Rethinking Disruptive Technologies: The Benefits, Harms, and Injustices of Human Niche Construction

Abstract

Disruptive technologies are a key theme in economics, the philosophy of technology, and situated cognition - yet these debates remain largely disconnected. This paper addresses four core questions that cut across them: (i) What, precisely, are disruptive technologies "disrupting" across the different contexts in which the literature situates them? (ii) Why do technological disruptions play such prominent roles, in multiple domains, concerning the development of our species, cultures, and personal lives? (iii) Are technological disruptions inherently beneficial or harmful, and how are potential benefits and harms brought about? (iv) What strategies are available for adaptation to disruptive technologies, and how accessible are they for different groups and individuals? To unify current debates and provide a conceptual and normative foundation for future research, we draw on *niche construction theory*. We argue that disruptive technologies are technological niche disruptions (TENDs) that occur at various spatiotemporal scales. TENDs pressure social groups and individuals to adapt. As the abilities and resources that adaptation requires are often unevenly distributed, so are the harms and benefits TENDs produce. TENDs, therefore, both reflect and sustain existing inequalities.

Keywords

Niche Construction; Negative Niche Construction; Niche Disruption; Disruptive Technologies; Social Inequality

1. Introduction

In *theoretical economics*, "disruptive technologies" are innovations that disrupt existing market structures and alter competitive dynamics (e.g., Christensen & Bower, 1996). In the *philosophy of technology*, this concept has been expanded to include any technology that interrupts or overturns entrenched norms and practices in various social domains: economic, scientific, legal, ethical, moral, or conceptual (e.g., Hopster, 2021; Hopster & Löhr, 2023; Löhr, 2023). In *situated cognition*, technology's disruptive nature is commonly addressed on the personal level: how technological structures and processes affect the cognitive, affective, behavioral, hermeneutical, epistemic, and interpersonal aspects of an individual's life (e.g., Andrada, 2025; Fabry, 2025; Fabry & Alfano, 2024; Krueger, 2024; Krueger & Osler, 2019; Osler, 2024).

As these debates have evolved mostly in isolation from one another, various conceptual and normative questions remain unaddressed:

(i) What, precisely, do disruptive technologies "disrupt" across the different contexts in which the literature situates them?

(ii) Why do technological disruptions play such prominent roles, in multiple domains, concerning the development of our species, cultures, and personal lives?

(iii) Are technological disruptions inherently beneficial or harmful, and how are potential benefits and harms brought about?

(iv) What strategies are available for adaptation to disruptive technologies, and how accessible are they for different groups and individuals?

To tackle these questions, we will examine disruptive technologies through the lens of *niche construction theory* (e.g., Coninx, 2023; Fabry, 2021; Odling-Smee et al., 2003; Sterelny, 2018), a promising basis for a unifying framework that explains what makes technology socially and personally disruptive. Its insights can be carried into the various debates that, though conducted in parallel, have so far been isolated from one another. We respond to the questions listed above with the following claims:

(i*) Disruptive technologies are specific forms of niche disruptions. We call these technological niche disruptions (TENDs).

(ii*) Human niches are inherently technological and are interconnected at various spatiotemporal scales. As such, human niches are particularly susceptible to disruptions induced by technology and to the adaptive pressures they create.

(iii*) Technological disruptions can prove beneficial as well as harmful to various stakeholders and at different times.

(iv*) The extent of these benefits or harms depends on the resources and abilities available for protecting or reconstructing niches. Their availability often reflects and reinforces social inequalities.

Section 2 introduces debates involving the concept of disruptive technologies and identifies key gaps in the existing literature. Section 3 presents crucial ideas from niche construction theory, arguing that human niches are fundamentally technological in nature.

Section 4 integrates the topics of disruptive technologies and niche construction to address questions (i) and (ii). By employing niche construction theory, we conceptualize technological disruptions as processes that interrupt or overturn the stably entrenched ways in which entities relate to and interact with their environment: those whose niche is disrupted find themselves under immediate pressure to adapt. Human niches are particularly vulnerable. Like the processes that construct them, they are both intertwined with each other and dependent on technology. We explore this by analyzing TENDs across various spatiotemporal scales.

Section 5 addresses questions (iii) and (iv). Challenging the dominant narrative that portrays technological innovations as inherently beneficial, we examine how such disruptions can be detrimental to social groups and individuals. We highlight how technological disruptions may generate and perpetuate inequalities, as adaptation to them requires certain resources and abilities, which are unevenly distributed. Section 6 concludes our discussion.

2. The Concept of "Disruptive Technologies"

Following central contributions to the literature in the philosophy of technology, we understand *technology* as a body of theoretical and practical knowledge, produced through cumulative learning, that gives rise to the construction and use of tools, which affect our innate ways of interacting with the world (Dusek, 2006; Nyholm, 2023; Spurrett, 2024). Such tools structure, modulate, or regulate our innate abilities and skills, including movement, memory, orientation, communication, and the regulation of our emotions. They include artifacts - objects constructed by humans, like hammers, computers, and firearms - but also normative systems, social organizations, cultural practices, and language systems.

Here, we are not interested in technology per se, but in *disruptive technologies*. This notion is associated with the economist Clayton Christensen and his idea of disruptive innovations (e.g., Christensen & Bower, 1996): advancements that cause an upheaval in existing market structures and change competitive patterns, sometimes by creating whole new markets (Schuelke-Leech, 2018). Disruptive innovations are more than simple enhancements of existing structures. The disruption of an established market is a dynamic process that

escalates over time. For example, an innovation may at first prove only weakly competitive within an existing structure, but then overturn it altogether.

A popular example of disruptive innovation is the business model developed by Amazon, which began as a relatively small and unremarkable online bookstore. However, its business model proved disruptive enough to shift the market dynamics in its favor, causing more established bookstores to perish. Instead of conforming to the norms of an established economic environment, Amazon initially operated outside them, putting itself at an apparent disadvantage. At some point, Amazon's rapid success reached a tipping point, altering the dynamics of the entire book market and ultimately constructing an economic dynamic that suits Amazon's model better than traditional bookstores'.

