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RESEARCH

Artificial instrumentalism? A critique of AI acceptance and AI anxiety research

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Abstract
The ongoing proliferation of AI technologies has created a need to understand and model how people relate to, accept, and feel about AI. Among the research traditions that attempt to capture how individuals navigate these changes are those centred on the concepts of "AI acceptance" and "AI anxiety". This perspective paper suggests that the typical use of these concepts often rests on instrumentalist perspectives of technology that are especially problematic in the context of complex sociotechnical transformations and ethical AI adoption. Firstly, AI acceptance, when based on the Technology Acceptance Model (TAM), presupposes technology acceptance as inherently rational and positive and focuses disproportionately on overcoming barriers to use, which limits its capacity to capture how people relate to AI. Secondly, the concept of AI anxiety has been used to frame critical and hesitant perspectives of AI as nonrational. By comparing these concepts and analysing their historically instrumentalist underpinnings, it is argued that both research currents require further theoretical examination and critical engagement. As contextual examples, I examine AI anxiety and acceptance as guiding concepts in select contexts, mainly education. I argue that research should engage with AI adoption as sociotechnical change where ethics, uncertainty, rationality and nonrationality interact, impacting use, non-use and sociotechnical reconfiguration.

Keywords AI acceptance · AI anxiety · Instrumentalism · Technology acceptance model · Sociotechnical change

1 Introduction

Technologies change our social and material conditions. As these changes affect our lives, communities, institutions and societies, we come to perceive them in various ways: with excitement, dread, indifference, puzzlement, convenience, and so on. Meanwhile, technologies and accompanying technology discourses change, branch and diversify [1]. The still ongoing process of digitalisation is a prime example, as is the blooming of discourses of AI adoption (e.g., Marenco and Seidl, [2]. Multiple areas of literature attempt to model, analyse and explain how people come to relate to technologies, and provide recommendations for supporting these processes. Among the most popular models are those in the family of the *Technology Acceptance Model* (TAM; [3]), including Unified Theory of Acceptance and Use of Technology [4] and AI Device Use Acceptance (AIDUA; [5]). These models aim at explaining how individuals learn to use, accept and adopt technology (or AI specifically).

'AI' currently refers to a somewhat heterogeneous cluster of computational methods, systems and applications, and numerous professional and societal fields are developing their own understanding of AI. For example, AI adoption discourse is blooming in the context of education; a branch of this discourse draws primarily from TAM-based acceptance models. A notably different current of research exists around consumer perceptions of autonomous vehicles (AVs), where TAM is also one common starting point. While a range of fields as diverse as these examples have applied TAM-adjacent models in understanding the dynamics of AI adoption, problematically, there has been sparse discussion on the normative assumptions of these models or the research traditions around them. This perspective paper examines how, from the perspective of technology studies, the assumptions of TAM and its descendants reflect on and limit the usability of AI acceptance research.

Acceptance research focuses on modelling rational decision-making around technology use. Because of this, it

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is interesting to compare it with another concept that has similarly seen almost no critical examination; *AI anxiety*. AI anxiety as a concept is largely concerned with emotion and affect and thus has often been positioned as a complementary perspective to the rational decision-making emphasised in acceptance research. However, as I will argue, AI acceptance and AI anxiety when considered together work well to capture the notion of *instrumentalism*. Instrumentalism is the assumption that technologies are neutral instruments for human ends with no inherent social qualities, such as shaping how people think and relate to each other [6]. In what follows, I provide a general exploration of instrumentalism in AI acceptance and AI anxiety research, before moving on to illustrate these challenges with examples drawn from a number of social contexts.

The critical starting point of this paper concerns the *complexity of sociotechnical change*. For AI adoption, this includes various reconfigurations of activities, relations and structures as technology becomes entangled with social processes. This goes considerably beyond technical solutions and technical skills: problems are not necessarily solved by 'fixing' either the technology or the user. While such fixes are desirable when available, this emphasis can stem from a simplistically instrumentalist perception of technology adoption, as will be outlined in the next section. If we draw on critical theories of technology [6, 7] and issues around democratic participation in AI discourse (e.g., Bao et al. [8], Floridi [9], we can contrast the outcomes of acceptance and anxiety with other sociotechnical modes, such as reasoned dissent, critical engagement or ambivalence, technomoral change, and value-based plurality around technology (see [10]; see also [11]). However, as will be argued, the instrumentalist learning of acceptance and anxiety research has neglected understanding reasoned actions stemming from a more critical basis (see [12]). Integration of acceptance and anxiety perspectives with sociotechnical and ethical perspectives of AI adoption is needed if they are to generate a fuller picture of how people engage with these technologies. Thus, current practices in AI anxiety and AI acceptance research should either engage in further conceptual development, for which I present a few suggestions, or be more explicitly positioned as instrumental examinations of AI adoption.

As psychometric models that aim to be testable, operationalised and maximally parsimonious, acceptance models remain somewhat popular. Here I will not review the empirical findings of acceptance research, as such reviews already exist [13, 14]. Neither is the goal to dismiss the positivist or psychometric nature or the empirical rigour or theoretical parsimony of acceptance models (see [15]). However, originating from the early days of mainstream digitalisation, this tradition stems from a somewhat managerialist and techno-instrumentalist perspective, which has seen limited critique (see [16]). Surprisingly, the standard conceptualisation of AI anxiety has also not been critically examined, despite some recent reviews [17, 18]. Thus, as in the current AI boom acceptance and anxiety research are both at a new crucial juncture, as researchers build standard frameworks for understanding how people in private and professional lives relate to AI (see, e.g., Koenig [16]. As AI may increasingly challenge structures at personal, institutional-managerial and social scales, these frameworks need to engage with the complexities of sociotechnical change.

