision of prediction errors") theory (Van de Cruys et al., 2014), autistics designate atypically high precision to bottom-up prediction errors and have trouble adapting to environmental uncertainties, which leads to a restricted focus in perception and demand for sameness and stereotyped behavior. These are strategies they resort to in order to cope with a significant amount of prediction error in an attempt to make the sensory environment more predictable (Constant et al., 2018a, 2018b, p. 614). In the case of autism, even slight noise will induce learning, which leads to overfitted models that do not generalize to new inputs. In the vocabulary of predictive processing, autism is characterized by "high and inflexible estimation of precision of prediction errors".

The same demand for predictable sensory experience can be witnessed in Temple Grandin's case with her sense of touch since she built a mechanical body squeeze machine for these purposes (Edelson et al., 1999; Van De Cruys et al., 2014). According to HIPPEA, "actions that reduce these prediction errors to extreme minima should be preferred (Van De Cruys et al., 2014, p. 660)." Autistic persons have to deal with proprioceptive, interoceptive (related to the sense of self) and exteroceptive prediction errors. In HIPPEA, these atypical behaviors are understood as ways of "regulating excessive amounts of prediction errors".

Concerning that, it has been noticed that these repetitive, *stereotyped* behaviors decrease through development (Richler et al., 2010: cited in Van De Cruys et al., 2014), although the demand for *sameness* even increases (Van De Cruys et al., 2014, p. 660; Constant, Bervoet, et al., 2018, p. 617).[18] This means that exteroceptive prediction errors stay precise, which explains why autistics demand rituals and routine.

Vast amounts of stereotyping movements are needed to establish a sense of self. Repetitive, rhythmic movements of the body, like hand-flapping, tapping objects, vocalizations, or rocking movements, are referred to as "self-stimulation" or "self-stims" (Leary & Donnellan, 2012, p. 51), and these could be "effective ways of managing incoming sensory flows" (Krueger, 2021), autistic habits of mind, as they call it. They argue that self-stims have a "norm-governed character", something that has not been noticed enough. De Jaegher notes that there is evidence that activities related to restricted interests and repetitive behaviors ("autistic sensorimotor and affective particularities") are related to pleasure and well-being, although they can be socially unacceptable, and interfere with daily life and the social environment. They

[18] "insistence on sameness" (Kanner, 1943).

seem to be "beloved activities apparently associated with great positive valence" (Klin et al., 2007, p. 97; cited in De Jaegher, 2013, p. 10). This is witnessed in the qualitative interviews by Mercier et al., (2000; cited in De Jaegher, 2013) on restricted interests. Such activities can have salience and relevance for autistic persons, which should be considered when dealing with them. In that case, there seems to be a possibility of "converting them into acceptable activities" rather than just extinguishing them (Mercier et al., 2000; Krueger & Maiese, 2018, p. 27; Boyd et al., 2012).

4.2 Niche construction in ASD

An ecological corollary of problematic precision estimation in ASD is a peculiar way autistic individuals construct their econiche. It was proposed that predictive processing can be used to model how niche construction influences evolutionary processes (Constant et al., 2018a, 2018b). Niche construction comes from evolutionary biology and designates a process whereby organisms modify their environment and steer their evolutionary path (Laland et al., 2015; Constant et al., 2018a, 2018b, pp. 615–616). In predictive processing, niche construction is viewed as a strategy of organisms for minimizing prediction error through changes in the environment so that it conforms to their expected states. Niche construction, thus, is a form of active inference under the FEP.

