Attuning the World:
Ambient Smart Environments for Autistic Persons

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Abstract: Autism spectrum disorder is usually understood through deficits in social interaction and communication, repetitive patterns of behavior, and hyper- or hyporeactivity to sensory input. Affordance-based Skilled Intentionality that combines ecological-enactive views of cognition with Free Energy and Predictive Processing was proposed as the framework from which to view autism integrally. Skilled Intentionality distinguishes between a landscape of affordances and a field of affordances. Under the integrative Skilled Intentionality Framework, it can be shown that autistic differences in the field of affordances stem from aberrant precision estimation. Autistics over-rely on the precision afforded by the environment - a stable econiche they build. According to this approach, autism is understood as characterized by an atypical field of affordances. I will build on the ecological-enactive account of autism to suggest that one way to shape the neurotypical landscape of affordances in accordance with autistic needs is through the use of Ambient Smart Environments (ASEs). Taking the cue from autistic lived experience, ASEs could help minimize environmental uncertainty and afford affective scaffolding by supporting dynamic and flexible niche construction in accordance with individual autistic styles.
Keywords: autism, field of affordances, skilled intentionality, ambient smart environments, niche construction

"What is the use of a house if you haven't got a tolerable planet to put it on?"
Henry David Thoreau

1. Introduction

According to DSM-5, autism (Autism Spectrum Disorder, ASD) is defined as a *neurodevelopmental disorder* characterized by persistent deficits in social interaction and communication, with restricted, repetitive patterns of behavior and interests (APA, 2013). Modern philosophical approaches have questioned if autism is a psychiatric disorder at all - there is no "before" or "after" autism (given that it is a neurodevelopmental disorder) - autistics have a different way of experiencing the world from neurotypicals, as Sanneke de Haan has pointed out (de Haan, 2020, p. 216).[1]

The condition is still primarily understood from a dominant cognitivist perspective, the "mindblindness" theory (Baron-Cohen, 1995), which has that autistic individuals do not properly develop the capacity to mind-read, to understand mental states (their own and of others). However, novel approaches that question this perspective are gaining traction. I have in mind phenomenological and enactive theories alongside the neurodiversity movement (Gallagher,

[1] I have a close family member diagnosed with autism at the age of three, so I possess a second-person understanding of an autistic lifeworld.

2004; Zahavi & Parnas, 2003; Bizzari, 2018; León, 2019; Milton, 2012). In addition to novel enactive theories of autism, extended and ecological approaches that borrow ideas from ecological psychology (Gibson, 1979) have emerged. Several authors have specifically used the concept of *affordances* (possibilities for action in the environment) in one way or another to understand certain aspects of autism (Loveland, 1991; Hellendoorn, 2014; Kiverstein, 2015; Roberts et al., 2018; Krueger, 2021a; Krueger & Maiese, 2018). What these embodied approaches are highlighting is that autistic differences come from a more fundamental source, the sensory and pre-reflective levels of the body, as problems of affectivity, empathy, and primary intersubjectivity.[2] These approaches have also expanded our understanding of autism as a relational condition and not an individualistic one, as a state that comes about between the autistic person[3] and their sociomaterial environment.

The neurodiversity movement has profoundly changed traditional views on autism and similar diagnoses by avoiding pathologizing these conditions and viewing them as dysfunctions. Chapman (2020) and Milton (2012) favor a social perspective on autism, while Bervoets and Hens (2020) work out their theoretical approach through Predictive Processing (HIPPEA, Van de Cruys, 2014) and plea for reconceptualizing the condition as *Autism Related Disorder* (ARD).[4]

Authors and researchers from different approaches (neurodiversity, enactivism, phenomenology), as well as autistic people themselves, are persistently calling for the phenomenological study of autistic lived experience and working towards including autistic voices in making these theoretical constructions (Milton, 2014; Nilsson et al., 2019; De Jaegher, 2021). Unfortunately, much is still to be done in autism research to reach this goal, but without the first-hand experiential knowledge and expertise of autistic individuals, none of this work would make sense, and epistemic injustice inflicted upon autistics would grow.[5] Usually, the first point of entry into the world of autistic experience is autistic life writing ("aut-ethnography", as autistic author Damian Milton calls it; Milton, 2015). I will use some of that writing in the present paper.[6]

The perspective on autism favored and expanded upon here builds on foundational ideas of neurodiversity through the theoretical frameworks of enactive and ecological approaches to cognition, supported by a phenomenological investigation into the autistic experience. Based on the ecological-enactive (EE) account, I will understand autism as a *different* or *atypical field of affordances*. Before, I proposed that autism should be viewed through the affordance-based approach of skilled intentionality (SIF; Rietveld, Denys, & van Westen, 2018) that combines enactive and ecological views of cognition (Nešić, 2023a). While older, cognitivist theories and models neglected the sensorial and bodily nature of the condition, phenomenological and enactive approaches expanded our understanding and added experiential knowledge of the inner autistic lives. Now, this change is a fundamental conceptual and methodological shift that has

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[2] The *weak central coherence* theory of Frith (2003) focusing on the problems with integration in autistic perception, came close to this. For good examples of phenomenological approaches to autism see Fuchs (2015), Bizzari (2018), León (2019).

[3] I will follow proponents of neurodiversity (Chapman, 2021) and the majority of autistic community in prefering identity-first language ("autistic person") to person-first language ("person with autism").

[4] A similar proposal for destigmatizing autism by using the label of *Autism Spectrum Condition* (ASC) comes from Constant et al. (2020). Van Es and Bervoets (2022) have also put forward an enactive take on autism and construe ASD as a sensorimotor atypicality ("different autistic embodiment").

[5] I have written about epistemic injustice in autism in Nešić (2023b).

[6] See Green and Shaughnessy (2023) for extensive discussion of these issues.

yielded a view of the human condition as relational and coupled with the environment (brain-body–environment system).[7] Such accounts of autism have already given enough argument to pursue more integrative views of the condition, where knowledge from neuroscience and phenomenology can be incorporated. Now, I think an even further step is necessary to fully develop the meaning of this relational story between an organism and the environment. So, the inclusion of the ecological aspect became important. And I think, given my myopic vision perspective, it is precisely in the case of autism that we are in need of a developed ecological and enactive account. Why is this so? Autism is a disorder of the interaction between an autistic person and their (sensory) environment, as well as with other subjects.[8] Even in the first (Kanner, 1943; Bosch, 1962/1970, pp. 7-8), as well as the most recent cases, we see a peculiar handling of the objects as first signs of autism in children. I have seen this firsthand in a person close to me, and this behavior demanded an explanation from a proper conceptual framework to be understood.

I find that the best contemporary framework that combines ideas from enactivism and ecological psychology, together with the neuroscience of predictive processing, is the SIF. To that, we have to add an already fast-growing literature on predictive processing (PP) in autism that has given some exciting models of autism. If we are to conjoin the PP view with more embodied approaches, we would not only outgrow the cognitivist theories but also incorporate them into an integrative account of autism.[9] To these demands, I find that the account endorsed here (Nešić, 2023a) provides the most comprehensive multidimensional take on the differences in phenomenology, embodiment, and situatedness. When we have a full grasp of why and how differences come about for autistic persons in their interaction with both the environment and other people, this will have a bearing on the ways we want to help such persons cope with those problems. For example, if many of the problems for autistic come from attuning to the environment, perhaps we, as neurotypical people, can adjust the surroundings to their needs. Why this account of autism is particularly suitable for one solution that aims to solve autistic disabilities (technological environments) will be more evident in the course of the paper.

