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RESEARCH ARTICLE

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Thinking Technology as Human: Affordances, Technology Features, and Egocentric Biases in Technology Anthropomorphism

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Abstract

Advanced information technologies (ITs) are increasingly assuming tasks that have previously required human capabilities, such as learning and judgment. What drives this technology anthropomorphism (TA), or the attribution of humanlike characteristics to IT? What is it about users, IT, and their interactions that influences the extent to which people think of technology as humanlike? While TA can have positive effects, such as increasing user trust in technology, what are the negative consequences of TA? To provide a framework for addressing these questions, we advance a theory of TA that integrates the general three-factor anthropomorphism theory in social and cognitive psychology with the needs-affordances-features perspective from the information systems (IS) literature. The theory we construct helps to explain and predict which technological features and affordances are likely: (1) to satisfy users' psychological needs, and (2) to lead to TA. More importantly, we problematize some negative consequences of TA. Technology features and affordances contributing to TA can intensify users' anchoring with their elicited agent knowledge and psychological needs and also can weaken the adjustment process in TA under cognitive load. The intensified anchoring and weakened adjustment processes increase egocentric biases that lead to negative consequences. Finally, we propose a research agenda for TA and egocentric biases.

Keywords: Psychological Needs, Technology Anthropomorphism, Affordance, Technology Features, Egocentric Biases

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1 Introduction

Anthropomorphism refers to a general human tendency "to imbue the real or imagined behavior of nonhuman agents with humanlike characteristics, motivations, intentions, or emotions" (Epley et al., 2007, p. 864). This tendency involves social cognitive processes that occur when people interact with inanimate objects (Epley, 2018). Since humans are bombarded and interact with novel, lifelike technologies in an increasingly unstable and insecure world, anthropomorphism is becoming ever more commonplace—and more consequential. Users attribute humanlike behaviors and characteristics to these technologies (Waytz, Epley et al. 2010; Waytz, Cacioppo et al. (2010). They might perceive their voice assistant as their "friend" or "partner," attributing a humanlike mind to the voice assistant and talking as they would talk with human partners (Moussawi, 2016).

Anthropomorphism can have positive influences on effectance, social connections, empathy, and responsibility—particularly when they face high levels of uncertainty, insecurity, and social isolation (Epley et al., 2007; Pfeuffer et al., 2019; Severson & Woodard, 2018). As people interact with novel and complex technologies, anthropomorphizing helps them make sense of and understand the technology's actions, and therefore to increase both trust in (Qiu & Benbasat, 2009) and adoption of (Benbasat & Wang, 2005) these technologies. For example, studies have found that people are more likely to collaborate with robots that they find playful (Kiesler & Goetz, 2002). In addition, virtual assistants make software easier for users to learn (Moreale & Watt, 2004).

Epley et al. (2007) developed a sociopsychological theory of anthropomorphism that is based on the perception of the mind (Heider & Simmel, 1944). Mind perception research (Waytz, Gray et al., 2010) argues that people attribute mental states such as belief and intention to other people. The psychological mechanisms involved in anthropomorphism are "exceptionally ordinary," in the sense that they involve the same mind perception, whether the target is a human or a nonhuman agent (Epley, 2018, p. 591).

Anthropomorphism is triggered by two fundamental motivations and one cognitive factor (Epley et al., 2007). The motivational factors[1]—sociality needs and effectance needs—lead to human engagement with the "mind" of a nonhuman agent and hence to humans' perception of humanlike traits in an agent. Sociality needs drive people to form a social bond, and this motivation can lead people to believe that the nonhuman agent has humanlike features, such as an extroverted personality type that fosters a sense of bonding. Effectance needs drive people to explain, predict, and control the behavior of a nonhuman agent. Epley et al. (2007) suggest that when a gadget behaves unpredictably, people are more likely to associate a humanlike mind with it.

Anthropomorphism also stems from the cognitive factor of elicited agent knowledge (Epley et al. 2007). This cognitive factor involves looking for humanlike features and movements in a nonhuman agent and then inductively creating associated connections in the brain that links the nonhuman agent to humans. When these features and movements are ambiguous or hidden, people project and imagine their own perspectives and other self-knowledge into their interpretations of the nonhuman agent and hence produce egocentric biases in their judgments of it.