2 Background

2.1 Sociotechnical change: instrumentalism and complexity

While common dictionary definitions of technology generally conceptualise it as applied mechanical and scientific knowledge, the field of Science and Technology Studies (STS) has devoted considerable effort to constructing technology as a complex, socially embedded phenomenon. In this conceptualisation, social configurations shape technology and vice versa; technologies embody politics; technologies constitute nonhuman actors; predicting technological shifts is clouded by epistemic uncertainties; and so on. All such views contrast with *instrumentalism* which conceptualises technology as primarily tools fit for a defined purpose (see [6]; cf. Stirling, [1]. Most reductively, instrumentalism conceptualises technology as merely facilitating or optimising existing activities: technologies are tools that solve known problems [6]. In this view, the structure of the social world is assumed to stay more or less static with the introduction of new technological elements: for example, AI makes tasks and actions easier, faster and more effective, without changing the range of human behaviours, creating new problems or needs, or having broader systemic effects in social organisation.

In contrast, in *critical* theories of technology, technological configurations entail the construction of technological power and new ethical dilemmas [7, 19]. This conceptualisation of technology is efficiently captured by Kranzberg's (1986, p. 545) "first law", which holds, "technology is neither good nor bad; nor is it neutral." Meanwhile, *constructivist* theories of technology examine how diverse actors collectively shape technologies and their adoption [20]. Technological change is a complex phenomenon: design, adoption, discourse, expectations, regulations, culture, pressures, and any eventual transformations entangle. A useful, clear example is that of the car: while a car instrumentally solves the issue of moving from A to B, the invention of

the car gradually came to define how entire cities are built, planned and lived in, contributed to climate change and health, and so on. Meanwhile, laws and culture on how cars are to be used took form, and the design of the car is still changing.

Sociotechnical change is not necessarily apparent by examining a technology, but plays out over time. Applications and relations are found by accident and experiment, expectations and conventions are challenged, disappointments and trade-offs are encountered, and so on [20, 21]. However, technologies come with accompanying sociotechnical imaginaries [22], hype cycles and discursive expectations [6, 23]. These carry over all the epistemic problems of discussing the unknown future. This is perhaps most evident in the concept of "Artificial Intelligence": the very concept has all the hallmarks of a vague futuristic imaginary, while also constituting a fluid category of existing or near-future digital technologies.

One conceptual entry point into the complexity of sociotechnical change is to consider the "interpretative flexibility" of technology, i.e., the discursive design-adoption process around new technology [21]. This can cover multiple designs, trials and errors, resistance, contestation and compromise [10, 20, 24, 25]. This entanglement between social and technological cuts both ways: for example, a new technology can become the locus of "technomoral" experiments, where existing ethical frameworks are challenged in ways that yield highly unpredictable results. A vivid example is the 2013 introduction of the augmented reality headset Google Glass, where the emergence of concepts such as "Glass etiquette" – and "Glasshole" – demonstrate the discursive formation of technological ethics (see [26]). A more expansive case is the area of biotechnology, which is also complexly entangled with expectations, governance and epistemology [9, 27]. Genetic engineering is hard to judge instrumentally, not least because of epistemic uncertainties [28]. Immediate risks and benefits are difficult to weigh against slippery slopes, issues of control and cultural phase transitions (e.g., Walton, [29]. This is a facet of "interpretative flexibility" ([21]; see [30]).

Thus, while technology can be a tool for a well-defined use, it can also warrant examination that looks beyond immediate functionality. From this perspective, an instrumentalist perspective is one that highlights adoption of new tools to the extent that it neglects various processes of sociotechnical reconfiguration. For example, in the field of education, the advent of large language models (LLMs) forces the re-evaluation of previously stable practices such as essay-writing exercises. Similarly, automatic grading can reconfigure the relationships between teachers and students [31]. Technology can create entirely new modes of action (such as being a "Glasshole"), shift responsibilities (e.g., regarding data and privacy), create new invisible labour (see [32, 33]), and so on. While such reconfiguration is relevant for understanding AI adoption, it may be difficult to situate in purely rational or purely affective conceptual models.

Of course, on a more fundamental level, a wealth of research challenges the notion of technological change as ultimately constituting "progress", where dissensus, caution and ethical foresight are seen as solvable problems, or even obstacles for advancing capability (e.g., [30, 34]). For technology critics, other technological "metanarratives" are also valid, such as "Faustian bargains" and "Pandora's boxes", or technocratic power accumulation around "algorithms" or "Big Tech" (see also [35]). Others posit a sociotechnical pragmatism in between [11]. Conflicting feelings should be expected: when AI is discussed broadly, even high-status experts may hold strongly conflicting views (e.g., Russell, [36], as can nonexperts and media representatives [8, 9, 12, 35]. However, in a postmodern fashion, not only may people resist optimistic metanarratives, they can also feel conflicting feelings intraindividually ([37]; see [38]; on "love-hate" stances on educational AI).

In an increasingly technological world, technology attitudes and perceptions are increasingly relevant. Here, perhaps the most established empirical tradition exists in the acceptance models descending from TAM [3]. While this current of research remains popular and is now adapted to perceptions of AI, it comes loaded with normative assumptions on how individuals ought to relate to technology, and whether technology, its adoption, and authority around technology is necessarily instrumental and rational.