I will employ this approach and see what possible strategies can be developed to alleviate problems in synchronization with the environment. The idea is to connect the ecological-enactive account of autism with the philosophical understanding of a new type of technology, namely, *Ambient Smart Environments* (ASEs, interior environments permeated with smart technology). Taking this approach could help us figure out what neurotypical people can do to change their environment to scaffold the needs of autistic individuals.

The understanding of ASEs as a meta-affordance that intervenes on the user's field of affordance, under the Free Energy Principle and the Skilled Intentionality Framework, was defended by White and Miller (2023). For example, ASEs can help autistic agents minimize uncertainty. This way, I think a strategy can be developed to alleviate some of the problems of autistic individuals. I do not want to claim that autistic people cannot lead fulfilled and satisfying lives or that they are unable to have any social life.[10] Many individuals face daily challenges in their attempt to be in tune with the sociomaterial environment around them, and this paper

[7] See Varela et al. (1991), Thompson (2007), de Haan (2020).

[8] This way the proposed account helps us connect two aspects of autism in which we see atypicality: *social* and *non-social* (Boldsen, 2022).

[9] For example, cf. Di Paolo, Thompson & Beer (2022). Arguments for integrative models in psychiatry can be found in de Haan (2020).

[10] Their quality of life needn't be measured with neuronormative standards. On how neurodiversity broadens our understanding of what can be a 'meaningful' life, see Pellicano & Houting (2022).

addresses one potential way of overcoming these challenges. The proposal seems especially pertinent for autistic children (and some adults) who are in need of very substantial support.[11]

I plan to do the following. In Section 2, I will lay out the foundational frameworks, that is, explain how autism is viewed from the ecological-enactive perspective. I will unpack the affordance-based framework behind this ecological-enactive account of ASD - the Skilled Intentionality Framework (SIF) and the Predictive Processing and Free Energy Principle, which are an integral part of the SIF. Then, I show how, when it is applied to the case of ASD, we can analyze the field of affordances of autistic persons in more detail. When I have the characteristics of the autistic field of affordances in place, I will introduce Ambient Smart Environments (ASE) (Section 3). ASEs are understood within the same frameworks of Skilled Intentionality and Active Inference as affordance landscapers. In Section 4, I discuss how we can see ASEs as helpful to autistic persons in reducing environmental volatility.

2. Ecological-enactive account of autism

As I mentioned, I put forward an account of autism that is affordance-based and combines the ecological with the enactive understanding of cognition (Nešić, 2023a). In this integrative take on autism spectrum disorder, the condition is viewed from the SIF, skilled intentionality framework. This account will show the importance of ecological elements in autism and how much of the pathology of autism is relational, coming from the landscape of affordances they find themselves in. To understand this account, we need first to unpack the conceptual framework behind it - the skilled intentionality. It will be shown that this framework is particularly valuable since it brings together very different perspectives (like phenomenology and predictive processing) on cognition. I will argue that although we have gained important insights from these individual perspectives, a fruitful integration of those perspectives through the lens of SIF will deliver an all-encompassing understanding of autism.

2.1. Skilled Intentionality

The skilled intentionality framework (SIF; Rietveld, Denys, & van Westen, 2018) is an integration of findings from different scientific disciplines, like ecological psychology (*landscape of affordances*; Gibson, 1979; Heft, 2001; Chemero, 2009), phenomenology (Merleau-Ponty, 1968/2003), emotion psychology (Frijda, 2007), and embodied neurodynamics. It brings together the enactive and ecological embodied programs, which in itself is a challenging task. Nevertheless, the strength of the SIF is in its integrative powers. In SIF, cognition is skilled engagement with affordances (understood as possibilities for action) in the sociomaterial environment when the organism tends to optimal grip. Every organism has its ecological niche. As members of the same species, humans have a corresponding ecological niche that lays a rich *landscape of affordances before us*. This is in connection to the abilities of the form of life. Now, a distinction between a landscape and a *field of affordances is to be made*. A field is comprised of inviting possibilities (affordances) for an individual in a situation (Rietveld, Denys, & van Westen, 2018, p. 52; de Haan et al., 2013; de Haan, 2020, p. 218). It is also called a *field of relevant affordances*, and the authors of SIF supply phenomenological notions that go with these ecological ideas. Affordances invite

[11] See different levels of autism in DSM-5 (levels 1-3).

the agent - there is an experiential, pre-reflective feel to the solicitations, and this is the field of affordances.

An integral part of SIF is an ecological-enactive interpretation of the free energy principle (FEP) and predictive processing (PP) (Bruineberg & Rietveld, 2014; Bruineberg, Kiverstein, and Rietveld, 2018). They see the difference between FEP as a unifying framework for self-organizing living systems and predictive processing, which is about the brain's neural functioning, although they are usually expounded together. According to the FEP, organisms maintain their organization as living systems by minimizing their information-theoretic free-energy in interaction with the environment (Friston & Stephan, 2007). Two ways of doing this are predicting sensory input or changing the environment to match what is predicted, *perceptual* and *active inference,* respectively. Predictive Processing (*prediction-error minimization*) is a theory of the brain and its cognition (Clark, 2013; Hohwy, 2014; Friston, 2010). The brain is involved in the minimization of prediction-errors between bottom-up sensory information and top-down predictions.

In the non-representational interpretation of the SIF, the *generative model*, the hierarchical probabilistic model of the environment, is perceived as a dynamical system of states of action-readiness that are sensitive to environmental affordances found in the landscape of affordances (Bruineberg, Kiverstein, and Rietveld, 2018). In a typically developing organism that acquires new habits and skills, the generative model becomes more and more attuned to the relevant affordances of the changing environment (growing openness).

According to the SIF, mental health is then understood through the goodness of the agent's generative model. Various psychopathologies arise when precision estimation goes wrong, that is, from *aberrant precision estimation* (Miller et al., 2022). Giving too much or too little precision to prediction errors leads to abnormal beliefs and produces something that can be (conditionally) called a suboptimal generative model. Agent's behavior in psychopathology becomes maladaptive. For an organism to be in a state of well-being, it needs to be on the edge of criticality, attain a balance between stability and instability, order and chaos, and maintain *metastable attunement* (Bruineberg et al., 2021; Miller et al., 2022). This can only be done when the organism is open to new possibilities, learning, and adapting, which seems to be lacking in psychopathological states.

Another related notion that will figure prominently later in the understanding of the behavior of autistic people is that of the ecological *niche construction*. Niche construction theory stems from evolutionary biology and the philosophy of biology and refers to the processes through which organisms modify their environment and steer their evolutionary path (Constant, Bervoets, et al., 2020; Laland et al., 2015; Odling-Smee et al., 2003).[12] Predictive Processing, FEP, and Active Inference can be used to model how niche construction influences evolutionary processes (Constant, Ramstead et al., 2018). In predictive processing, niche construction is observed as a strategy of organisms for minimizing prediction error through changes in the environment to conform it to their expected states. Niche construction is a form of active inference under the FEP. The ecological niche is a meta-learning mechanism, "learning what can be learned" through learnable sensory cues (Constant, Bervoets et al., 2020, p. 612-613). It is

[12] We can find *four kinds of niche construction* in the literature: (1) phylogenetic, the collective modification of the environment of the whole species, (2) sociogenetic, collective modification through the activities of a subpopulation, (3) ontogenetic (personal), or the individual's idiosyncratic activity with their environment and (4) microgenetic or local, referring to singular environmental modifications in the here-and-now (Coninx, 2023, pp. 3007-10).

argued that artifactually supported rituals can regularize behaviors and stabilize expectations, improving predictability (Constant, Bervoets et al., 2020).[13]

As it has become apparent by now, the SIF is an interesting and volatile mixture of research programs that have not been put together before. Some would argue that they cannot be put together and made compatible. This is mainly a problem when it comes to the incorporation of FEP and PP in the SIF. Some philosophers resisted the move of embodying and enacting free energy and predictive processing/coding. My goal will not be to defend or strengthen SIF's arguments. However, I believe that the payoff from such a daring framework is huge and that we should harness its power to understand autism better. Much can be distilled from a multidimensional approach like this one, both from the side of neuroscience and phenomenology and embodiment. That said, I do not think that SIF is without its problems and shortcomings.[14] Fortunately, others have already done much towards achieving this goal of integration, and I am only humbly building on their ideas and applying them to understand autism better.[15]

The reasons why I am laying this conceptual barrage on the reader will become apparent in Section 3 with the analysis of ASEs, which are also understood through the same concepts, so I beg the reader to bear with me.