The ecological niche functions as a meta-learning ("learning what can be learned", learnable sensory cues) mechanism (Constant et al., 2018a, 2018b, pp. 612–613). It is argued that artifactually supported rituals can regularize behaviors and stabilize expectations, improving predictability (Constant et al., 2018a, 2018b). The child needs to perceive the affordance of things for others and herself in order to be socialized (Constant et al., 2018a, 2018b, p. 619; Gibson, 1979, p. 141). They do not see solicitations that other people see in the environment; they perceive a small portion of the rich landscape of affordances. Autistics do not join in the so-called *collective niche construction.*

Precision estimation can be viewed within the context of cultural niche construction (Constant et al., 2018a, 2018b). The ecological niche is a meta-learning mechanism. It is argued that *cultural affordances* have a supporting role in estimating the precision of incoming sensory inputs (Kirchhoff, 2018; Constant, Bervoets, 2018, p. 616)—e.g., artifactually supported rituals, like religious ceremonies, increase environmental predictability.[19] Using the reports and experiences of autistic individuals, Constant, Bervoets, et al. show that there is an "ecological counterpart" to their problems in estimating precision. Because of high and inflexible precision estimation, they over-rely on the precision afforded by the environment. To sum up, due to the atypical processing of prediction errors, autistics develop a learning style that does not attune

[19] The ecological approach of Constant et al. (2018a) is complementary to the dialectical misattunement hypothesis (Bolis et al., 2017), embracing the intersubjectivist turn in cognitive science and autism research, and viewing ASD as a relational disorder, while the original PP theories (HIPPEA) viewed ASD individualistically.

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to the environment, and this produces a specific kind of scaffolding and behavioral traits in autism (Bervoets & Kristien, 2020).[20]

Constant, Bervoets, et al. use HIPPEA, because of its interpretation of the mechanism of meta-learning and the role of actions in meta-learning "to leverage ecological and embodied implications of PP to discuss aspects of the relational self in ASC" (Constant et al., 2018a, 2018b, p. 612). Similarly, Perrykkad and Hohwy (2020) focus on the disturbances of the autistic self based on Bayesian and predictive processing accounts of autism. Both Constant, Bervoets, et al. and Perrykkad & Hohwy assume the PP accounts of the self from cognitive neuroscience—those of Apps and Tsakiris (2014), Limanowski and Blankenburg (2013). Again, for an *ecological and enactive interpretation* of free energy and the self that follows such ideas, see Kiverstein (2018). Self-model is a model of the agent's selective engagement with affordances (Kiverstein, 2018, p. 7). Through active inference (cycles of perception and action) the whole organism regulates its own dynamical coupling to the environment so as to sustain its operational closure across multiple levels of the organization (2018, p. 9). Such systems are "self-specifying because of the systematic relation between sensing and moving realized through the perception–action cycle". They have both perceptual states (sensorimotor integration) and purposive agency. This is not yet enough for mineness (basic form of self-awareness). Kiverstein argues that in addition, we need temporally thick self-models (Friston). Self-models must have temporal thickness for subjectivity. His understanding of mineness supports a *relation theory of the self,* because in an ecological and enactive interpretation of active inference, "the organism and its environment are co-specifying, and co-determining." (Kiverstein, 2018, p. 3; Gibson, 1979, p. 4), the self and the other are co-determining.

5 Bodily normativity and autistic field of affordances

Predictive processing accounts indicate that in ASD too much precision is assigned to prediction errors. These accounts of autism offer a detailed explanation, that has ecological implications, on why the autistic self and autistic habits differ from those of neurotypical individuals. According to the HIPPEA theory (Van de Cruys et al., 2014), autistics designate atypically high precision to bottom-up prediction errors and have trouble adapting to environmental uncertainties, leading to a restricted focus in perception and demand for sameness and stereotyped behavior. In order to cope with a great amount of prediction error, they resort to these strategies to make the sensory environment more predictable (Constant et al., 2018a, 2018b, p. 614).

Autistics experience complex social environments as foreign and avoid natural sensory niches that cannot be reliably predicted. To reduce uncertainty, they overrely on routinized behavior, strict habits, sameness, and a familiar environment—a predictable ecological niche they construct. Although such individuals seem to be pathologically embodied, with disordered bodily normativity, some autistic habits are very environmentally responsive and adaptive. Such individuals instantiate suboptimal

[20] Van Es and Bervoets (2022), in their recent enactivist take on autism, construe ASD as a *sensorimotor atypicality* ("different autistic embodiment").

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generative models that fail to reach higher levels of abstraction and generality. In other words, they build "overfitted" models.