2.2 Technology acceptance models

The Technology Acceptance Model (TAM) is the most classic approach to understanding how individuals perceive technology entering their lives and professions. Originally designed to aid and analyse user acceptance of computers [3], TAM has generated a wealth of research on attitudes towards technological systems. As a psychometric model, TAM is a framework for mapping design features to the cognitive and affective responses of users, and the resulting behavioural response [39]; essentially, TAM is a rational-actor framework for understanding how people (in organisations) may come to accept and adopt some newly introduced (digital) technology. TAM focuses on two predictors for technology acceptance: *perceived ease of use* and *perceived usefulness*. These are seen as coalescing through rational decision-making, outputting an intention or attitude, and subsequently behaviour. Specifically, the system design dictates perceived usefulness and ease of use, which dictates attitude towards using, which dictates use [40].

TAM has later seen a number of extensions, improvements and alternatives, such as TAM3 and UTAUT (see [4, 39, 41]). The newer models have augmented TAM with new dynamics around beliefs, habits, and contextual factors. Hinting at further complexity, these models point to a wide range of *external variables* from privacy concerns and risk perceptions to charismatic leadership and availability of training [4, 39]. Yet, despite branching, they share their core with TAM. That is, new factors are constructed as antecedents to perceived ease of use and usefulness [39]. This means, for example, that extended acceptance models still focus strictly on acceptance about instrumental *use*, not *social* acceptance [16], even if this is not stated. This can be consequential if individual benefit clashes with wider benefits such as security and fairness. As Koenig [16] also argues, the act of, e.g., automating a task is a matter of trust, explainability and responsibility more than ease of use. One reason for this bias may be that TAM descends from a time where computers were more difficult to use and posed less risks for users and organisations.

During the turn of the millennium, TAM became quite popular as an empirical research approach amidst the waves of digitalisation (see [15]), and it remains an active area. Acceptance research is certainly valuable, especially due to its empirical nature and attention to major instrumental dynamics between technologies and users. However, it largely presupposes technology acceptance as a necessarily desirable goal, and focuses almost exclusively on use versus non-use. This indicates that motivation for TAM research has largely been to overcome non-acceptance of technology: as the original formulation of TAM begins, "Information technology offers the potential for substantially improving white collar performance … but performance gains are often obstructed by users' unwillingness to accept and use available systems" ([3], p. 319). As will be shown, this stance explicitly persists in acceptance research today.

In the ongoing proliferation of new AI technologies, the tradition of TAM promises an avenue into understanding how AI tools are adopted especially in various professional contexts and the managerial implications of, e.g., user attitudes. A recent review [13] shows that perceived ease of use and perceived usefulness are worthwhile concepts in modelling how people relate to AI. However, as the authors note (p. 30), there is need to "consider that willingness and rejection might co-exist [whereas TAM views] willingness as the absence of rejection" ([13], p. 30; see also [37]).

The construction around the nucleus of "ease of use" and "usefulness" can externalise issues such as risks, uncertainties and complexities. Adapting acceptance models to the context of AI has prompted researchers to try to work these complexities around this nucleus. In a recent paper, Shao et al. [42] set out to integrate perspectives of AI ethics and user self-efficacy into TAM. This is a fresh take on AI acceptance, as it incorporates perspectives such as anthropomorphic thinking, privacy, and legal concerns. However, the authors construct ethics as a unitary scale (whether using AI is ethical), which in turn is positioned as a variable mediating "perceived ease of use" and "perceived usefulness". As the authors note (pp. 3060–3061),

> Individuals who think using AI technology is ethical were more likely to perceive AI technologies as easy to use and useful. Such a result underscores the critical role of ethics in the technology acceptance process … Product developers and marketers may benefit from considering users' perceived ethics in designing and promoting AI-enabled products … [it] would be worthwhile to explore whether users' exposure to information about AI ethical principles and related regulations alleviates their ethical concerns, leading to a more positive attitude and stronger adoption intention toward AI technologies.

This approach can be seen as problematic: as ethics *mediate* acceptance, the goal of acceptance research is to show how to rather simply fix either the artefact ("considering users' perceived ethics in design"), or the user (alleviating ethical concerns). This is the instrumentalism of acceptance research in action.

Many limitations of TAM have been acknowledged. Bagozzi [15], also an influential TAM researcher, has provided a key critique: TAM can be shallow, and despite various additions, research has barely deepened it, addressed its rational-actor assumptions, or integrated social or cultural dynamics into it. Yet, Bagozzi's critique does not extend to the instrumentalist assumptions of TAM. Another major critique by Benbasat and Barki [43] comes closer to a socio-constructivist perspective by noting that interesting user behaviour when faced with new technology includes learning about and adapting ("reinventing") it, not only frequency of usage. This is a crucial observation given the flexibility and generality of many AI applications. Complementing this, Liu et al. [44] have examined the social dynamics of how AI ethics are perceived and how this in turn mediates acceptance; an example is the proliferation of ethically problematic norms. Each of these studies recommends the effort put into TAM research be partly redirected to more nuanced models. Despite these and other constructive arguments, AI acceptance research has engaged in limited reflection on this front, and still partly rests on the assumption that successful technology adoption is best measured in extent of use, and obstacles for this are easily fixed. As one interesting consequence, acceptance highlights knowledge deficits of those hesitant towards technology. Meanwhile,

knowledge deficits linked with hype, anthropomorphism or mysticism are not addressed [23, 45, 46]. For conscious and ethical AI adoption that goes beyond pure instrumentalism, the behavioural output of *reasoned non-use* can be more desirable in some contexts.