2.2. Autistic field of affordances

A whole range of predictive processing accounts of autism has appeared in recent years (see Palmer et al. 2017 for a review of all theories). In the case of autism spectrum disorder, it is hypothesized within some of the Predictive Processing accounts that a significant amount of precision is assigned to prediction errors. According to the computational theories of ASD, autistics suffer from problems in *estimating precision* (Pellicano & Burr, 2012; Van de Cruys et al., 2014). The highly influential HIPPEA theory ("high and inflexible estimation of precision of

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[13] Furthermore, niches are culturally structured. The *cultural affordances* also have a significant role in estimating the precision of incoming sensory inputs (cultural niche construction, Constant, Ramstead et al., 2018; Kirchhoff, 2018; Constant, Bervoets et al., 2020, p. 616) - e.g., artifactually supported rituals increase the predictability of the environment.

[14] For example, Dings (2021) has pointed out that SIF does account for the meaningful affordances and tried to built his own amendments to the affordance-based framework.

[15] Enactivists have criticized Gibson's ecological theory of perception as a one-sided understanding of the organism-environment relationship. At the same time, the ecologists, for their part, pointed out that according to the enactive approach, the environment is without any meaning until it is given meaning by the organism (Toro et al., 2020, p. 2). Those who advocate the ecological-enactive approach do not believe that the organism completely, from itself, creates and projects meaning onto the environment but that the environment is filled with affordances and has significance for the organism in accordance with the capacities and dispositions of the organism. The organism is coupled with the relevant affordances in the environment (Kiverstein & Rietveld, 2018, p. 155). The literature is also abundant with both objections to the marriage between enactivism and FEP and PP (Di Paolo, Thompson & Beer, 2022; Gallagher, 2023; and the "marriage made in heaven" arguements (Bruineberg, Kiverstein & Rietveld, 2018; Toro, Kiverstein & Rietveld, 2020; Clavel Vázquez, 2020; Ramstead, Kirchhoff & Friston, 2020; Kirchhoff & Kiverstein, 2020).# Compatibilism between active inference/predictive processing and enactive-ecological-embodied approaches has been criticised on grounds of different understanding of representationalism/non-representationalism, as well as *internalist* vs *externalist* and *individualist* vs *collectivist* commitments. Predictive processing and FEP have been accused of being unable to explain play, improvisation and seeking novelty when it comes to the activity of living beings (answers to those worries can be found in Kiverstein, Miller & Rietveld, 2019; Miller, Kiverstein & Rietveld, 2022; Kiverstein & Miller, 2023). Much work has been done but this far from a settled matter. I thank the anonymous reviewer for pressing me to expanded on this point.

prediction errors", Van de Cruys et al., 2014) points out that autistics give atypically high precision to bottom-up prediction errors and thus have problems adapting to environmental uncertainties, which then leads to a restricted focus in perception and demand for sameness and stereotyped behavior that is witnessed in this condition.

In extension, Lawson and colleagues (2014, 2017) add that the root of the problems is *aberrant precision* (encoding of precision being aberrant) in autistic individuals who tend to overestimate the volatility of the sensory environment. So, the most considerable difficulties for autistics will be when there is high environmental uncertainty and social interaction, as predicted by this account (Lawson et al., 2014, p. 7). As Bervoets, Milton, and van Cruys (2021) point out, it is not that autistic people are "intolerant to uncertainty" - we are all "surfing uncertainty", both neurotypicals and autistics - but due to aberrant precision estimation, they "tend to *create* more uncertainty because of their heightened attention to prediction errors" (2021, p. 2) and this is why they resort to stimming and restricted behavior and build more "tight" environmental niches.[16] Uncertainty is being reduced (external causes made less volatile) by movement strategies such as stereotyped and repetitive behavior (Palmer et al., 2017, p. 16). The aforementioned problems lead to a different development of higher levels of the generative model of the narrative self. I will come back to the issue of autistic narratives later, in Section 4, and unpack these claims.

In autism, "too much precision is given to prediction errors relative to prior predictions", and autistic persons depend heavily on current sensory information and less on prior beliefs (Miller et al., 2022, p. 18). Autistics give too much weight to novel sensory evidence and cannot attune to stable regularities (Lawson et al., 2014; Palmer et al., 2017; Karvelis et al., 2018; Kirchhoff & Kiverstein, 2020). Thus, the problem is handling environmental volatility.

The behavior of autistic people is characterized by strategies they develop to cope with a pilling amount of prediction error (Constant, Bervoets, et al., 2020, 614). In the terminology of PP, even slight noise will induce learning, leading to *overfitted* models that do not generalize to new inputs (models for particular situations). Repetitive movements, like hand-flapping, tapping objects, vocalizations, or rocking movements ("self-stimulation" or "self-stims"; Leary & Donnellan, 2012, p. 51) are "effective ways of managing incoming sensory flows" (Krueger, 2021a, p. 379) and an adaptive mechanism (Kapp et al., 2019). Self-stimulation can be seen as a way to reduce prediction error and establish a clear sense of self (according to HIPPEA, Van de Cruys, 2014, p. 660). These activities bring well-being to autistic individuals, as they themselves report (Klin et al., 2007, p. 97; cited in De Jaegher, 2013, p. 10).

Part of those strategies is a peculiar niche construction in autism, as Constant and colleagues (2020) have demonstrated. These authors argue that there is an "ecological counterpart" to autistic problems in estimating precision. Since autistic precision estimation is inflexible, they have to over-rely on the precision afforded by the environment. This is the ecological side of the condition, while movements are the enactive part. To understand this ecological side of autism, let us look at a case from the literature.