While Christensen and his colleagues primarily focused on disruptions within economic markets, this represents only a subset of disruptions within the social sphere (Hopster, 2021). The concept of disruption also has broad and significant applications within the philosophy of technology (van de Poel et al., 2023). According to Hopster (2021, p. 4), technological innovations can cause a social disruption that "manifests itself in the overturning of stably entrenched [social] norms [and] practices." Paradigmatic examples of disruptive technologies include agriculture, letterpress printing, pistols, birth control, and artificial intelligence (Hopster & Löhr, 2023; Hopster et al., 2022; Löhr, 2023; Van de Poel et al., 2023).

Within the philosophy of technology, the concept of disruptive technologies now encompasses technologies that overturn established norms and practices in any of various domains: economic, scientific, legal, ethical, moral, or conceptual. These discussions still focus primarily on the social, however, examining how technologies impact larger groups. In contrast, a parallel line of research within the tradition of situated cognition emphasizes how technologies function as environmental structures that affect individuals in multiple domains: cognitive, affective, behavioral, epistemic, hermeneutical, or interpersonal. Common examples include algorithms in online recommendation systems (Figa-Talamanca, 2024), social media and image editing software (Andrada, 2025; Fanti Rovetta, 2025a; Krueger & Osler, 2019; Osler, 2024); online community platforms (Eickers, 2025); and artificial intelligence as a co-writer (Coeckelbergh & Gunkel, 2025; van Woudenberg et al., 2024) or communication partner (Fabry, 2025; Fabry & Alfano, 2024).

So far, each of these debates on technologies' nature and impact has largely unfolded in disciplinary isolation. This fragmentation raises several critical conceptual and normative questions.

(i) It remains unclear whether the discussions in the philosophy of technology and in research into situated cognition address the same underlying phenomenon. While the term "disruption" plays a central role in the philosophy of technology, the literature on situated

cognition employs it more rarely. This tradition instead tends to focus on how environmental structures support, enhance, or modulate an individual's capacities (Coninx & Stephan, 2021). Nonetheless, several of its debates, for example, on image manipulation tools, or on engagement with social media platforms (e.g., Andrada, 2025; Osler, 2024), involve disruptions which, though at the level of the individual, resemble those at the social level that the philosophy of technology paradigmatically discusses. Some authors even explicitly state this, such as Regina Fabry (2025), who investigates how deathbots disrupt experiences of grief. If we accept that in all these cases technologies can meaningfully be described as disruptive, this raises a challenge: Is it possible to develop a unified account of disruptive technologies: one that specifies what, exactly, is being disrupted, at both personal and social levels of analysis?

(ii) If there is demonstrably a recurring pattern in which certain technologies exert disruptive effects at both the social and the individual level, this invites a deeper inquiry into why technologies matter so profoundly in human life, and why such disruptions are so pervasive. Why do technological disruptions function as central drivers in the development of our species, cultures, and personal lives (Basalla, 1988)? Valuable resources for answering these questions might be found in human evolutionary theory and anthropology (Henrich, 2015; Tomasello, 1999): both have emphasized technology's constitutive role in shaping human cognition and social organization. The idea is that if the technologies that foundation for our social or individual practices and capacities change, we change with them, or are forced to.

(iii) Important normative issues also arise: Are technological disruptions inherently beneficial or harmful? What can guide our thinking on what we ought to do about them? For example, to what extent is the prevailing focus on technological innovation's positive aspects empirically and ethically justified? This optimism about technological disruptions is prevalent not only in economics (Christensen, 1997) but also in various fields of philosophy related to technology, known as the "dogma of harmony" (Aagaard, 2021). As disruptive technologies can cause both benefits and harms, it is vital to explore the precise conditions in which they give rise to either.

(iv) What mechanisms are available for responding to disruptive technologies, and to whom? Access to resources and abilities with which to adapt to disruptions is significantly asymmetrical; this may exacerbate or perpetuate existing forms of injustice. The philosophy of disruptive technologies could profit from recent work on situated cognition, as this tradition has increasingly engaged with environmental structures' impact on injustice (Fabry, 2025; Krueger, 2024; Liao & Huebner, 2021; Mossner & Walter, 2025; Osler, 2024; Timms & Spurrett, 2021). This new body of literature also offers nuanced accounts of how technology can lead to exploitation, manipulation, and oppression, whether through design flaws,

structural oversights, or intentional choices. These insights have not yet been systematically integrated into the discourse on disruptive technologies.

To fill these conceptual and normative gaps in the current literature, in this paper, we will address disruptive technologies through the lens of *niche construction theory*. This theoretical framework is sufficiently sophisticated to unify debates from both the philosophy of technology and situated cognition while allowing each to enrich the other. With its conceptual tools, we can systematically address the questions we have raised, offering an account of how a technological structure can disrupt both individuals and social groups, for good and for ill. In Section 3, we will introduce the central ideas of niche construction theory, elaborating on what it brings to the analysis of disruptive technologies.

3. Niche Construction Theory

The concept of a *niche*, central to evolutionary biology and ecology, has been critical for describing and understanding how organisms live and change over time. Instead of studying organisms and their environments separately, the concept of a niche enables us to describe how an organism lives in terms of the relation between its environment - both biotic and abiotic - and its traits, abilities, and interests (Gibson, 1986). In other words, niches characterize an organism's *form of life* (Rietveld & Kiverstein, 2014): the stably entrenched patterns of its relation to and interaction with its environment. Such patterns include, for example, the norms that govern how a concept is used in a linguistic community; the habitual structures of coordinated behavior in joint action, or those affectively relating to another person; how someone engages in a particular profession; or the skilled navigation of a familiar environment (Rouse, 2018). The concept of a niche is inherently relational, as it is co-constituted by two relata: the features of the organism and the relevant features of its environment (Chemero, 2003).