In terms of social interactions and social environment, and this a core deficit, autistics fail to respond to social affordances.[21] In PP, narratives (self-models, sitting at the highest levels of generative models) can generalize to many social contexts. Problems and deficits of social interaction and intersubjectivity in ASD can also be modeled through PP and active inference, for example, as done by the dialectical misattunement hypothesis (Bolis et al., 2017). Constant, Bervoets, et al. describe "the other" in ASD as less generalized, which means autistics have an overfitted model for social responses to well-known environmental cues which will be very formalized (Constant et al., 2018a, 2018b, p. 619).

I argue that in terms of SIF, autistic patterns of action-readiness pick out particular solicitations in the environment and achieve optimal grip only in well-known situations and specifically constructed ecological niches. They make interventions in the environment with reliable cue-effect relations. Autistic individuals lack the openness (pathological embodiment) needed to be responsive to the relevant affordances, pilling up inflexible habits and skills that are rigidly applied without adjustment to the changing environment. Autistic persons favor social environments that increase predictability through ritual behavior and routines. They use environmental cues as scaffolding.

Since precision-modulation in autism is fixed and inflexible, when developing their generative models, they will have difficulty gaining abstraction and with the alignment of their model with other people's models (problems with abstraction and flexibility). In ecological-enactive terms, patterns of action-readiness only pick out very specific solicitations in the environment. Moreover, the agent can only achieve some optimal grip in these situations. When confronted with a different (sociomaterial) environment, they cannot generalize and apply skills that they have acquired but in a very crude and inflexible way.

Autistic individuals make interventions in the environment to make it fit their model (active inference), with reliable cue-effect relations, in trying to attain optimal grip. The autistic generative model is such that it does not allow the individual to maintain a robust brain-body-environment system. They make special changes in the environment, organizing their own idiosyncratic affordances (i.e., autistic affordances) in the landscape for their autistic field of relevant affordances. Only specific, very precise affordances stand out for them in the environment, and their field of relevant affordances (de Haan et al., 2013; Rietveld et al., 2018) is structured according to their idiosyncratic skills and habits.

Autism is to be considered a *relational* disorder, in which there is a common atypical way of "tuning in to the material world" (Constant et al., 2018a, 2018b; on tuning into the intersubjective world see Bolis et al., 2017). If so understood as a relational

[21] Kiverstein has construed empathy as responsiveness to social affordances. The empathic abilities of ASD persons are diminished, and their empathy is less direct (Kiverstein, 2015, p. 8). Applying his model of empathy to ASD, Kiverstein argues that autistic persons do not orient attention to the aspects of the environment that others see as important (because of "abnormal patterns of gaze fixation") and thus have difficulty sharing perspectives with others (they are without those states of bodily action readiness that would direct them to shared aspects of the environment).

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phenomenon, then the "intervention strategies should be tailored toward the creation of constructive environmental scaffolding" (Krueger & Maiese, 2018; Maiese, 2021, p. 57).

Now, what I want to claim is that if in the enactive approach, autism is understood as disordered sense-making (different forms of participatory sense-making or disordered patterns of sense-making), now, in the terminology of the enactive-ecological approach, autism can be seen as *disordered* (or *different*) *bodily normativity*.

A healthy agent constantly creates new bodily norms to answer environmental challenges by adding new skills and improving old ones. However, due to the aberrant weighting of sensory information, autistic people learn differently. For them, noise induces learning and creates overfitted models (Constant et al., 2018a, 2018b, p. 614). They have difficulties modelling regularities, which influences their bodily normativity, the sum of all skills and capacities. In the terminology of Miller et al. (2022), to be healthy, agents sometimes need to disrupt their habits and allow actions that would lead to a build-up of error and uncertainty. Autistics may only have local success in error reduction, which is not enough for achieving and maintaining the state of metastable attunement.