I came across a beautiful book by Margo Vicedo, *Intelligent Love* (2021). She depicts the struggles of Clara Park to understand and defend her daughter's autism in the 1960s United States. This fierce and educated woman wrote to the best psychiatric minds of her time (like Kanner) in

[16]Lawson et al. (2014, 2017) offer computational and empirical evidence for their claim about the "imbalance of precision" in autism. Findings from Karvelis et al. (2018), who used visual motion estimation tasks, suggest that there is a weaker influence of prior expectation due to "enhanced sensory precision" in line with Lawson et al. (2014) and Van de Cruys et al. (2014).

order to better understand the mysterious condition and find the right pedagogical strategies to help with the child's development.[17] Along the way, she challenged the orthodox theories of her time and influenced how science and the general public see autism. Her daughter, Jessica Park, is also the subject of Clara Park's two books. In the first book, *The Siege: The First Eight Years of an Autistic Child* (1967), we find the following poignant description of Jessica's behavior:

> "The autistic child is complete in itself. Its every action — or inaction — functions to keep it that way. Elly's consciousness seemed empty, her responses simple or nonexistent, her activities rudimentary. Yet as we lived with her at that time of her most extreme withdrawal, what impressed us was not, as one might expect, the inadequacy of this child, but rather the extraordinary degree to which her environment was within her control. Having found ways to keep her world one that she could cope with, she was the most undisturbed of 'disturbed children'. A normal two-year-old experiences in a day more of anxiety and frustration than came to Elly in a week. Elly's inabilities operated to tailor the environment to her needs." (Park, 1967, p. 74)

A compatible take on autism is found in the *dialectical misattunement hypothesis* (Bolis et al., 2017). These authors use an intersubjective approach to 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).[18] Authors understand subjects as thoroughly social, "through others we become ourselves". Significantly, this is where the divergence is found in the autistic. Like Constant and colleagues, their approach employs the Bayesian perspective on ASD. In their latest work, they synthesize findings from second-person neuroscience, enactivism, dynamical systems, and machine learning to argue how psychopathology can be construed as *interpersonal misattunement,* which is to be studied through the methodology of *collective psychophysiology*. There is an environmental misattunement of autistic persons in a neurotypically designed world. The anxiety of this misattunement can be alleviated by redesigning our living spaces (Bolis, Dumas & Schilbach, 2023), they argue.[19]

Based on these considerations of ASD from the PP perspectives (that do have an ecological interpretation) and from enactivist approaches, now integrated under the Skilled Intentionality Framework, I argued that autism could be understood as a *different or atypical field of affordances* (Nešić, 2023a).[20] It would be wrong to say that autistic norms of the body are closed and inflexible; autistic persons do develop new skills, though not in the same way as neurotypicals. Autistic people can be pathologically embodied if the sociomaterial environment is rigid and does not allow the individual to find her own skilled ways. The same goes for the

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[17] Clara Park practically invented autism advocacy, which testifise to one mother̀s strength to move mountains to help her child. Later in life, Jessica Park became a painter.

[18] Taking inspiration from Vygotsky's work, Bolis and colleagues partake in the interactive turn happening in philosophy and cognitive science. They are engaged in second-person neuroscience (Bolis & Schilbach, 2020), studying social cognition through social interaction and argue that social cognition is decidedly second-personal and interactive.

[19] Such view of autism as a relational disorder, rather than an individualist one, is in line both with enactive and interactionist ideas (De Jaegher, 2013; Gallagher, 2014) and neurodiversity advocacy (expressed in the famous *double-empathy problem* of Milton, 2012). Dialectical misattunement shares other core commitments with the neurodiversity movement, like treating psychopathology as human variation and not *a priori* disorder.

[20] It is thus similar to Van Es and Bervoets (2022) enactivist take on autism, and the enactivist "different embodied way of being" of Milton et al. (2022).

construction of their econiche. Due to the aberrant weighing, autistic individuals will have trouble phenomenally attuning to the norms of neurotypical people (and their norm-regulated cultural practices) (Kirchhoff & Kiverstein, 2020). So, there seems to be a collective misattunement with different interaction styles of autistic and non-autistic persons, meaning their respective generative models are non-aligned. On the other hand, there is evidence that autistic people are more quickly attuned to the norms of other autistic people[21] (Nešić, 2023a, p. 15).

We can find the distinction between three different dimensions of the field of affordances (de Haan, 2020): width ("broadness of the scope of affordances"), depth (temporal aspect), height (salience of affordances, identified by their "intensity of the relevance" and "affective salience"). I argue that, given the specific ways of development of their bodily normativity, autistics end up with a field of affordances that are characterized as being narrow (limited range of affordances picked out), shallow temporal depth[22], with great intensity and affective salience (the great affective allure of very specific affordances) of those affordances that do come up in their field (Nešić, 2023a, 16).[23]

Some authors working in affordance-based frameworks have postulated that autistic people have an altogether different and distinct landscape of affordances (e.g., Catala et al., 2021). The distinction Catala and colleagues make between the distinct landscapes of affordances for neurotypicals and autistics could raise some concerns. If we adopt the ecological-enactive framework of Kiverstein and Rietveld, as I did in this paper, it would be incorrect to suggest multiple landscapes of affordances. Instead, there is a singular landscape for the entire human species. Nevertheless, the realm of affordances for individuals on the autism spectrum is distinct from that of neurotypicals, it would seem.[24]

Given what we have learned about the field of affordances in ASD, it seems that the natural next step is to seek strategies that would help autistics achieve attunement to their sociomaterial environment. Ideas for that can already be found in the behavior of autistic individuals, as well as the enactive and ecological strategies they rely on to cope with the volatility of the world. The landscape of affordances, as built to fit the normativity of non-autistic people, is

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

[22] This characteristic relates to problems with overly precise sensory precision in autism which shrinks the depth or time horizon of (inter)actions. See footnote 27 in Nešić (2023a) for details.

[23] Recently, the very utility of the concept of affordance has been criticized. Ratcliffe and Broome (2022) have voiced this worry, saying that the affordance concept is not illuminative enough since things can afford action in all sorts of ways ('what matters' can be very diverse). Dings (2020) has argued that a distinction should be made between "merely relevant" possibilities for action and "meaningful" possibilities for action to refine the Gibsonian concept of affordances. Some affordances are experienced as low-level, and others are experienced as high-level (long-term goals). Accordingly, there is low-level ('how' to do something, movements) identification and high-level ('why', diachronic goals) identification of affordances in the experience of a particular object (Dings, 2021, p. 1866). Getting to a better understanding of higher-level identification of affordances of autistic persons could help illuminate her lower-level affordances. People self-regulate, have self-referentiality, and shape their own fields (Dings, 2019, 2020). The fine-grained construal of the field of affordances through the addition of meaningfulness can help us better comprehend autistic experince, why they have such a field of affordances and how they shape it. This is something that I will thematise in a different paper.

[24] The concept of "mental institutions" (Krueger & Maiese, 2018) can be considered a valuable construct that lies somewhere between the landscape and the field of affordances. The mental institution of neurotypicals has its own "norm-governed practices, artefacts and traditions" (Krueger & Maiese, 2018, p. 10), to which autistic persons cannot skillfully engage and have problems attuningSimilarly, Gallagher (2018) has acknowledged that his "affordance space" resides somewhere between the field and the landscape. See Nešić (2023b, pp. 349-50) for a discussion.

hostile to autistic people. However, the design of the landscape of affordances can be changed to accommodate the needs of the autistic and, perhaps, promote novel actions from autistic persons (e.g., through the arrangement of "place-affordances" Nešić, 2023a, p. 17; *field of promoted actions,* Reed & Bril, 1996; Bruineberg et al., 2021, p. 12834-36). Still, in Nešić (2023a), these possibilities are only hinted at. It will be the original contribution of this paper to argue that one way (and possibly the best way) to change the landscape of affordances is through the use of Ambient Smart Environments or ASEs.

EE account based on the SIF opens the door for this kind of understanding of autism, and now appropriate strategies operating within this framework are to be found or developed to better the lives of autistic people. In the next section, I will make what I think is the natural step forward and introduce a type of smart environment (machine learning-based technology) as one possible way of flexible scaffolding for autistic needs. The Ambient Smart Environments (ASEs) are the first in the conceptual vicinity. Making this connection in theoretical terms is made easy by the work of White & Miller (2023). This innovative technology easily stands out as a reasonable solution for ecological scaffolding because it is, from a philosophical perspective, best understood through the same framework, namely the SIF, that we have used to understand the autistic field of affordances. This connection has yet to be made, and this paper's novelty is to theoretically prove, in great detail, how and why ASEs help autistics. I will say more on this connection in Section 4. In the end, the copying strategies of autistics themselves will be the inspiration and source of learning for the proper design of these smart environments. ASEs are particularly interesting for another reason. Not just neurotypical people but the environment itself will be able to learn about what it can do to attune to its neurodivergent user.