The concept of *niche construction* emphasizes that organisms do not just "passively" occupy niches but construct them through interaction with whatever resources are available (Odling-Smee et al., 2003). Organisms are not simply molded by environmental pressures to fit invariant external conditions, but they actively (though not always intentionally) alter their environment "by being both the object of natural selection and the creator of the conditions of that selection" (Levins & Lewontin, 1985, p. 106). Organisms are not only shaped by their living conditions but shape them too, co-determining how they evolve.

Broadly construed, niche construction characterizes any activities (or choices) through which organisms modify, create, or sustain their niches (Laland et al., 2016; Odling-Smee et al., 2003). There are at least *three different mechanisms* of niche construction (Aaby & Ramsey, 2019):

Perturbative niche construction is the most paradigmatic form. It occurs when organisms actively modify features of their environment. Examples include constructing nests, altering an environment's chemical composition (e.g., through excretion), and cooperating with other organisms of the same or another species (e.g., pack hunting). This mechanism of niche construction involves making tangible alterations to environmental structures.

Niche relocation occurs when an organism relocates itself, whether permanently, periodically, or episodically (e.g., through migration). In doing so, organisms are not directly making changes to their environment, as in perturbative niche construction, but they actively select an environment to live in. What changes is neither the environment nor the organism, but their relation to each other.

Niche conformance occurs when an organism's phenotype adjusts in response to environmental variation. For example, some organisms are sensitive to differences in temperature and show variation in the timing of reproduction, selecting times at which food is sufficiently abundant. Unlike the passive shaping of genotypical variation through evolutionary selection, this mechanism is an expression of organisms' phenotypical plasticity.

The mechanisms of niche construction have been examined from various epistemic perspectives, addressing different *spatiotemporal scales* to account for the complexity inherent to human niche construction (Coninx, 2023; Fabry, 2021; Sinha, 2015; Stotz, 2017). For example, a niche may be considered more "global" or more "local," depending on whether it involves more or fewer stakeholders (e.g., an entire population, a regional community, a family, or an individual) and whether it covers more or less extended periods (e.g., millions of years, a few generations, a lifespan, or a single moment in time). In this paper, we distinguish *four kinds of niche construction*: phylogenetic, sociogenetic, ontogenetic, and microgenetic (Coninx, 2023; see Table 1 for illustration).

At the group level, *phylogenetic niche construction* is the collective modification of environmental features by human populations over evolutionary timescales, typically spanning thousands or even millions of years. These modifications influence both internal genetic inheritance, transmitted biologically across generations, and exogenetic inheritance, such as ecological or cultural conditions, so that genes and cultures co-evolve (Laland et al., 2016; Odling-Smee et al., 2003). In more recent historical periods, *sociogenetic niche construction* captures environmental modifications that span multiple generations, facilitating phenotypic variation among social groups. These changes typically occur at the level of social practices, institutions, or knowledge systems. They enable adaptation only through exogenetic means, bypassing the slower processes of genetic modification (Stotz, 2017).

At the individual level, *ontogenetic niche construction* is an individual's idiosyncratic and relatively stable patterns of interaction with their environment; these interactions both shape and are shaped by developmental trajectories over the individual's lifespan. They modulate phenotypic properties and are part of what makes individuals different from one another (Coninx & Stephan, 2021). Finally, *microgenetic niche construction* concerns an individual's short-term, situational engagements with their environment. It captures how an individual coordinates with their local surroundings to accomplish specific tasks in real time, often without long-term persistence or inheritance (Clark, 2006; Constant et al., 2020).

A key aspect of this argument is that processes on more local scales contribute to, and at the same time are shaped by, processes on more global scales. The different kinds of niche construction partly overlap and are profoundly intertwined, so that more extended processes emerge as less extended ones scale up to involve more individuals and longer periods of time; less extended processes are constrained by more extended ones. Notably, the relationship between more local and more global niches is asymmetric. Changes in more local niches do not necessarily translate into changes in more global ones, whereas alterations in broader, more global niches always impact processes in more local ones, constraining them in one way or another (Coninx & Stephan, 2021).

Why do we think that the niche construction framework can help us analyze disruptive technologies?

While the concept of niche construction originated in evolutionary biology, it has been employed and systematically broadened in different areas of research: cultural evolution, personal development, and local coordination with the environment (Constant et al., 2020; Sterelny, 2018; Stotz, 2017). The resulting framework is naturally quite broad: it characterizes niche construction as any activity or choice through which organisms alter their relation to and interaction with their environment. Nonetheless, it is not overly permissive when it is based on a clear conceptualization and systematic taxonomy (Coninx, 2023; Fabry, 2019).

The framework offers something valuable for many of the debates in which it is employed. It provides useful tools that emphasize different aspects of the bi-directional relation between organisms and the environment they actively construct. Its broad conceptualization provides a unifying framework for otherwise fragmented approaches, helping them to study mechanisms' similarities and interconnections, and how different disciplines address these, for example, in debates on oppressive narratives and narrative harm (Byrne, 2025; Fabry, 2024; Fanti Rovetta, 2025b).

The niche construction framework is equally promising for debates on disruptive technologies, though not uniquely so. We are not the first to have this idea. Drawing an analogy to evolutionary mechanisms, Schot and Geels (2007) employ niche construction theory to analyze how radical technological change leads to new rules for specific

technologies' production, use, and regulation. Their focus, however, remains largely on markets' structures and dynamics; they pay limited attention to how, for better or worse, such changes impact human norms, practices, habits, or skills. By contrast, Hopster et al. (2022) take the concept of a "niche" more seriously in this regard, exploring how disruptive technologies affect human niches. Their analysis primarily focuses on moral issues at the social level. Meanwhile, authors such as Krueger and Osler (2019) conceptualize the internet as a socio-technological niche that both shapes and is shaped by those engaging with it. Despite these important contributions, no integrative framework has yet considered the role of disruptive technologies through the lens of niche construction theory at both the social and the individual level.