Autistics develop new skills, but these are very specific and overfitted; such skills are used for particular situations and cannot be generalized to other contexts. The rituals and routines of autistic people, their strict habits constraining the sensory space, map onto DSM-5 non-social criteria of stereotyped behavior and insistence on sameness. The HIPPEA (and related niche construction theories) can explain why stereotyped (self-focused) behavior decreases over time and insistence on sameness (and routines and rituals) persists and even increases. Another consequence is an overreliance on their own ecological niche (sensory environment) to reduce uncertainty.

Bodily normativity includes social skills, given how Toro et al. define it (2020, p. 6). In the social domain, interactions of autistic persons will be "highly formalized, conventional social responses to familiar environmental cues", with "the other" being "less generalized" (Constant et al., 2018a, 2018b), which means that rituals and routines also reign in the social dimension of their bodily normativity. Interactions and norms in the social domain bear the same "autistic" mark as the material interactions due to the general problem of aberrant precision estimation.

It would be wrong to say that autistic bodily normativity is closed and inflexible; they do develop new skills, though not in the same way as neurotypicals. Autistic people can be pathologically embodied if the sociomaterial environment is inflexible and does not allow the individual to find her own skilled ways. This goes for the construction of their econiche, as well.

There is a cumulative, collective misattunement or lack of synchrony together with different interaction styles of autistic and non-autistic persons,[22] meaning that generative models are non-aligned. Autistics more easily attune to the norms of other autistic people.[23] Because of the way autistic social interaction styles are, they attune better to other (autistic) individuals with the same kind of bodily normativity.

[22] See footnote 7.

[23] See Bolis et al. (2021) for a study on interpersonal synchrony that corroborates this claim.

Autistic people have trouble phenomenally attuning to the norms of neurotypical people (and their norm-regulated cultural practices) (Kirchhoff & Kiverstein, 2020). This is a consequence of their aberrant weighting of sensory information. Due to the problems with precision estimation, the development of bodily normativity of autistic and non-autistic (neurotypical) people take disparate trajectories. What ensues is a mismatch between autistic and non-autistic norms—a mismatch between autistic bodily normativity (as a whole) and neurotypical bodily normativity. Neurotypical people bring with them their "pre-established normativity" (Toro et al., 2020) that conflicts with the skills and habits of autistic persons. Neurotypical people also lack the skills to interact with autistic people. Therefore, the sociomaterial environment should be more flexible to enable autistic people to develop new skills.[24]

The bodily normativity of the ecological-enactive framework is equivalent to enactivist sense-making. I think that if we are to stay in the spirit of the ecological-enactive approach, we need to understand the mismatch as something that is present between the bodily normativity of autistic and non-autistic people. No single dimension is disordered; we see differences across biological, psychological, and social domains. The underlying mechanisms of predictive processing put meat on the bones of these basic claims about bodily normativity; they show what is exactly different in the development and acquisition of bodily norms in autism. The PP part of the SIF account helps us understand why and in what way autistic people have trouble attuning to their sociomaterial environment.

The present account's novelty is viewing autism from the EE perspective through the lens of notions like bodily normativity and the field of affordances. We could summarize that autistic bodily normativity is mostly fixed, inflexible, and with slow development. Based on different types of affordances and how the world and self are modeled in PP, we could make a distinction between forms of bodily normativity that concern the *material, social* and *self-related* (toward one's own body) skilled actions. These are all interconnected, and autistic differences seem to span all domains. Although differences in social normativity are most prominent, they are present in the material and body(self)-related normativity. As it was pointed out, self-related normativity, with stereotyped behavior, can lose its rigidity over time, while strict habits and routines do persist (and multiply) in material and social normativity. How norms and habits are formed and applied in skilled action in autistic persons is markedly different from the skills of non-autistic, neurotypical people.[25]

A closely related notion to bodily normativity is the field of relevant affordances. A field of affordances is the expression of autistic bodily normativity. In psychiatric disorders, the person's field of affordances is altered. "Disordered sense-making discloses an altered field of relevant affordances" (de Haan, 2020, p. 218). There is no before or after autism, and a question could be posed: is autism to be considered a disorder in the first place? In de Haan's terminology, this would be to claim that sense-making in autism is not just disordered but utterly different sense-making (de Haan, 2020,

[24] Corlett and Fletcher, in their discussion on computational psychiatry, recognize that even the smallest changes in information processing can have catastrophic consequences but add that "many junctures exist at which intervention might be possible" (2014, p. 401).