Finally, it is interesting to note that as acceptance research weakly theorises on the nature of technology, it is difficult to assess what technological contexts can be meaningfully examined using TAM and its descendants. TAM was originally intended to analyse acceptance of computers especially in workplaces, but has been adapted to highly dissimilar contexts (see Sect. 3). This is a challenge, if adapting TAM to the case of AI adoption requires making an implicit analogy with 90s computerisation; it is debatable how well this analogy holds up. AI adoption, like digitalisation, drives task reorganisation, new competency requirements and automation of routine tasks. However, AI adoption relates more deeply to cognitive and epistemic facets of work and life [47], with an unprecedentedly rapid diffusion. For example, while digitalisation made access to information effortless over the span of a few decades, the nature of information and communication remained a proxy of human thought and effort. Yet, in the span of a year or two, the role of text as a marker of expertise, or at least communicative intent, has changed considerably (see Sect. 3). Additionally, the impacts of digitalisation have not been purely instrumental either, which has become clear only in retrospect.

2.3 AI anxiety

Acceptance research is largely concerned with rational decision-making and related beliefs. An interestingly complementary, and similarly popular concept that has emerged as a focal point in examinations of how people relate to AI is that of *AI anxiety.* Defined as "the general apprehension or unease individuals experience in response to the rapid development and integration of AI technologies into various aspects of society" [17], AI anxiety has also been garnering significant attention in recent years. In fact, AI anxiety has been commonly positioned as another missing piece of the TAM puzzle. Schiavo et al. [48], for example, attempt to bridge the concepts of "AI anxiety" and "AI literacy" to TAM.[1] The authors note (p. 8) that "AI anxiety is not inherently negative, as it can serve as a cautionary signal toward AI technology … a certain degree of anxiety towards it might be justified by the fast development of AI technology and the several ethical, technical and regulatory issues it poses". However, anxiety remains a barrier to be overcome: "Enhancing AI Literacy might empower individuals with the necessary skills and knowledge to critically assess and engage with AI technologies, thereby fostering acceptance and ultimately facilitating the adoption of this potential transformative technology" (p. 9). Notably, the common assumption that understanding moves individuals from anxiety towards acceptance is not necessarily sound. Some evidence suggests that understanding AI *lowers* receptivity to using AI, as low understanding gives rise to "magical" beliefs regarding AI capabilities and its technological nature [45, 46]. Narratives, technical literacy, acceptance and anxiety seem especially fraught with sociotechnical complexity in the context of AI; consequently, there does not necessarily exists a separate "affective dimension" that confuses and mediates rational, belief-based attitudes.

AI anxiety seems nevertheless to be a real phenomenon. Somewhat analogously to the concept of climate anxiety, it attempts to capture the psychological effects of ongoing or anticipated AI-related changes in people's lives [17]. Such anxiety is well worth examination; however, this should of course not omit discussion of the issue at hand via the reduction of any and all concerns to a category of emotional fear responses. Existing conceptualisations indeed differ in how they judge AI anxiety as rational. For example, in a key paper in the field, Li and Huang [50] have categorised various AI anxieties in terms of whether they are fears caused by direct experience (i.e., fear acquisition) or not. In this model, experiences of discrimination cause "bias behavior anxiety". The authors list other varieties: the real prospect of conscious AI creates anxiety of the unknown, while worries of existential AI risks are a irrational fears caused by media propaganda.[2] This conceptualisation of fear suggests a rather sharp divide between AI anxiety and rationality. Li and Huang do however mention some deep sociotechnical complexities, such as that "lack of transparency can raise a number of issues, including the destruction of accountability" (p. 5).

In AI anxiety research, sociotechnically open-ended framings are frequently used to justify *the need for* research, but weakly carried over to assessments of the rationality of negative perceptions. Thus, anxiety research can be "helpful for governments and the tech industry in communicating to the public for a stronger acceptance of new technologies" ([51], p. 1523; [52]). Similarly, Türk et al. ([53], p. 2) point out that AI technologies "have transitioned from a simple technical tool in higher Education to a crucial element transforming the very nature of Education", but acceptance and

[1] This is difficult: AI literacy, for example, highlights ethical-critical assessment of AI rather equally to capacities of using or comprehending AI (see [49]; see also [46])

[2] Li and Huang [50] do still cite both Bostrom and Yudkowsky, who are among the most known proponents of discussing existential AI risk. Furthermore, in their paper (p. 7), they also argue that "the autonomous evolution ability of AI makes super AI possible, leading to existential risks".

anxiety research are needed to "understand people's attitudes, perceptions, and opinions towards AI and to accelerate AI adoption." As with AI acceptance, this branch of research would benefit from positioning itself more clearly either with sociotechnical change in general, or with the dynamics of irrational opposition to new technology in particular.

If AI anxiety is conceptualised as irrational hesitancy, augmenting (rational) acceptance with perspectives of anxiety seems unlikely to yield a less instrumentalist perspective to how people relate to AI in their lives. Yet, to my knowledge there has been almost no research critically analysing the concept of AI anxiety. Notably, a recent study by Marolla and Vezzoni [37] on Italian AI attitudes examines AI anxiety as complexly determined by concern for societal effects, individuals' own social positions and partly independent assessments of benefits and risks. As they argue, (p. 8), individuals familiar with AI "do not simply feel more or less anxious, but translate their sociotropic appraisals into emotional responses more effectively". In other words, rational assessment is not the opposite of anxiety. Indeed, establishing a domain of applicability could help identify the strengths and limitations of anxiety as a guiding concept.