Besides these general advantages, we think the niche construction framework is readily applicable to disruptive technology, since human niches are essentially *technological niches*. Various organisms at least partly construct their niches: niche construction theory itself is rooted in evolutionary biology, with many examples from the non-human animal kingdom. Humans are an exception only insofar as they construct their niches with greater radicality, flexibility, and variability than other animals (Sterelny, 2018).

Why are humans such radical niche engineers?

Humans are distinguished by the fact that their niches are inherently technological (Clark, 2004; Henrich, 2015; Sterelny, 2003). Technology predates our genus, emerging well before *Homo habilis*. Tool use appears to be a hominid homology, as closely related apes like chimpanzees also make and use tools, perhaps even transmitting this practice culturally. What may have originated with *Homo habilis* is not toolmaking itself, but how tools became durable, ever-present parts of the environment, likely reused in new contexts rather than discarded after a single use (Jeffares, 2010). This allowed our niches to become inherently technological, as the growing and interconnected development and use of tools allowed technology and human nature to co-evolve. This influenced our species, our varying cultures, and even our individual lives (Boyd & Richerson, 2005). We build on this assumption in Section 4, where we reconceptualize technological disruptions as niche disruptions.

Another advantage of the niche construction framework is that it can address normative issues surrounding disruptive technologies. Niches and niche construction are often described positively, as processes that increase the "suitability" of the organism–environment relationship. By themselves, however, these terms are value-neutral: they only concern the relationship between organisms and their environment, or changes in this relationship, including both beneficial and harmful expressions (Coninx, 2023). Humans are not the only organisms capable of constructing harmful niches, for example, by depleting their environment of resources, leading to habitat degradation or extinction (Laland et al., 2016). Negative niche construction does, however, spread more widely when human beings

and their technological innovations drive it (Aagaard, 2021; Bertolotti & Magnani, 2015; Spurrett, 2024). We will return to this point in Section 5.

4. Technological Niche Disruptions (TENDs)

We will now revisit some of the questions we posed concerning disruptive technologies. What exactly is it that some technologies disrupt? What is it about technological innovations that sometimes makes them socially as well as personally disruptive? And what makes humans so vulnerable to disruptions by technological innovations and disruptive technologies that these are central drivers of humans' social and personal history?

We argue that technological disruption is a specific form of *niche disruption* that may occur on various spatiotemporal scales. Once constructed, niches can be disrupted.[1] Niche disruptions are processes that interrupt or overturn forms of life, and those whose niches are disrupted can no longer relate to and interact with their environment in relatively stable, entrenched ways.

Contrary to the current understanding in the debate on disruptive technologies, which regards technologies as disruptions to a person or society, we propose to reconceptualize them as disruptions to niches, understood relationally. Such disruptions prevent the maintenance of established ways of relating to and interacting with one's environment.

This implies two central insights. First, by definition, niche disruptions require us to establish new ways of relating to and interacting with our environment - slightly changing our practices is not enough (Blok, 2022). Niche construction theory helps us identify concrete mechanisms of adaptation, as TENDs force us to adapt and to engage in the new mechanisms of niche construction: perturbation, relocation, or conformance. Second, no instances of environmental change are inherently disruptive, but only in relation to a certain social group or person, and often only within a certain temporal scope.

We therefore define *Technological Niche Disruptions* (TENDs) as

> dynamic processes, brought about through technology, that interrupt or overturn a social group or person's current niche - the stably entrenched pattern of relating to and interacting with their environment.

What do we gain by conceptualizing disruptive technologies as TENDs? It enables us to emphasize four different aspects of TENDs that also illustrate our central ideas.

[1] In principle, niche disruptions can stem from alterations to the stakeholder at play (e.g., change in a person's abilities due to an injury), the relevant characteristics of environmental features (e.g., flooding of an area), or their relationship to each other (e.g., forced relocation). We focus only on niche disruptions induced by alterations to environmental features, as is commonly the case in the context of disruptive technologies.

First, niche construction theory shows how disruptive technologies occur at various spatiotemporal scales. Despite their varied contexts, such disruptions share a defining feature: They interrupt or overturn relatively stable, entrenched ways of relating to and interacting with one's environment. This analysis, however, is contingent upon the chosen epistemic perspective. Here, the niche construction framework provides us with spatiotemporal scales that let us pick out causal patterns in how a stakeholder's activities and the relevant environmental features influence each other (Fabry, 2021). By selecting examples of disruptive technologies that involve the four different kinds of niche construction, we identify phylogenetic, sociogenetic, ontogenetic, and microgenetic TENDs (see **Table 1** for illustration).

	Phylogenetic	Sociogenetic	Ontogenetic	Microgenetic
Spatial Scope	populations	(sub)populations	individual	individual
Temporal Scope	up to thousands and millions of years	multiple generations	developmental stages	here-and-now
Inheritance	genetic-exogenetic	exogenetic	intra-individual	situation-bound
Examples: Disruptive Technologies	Control and use of fire – physiology and social tolerance	Invention of mechanical ventilators – conceptual norms and practices	Individual entrenchment of deathbots – grief experience	Situational use of smartphones – attention and

Table 1. Four Types of Technological Niche Disruption (adapted from Table 1 in Coninx, 2023)

In *phylogenetic niche construction*, technological disruptions come into focus that overturn cultural norms and practices; since these influence genetic traits, over time their disruption leads to significant co-evolutionary changes in both culture and genetics (Laland & O'Brien, 2011). One central example concerns the control and use of fire, which fundamentally shaped our dietary habits and physiology, as well as our interactions with each other (Dunbar & Gowlett, 2014; Sterelny, 2018). Researchers have argued that the use of fire overturned daily routines, as people could make greater use of periods with little natural light. This extra time appears to have been particularly devoted to social activities, promoting social tolerance among those sharing a fire. Similarly disruptive technologies might include the construction and use of the first stone tools (e.g., Acheulean tools; Jeffares, 2010) or the introduction of dairy farming (Sterelny, 2010).