Subsequent research has validated Epley et al.'s (2007) three-factor theory of anthropomorphism and has demonstrated the existence and prevalence of anthropomorphism: Humans construe many nonhuman agents as human. However, the theory was not developed to explain information technology (IT). The theory treats technology like any other inanimate object.

Thus far, the information systems (IS) literature has not systematically discussed what gives rise to technology anthropomorphism (TA)—that is, how and why humans perceive advanced IT as humanlike and how anthropomorphizing varies by technology. In addition, the IS literature, with few exceptions (e.g., Demetis & Lee, 2018; Schuetz & Venkatesh, 2020), has focused primarily on the positive consequences of perceiving IT as humanlike. Studies have identified increased trust among users (Qiu & Benbasat, 2009), adoption behavior (Benbasat & Wang, 2005), and higher purchase intentions (Wang et al., 2007) when IT induces anthropomorphism.

Despite the general neglect of negative implications, some negative aspects have been empirically reported. For example, humanlike features attached to nonhuman agents can create agency tensions that can reduce users' connectedness to the agent (Kang & Kim, 2020). In addition to the perception of threat, negative implications can involve stereotypes projected onto the technology. A recent popular press article about a technology exhibition in Germany described how a "a sex doll called 'Samantha'—on display at Linz's Arts Electronica Festival—was so severely 'molested' by a group of men, it was sent home in desperate need of repair and 'badly soiled'" (Norris, 2017). The article suggests that the robot may reinforce causes of sexual violence against women, namely male entitlement and power.

In this paper, we enrich the prevailing explanations of anthropomorphism to develop a more detailed theory that explains research questions and perspectives related to TA: (1) Why is anthropomorphism more likely to take place with some technologies than others, and (2) how do egocentric biases of TA occur? Our development of a theory of TA integrates the three-factor theory of anthropomorphism with the needs-affordances-features perspective offered by Karahanna et al. (2018). We then explain how certain features of technology enable the affordances of TA and how affordances can intensify egocentric biases. Egocentric biases also occur because people consider the perceptions of others, including their thoughts and feelings, to be the same as their own (Epley et al., 2004).

Through the TA theory we advance here, we make several contributions to the IS literature. The theory of TA can help in predicting how different technological features might affect users' anthropomorphizing. Our theory considers both the users' psychological factors

[1] To connect Epley et al.'s (2007) theory and Karahanna et al.'s (2018) perspective, we us the term "needs" rather than motivation referring to sociality and effectance.

and the technological artifacts to address the differentiating effects of technology. In addition, our theorizing on the operation of egocentric biases helps explain some of the negative consequences of anthropomorphism related to advanced technologies. Egocentric biases can be an important antecedent to the misuse of technological artifacts. Exploring how egocentric biases are produced during users' interactions with advanced technology is important because complex, humanlike mental capacities, including morality, are increasingly being attributed to technology (Epley, 2018; Kahn et al., 2013).

2 Background on Anthropomorphism

In this section, we provide a definition of anthropomorphism and review both the IS and human-computer interaction (HCI) literatures. In the next section, we introduce Epley et al.'s (2008) seminal three-factor anthropomorphism theory.

2.1 From Prehistoric to Modern Times

The term "anthropomorphism" dates to at least the sixth century BCE, when Xenophanes used it to describe "how gods and other supernatural agents tended to bear a striking physical resemblance to their believers" (Waytz, Cacioppo et al., 2010, p. 220). Over the centuries, scientists and philosophers have "advocated anthropomorphism as a necessary tool for understanding nonhuman agents" (Epley et al., 2018, p. 871). Anthropomorphism has generally been viewed as a universal, invariant, and automatic process.