3. Ambient smart environments

What is the nature of this new technology? They are smart ambients because this type of technology is embedded in the material environment and silently monitors and answers the user's needs; interior environments are permeated by smart technology. These refer to a plethora of devices that can be worn by the user but are also embedded within the home environment to collect data about the user and use machine learning to follow users' patterns of behavior and routines and respond to and assist the needs of the agent (Blott, 2021; White & Miller, 2023, 3). This kind of ambient smart technology does not have to be monitored by the user. It is invisible, an environment that is adapted to and responsive to a particular user. Wearable biosensors and tracking apps are applied to collect data about the patient, which is then fed into artificial intelligence. Why are ASEs an exciting option to take into consideration? Is it a better solution to the usual environmental design that is being implemented today to help autistic people?

Bolis, Dumas, and Schilbach (2023, p. 5) mention the environmental misattunement of autistic persons in a neurotypically designed world. Redesigning our living spaces can alleviate the anxiety of this misattunement. As for the practical implications, they propose, e.g., in pedagogy, "an interactive, collaborative and participant-oriented learning framework" instead of a hierarchical and competitive one. Milton and colleagues (2016) have written about autistic-friendly spaces and *Universal Design (UD)* in education and society, which eliminates barriers via initial design and not by supplementing "the mythical norm" with individual adjustments. Since autistic learners commonly struggle with unpredictable changes, routines, and visual aids could be valuable support. Their very specific interests, while highly personal, can

serve as powerful motivators in learning if adequately made part of the curriculum in inclusive education. The same goes for visual presentation through technological aids (tablets) that both engage the autistic person and make them feel safe. The SPELL approach principles from the National Autistic Society, which stands for *Structure, Positive (approaches and expectations), Empathy, Low Arousal, and Links*, demonstrate how to organize the sociomaterial surroundings for practical work with autistic people. These are prime examples of autism-friendly Universal Design. This type of design is not based on the "myth of the average" (mythical Norm). The principles of UD are *Equitable use*, *Flexibility in use*, *Simple and intuitive use*, *Perceptible information*, *Tolerance for error*, *Low physical effort*, and *Size and space for approach and use* (Milton et al., 2016, p. 82).

Others have studied the most relevant architectural strategies that are to be prioritized in the design of public spaces to accommodate autistic children's needs (Sheykhmaleki, Yazdanfar, Litkouhi, Nazarian, Price, 2021). It was found that the following strategies are highly significant for design: (1) acoustical control, (2) visual control, (3) legibility, (4) safety and security, and (5) predictable spaces. The limitation of such approaches is that they do not consider how varied and individual sensory and behavioral differences are in autistic people; one universal autistic design could not encompass all of them.

Now, ASEs have come into play. They seem like an incredibly valuable scaffold for the needs of autistic people and a way to solve the problems with the environment they face precisely because they are envisioned as responsive and adaptive environment designers. Making only particular and static changes in the design of the environment (of the city, for example) does not solve all the problems for autistic people most of the time. The "living environment" of the ASEs, once set up, will learn about the behavior of its autistic end users and adapt for them a personal niche and environment that will still be able to change and evolve further and help the user develop with its prompt responsiveness in a manner suitable to an autistic person. This technology would facilitate the proper two-way, relational adaptivity and co-evolution of the autistic individual and their environment. Given the characteristics and performance of ASE, they would seem to satisfy the conditions put forth by the Universal Design and even deliver more than what is needed. We will see how in the following section.

White and Miller suggest that new work in affordances frameworks could be of help when trying to conceptualize these new technologies. Nevertheless, using the language of affordances does not seem enough to conceptualize ASEs. They argue that the Skilled Intentionality Framework, with its distinction between a field and a landscape of affordances, is better equipped for the task. They want to understand ASEs as *affordance landscapers* (White & Miller, 2023, p. 5). These technologies are organizing affordances on a meta-level "to actively shape, or *landscape* an agent's field of affordances". ASEs learn about the human user's habits and behavior and offer optimal solicitations in their environment (like a smart refrigerator or a coffee machine). This understanding of ASEs as affordance landscapers from the SIF is developed further with the use of the Free Energy Principle and Active Inference Framework (AIF).[25] They try to show that ASEs can be used to sculpt the environment to produce healthier metastable dynamics in the agent. How do ambient smart environments achieve this?

[25] The Active Inference Framework (AIF), which is derived from FEP, is closely related to and part of the family of "predictive theories" of cognition, like predictive processing and predictive coding (White & Miller, 2023, p. 6). Again, here, action and cognition are understood, in computational terms, as surprise minimization.

Metastable dynamics can be compromised or degraded in different psychopathological conditions (Schwartenbeck et al., 2015; Miller et al., 2022), as I discussed in Section 2.1. A metacognitive level is needed to monitor the behavioral patterns and ways to "unstuck" the patient from avoidant behaviors. Higher levels of the generative model work with abstract concepts and with longer, slower timescales. As said before, agents are in the business of minimizing surprise, that is, "minimizing prediction error, an agent minimizes its variational free energy", and "maximizing generative model evidence". Precision is a crucial process here, and effective precision weighting in action and perception is important to healthy predictive dynamics.

Finally, they add that metacognition, the ability to monitor (to have meta-awareness) our own cognitive processes and control them (Sandved-Smith et al., 2020), can be dysfunctional and a source of many psychopathologies. In Active Inference, metacognition and precision weighting are closely linked. Having metacognition is just adding layers to the hierarchical generative model in which there is a precision weighing about lower-level beliefs (Hesp et al., 2021; Sandved-Smith et al., 2021). The crucial point is that metacognition, according to the authors, can be distributed outside, in the material environment, so there can be a chance to repair pathological metacognition, which can be done with ASEs. Through structuring affordances in the environment (design), metacognition can be made more efficient (Kirsh, 2004), which is what the ASE's meta-affordance is doing. ASE can be used to change the volatility of the environment and subvert damaging suboptimal routines.

Another corollary of these frameworks that must be highlighted is that the environment's characteristics can help the agent make effective precision weighting. Organisms rely on external cues and environment for learning and precision estimation. This is how Niche Construction is understood under FEP. The process of surprise minimization happens between an organism/agent and the environment (Bruineberg et al., 2018; Constant et al., 2020). Usually, these are static material structures, like signs, but FEP and Active Inference offer new ways of viewing cognitive niches as dynamic and in flux. Regular niches are nonresponsive, and ASEs are dynamic and responsive to the needs of the agent/user and model the inner states of the user. Thus, their understanding of ASEs fits well with an FEP and Active Inference view of niche construction.

This is why ASEs are such potent technological tools, because of their possible role in bettering the well-being of their users as a way of cognitive and affective scaffolding (Colombetti & Krueger, 2015) through the process of niche construction. Since niches are culturally structured and cultural affordances play an important role in the development of children, as was pointed out earlier, these trajectories and cognitive abilities will be influenced by *sociocultural biases,* affording different opportunities to diverse social groups (de Carvalho & Krueger, 2023). Implicit biases of their caregivers will characterize the niche surrounding autistic children, and these are understood as embodied perceptual habits. Such a developmental niche, characterized by influences that see autism as a neurocognitive deficit, will be maladaptive to autistic children and severely restrict their possibilities by bodily stopping them (Krueger, 2021b). Neurotypical practices strive towards the elimination of "self-stims" in autistic people, although they are very important to them as an adaptive mechanism (Kapp et al., 2019).