[25] I thank the anonymous reviewer for pushing me to flesh out the dynamics of autistic bodily normativity in more detail and to distinguish different forms of bodily normativity.

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p. 204). Some think that we can speak of a whole autistic landscape of affordances different from the neurotypical affordance landscape. I find that such a claim is too strong.[26]

In the end, what needs to be pointed out is the following: autistic persons experience very restricted fields of relevant affordances, a limited range of affordances with which they engage, lacking the openness needed for well-being and healthy attunement to the environment. Three dimensions of the field of affordances have been distinguished (de Haan, 2020; de Haan et al., 2013): width ("broadness of the scope of affordances"), depth (temporal aspect), height (salience of affordances, characterized by their "intensity of the relevance" and "affective salience"). When all said is considered, it appears that autistics have a narrow field, shallow temporal depth,[27] with great intensity and affective salience of those affordances that do come up in their field.

6 Concluding remarks

Finally, and based on the discussion so far, I want to put forward some suggestions for a more inclusive landscape of affordances for autistic individuals. How should we help autistics learn new skills and habits and attune in a more robust way to the sociomaterial environment? Could this be done by designing "rich and attractive landscapes of affordances" that promote creativity and learning (so-called "metastable zones" of Bruineberg et al., 2021, p. 12,836) or by providing them with adequate environments that give stability and reduce uncertainty?

Contemplate this field note by psychologist Sophie Boldsen that describes a trip to a museum of rock music (Roskilde, Denmark) by an autistic women's group.[28] The women first move through a funhouse-like sensory space that is filled with loud noises and screams, lights, and mirrors, which are too invasive for the women. One of them is "sitting down on a platform, crouched together and covering her ears with her hands". Later they come to a large room with a rotating LP record on the floor. They lie down on the rotating LP record, and the music and motion calm them down. "We lie still and

[26] In the case that autism can be considered a form of life for itself, then we would be in a position to claim that there is a different autistic landscape of affordances (cf. Catala et al., 2021). It would be a very desolate landscape of affordances. See Chapman (2019), who argues for a Wittgensteinian account of autism as a different form of life. They propose an account of epistemic injustice, epistemic agency, and epistemic disablement in autism based on this ecological-enactive model of disability and enactivist cognitive science. They talk of an autistic landscape of affordances.

[27] Let me explain the temporal depth claim a bit further. Temporally thick self-models concern the depth of prior beliefs about the enactable future, namely, prior beliefs about the consequences of committing to this or that plan of action (where prior beliefs are read in a strictly Bayesian sense, e.g., subpersonal). These kinds of prior beliefs are agential and pertain to the self. However, they are still just prior beliefs and will be subverted if held with unduly low precision or (subpersonal) conviction. This is precisely the pathology induced by overly precise sensory precision (i.e., imbuing the likelihood part of the generative model with too much precision). The pathology of precision that accounts for ASD necessarily shrinks the depth or time horizon of any planned interaction with the world (or body), whether these plans are in the interoceptive or prosocial domains. I thank the reviewer for providing valuable comments on the temporal depth of self-models.

[28] This is taken from Boldsen's fieldwork in a social group for adolescents and young adults with autism. This part describes how one of the women, Eva, reacts to the environment of the museum.

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listen together for a while, and it is like not only the music, but everything has slowed down. Eva smiles. "This is a great sensory reset", she says. We feel the slow rotations of the LP record and chat a bit more about the music playing" (Boldsen, 2021, p. 32). The LP record helps them attain a "sense of togetherness", Boldsen explains. These social encounters and interactions are happening within a certain sensory space, and this should be considered. The particular surroundings seem to present a pleasant and appealing landscape of affordances for the group of autistic women.[29] Here we can see a clear case of ecological disturbances in autism, but also an example of some of how situating these individuals in an appropriate environment (with positively valenced affordances) can be enabling for autistics, providing less volatile sensory space and even facilitating better social interactions (at least within a group comprised of autistic individuals).