This is worthwhile to contrast with the concept of *climate anxiety* (see [54]) or the related eco-anxiety [55]. In AI anxiety research, the capacity of individuals to *impact* the sociotechnical changes that cause the stress is often disregarded. Whereas the action or the paralysis of the anxious are central concerns for climate anxiety research [54, 56], AI anxiety research typically highlights the responsibility of technology designers and regulators in communication and action (e.g., [51, 52]); Kaya and Çelebi [57] even tentatively suggest using AI-assisted therapy to alleviate AI anxiety. Meanwhile, research on climate or eco-anxiety can be very nuanced, discussing the usefulness of emotions in direction attention and engagement, the nature of conflicted feelings, the effects of anxiety on social and individual levels, cultural biases, and how research can try to accurately represent the complexity of distress about uncertain futures [55, 58]. This literature illustrates how rich, even if difficult, discourse around the concept of AI anxiety could be, were it to engage with its topic in a similar manner. Indeed, while beyond the scope of this article, the comparison between climate anxiety and AI anxiety seems highly instructive and worth a separate investigation.

Like acceptance research, AI anxiety research may suffer from an undertheorised relationship with technology that is unable to accommodate sociotechnical novelty and complexity. To illustrate this, let us consider the question of AI agency. Li and Huang [50] note that AI anxiety is different from its conceptual relative, computer anxiety, as AI systems unlike computers can "make autonomous decisions and operate independently of humans, which may cause unpredictable harm" (p. 1). Meanwhile, Johnson and Verdicchio [59] call anxiety related to perceived AI agency "sociotechnical blindness", insisting that the "target of our anxiety should be the people who are investing in AI and making decisions" about the design and implementation of AI (p. 2270).[3] This may be largely true, but is a rather sweeping statement about technological responsibility and neutrality (see [61]). Theorising technology remains necessary, if assessments of anxiety depend on whether some stances are construed as rational or nonrational (see [9]; see also [62]).

As in acceptance research, various approaches have worked perspectives of ethical AI (see [9]) into anxiety models. To take an illustrative example, Kim et al. [17] link AI anxiety to issues such as unpredictability, explicability, complexity, justice, bias and privacy. For example, regarding privacy, the authors note (p. 8):

> As the digital age progresses, the integration of AI into various digital services raises significant concerns about the erosion of personal privacy. While AI offers unparalleled innovations, its capacity to process vast amounts of personal data challenges user confidentiality, which can lead to profound psychological impact.

Kim et al. go further than this, and eventually link psychological anxiety to broader issues of inclusive design, regulations, ethics and so on (but, notably, not the case of reasoned non-use). Arguably, their approach is neither simplistic nor void of actionable recommendations, and seems more likely to interface well with the range of literature around AI in society. Their treatment is openly in favour of AI proliferation, but also highlights moderation, caution and care, not only the soothing of concerns. This contrasts with more instrumentalist or determinist discourse around anxiety elsewhere:

> Increasing applications of AI and robotics technologies are inevitable. Accurate information and communication about what impact these technologies have on economies and societies as well as what skill sets are needed to adapt to the technological-advanced

[3] The question of the agency of technology is ever relevant in technology studies. This issue is well beyond the scope of this paper, but as a provocative thought, we may ask with what conditions can the behaviour of systems in principle emerging from underlying mechanisms necessitate that they have no agency, and how agency can then be construed. This is a theoretically and philosophically important question, partly in regard to AI ethics. It should also be noted that dependless of philosophy, people do, in fact, form complex relationships with technological objects and entities [60].

> environment may be helpful to triumphing fear and anxiety. (Vu and Lim [51], p. 1517)

As has been noted, a key contribution of AI anxiety research is an explicit focus on emotions related to technological behaviour (see [15]). This is a small step towards considering how people act when encountering complex sociotechnical transformations; AI anxiety is a phenomenon with implications worth extensive research. However, fear and anxiety can concern meaningful risks or real epistemic uncertainty. Hesitancy or criticality towards AI can stem from, e.g., technical dependency on multinational corporations, new kinds of risks caused by new kinds of technical mistakes and cognitive oversight, redistribution of tasks [16, 32, 47], the sudden speed and scale of economic reconfiguration, and so on. In any context, a number of diverse, legitimate concerns can mesh with an affective response ([37]; cf. Kurth and Pihkala [55]; this is easily overlooked, if sociotechnical change is seen as instrumental uptake. Indeed, some surveys report that *most* people are at least somewhat concerned by AI [63]. Thus, more open-ended inquiries into stances and concerns of people potentially affected by AI are worthwhile.

3 AI acceptance and AI anxiety in context

While this paper is centred on arguing that at least some acceptance and anxiety research retains instrumentalist commitments, here I want to provide some more contextual examples. The reason for this is that, as I have argued, technology adoption is a complex socioconstructive process; this is one key issue that anxiety and acceptance research neglect. To choose the example most familiar to myself, in this section I discuss AI adoption in education. In closing this section, I give a few other examples only to illustrate that AI acceptance and AI anxiety are used, and at least sometimes problematically, also in other areas of study.

The practice, policy and research literature of education has been profoundly impacted by digital technologies. As in other institutions undergoing digitalisation, the relevant discourse has at times had a markedly instrumental lean, even if it may show signs of emerging criticality and plurality (see CSET Collective, [64, 65]). For example, a top-cited 2005 study ([66], p. 25) begins by noting:

> Although the conditions for successful technology integration finally appear to be in place, including ready access to technology, increased training for teachers, and a favorable policy environment, high-level technology use is still surprisingly low. This suggests that additional barriers, specifically related to teachers' pedagogical beliefs, may be at work.