When considering the less extended timescales involved in *sociogenetic niche construction*, we see that different groups' phenotypical traits developed alongside technological disruptions, and may in turn have influenced the technologies' development and use. Disruptive technologies frequently challenge the applicability of common concepts which are central to a human language, requiring us to navigate corresponding uncertainties and

establish new socio-linguistic norms. For example, with the introduction of the mechanical ventilator, heart function in patients with no brain activity could be maintained artificially. This led to a conceptual disruption of the distinction between "being dead" and "being alive." The concept of "brain death" emerged in response (Baker, 2019). Another paradigmatic example is artificial intelligence, which challenges our notions of intelligence, authorship, or romantic partners (Coeckelbergh & Gunkel, 2025; Hopster & Löhr, 2023; Löhr, 2023; Van de Poel et al., 2023; van Woudenberg et al., 2024).

At the individual level, our capacity to use tools to shape our niches in different ways leads to significant inter-individual and intra-individual niche variation, depending on each person's ongoing engagement with and entrenchment of technology. In *ontogenetic niche construction*, disruptive technologies may impact, for example, a person's memory, agency, emotions, behavior, or interpersonal relations. Fabry (2025) discusses the possibility that engaging with deathbots disrupts the temporal dynamics of grief, negatively affecting autonomy and well-being; fixing engagement with the deceased in the present may hinder the processes through which bereaved individuals navigate, negotiate, and adapt to their absence over time.[2] Other examples may include how social media and image editing software (Andrada, 2025; Osler, 2024) change how we perceive ourselves, enforcing new ways of relating to ourselves (e.g., by normalizing distorted body images, or by encouraging a detached, third-person perspective on the versions of ourselves we project online).

The category of *microgenetic niche construction* contains technologies that are designed to affect our attention economy in our present situation, such as notifications or pop-ups that cognitively and affectively disrupt our concentration or enjoyment (Kärki, 2024). They overturn the ways in which one used to engage situationally with one's environment, often reinforcing others instead, such as rumination (Fanti Rovetta, 2025a) and letting the mind wander (Bruineberg & Fabry, 2022).

The second aspect is that the niche construction framework emphasizes disruptive technologies' relational character. Since niche disruptions are relational phenomena, technologies are not intrinsically disruptive: they become disruptive only in relation to specific individuals or social groups. Whether a given technology counts as disruptive thus depends on which stakeholders are involved. For example, as attention regulation and executive function both vary, individuals might resist microgenetic TENDs' distractions in different ways and to different degrees (Kärki, 2024).

Technological disruptions are not linear or uniform processes; they are dynamic and often involve competing trajectories, transitional states, or even regressions. For example, a

[2] Interestingly, in this case, the death of the significant other constitutes a form of niche disruption that requires adaptation, while the introduction of the deathbots disrupts the processes of long-term adaptation to this initially disruptive life event.

technology may cause upheaval on social and individual levels, be lost or intentionally abandoned, and then be reintroduced. Thus, whether a technology is disruptive or not also depends on the temporal focus one chooses.

Third, the niche construction theory emphasizes that humans' environment is less natural than technical: heavily shaped and maintained by others, and thus beyond one's direct control or influence. Whereas niche disruptions in non-human species typically result from exogenous environmental changes, such as abiotic changes (e.g., volcanic eruption) or other species' niche construction (e.g., animals' migration), human niche disruptions are more frequently the result of technological interventions. Being inherently technological, human niches are particularly susceptible to disruption by new "invasive" technologies.

Technologies do not simply "happen" to us. They emerge in the niche construction process, whether one's own or, most often, others'. TENDs characterize the disruptive effects these processes have on (other) humans' niches at the social and individual levels, which are intricately intertwined at multiple spatiotemporal scales. TENDS may follow various pathways, but a prototypical one sees technologies undergo development within specialized, rather local niches (e.g., biomedical research institutes) and then, upon reaching a critical tipping point, enter broader socio-economic contexts and destabilize their established norms, practices, and regulatory structures. At such junctures, a technology's reach necessarily extends from global to local niches, and the disruption asymmetrically affects individuals in these broader social niches.

Fourth, disruptive technologies exert immediate adaptive pressure on those whose niche is destabilized, who must reconfigure how they relate to and interact with their environment. Understanding disruptive technologies as TENDs helps explain their developmental significance. By challenging existing behavioral patterns and modes of engagement, they catalyze the formation of new norms, practices, skills, and habits, becoming powerful drivers of human transformation (for example, as the invention of the mechanical ventilator forced the formation of the new concept "brain death").

Assuming that not all technologies are disruptive, what distinguishes genuinely disruptive technologies from those that are merely influential or perturbative? We follow Hopster's (2021) suggestion that "disruptiveness" is gradual and may occur along multiple dimensions, such as depth, range, pace, reversibility, and meaningfulness. These dimensions may apply to both the social and the individual level. Generative AI is an example of technology that might be considered particularly disruptive along all dimensions.[3]

[3] The dimensions of depth, range, pace, and reversibility are directly taken from Hopster (2021) and applied to the social and individual level. The notion of meaningfulness is newly introduced, partly covering ideas that Hopster mentions under the 'value' and 'ethical salience' of a technology's impacts. The notion of meaningfulness seems more fitting when addressing dimensions that concern social groups and individuals alike.

The more profoundly technologies challenge foundational norms, practices, concepts, habits, or abilities, the greater their *depth of impact*. For example, generative AI profoundly alters our understanding of what it means to be an author, as it reaches the core of this very concept. The *range of impact* captures how broadly technologies disrupt different domains of our niches, such as generative AI that affects healthcare, education, science, and personal relationships alike. The *pace* of change further amplifies disruption when technologies evolve faster than a society's or an individual's capacity to make sense of them. The *reversibility* (or irreversibility) of impact characterizes whether technologies alter how stakeholders can relate to and interact with their environment in a way that cannot be easily undone. We may think here of the impact of AI, which is unlikely to reverse. *Meaningfulness* characterizes the significance that we ascribe to the disruptive technology - whether it concerns core features of our self-understanding as human beings on the social or the personal level. Generative AI affects our understanding of what it means to have a genuine interpersonal or even romantic relationship with another entity.