Krueger and Maiese note that high-functioning autistic persons enjoy better interactions with *other ASD people*. "This is because their interactions with other people with ASD take place within mental institutions governed by ASD-friendly norms and expectations." (Krueger & Maiese, 2018, p. 29; Kirchhoff & Kiverstein, 2020; Schilbach, 2016). In this regard, and in line with predictive processing theories of autism, both the ecological approach and the dialectical misattunement hypothesis emphasize that autistics are after a decrease of uncertainty in the sensory environment and social interactions. Predictable interactions with others are then favored. It would seem that autistic persons are more easily attuned to other autistics, as their behavior is more predictable (see Bolis et al., 2021). Therefore, I think that future autism research should focus more on social interaction between autistics themselves, not just with neurotypical people. Autism research could benefit from the addition of ethnographic methods to phenomenological research through which one can investigate social-spatial–temporal fields of interacting bodies, given that all social interactions are situational (Boldsen, 2021; De Jaegher et al., 2017).

It seems pertinent that we try to understand the exact nature of the autistic fields of affordances,[30] which I have pursued in detail in this article. It is my strong contention that understanding the autistic responsiveness to affordances can help us in achieving better and more appropriate designs of attractive landscapes of affordances that promote actions from autistic persons (e.g., through the arrangement of "place-affordances"). Like in the museum example, by restructuring the available affordances in a place, it could be possible to generate behavioral change in these subjects (*field of promoted actions,* Reed & Bril, 1996; Bruineberg et al., 2021, pp. 12834–12836). I find that such modifications in the landscape of affordances could enable autistic individuals to adopt new norms of bodily normativity and be more open to engaging with the environment. If autistic repetitive movements, habits, and restricted interests

[29] Boldsen utilizes Merleau-Ponty's phenomenological notion of *milieu* (Merleau-Ponty, 1945/2002, 2010) to clarify how social interaction is not just embodied but also "material and situational". The *milieu* is described as a *field of forces* (Merleau-Ponty, 2010, p. 346), and "milieu is not merely a material space that contains bodies but a field of potentiality within which body and world emerge" (Boldsen, 2021, p. 35). There is a clear similarity and close connectedness of this notion with phenomenological notions mentioned earlier—Fuchs's *lived space* (which has field forces towards affordances) and SIF's *field of affordances*.

[30] The skills and habits the agent has developed are what explains why certain affordances in the environment stand out and are inviting for action, and other affordances are not (Bruineberg et al., 2021, pp. 12824–12825).

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are not something that can be (or should be) eradicated, a suitable ecological design of affordances should accommodate them. In line with the integrative approach to autistic disturbances that I have been defending, it seems that embracing and maintaining meaningful, structured routines and habits could be a way for autistic persons to control their lived experience and a helpful resource for their creativity and well-being.[31]

I have proposed to view ASD through the lens of SIF, a framework that integrates insights from phenomenology and ecological-enactive cognitive science. The ecological-enactive approach to ASD, together with the predictive processing paradigm, can show how the sociomaterial environment is to be changed in order to become more attuned to the bodily normativity of autistic persons and even therapeutic so that their disability can be transcended.[32] I have presented only a sketch of an ecological-enactive account of autism in terms of affordances, and future work is to be dedicated to properly developing this integrative approach to ASD.

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[31] Activities like swimming and collage, for an autistic woman Penelope Dunbar. On how structured routine with clear narrative purpose can help autistic individulas, see Delafield-Butt et al. (2022).

[32] Following in the ecological and enactive theories of Fuchs (2007, 2019), and the SIF (Rietveld et al., 2018), in other work (Nešić, Subotić & Nurkić, *manuscript*), we discuss social environments that increase predictability through ritual behavior and routines (e.g., religious communities) and which could prove to be beneficial for people with ASD. We argue that a monastic environment can be regarded as providing shelter for autistic individuals, as witnessed in the historical case study of Hildegard of Bingen (c. 1098–1179).

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