Currently, it is widely acknowledged that educational technology is not a neutral instrument simply delivering pre-existing pedagogy more efficiently, with entire journals (such as *Learning, Media and Technology*) devoted to this matter. For example, Selwyn [67] points out how technologies are politically embedded in commercial interests, institutional pressures and cultural assumptions about learning. Williamson et al. [68] outline that the "datafication" of education drives indicator-driven governance and infrastructures of surveillance and commercialisation, while potentially forcing educators to adopt strategies that fit the operationalisation of inflexible digital systems. Recently, research has been concerned with how actors in the field of education can legitimately disagree about technology: dissenting sentiments are, in fact, a generative resource for nondeterministic debates about the role of technology in educational futures [30, 34]. Unsurprisingly, there has also been a surge of research around AI in education, some of which is optimistic and instrumental, some ambivalent and hesitant, and some foremostly critical; reviewing all of these is beyond the scope of this paper. Yet, the usual starting point is that AI *will* transform how we educate [69]. This does not seem far-fetched, if we consider, e.g., the impact of LLMs on the many educational practices built around producing texts. However, this argument can become a rhetorical tool for creating urgency for policy decisions [70]. Indeed, in their literature review, Bearman et al. [69] have recognised a central theme in educational AI research: a constant "imperative to respond", where AI "operates as a concrete technology, an abstract ideal, a rhetorical device, a metaphor and a social imaginary all at once." (p. 381). This mixing of levels is natural if we define AI broadly and examine its effects across educational systems. After all, it is different to argue for using AI for teachers' time-saving and for replacing teachers [71, 72], and even then discourses and metrics around efficiency can overshadow students' actual learning and growth [73]. This is not only an issue of ambiguity. Language that describes the instrumental value of AI in education also undertheorises *education*: if AI is seen as "solving" a problem, it is implicitly assumed what the "problem" is ([74]; cf. Feenberg [7]. This is a rich example of the sociotechnical process of closing "interpretative flexibility" [21].

If the complexity of sociotechnical change is overlooked, crucial dilemmas can be narrowed down to pre-defined ethical guidelines, accountability can become hard to locate, and practices such as student assessment can become qualitatively different processes when carried out by AI rather than humans ([31]; cf. Moore et al. [75]. Yet, education as a whole is a tangle of such practices and traditions. This is to say, teaching with AI is not necessarily immediately recognisable as "better" or "worse", but constitutes a different

activity that is not easy to evaluate and debate [30]; AI adoption is not independent of context, such as how we construe the goals of education. In fact, this blind spot has been recognised also in studies of how educational technology is designed and how technology designers theorise education [76].

Yet, education is among contexts where TAM-based research has been conducted most extensively [77, 78], most recently in relation to AI. Here, I will not provide a systematic review of these studies, but challenge the ways instrumentalism limits their approach. The examples below were found by searching Web of Science for AI acceptance and AI anxiety research from the last five years, scanning the results (55), and reading relevant papers, mostly focusing on teacher perspectives, with the intention of thereby emphasising the state-of-the-art of these research currents.

In their TAM-based analysis of a survey of 400 teachers, Hazzan-Bishara et al. [79] frame teachers' lack of knowledge about AI as the main bottleneck for AI acceptance. Their model is built around the TAM nucleus of "usefulness" and "ease of use", which are mediated by available information on AI. While this model does not include anything regarding ethicality of AI, the authors argue (p. 15064) that "understanding what factors contribute to teacher resistance in this area could assist researchers in devising strategies for ethically integrating AI tools into educational environments." Furthermore, they note that institutional support needs to be matched with teacher autonomy and individual needs. This fits in the common trend of AI acceptance research: interesting complexities are noted, often within final paragraphs, but weakly integrated in the methodology itself, likely due to the legacy of TAM. Similarly, analysing a large Estonian sample, Granström and Oppi [80] discuss the relevance of ethics, but do not clearly include ethics in their TAM-drawn method (cf. Cabero-Almenara et al. [81]. Some attempts in bridging ethics to educational AI adoption equate this with, e.g., awareness campaigns or informed leadership ([82]; see also [80]). While both are needed (see, e.g., Gouseti et al. [83], this need for immediate sociotechnical closure strongly reflects instrumentalism.

While some studies attempt to evaluate general AI acceptance and/or anxiety, others seek to analyse the dynamics of some specific, narrower use case, such as whether students turn to generative AI to help them in various tasks [84, 85]. Here, TAM is easier to map to specific user decisions. However, this may overlook the meta-context of education. After all, it is a different thing to use generative AI to complete an assignment, and to use it to learn (see [73, 86, 87]); this is not captured by the outcomes of use and non-use.

As an example of undertheorising the "socio" in "sociotechnical", in their TAM analysis Choi et al. [88] aggregate the professional context of teaching and learning into a single category of "pedagogical beliefs", positioned as an external factor mediating usefulness and ease of use. The troubling implication of this framing is that teachers' considerations of learning should change if it clashes with AI acceptance. Through similar coarse-graining, Cabero-Almenara et al. [81] have found that constructivist teachers are more inclined towards AI acceptance than transmissionists, and thus constructivism should be encouraged. As these are broad philosophies of education, such argumentation seems odd.

Relatedly, and to now turn to AI anxiety, in their study on teacher AI anxiety, Darancik et al. ([89], p. 13) argue:

> Concerns that AI might weaken the teacher-student relationship could prompt teachers to place greater emphasis on social and emotional learning in their pedagogical strategies. Such anxieties may cause delays in the integration of AI technology into the curriculum.