Early psychological research on anthropomorphism focused on the psycholinguistic representation of nonhuman agents and on the tendency to attribute humanlike features to animals (e.g., Cheney & Seyfarth, 1990). Anthropomorphic descriptions of animals continue to be popular in entertainment. To illustrate, in the recent movie *The Art of Racing in the Rain,* the golden retriever Enzo (named after Enzo Ferrari) was depicted as experiencing car racing like a human: as exhilarating and as a way to learn critical life skills.

Modern research on anthropomorphism generally focuses on psychological mechanisms that lead people to attribute humanlike qualities, such as competencies and mental states, to nonhumans, or on people's propensity to turn nonhuman agents into humans (Epley et al., 2007). Research on psychology mechanisms strives to explain variability in anthropomorphism and how it is moderated by situational factors (Shin & Kim, 2018; Chen et al., 2017; Bartz et al., 2016), dispositional factors (Epley et al., 2008; Eyssel & Reich, 2013; Kim & McGill, 2018), and cultural factors (Epley et al., 2007; Ötting and Mayer, 2018).

Anthropomorphism applies not just to behaviors but also to mental and affective states, intentions, conscious awareness, and emotions associated with nonhuman entities (Waytz, Cacioppo et al., 2010). This research is important because, as Epley et al. (2007, p. 864) write, "treating agents as human versus nonhuman has a powerful impact on whether those agents are treated as moral agents worthy of respect and concern or treated merely as entities, on how people expect those agents to behave in the future, and on people's interpretations of these agents' behavior in the present."

2.2 Anthropomorphism in IS and HCI

A limited discourse in IS addresses the attribution of humanlike dispositions, traits, and processes to nonhuman agents. Suh et al. (2011, p. 712) defines avatars as "another self in the virtual world with the characteristics of a person." Lankton et al. (2015, p. 881) argues that technologies take on "humanness," "having the form or characteristics of humans." Such humanness then implies that trust—traditionally a human mental state directed toward another human entity—can be placed in or directed toward IT. Riedl et al. (2014) provides neuroscientific evidence revealing the similarities and differences between the perception and trust of humans versus the perception and trust of humanlike avatars. Although "people are better able to predict the trustworthiness of humans than the trustworthiness of avatars," they note, "the trustworthiness learning rate is similar, whether interacting with humans or avatars" (Riedl et al., 2014, p. 84). In a different research trajectory, Yuan and Dennis (2017) found that consumers were willing to pay more when the product or its presentation induced anthropomorphism.

Recent attention has turned to nascent anthropomorphic design theories of IS—for example, those related to conversational agents and robo-advisers (e.g., Jung et al., 2017; Pfeuffer et al., 2019; Diederich et al., 2020). Pfeuffer et al. (2019) derived categories of features that give rise to "humanness" and studied when individuals do and do not attribute human characteristics to a technology. According to Pfeuffer et al. (2019), anthropomorphic design involves various sensory features (e.g., auditory, visual, and mental or personality features) that would induce a user to infer humanlike characteristics, intentions, behaviors, or emotions. Diederich et al. (2020) have advanced a design theory of anthropomorphic enterprise conversational agents.

Meanwhile, other studies in the IS literature discuss more generally how systems are growing in their cognitive capabilities and how human-machine interactions resemble human-to-human interactions. Such cognitive systems are self-adaptive and self-referential and are neither stable nor transparent in their functions (Schuetz and Venkatesh, 2020). Demetis and Lee (2018) provide vivid examples of how humans might become the "artifacts" that are manipulated by highly humanlike technology.

In the HCI literature, the discourse is empirically rich in terms of how nonhuman agents that have anthropomorphized features influence interaction. For example, Nass et al. (1994) initiated the use of the phrase, "computers as social actors" (CASA). They suggest that users interact with computers that have humanlike features (e.g., voice outputs) in a manner similar to the way in which they interact with humans (e.g., exhibiting politeness and assigning stereotypes). Anthropomorphic interfaces (e.g., humanlike language used by personal computers when humans interact with them) have been shown to increase engagement and promote more effective collaboration (Nass et al., 1994) and decision-making (Burgoon et al., 2000). In addition, research has found that different anthropomorphic features can compensate for each other. For example, limited conversational capabilities can be compensated for with visual interface cues in interactive conversational agents (Go & Sundar, 2019). But humanlike features attached to nonhuman agents can also create agency tensions that may reduce users' connectedness to the technological agent. Kang and Kim (2020) found that anthropomorphic features can modify these tensions.