But the built environment can also be bodily stopping for autistic people. Hostile neurotypical affordances and absent positive affordances will restrict autistic behavior and contribute to autistic disability and impairment. As Coninx (2023) has shown, there is also a dark side to niche construction; *negative niche construction* can occur and be harmful, and such

environmental changes will become *maladaptive* and hinder the well-being of agents. It is in this sense that the neurotypical developmental niche can be maladaptive for autistic children. To have more inclusive niches for autistic needs, we must make the habitual changes that will be collective in the social environment, so we must change the landscape of affordances. Autistic bodies have to carve out their own niches, working around the absences in affordance landscapes that are hostile for them (Krueger, 2023; Dokumaci, 2023). Neurotypical niches, while adaptive for this population, are maladaptive for autistic people.[26]

Autistic bodies are "misfitting" the affordances of the built environment. In their case, this misfit is a permanent, life-long condition. In the neurotypical environment, they are unable to achieve *basic trust* ("the attitude of certainty we express when we act in skilled, often unreflective, habitual ways in the living environment," Habets, Rietveld, Kiverstein, Denys, 2024, p. 2) and incorporation of *trusted urban places* will also be a problem for them. Places like smart homes built with the help of ASEs could be the interventions needed to establish some basic trust in the world for autistic individuals.

I will now sketch some new ways in which ASEs could be beneficial for autistic people.

4. Affordance landscapers

I propose connecting the EE account of autism with understanding ASEs as affordance landscapers. I link them because both the EE account of autism and White and Miller's account of ASEs work within the same frameworks. Both accounts use Skilled Intentionality's landscape/field of affordance distinction, and both understand well-being through surprise minimization/minimizing prediction error (managing volatility of the environment). The EE account works under the Skilled Intentionality Framework, which is an ecological-enactive interpretation of the free energy principle coupled with predictive processing. The ASEs account employs the Active Inference Framework under the FEP and the Skilled Intentionality Framework. The difference is that the EE account works with the Predictive Processing Framework, and the ASEs account employs the Active Inference Framework. Both cases' frameworks are affordance-based and rely on Niche Construction Theory (interpreted in PP/Active Inference terms). In both accounts, effective precision estimation is crucial for healthy predictive dynamics, and psychopathologies are modeled through aberrant precision estimation.

As we can see, the core commitments between these accounts are shared, which makes them a good fit. EE account understands autistic experience and behavior through aberrant precision estimation, which has ecological/niche construction corollaries. White and Miller's account of ASEs sees them as fully extended cognitive systems[27], so they partake in niche construction understood under the Active Inference (niche construction as an extended cognitive process), and this is in line with the predictive processing approach to niche construction theory (Constant et al. 2018), as well. The said characteristics of these two accounts support the argument for their compatibility.

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[26] I am grateful to one of the anonymous reviewers for recommending to delve deeper into these concepts.

[27] They couple Extended Mind thesis with Active Inference based on the work of Kirchhoff & Kiverstein (2019; *Extended Active Inference*). Extended Cognition refers to the idea that material artefacts can be involved and even constitutive of cognitive processes (Clark & Chalmers, 1998). White and Miller argue that ASEs are good candidates for extension, given that they form a *distributed metacognitive network*. Compatible ideas can be found in SIF.

Through White and Miller's work, it was observed that these emerging technologies could be understood as affordance landscapers, something that can organize the affordances for a patient on a meta-level and thus shape one's field of affordances. In characterizing the autistic field of affordances, we said that they have a narrow field and shallow temporal depth, with great intensity and affective salience of those affordances that come up in their field (Nešić, 2023a, p. 16). The first dimension relates to the broadness of the scope of affordances. Since the autistic field is narrow (usually fixated), ASEs could be used to broaden it, deliver or suggest new affordances and solicitations in line with (or perhaps contrary) the user's interests. Given that they have a low depth of the temporal aspect, ASEs could plan any interaction with the world (or body) for the autistic person on a longer timescale, widening the time horizon of the agent's actions. ASEs would be valuable as an external repairer of metacognition, an environmental scaffold for distributed metacognition in autistic individuals. ASEs help the user maintain metastable attunement on longer, slower timescales. In previous sections, I have shown how the behavior and ecological strategies of autistic people can be regarded from Skilled Intentionality. Niche construction in these individuals and relying on external cues and objects for the proper error minimization and precision estimation also tell what needs to be done in devising more helpful therapeutic strategies.

The primary purpose of ASEs would be to *decrease the uncertainty of the environment* (to reduce the volatility artificially), which is the main problem autistic people struggle with. In other cases, ASEs could warn people about highly volatile environments and how to avoid them. ASEs that learn about the idiosyncratic routines of ASD users could point out plausible, contextually relevant new movements and habits the person should apply in a particular situation, for example, how to respond in a delicate and complex social encounter. Autistic individuals already use external cues and structures to scaffold precision. They rely on the sensory environment to limit uncertainty. ASE in the house could keep the sensory space constrained and with low uncertainty (lights, sounds, odors). They could help maintain a sensory niche warranting certainty, adapted to the needs of the particular user, and thus, potentially, allow decreasing stereotyped behavior in the person (Richler et al., 2010; Van de Cruys et al., 2014; Constant et al., 2020, p. 617).

Let us take into account how ASEs have been used successfully with dementia patients and see if similar considerations could inspire strategies for autism. The philosophical implications of ASEs have been picked up by Heersmink (2022), who argued that ASE could help dementia patients maintain their personal identity by preserving autobiographical memories through distributed material structures. Thus, theoretically, he employed notions of extended cognitive systems and distributed memory to understand how and why this technology would work. Employing so-called lifelong technologies, such as ambient intelligence systems, SenseCams, life story books, memory boxes, and VR, would allow dementia patients to remember even when biological structures are failing, thus maintaining their narrative identity. Environmental structures can be therapeutic in such cases. For example, viewing recent images from Sense Cam could help them with anterograde amnesia and forming new episodic memories. Using “memory books” and “life story books” are great examples of these identity-preserving strategies in dementia (Elfrink et al., 2018). These are made by the person themselves or with a caregiver. Similar is the idea behind “self-memory boxes” (Gulwadi, 2013). Evocative objects that have autobiographic significance are used. Heersmink quotes a reminiscence therapy from Denmark in which dementia patients are situated in the whole environment of the Danish 1950s

apartment replica full of generic evocative objects (Miles et al., 2013; Heersmink, 2022, p. 10). Now, on top of those existing strategies comes a more speculative suggestion that ambient intelligence systems (Aarts, 2004) (in our terminology, ASEs) could be beneficial since they can be personalized, adaptive, anticipatory, and responsive with a great many embedded sensors (Heersmink, 2022, pp. 11-12).

Some of the strategies similar to the ones that are discussed in the case of dementia, I think, could, in some form, be employed to help autistic individuals. Now, mind you, I am not implying that autism and dementia are connected conditions, though they share some similarities in certain aspects, and so the strategies employed could be analogous. I am using dementia as one positive example of the use of such ambient technology. This technology would be helpful not only for the user, the autistic person but also for neurotypical people. ASEs could make a profile of the autistic individual's behavioral patterns and interpret them to the interacting neurotypical, thus making social engagement more fluent and with better understanding and empathy, thus reducing the probability of misattunement. This could go both ways for both parties in the interaction, for the autistic person and the neurotypical person.[28] One possible injustice that could arise from the application of ASEs is that some autistic children of privilege would have the opportunity to acquire such technology while others would not.