Elsewhere, Zhang et al. [90] have examined the AI anxiety and AI acceptance of German preservice teachers, noting that these are not correlated because teachers "lack of awareness or sufficient background knowledge to understand AI technology's complexity" (ibid. p. 15). Contrasting with this, Huynh et al. [91] have analysed how including ethical-pedagogical components in teacher AI training affects AI anxiety and AI competence. Their results show that an ethics-excluding, "tools-only" approach was *more* effective in most regards; yet, the authors still advocate the inclusion of ethical perspectives. In fact, the authors interpret their finding as ethically oriented anxiety *moderating overconfidence*, fostering "greater metacognitive awareness of what responsible AI integration entails" (p. 15; see [37]). This is somewhat antithetical to the idea of "fixing" the user by "soothing" concerns, and provides a great and notable exception to the more instrumentalist-leaning literature; the authors note that "teachers serve not only as users of AI but also as facilitators of critical dialogue regarding its impact on learning, equity, and democratic values" (p. 14). Finally, in motivating their review Wu and Li [18] give an excellent account of ethical challenges for AI adoption in education; however, they follow with a treatment of AI anxiety that highlights the need to manage negative emotions and points only to expected (and assumed) positive effects of AI on learning.

Before concluding, to not limit the critique above to the context of education, I would like to give a handful of examples from some completely different research areas where both acceptance and anxiety have extensively been used. One such area concerns how people (as consumers) relate to autonomous vehicles (AVs). For example, Cugurullo and

Acheampong ([92]; see also [93, 94]) write about struggling to reconcile the rationalist-instrumental picture of AI adoption and related anxiety with issues such as AV users' fear of death: "all [reported] fears and concerns are rational … [they] reflect several reasons found in academic research on autonomous cars, according to which AI technology involves numerous risks" (p. 1574). However, they attempt to stay within the limits of TAM, which in my view seems primarily a hindrance for the sociotechnical analysis that the authors reach for (p. 1576):

> Furthermore, there are bigger philosophical and psychological questions at play here. Where is human rationality in the intention to adopt in our daily lives a technology that we feel might harm us? And, above all, does this mean that we are irrational creatures who fear something while being willing to embrace it? We argue that the situation that we are observing in the data is so complex that the answer cannot be a simple yes or no.

Similar hindrances are present in the works of Hasija and Esper [95] and Russo [96], who do excellent work examining reasons why people may feel conflicted about AI in the respective contexts of supply chain logistics and software engineering, but finally recommend acts of "fixing" the user. For Hasija and Esper [95], this is called "soothing" or "addressing the fears related to ethical concerns" (p. 397); for Russo ([96], p. 16), "[ethical and other] concerns align with TAM's concept of perceived ease of use, as they can hinder the adoption of LLMs". And finally, a highly instructive point of comparison comes from yet another context: Frennert [97] has analysed issues of robots, AI and digital technology in the context of Swedish eldercare. Frennert's analysis involves considerable theoretical work, such as contrasting acceptance models to the notion of multi-level sociotechnical transitions [98] and technology assessment models (see [99]). This work is an extremely lucid example of situating TAM in a more comprehensive notion of sociotechnical change, theorising technology, and theorising the social context: it discusses uncertainty, processes of institutional change, the problem of holding technology providers as sole authorities the use of caution and experimentation, and warns against "blaming the individual instead of re-evaluating the given technology" when technology is not accepted (p. 106). This kind of theoretical work easily transcends the specific sociotechnical context of eldercare, and illustrates well how acceptance research could develop in the future.

4 Discussion

In this paper, I have attempted to illustrate the problematically instrumentalist underpinnings of AI acceptance and anxiety research. Despite the relatively high awareness of sociotechnical complexity elsewhere, the literature examined here has not developed a clear relationship with this complexity. This allows for externalising concerns as barriers for fast acceptance, disregarding the possibility of reasoned non-use and further reflection, and generally overlooking issues such as how AI challenges long-standing structures, generates new risks, and so on. Thus, there is need for AI acceptance and AI anxiety research to reflect and meta-theorise on this instrumentalist bias, and for subsequent research to acknowledge this instrumentalist focus to generate a fuller picture of how and when people choose to use AI tools in various contexts. Indeed, while most works within these traditions seem to be motivated as research yielding recommendations for AI adoption and understanding how people relate to AI, the conceptual tools adopted can, ironically, give rise to new and difficult problems.

This specific criticism comes from an agnostic point of view regarding AI adoption in any context (as well as the definition of 'AI'). The intention is not to say these authors are overly optimistic about AI and its potential; rather, that these approaches often glaringly overlook many of the interesting, timely and necessary dynamics regarding AI adoption. Yet, as both anxiety and acceptance research may be insulated from other, critical or sociotechnical discourses on AI, a critical evaluation of these blind spots is needed. There is need for meta-theorising on what is or is not captured when instrumentalist constructs are positioned at the centre of user perceptions of technology. Acceptance research has yet to deeply reflect on this, even as the tradition jumps to new and increasingly complex and unknown technological contexts (however, see [16]). As a simple strategy, new models should reconsider using the predictors of perceived usefulness and ease of use as the nucleus of decision-making. Similarly, AI anxiety research needs to theorise on the definition of anxiety in regard to reasoned criticism, hesitancy, dissent and action. Here, the analogy with climate anxiety can be instructive and provocative and is a promising avenue for further analysis.

Theoretically, one possibility is in differentiating between "appraisal" and "commitment" as people encounter sociotechnical change [1]; from this perspective, paralysis and critical non-use are clearly different behaviours, even if they look the same for TAM (see [10]). In fact, it could be useful to model how the behaviour of reasoned non-use is shaped by various factors (see [16, 37]). Even more generally, AI adoption research should examine how individuals make decisions that mediate their AI use in contexts they

understand, navigating their contextual knowledge (such as educational expertise) and technical knowledge (such as AI proficiency), and how ethics mediate these considerations; so far, research around acceptance and anxiety has rarely done this.