We may ask what opportunities for adjustment we have when TENDs are present. Other questions are also still up for debate: whether niche disruptions are inherently positive or negative, and which factors determine whether adaptations to niche disruptions are beneficial or harmful. We will address these questions in Section 5.

5. Benefits, Harms, and Injustices

Having reached a better understanding of what TENDs are, we move on to the remaining two questions. Are technological disruptions inherently beneficial or harmful? There is a tendency in the literature to praise the benefits of disruptive technologies, but is this warranted? In order to understand where potential benefits and harms might come from, we need to study the adaptive strategies that are available and how accessible they are to different groups and individuals. The niche construction theory provides us with the tools we need. We argue that TENDs impose pressure at both individual and societal levels, carrying the potential for both significant benefits and diverse harms. Such harm is often not inherent to the technological disruptions themselves, but depends on the resources and abilities a stakeholder has available to protect their niche from disruptions or to (re)construct it in their aftermath. There is a striking inequality in how disruptive technologies affect individuals and their access to adaptive resources. This underscores the need to scrutinize how stakeholders adapt to TENDs and whether their mechanisms of adaptation should be regulated.

5.1 Benefits and Harms

"Niche construction" refers to changes, beneficial or harmful, in organisms' relationship with their environment. *Positive niche construction* makes a niche more "suitable" for an organism, while *negative niche construction* has the opposite effect. The definition of

"suitability" varies with both the epistemic perspective we employ and the aim of our analysis: fitness, economic or cultural prosperity, robustness of interpersonal relationships, flexibility in self-narration, autonomy, agency, well-being, or performance in a specific task (Coninx, 2023; de Carvalho & Krueger, 2023; Fabry, 2024, 2025).[4]

These considerations also apply to TENDs' benefits and harms. Initially, TENDs may seem necessarily negative: they render the status quo untenable, but adaptation requires resources. Thus, they always come with some sort of "transition costs." However, niche disruptions and subsequent adaptations are not inherently positive or negative. Their impact depends both on how individuals and societies manage to adjust their niches and on the short- and long-term consequences, positive as well as negative.

There are various cases of positive technological niche disruption whose benefits emerge either immediately or through slower transformations. Prominently, niche disruptions can be positive when the disrupted niche has previously been harmful to the relevant stakeholder. Thus, in some cases, technological innovations require resource-intensive adaptations but offer immediate relief from harm. For example, assistive technology requires lifestyle adjustment, but the new niche might better suit the user's cognitive abilities and needs (Candiotto & Stapleton, 2024). In other instances, technological disruptions can catalyze creative adaptation, pushing individuals and societies to overcome convenient but damaging habits through slower processes of transformation (Hopster et al., 2022).

That said, our goal is to contribute to the growing body of research that focuses on the negative effects of technological changes. Earlier research recognizing their potential for cognitive harms includes Bertolotti and Magnani's (2015) concept of a "terminator niche": a cognitive niche that becomes harmful due to externalized knowledge structures that initially seem beneficial but later cause socioeconomic harms.[5] Aagaard (2021) challenges the "dogma of harmony" in the philosophy of technology, arguing that individuals often engage with technological innovations in ways that help them address a specific task but are detrimental to their overall well-being. For instance, while digital devices can aid in specific

[4] The normative criteria we employ to evaluate niches as suitable do not immediately follow from the niche construction theory, but they need to be specified in relation to the interests, needs, and goals of the stakeholders at play. A more detailed discussion has been provided by de Carvahlo and Krueger (2023) or Fabry (2025). Furthermore, in talking about the suitability of a niche we are not talking about moral issues. A disruptive technology may be beneficial for a person while being morally questionable in that it harms others. To make a further step to moral judgments, we need more than niche construction theory. For a more detailed discussion on the ethics of disruptive technologies, see Hopster (2021) and van de Poel et al. (2023).

[5] Among others, Bertolotti and Magnani analyze financial markets as socio-economic niches that heavily rely on software, algorithms, and trading systems, many of which are disruptive technologies that reshape the norms and practices of the market. While such technologies may be integrated to enhance welfare, the authors argue that the opposite may occur in the long term, citing global crises as exemplary outcomes.

tasks, the behaviors they encourage may be misaligned with users' personal values, undermining their autonomy and agency.[6]

Once we accept that potentially harmful TENDs are possible or even prevalent, further questions arise: How do these harmful effects come about? Why should we construct and use technologies that disrupt our niches in negative ways? First, niche construction is complex and flexible, while technological changes have asymmetric cascading effects at both social and individual levels. As a result, disruptions are likely, but it is difficult to identify and anticipate their outcomes (e.g., Bertolotti & Magnani, 2015; Spurrett, 2024). Disruptive technologies might provide short-term benefits but have long-term negative effects on certain stakeholders, at both social and individual levels. Second, technology may benefit some individuals while disadvantaging others, particularly when the former can impose the use of certain tools on the latter.

To illustrate this, we examine two case studies that involve both group and individual levels, along with their interconnections. We do not discuss genetics or its links to cultural evolution, as many disruptive technologies that are of interest in current debates are too recent to be linked to genetic adaptations. Instead, we explore disruptive technologies' negative effects on phenotypical traits. We focus on social norms and practices, including conceptual uncertainties and hermeneutical harms, examining issues raised by smartphones, dating apps, and their relation to image-based abuse. We then examine the long- and short-term effects of the introduction of firearms, assessing their impact as a disruptive technology at the individual level.