The particularities of how this technology would apply to autism and how it would be helpful to such individuals will come from EE account of autism, namely how we understand their ways of managing environmental volatility and how they construct econiches. Autistics construct their extended self through their personal econiche and external scaffolding. Some autistic people need material "copies" of episodic memory and have difficulty integrating episodic components into autobiographic memory. They also require cues for self-narrative reports (autobiographical memory retrieval).[29] Constant and colleagues argue that even the minimal or embodied self is hardly kept together in ASD. Since, in the PP paradigm, the construction of the self "coincides" with niche construction, the extended self is built through the construction of the niche. Given that the autistic extended self is built with a reliable, fixed niche, the authors conclude: "...we can expect autistic individuals to experience a stronger, *albeit* less seamlessly integrated sense of extended self in familiar environments" (Constant et al., 2020, p. 617). If this is so, perhaps the ASEs could skillfully help in performing the mentioned tasks, or these technologies could help autistic individuals in their routines. Still, more empirical evidence would be needed to back up Constant and colleagues' claims and investigate if ASEs could, analogously to the dementia case, be beneficial in scaffolding narrative identity.

ASEs could help autistic children develop narrative identity (higher abstract levels of the generative model). ASEs are affordance landscapers and, as such, could be meaningful affordance shapers. This issue is connected to the previous discussion on self-regulation and self-referentiality and shaping one's own fields of affordances (Dings, 2019, 2020).[30] Dings highlights those affordances that are missed by most frameworks, the affordances on the higher level of abstraction of concern for the narrative.

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[28] This technology could, then, be a useful tool in the battle against epistemic injustice that autistic people suffer from. On how the ecological-enactive approach to ASD can lead to better understanding and eventually help afford greater epistemic justice to these people, see Nešić (2023b) and Catala et al. (2021).

[29] Consider the case of AB, a 34-year-old with Aspergers who was collecting and categorizing many items in her two-bedroom apartment since 16 years old. She described her collection as a "photograph album or personal diary". See details in Skirrow et al. (2015), cited in Constant et al. (2020).

[30] Recall what was said in footnote 22.

According to the embodied understanding of the narrative self, which is compatible with all the frameworks under consideration here, the narrative part of the self is not isolated from other aspects (Hutto & Gallagher, 2017). It is built on or interwoven and developed with experiential and embodied practices (Miyahara & Tanaka, 2023; Dings, 2019; Hutto & Gallagher, 2017). Narrative self-constitution can be regarded as an embodied practice grounded in the habituality of the body (Miyahara & Tanaka, 2023). Case studies show that embodied narrative meaning-making can be realized with autistic individuals, and pre-linguistic narratives are the foundation of linguistic intelligence (Delafield-Butt et al., 2020). Now, habits are "special adaptive tendencies that make [living things] disposed—unlike purely mechanical and physical systems—to sensitively adjust in characteristic ways to the particularities of their situated circumstances" (Hutto & Robertson, 2020, p. 207). We can see that if autistic individuals have peculiarly developed and precise habits that are fixated and lacking adaptability, how this would, in turn, influence the rise and development of narrative self-constitution grounded on that bodily habituality (Nešić, 2023, refers to this as bodily normativity). This does not mean autistics do not develop narrative selves, just that they will do so through a different developmental trajectory. Here, embodied narrative therapies (embodied stories) and using ASEs would support autistic individuals in creating their own stories. Smart environments, apart from providing safe and certain (trusted) niches in which social connectedness can happen, could help autistics develop more open habits, acquire new ones, and support better adaptability, thus contributing to the building of self-narrative. ASEs would be part of the distributed autistic autobiographical self. The objects themselves in the living space (smart home) of the autistic person could be digitally imbued through the *Internet of Things* (IoT) with episodic memories of previous contact to be recalled with a simple touch of the user they are programmed to recognize.[31]

Boxes with beloved objects of autistic people that they make and collect could also be one strategy for environmental and material ways of dealing with overwhelming uncertainty and error minimization.[32] The most complex but, at the same time, the most beneficial strategy could come from the development of personalized and responsive ambient smart environments. Since no autistic person is the same as any other, and their niche construction styles are idiosyncratic, only a system that learns about the particular user's behavior patterns would be equipped to respond appropriately (besides the possible caregiver).

Changes in surroundings, that is, the environmental affordances, are therapeutic in diverse psychopathologies. Recall the touching scene from the movie *Awakenings*, when Dr Malcolm Sayer helps his catatonic patient, Lucy, move for the first time in decades through the hospital room by painting the chequerboard floor tiles! The scene is not only metaphorical because Oliver Sacks (1973) writes about different "behavioral prosthetics" and external methods that help post-encephalitic patients move. He cites the cases from the work of A. R. Luria and James Purdon Martin. These patients, otherwise unable to move, do so when they are given an object or an external regulator, so-called "algorithms of behavior".

In the case of autism, Sophie Boldsen (2022) has argued, based on theoretical considerations from the phenomenology of Merleau-Ponty and from her fieldwork with adolescents, that material objects have the potential to enable new forms of social connectedness

[31] I thank the anonymous reviewer for suggestiosting to pursue these questions further.

[32] An autistic person close to me collects paper cutouts of drawn doors and writings of labels. These are usually made by his mother in accordance with his instructions on what should be written. His favourite stimming objects are branches and straws, which he waves in his hands and in fron of his eyes.

for autistic individuals. She has observed that objects like a guitar can facilitate intracorporeal encounters. Another is a board game with a clear spatial structure and rules, like a map. The same goes for the dance gathering in the rock museum, in which the rooms' whole sensorial surroundings facilitate the previously unimaginable engagement. These objects and environments are *scaffolding interpersonal attunement* (Boldsen, 2022) and affective experiences (Colombetti & Krueger, 2015). We could now envision ASE doing precisely this kind of scaffolding work, but in a more complex and contextual way, providing the right environment to achieve better attunement and functioning, e.g., facilitating social connectedness with neurotypical people that enter the personal ecological niche of the autistic individual.

In Hendren (2020), we find a story about a ten-year-old autistic boy, Stephen, who was obsessed with maps and navigation but scared of open spaces in the landscape of his hometown, Boston. He needed discrete division to have a grip on the world, and he even wore glasses with clear lenses that helped him focus. When the boundaries were missing (like when it was snowing), his parents would configure lines to forge a way for the time being. The real breakthrough came when the boy partnered with the artist Wendy Jacob (who had previously collaborated on artworks with Temple Grandine) to form the *Explorers Club*. Wendy and her assistant would spool out lines and lines of pink and orange tape around the city and invite Stephen to explore new grounds in Boston. This was "an unusual prosthesis that helped an autistic ten-year-old master public space" (Hendren, 2020, p. 126)

I have noticed this in the autistic person close to me - rewatching old video footage of me, our family, and my house and doors while naming them. Recently, he has begun taking his own photographs with a mobile phone and rewatching recorded pictures and videos. When we last saw each other, he intentionally asked us to sit down together and gave his father the phone to take a picture of us. I have never before seen something like this in his behavior! I hypothesize that he does those photographs and videos because he finds pleasure in viewing them and repeating video clips (this much seems obvious) and probably is drawn to the details of the picture that he finds interesting. They are also a learning tool for him to name things he has pictured. He has found a way to have those objects and images on repeat so that he and his mother can analyze them together.