Of course, research on acceptance and anxiety can have much to offer. Instrumentalism can be a defensible position especially when the task, context and technology are relatively well-defined, and their mutual configuration is stable. Arguably, AI not always meets these criteria. Thus, research that focuses exclusively on (rational) usage or (irrational) non-usage may capture some, but not all essential dynamics of how people relate to AI. If we accept that sociotechnical action can include opposition, mediation, learning and engaging (critically or noncritically), testing and then abandoning, and actively shaping how technology is used in the relevant context, then the concepts of acceptance and anxiety give only partially instructive recommendations on AI adoption. Thus, further research on these fronts could reasonably either explicitly take this limited position or broaden their scope, for example by conceptualising ethics as more than following clear guidelines. In fact, such studies could try to examine rational decision-making, epistemic uncertainty, affect and emotion, and social and individual values, possibly without privileging any as strictly mediated by the others. This kind of more complex analysis has been recently employed by Liu et al. [44], who have examined how ethical norms and technology adoption evolve in tandem. After all, we can reject and oppose technologies for many reasons just as we use them for many reasons (e.g., through imitation, experiment, pressure, trust in authority, curiosity, or hype). Individuals can, for instance, associate AI with high risks and high rewards [8], which is difficult to define in terms of rationality. These assessments can be tricky to uncover, especially through rigid questionnaires [6]; discussion of values is almost necessarily open-ended. However, discussion of technology is also tricky due to various asymmetries in social roles [30]. For example, teachers, policymakers and technology designers may see the same artifact entirely differently (e.g., if what is idealised as an automatic grading tool in practice creates not only extraneous and invisible labour but also weakens teachers' understanding of and relationship with their students – see [31]). Ease of use and usefulness are only part of the story. New instruments for gauging AI attitudes could supersede or complement acceptance or anxiety research in the contexts where they are too limited to provide actionable recommendations.

As I have discussed, both AI anxiety and AI acceptance literatures have attempted to incorporate ethical perspectives, but this has proven difficult. From a sociotechnical point of view, this is because ethics are debated purposively, embedded in subjective considerations regarding the tradeoffs and politics of technology [75], all the while creating new technomoral concepts (as in the evocative case of the concept of "Glasshole", as reported by [26]). People may not be able to articulate the related uncertainties and moral concerns, which can take the form of vague senses of risk or possibility. People can also to different extents give credence to "boiling frog" or "slippery slope" effects [29, 30]. Thus, constructing these perspectives cannot begin from the assumption that technology attitudes stem primarily from knowledge deficits. This assumption may however explain the relative lack of research in deficits of technology *designers'* understanding of technology users [76]. That is to say, ongoing sociotechnical change may not have a single privileged vantage point that facilitates rational decision-making. Yet, the rational-instrumental focus of acceptance and anxiety research may presuppose such a top-down vantage point. For complexly social, distributed phenomenon, top-down managerialist views of incompetent users are at most a part of the picture. Working in a changing sociotechnical environment involves dealing with changing, conflicting, contradictory, ambiguous and discontinuous perceptions of technology. These do not necessarily correspond to the concepts of acceptance or anxiety: instead of moving linearly from nonacceptance to acceptance, stances can form and complexify over time alongside sociotechnical discourse and ethical frameworks. For example, teachers' AI use ideally becomes more conscious and reflective, differentiating between contexts and relating one's own agency and accountability to AI processes (see [75, 91]; see also [86]; for an account of students' LLM reflections; see also [100]). Decisions in this more complex view include not only use but committing to develop new categories of thinking, taking efforts to learn skills, actively interrogating ethics, and situating oneself in broader technological debates. This is insightfully demonstrated by Frennert's [97] positioning of acceptance as one perspective to technology in eldercare, and likely many more such works. For example, the AI acceptance model by Schepman and Rodway [12] well acknowledges that sociotechnical adoption of AI can happen in people's social contexts without their active acceptance, and that AI attitudes can be more or less general or application-specific, e.g., distinguishing between AI assistance and AI decision-making [12].

The goal of this paper has been to contrast the theoretical underpinnings of AI acceptance and anxiety research with the broader sociotechnical complexity of AI adoption. However, various limitations need to be acknowledged. Firstly, this paper is not based on a systematic review of the literature, even if efforts were made to capture the key papers of both fields, and to find both more and less instrumentalistically leaning examples. Literatures may be different

across domains, and the case of education may not translate to other contexts. Secondly, the paper is necessarily based on interpretative reading and its claims should be be seen as suggestive. For example, any operationalisation of "acceptance" or "anxiety" is necessarily somewhat limited, and AI as a concept is also rather fluid. This paper should not be construed as the definitive critique of these fields.

Acceptance, as learning and overcoming unhelpful resistance to change, can at times be a major requirement for leveraging the potential of new technology. The concept of AI anxiety is also crucial in understanding the emotional components of sociotechnical transformations. However, I have argued that in their current usage, these concepts may make it difficult to use them to model technological perceptions in their full diversity and complexity. Through paying attention to the matter of instrumentalism, this paper tries to make a structured introduction between the disparate fields of sociotechnically oriented research, and acceptance and anxiety research traditions. I wish to invite further research around AI acceptance and AI anxiety to engage with the rich complexity of the ongoing or projected AI transitions, and to point to some possible starting points for this critical engagement.

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Declarations

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