Normative frameworks are intricately woven into our language and concepts, but emerging technologies frequently disrupt this crucial element of modern cultural evolution (Löhr, 2023). Such disruptions prompt normative and conceptual adjustments at the societal level. Both stages of this process can result in harm. Technological disruptions can create normative and conceptual uncertainty, so that individuals struggle to understand or articulate their experiences due to insufficient concepts, linguistic limitations, or other people's interpretative deficiencies (Hopster, 2024). While conceptual adjustments are necessary, they are not always beneficial or sufficient, as forced adjustments do not equate to improvements (Hopster & Löhr, 2023).

[6] Aagaard argues that individuals may adapt to technological disruptions by becoming overly reliant on these technologies, leaving them vulnerable when access is limited. He discusses examples related to social media, which may facilitate distant communication but can lead to inattentiveness in face-to-face interactions. Similarly, the use of GPS systems may be considered useful for navigation, but it could result in cognitive deskilling. These ideas can already be traced back to Plato arguing that the practice of writing might negatively affect our memory skills (see Heersmink, 2024).

Image-based abuse is a contemporary example. The emergence of camera-integrated smartphones and dating apps has arguably led to more non-consensual sharing of intimate images and personal information: a form of victimization which these disruptive technologies have made possible. This creates a conceptual gap, demanding a new vocabulary to identify such forms of abuse. The widely used term "revenge porn" is, however, problematic, as it reflects the perpetrators' perspective, suggesting that the victim deserves "revenge" and labeling the images as "pornographic." This deviates from the victim's own understanding. Hopster (2024) argues that although a conceptual adaptation has taken place in the aftermath of the technological disruption, it is one that generates hermeneutic harm. It further marginalizes the victims by framing their experiences within a socially dominant narrative that diminishes their suffering.

Similarly, there are growing concerns that the proliferation of deepfake technology, used to create realistic but fake images or videos, may significantly increase the spread of non-consensual intimate content. Viola and Voto (2023) hypothesize that the widespread use of deepfakes may ultimately erode the special epistemic and affective trust we place in photographic images and videos - a potential adaptation that may reduce deepfakes' appeal to perpetrators. Whether society at large would be unharmed by such a loss of trust remains uncertain. In any case, as Viola and Voto indicate, deepfakes may cause significant harm before the transition is complete, disproportionately affecting female bodies.

Firearms, meanwhile, not only force social, moral, and legal adaptations at the group level (Hopster et al., 2022), but also foster new ways of relating to and interacting with one's environment at the individual level. Saarinen (2024) provides a compelling analysis of how firearms, as socio-culturally dominant technologies, substantially disrupt one's experience of oneself, others, and the world as they become more and more entrenched in individuals' lives. For many, firearms hold deep personal significance as affective artifacts: objects that become incorporated into the sensory body while altering an agent's affective condition. Saarinen's analysis suggests that although people often arm themselves to feel safer, carrying firearms actively reshapes one's emotional landscape by amplifying perceptions of danger in the surrounding environment. When firearms become part of one's everyday life, this may disrupt one's affective niche, promoting a permanent and likely harmful change in one's perception of real-world risks.

Harmful effects can emerge in a short timeframe. One of the disruptive effects of firearms is their availability as a means of suicide; many people decide to attempt suicide impulsively, often only minutes before the act itself, without prior extensive planning or serious suicidal ideation (Simon et al., 2001). Restricting access to firearms reduces overall suicide rates, not just suicide by shooting; it seems that individuals do not necessarily turn to alternative methods when their first choice is unavailable (Yip et al., 2012). Firearms' availability is a

stronger predictor of suicide than factors like mental health (Azrael & Miller, 2016). This suggests that their availability plays a critical role in the decision to commit suicide, making guns more than just a means; their mere presence increases the risk of suicide by heightening its cognitive salience as an immediate option (Rucińska et al., forthcoming).

5.2 Adaptive Mechanisms and Inequalities

Niche disruptions and adaptations to disruptive technologies occur within a larger social context. Since groups are biologically, psychologically, and socially diverse, technological niche disruptions affect individuals in divergent ways. Even within the same global niche, individuals may have varying resources and abilities with which to adapt to technological disruptions. This is often due to the relationship between their local niches and more global contexts. Thus, technological disruptions may benefit some individuals while marginalizing others and exacerbating existing inequalities.

We argue that whether adaptations to technological disruptions yield benefits or harms significantly depends on one's resources and ability to engage in niche (re)construction. Other people often restrict one's capacity to protect one's current niche from technological disruptions and flexibly adjust it in response to them. Technological disruptions may *trigger* inequalities when, for example, certain individuals are excluded from access to tools or their benefits. The disruptive technologies themselves may *sustain* inequalities by, say, actively perpetuating and reinforcing marginalizations (Hopster, 2024). These inequalities may be created intentionally; some technologies are not only disruptive but potentially hostile, compelling some individuals to adapt in harmful ways for others' benefit (Timms & Spurrett, 2023). In other cases, however, the resulting inequality is (arguably) unintentional (Liao & Huebner, 2021); marginalizing or discriminatory elements are often neither foreseen nor recognized. In the following, we illustrate different forms of inequality by revisiting the three mechanisms through which humans can (re)construct their niches when they foresee or must react to technological disruptions.

First, individuals can, in principle, engage in *niche relocation*: an organism's permanent, periodic, or episodic movement to a new environment. Individuals could relocate to a place where a disruptive technology has not (yet) impacted the social niche, avoiding forced adaptation and its corresponding harms. For instance, someone might move to a country with stricter firearm regulations to escape the negative cognitive effects of permissive gun laws. For many, however, relocation is not an option, due to personal responsibilities, a lack of financial resources, or legal restrictions on migration.

Similarly, a key aspect of social inequality is that the same technological niche may privilege certain groups over others by presenting different opportunities and constraints to different individuals (Crippen, 2022; Osler et al., 2024). Consequently, relocation may become an urgent need only for some, especially when technology is deliberately used to disrupt their

niches to exclude them from specific public spaces. For example, urban spaces often feature technologies designed to disrupt the existing niches of young or homeless people through visual, auditory, or olfactory signals. In the literature on architectural design, there is increasing interest in these forms of selective permeability, through which urban spaces can be made inviting to certain individuals while excluding others, selectively shaping spatial agency (Crippen, 2022; Crippen & Vladan, 2020; Osler et al., 2024). These selectively permeable barriers can deprive some individuals of access to (technological) resources that are essential for their well-being, without providing suitable alternatives (Krueger, 2024).