This could be speculative and neurotypically biased, but could this new behavior help him develop his self-awareness further? Is this strategy, though unconscious, a way for him to externally preserve the episodic memories that are so essential to the constitution of our autobiographical self? If this is the case, technology is helping him scaffold the preservation and recall of narratively important memories, which he can quickly summon on the computer. We see environmentally scaffolded affectivity and narrativity. Even if he is not deliberately doing these things to achieve the neurotypical phenomenon we call self-awareness and episodic memory, it is these strategies that we are to use to learn from and to build on with ASEs and help autistic persons overcome their disabilities.

In his book *Fall Down 7 Times, Get Up 8*, Naoki Higashida (2017) describes an event of listening to the rain shower in striking detail that sounds almost cinematic. First, he is mesmerized by the rain: "Yet as I watch now, I hear nothing; it's like a close-up scene of rain in a silent movie" (Higashida, 2017, p. 25). Only after does he start to register the sound of rain, though now he cannot "connect the concept 'rain' to its sound". He is also baffled by his mother's behavior as she quickly gets to the balcony to save the laundry from the rain. Higashida tries to explain. "What remains a mystery is how to infer that it's raining purely from the noise. To me, the

sound of rain is an abstract. Identifying the voices of my family or the trill of a phone, the barking of dogs or meowing of cats, these are relatively easy. Some sounds, however, take me forever to figure out, like the chirruping of cicadas at the start of summer" (2017, p. 26). He seems to be "stuck" in the moment of the rain; his senses focused on details of the scene, his phenomenology of time being different.[33]

In such instances, the ambient system would serve to "unstuck" him or help him function by providing metacognitive and affective scaffolding. He is unclear as to why it is raining now; why does laundry have to be brought in? Smart home ASEs, based on machine learning, encompassing a context-aware network of sensors and devices embedded in the environment, even without the explicit prompt from the autistic user (or through voice-activated assistants), in case of rain, would help the boy identify sounds and help make everyday inferences. The system could even predict the occurrence of rain and prepare the user for the event. Smart home technology would enable blocking out intrusive sounds and lights that could be overwhelming for an autistic boy. This would greatly reduce the uncertainty in the environment and lessen the agent's stress; the ASEs would provide a sensory-friendly design with the stability, sense of security, and trust that autistic individuals need. Such a structured environment would help reduce stereotyped behavior (Richler et al., 2010; Boldsen, 2022)[34]. ASEs have routine management support systems to help with the routines.

However, the uncertainty of the environment is not only represented by sudden and unknown noises and sights. The unpredictability and unintelligibility of the unfolding natural and social events (what is rain, why is it raining, why is mother gathering the laundry, how did she know) are part of the atmosphere that does not bring basic trust in the world for the boy. The uncertainty seems to be even stronger and more stressful in social interaction (less or no eye contact, fear of touch). Autistic persons are more able to communicate when the predictability and unpredictability of the speaker's voice ratio are just right (Williams, 1992, pp. 208-9).[35] These calibrations could be investigated and realized with the help of machine learning,

Even difficult social contacts could become achievable in an appropriate environment. ASEs, which involve the use of wearable devices on the person, starting from smartwatches and personal medical devices, would be able to learn the boy's language, his manner, the timing of his replies, and the specific ways of his communication, be it verbal or bodily.[36] Such devices can be used to monitor stress levels and control sensory overload. At the time, Higashida communicated via the alphabet grid. Similarly, devices with eye-gaze control and apps are used nowadays to facilitate easier communication and learning of new words. The smart home of the ASE would "grow" and learn synchronously with the autistic individual because ASEs are adaptive and

[33] I think that this also testifies to the atypical time processing in autism and the shallow depth of the field of affordances.

[34] Here is a quote from Daniel Tammet: "At school I had told the careers officer that I wanted to be a postal sorter or a librarian one day. The idea of working in a sorting office, putting each letter in exactly the right slot, or in a library, surrounded by words and numbers, in environments that were structured, logical and quiet, had always seemed ideal to me" (Tammet, 2006, p. 102).

[35] This has to do with the achievement of autistic metastable attunement.

[36] Already we are witnessing the first use of AI tools like ChatGPT in clinical settings to diagnose developmental disorders like autism through recognition of atypical language usage (Hu et al., 2024).

responsive.[37] This "personalized environment" of ASE would be the ecological niche buffering adaptability. This would go beyond the capabilities of sensory rooms and multi-sensory environments developed and commercialized so far.

Similarly to dementia patient solutions, we can envision using immersive virtual reality simulations of episodic memories to strengthen the integration of the autobiographical self of autistic children. Virtual reality could be used to simulate social interactions in more favorable environments, helping autistics try out new settings and situations or at least imagine how new encounters would occur and analyze complex social situations.[38]

Specific interests and pleasurable smells, flavors, sounds, and music, can be very idiosyncratic and different for every autistic individual. Machine learning of the ASEs can be the way for the smart environment to pick up these habits of the autistic user and attune the ecological niche of the home. As affordance landscapers, ASEs can shape meaningful affordances relevant to the autistic person. This application of ASEs should be extrapolated to whole buildings (e.g., psychiatric hospitals, autism centers) and whole cities as place affordances. Ambient smart environments could help to achieve the ideals of Universal Design.

Although the first logical use of ASEs is to help autistics with the uncertainty of the environment, and perhaps VR and smart homes would be the best ways for them to achieve this, it does not seem advisable to employ ASEs as a glass bubble for them to live in, cut of from the world. ASEs would also enable better development and learning, engaging in novel social connections, and acquiring new skills.

5. Conclusion

According to the ecological-enactive account and following PP approaches, autistics designate atypically high precision to bottom-up prediction errors and have trouble adapting to environmental uncertainties. Routines, strict habits, and a fixated ecological niche they construct are strategies they use to cope with a significant amount of prediction error to make the sensory environment more predictable. This paper expanded upon the ecological-enactive perspective of autism and proposed an approach to enhance the range of opportunities available to autistic individuals by utilizing ambient smart environments. Drawing upon the Free Energy Principle and the Skilled Intentionality Framework, White and Miller (2023) advocated for understanding ASEs as meta-affordances that influence the individual's possibilities for action. The ASEs could be used to help autistic individuals reduce environmental uncertainty, thus offering a potential strategy to address their daily challenges in the form of dynamic and responsive scaffolding. I have argued that White and Miller's approach to ASEs is a fitting upgrade for the EE account of autism since it is based on the same frameworks and shared core commitments. Taking this approach helps us figure out what neurotypical people can do to attune their environment and scaffold the needs of autistic individuals.[39]

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[37] Understanding of autism is based on research programmes that apply to cognition of living systems. If we want AI and artificial systems to come as close as possible to human cognition then we are to develop them based on the same principles of embodiment and enaction. See, for example, the editorial and papers in Safron, Hipólito, & Clark (2023).

[38] For a review of of current approaches and evidence-based virtual reality applications for autistic children see Carnett et al. (2023).

[39] In the meantime, a similar paper has appeared in which authors defend a complex systems approach to the implementation of ASEs for personalised cognitive styles (Hipólito & White, 2023).

Furthermore, the ASE would be a useful tool for further research in autism, for data collection and analysis, and as a device that records the bodily style and interactions of an autistic person, even phenomenological insights from verbal individuals. So, it would be useful in participatory autism research. Finally, it could lead to new assisted communication technologies.

Theory can only take us so far, but empirical research will provide concrete solutions and show if these proposed strategies are viable and helpful for autistic people. The final word will come from autistic individuals through phenomenological research on their intersubjective and ecological experiences; they will have a say on what works for them. Moreover, such evolved systems could even replace caregivers to some extent or at least help the caregivers. Perhaps this will be possible only in the future, so these are tentative suggestions that will, hopefully, encourage empirical research into the usefulness of ASEs for autistic people who require support.

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