A second form of niche construction is *niche conformance*: the adjustment of one's phenotype in reaction to environmental changes, at both group and individual levels. In the context of technological disruptions, this entails acquiring and developing whatever practical or theoretical skills a new tool's use or integration requires, including the adjustment of various aspects of one's life. For example, when social media and digital communication disrupt traditional social interactions, individuals adapt by, say, learning how to manage attention and to process social cues in online environments.

Social inequalities can affect who has the means to use existing tools or to acquire the necessary theoretical and practical knowledge. Sometimes groups or individuals are not equally successful in rebuilding their relationships with their environment because some are excluded from using the necessary tools. For instance, as social interactions increasingly shift online, those lacking relevant computer skills or faced with non-integrative technologies designed exclusively for able-bodied people may be excluded from the niche conformance they need. This increases the cognitive harm they experience, such as limited access to information or fewer options for meaningful interpersonal connections. Disparities in online access, whether due to infrastructure or to financial constraints, can also increase social deprivation and limit access to opportunities in education, employment, or social discourses (Archer & Wildman, 2021).

Injustices due to technological niche disruptions may be partly unintentional. When implicit biases stemming from ableist attitudes shape the construction of social niches, for example, they can enable or restrict technology-related learning processes (de Carvalho & Krueger, 2023; Huebner, 2016). Unequal access to tools does not render them inherently problematic. However, some tools have aspects that may mediate inequalities, preventing some individuals from utilizing them in beneficial ways, and sometimes these restrictions are even intentional. Wildman et al. (2022) and Nyholm (2022) examine how online affective manipulation, like social media platforms' generation of filter bubbles, intentionally deceives individuals, exploits their vulnerabilities, or discourages their use of deliberative capacities, restricting their opportunities to live a meaningful, autonomous life. By exploiting specific individuals' vulnerabilities, it prevents them from engaging (or learning to engage) with

technologies like social media in a more beneficial way (see also Kärki (2024) on attention economics and vulnerabilities).

A third form of niche adaptation uses *perturbative niche constructions*, where the stakeholders respond to a TEND by actively altering their environment on different levels. On the individual level, people can choose to adapt their niches to accommodate or compensate for disruptive technologies. The construction of one's own niche, however, is often restricted by other people. Since both technology and adaptation to it are cumulative, no human can create or adjust technological niches entirely on their own. Instead, individuals inherit technological niches, and stakeholders might not control, share, or be aware of the designs, interests, and values embedded in them. On the group level, responses to new technologies typically involve regulating, mandating, or prohibiting their use (e.g., through laws governing technology) to manage their disruptive effects. The disruptions' complex and cascading nature makes adaptations on this level challenging: there is a high risk of unforeseen and delayed harm, and affected stakeholders' interests may simply be ignored (Williams, 2016).

One option that falls within the scope of perturbative niche construction is *exnovation*, the deliberate phasing out or removal of technologies. Niche construction involves not only introducing technologies but also dismantling them (Fuchs & Ziegler, 2024). This may seem an intuitive response to technologies that disrupt niches in harmful ways. Various constraints, however, make exnovation an unviable option for many individuals: for instance, the risk of social exclusion (e.g., reliance on digital communication or online banking), or certain technologies' deeply ingrained role in everyday life, habits, and even addiction (e.g., to social media). Social groups that do attempt to phase out established technologies often face significant limitations that can effectively compel their continued use: infrastructural entrenchment, systemic dependencies, and the foundations of intergenerational injustice (e.g., in energy systems or urban planning).

Another major source of inequality, whatever the exact mechanism, is grounded in the capacity to determine the context in which tools are created and used. People possess this to varying degrees. Stakeholders are not merely users who benefit from technologies: they also play a role in determining which technologies are developed, under what conditions they are used, and to what extent they can disrupt established patterns of behavior. We assume that technological innovations, as well as adaptation to the disruptions they cause, benefit stakeholders when they do not violate their agency and autonomy (Nyholm, 2022; Wildman et al., 2022).

The scope of this guarantee might depend on multiple factors (Coninx & Stephan, 2021): *awareness* (the extent to which a stakeholder is aware of the processes of disruption and adaption), *intent* (the extent to which a stakeholder intends them to occur), and *control* (the

extent to which a stakeholder can influence them). The degree to which any stakeholder possesses these depends on the more global niches the stakeholder is part of; such niches enable their possession but also restrict it (Arfini, 2021).

Consider innovations developed within technology companies. While these products often evolve logically within such isolated niches, their introduction to broader contexts can be highly disruptive. Factors such as advertising, consumer utility, and market protection against less harmful alternatives can all complicate their impact. These processes might be unapparent to the users, who neither intend or control them but instead are left to adapt to a technological niche. They were not involved in creating this niche or determining its use. It might seem that some technologies are more or less designed for abuse, and thus for harming particular groups (see discussion in Viola & Voto, 2023).

6. Conclusion

This paper's contribution to the literature on disruptive technologies is a conceptual and normative framework for understanding what it means for a technology to be socially or personally disruptive. We have proposed that disruptive technologies can be usefully understood as technological niche disruptions: specific forms of disruption that generate adaptive pressures within niches, across multiple, intertwined spatiotemporal scales. Human niches are particularly vulnerable to such disruptions because they are inherently technological and interconnected. We have shown that TENDs can be both beneficial and harmful, as their outcomes depend on the resources and capacities that are available for responding to them. Crucially, such disparities often mirror and reinforce existing social inequalities. Greater attention should be directed toward understanding how harms arise from TENDs and whom they affect.

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