In contrast to some of this research, in the HCI literature, Nass et al. (1994) rejected the assumption of *anthropomorphism as a psychological process*. Nass and Moon (2000) argued that human-to-human scripts are applied to computers mindlessly (and inappropriately). Nass et al. (1994) found that experienced adult computer users, when they were debriefed, did not admit that they would respond to a computer in the same way that they respond to humans. Nass and Moon (2000) argue that models of "thoughtful, sincere belief that the entity has human characteristics" (p. 93) cannot explain the processes that elicit stereotyping, politeness, and reciprocity toward a computer. Other studies challenge this notion because researchers have found evidence of "mindless anthropomorphism" (e.g., Kim & Sundar, 2012). Kim and Sundar (2012) also found in their lab studies that although users refused to claim that they perceive IT entirely as humanlike, they did mindlessly attribute human features to IT. Meanwhile, Araujo (2018, p. 188) demonstrated support for both mindful and mindless anthropomorphism with conversational agents: "Users have less of an issue attributing anthropomorphic qualities *mindfully* to conversational agents than to websites and computers."

Research on anthropomorphism in HCI is expanding beyond the immediate visual or auditory humanlike features in the interaction. Studies have been more deeply considering mental states such as agency and intention and often include more general outcomes, including competition, ethical evaluation, and moral judgments about the nonhuman agent, as well as attitudes and connection to the company or organization (Araujo, 2018; de Graaf, 2016; de Kleijn et al, 2019; Ötting and Mayer, 2018).

3 Three-Factor Model of Anthropomorphism from Epley et al. (2007)

Research on anthropomorphism is most developed in social and cognitive psychology and in the neural sciences. On the basis of induction reasoning, Epley et al. (2007; p. 865) define anthropomorphism as a "process of inductive inference about nonhuman agents." Epley et al. (2007) developed a generalized three-factor theory of anthropomorphism to provide a psychological account of anthropomorphism itself and to explain or predict systematic variability in people's tendency to anthropomorphize nonhuman agents and "variability in the consequences that follow from anthropomorphism as well" (Epley et al., 2007; p. 865). Note that the model is a generalized one that treats technology like any other nonhuman entity (Waytz, Cacioppo et al., 2010). At its core, the model has three factors: elicited agent knowledge, effectance needs, and sociality needs.

3.1 Elicited Agent Knowledge

Elicited agent knowledge is the first factor of anthropomorphism and is a cognitive factor (Epley et al., 2007). Anthropomorphizing is an inductive reasoning process, and inductive reasoning requires prior knowledge that can be transferred to the target. Anthropomorphism is predicted largely "by cognitive factors that determine the likelihood of activating, either chronically or situationally, knowledge about humans when making inferences about nonhuman agents; the likelihood of correcting this anthropomorphic knowledge; and the likelihood of applying knowledge about humans to nonhuman agents" (Epley et al., 2007; p. 868). This knowledge might be knowledge about humans in general or self-knowledge, and people access it during inductive reasoning concerning nonhuman entities. Knowledge about humans is accessed because it is the most widely available and accessible category, with the most detailed and rich knowledge base—whether general or egocentric. For example, when trying to make sense of what it means to be a bat, people access generalized human sensory experiences or their own self-knowledge about sensory experiences and apply it to the actions of the bat (Epley et al., 2007). Inductive reasoning may be based on perceived similarities in appearance, movements, or action (Shin & Kim, 2018).

Elicited agent knowledge is corrected only if alternative knowledge structures are available and if the motivation to access these knowledge processes is present. Epley et al. (2007: p. 865) argue that "such correction processes are generally insufficient; such that final judgments are influenced in the direction of the most readily accessible information." Hence, even when alternative knowledge structures are available, people do not necessarily use them; their readily accessible knowledge about humans in general and their self-knowledge about themselves still dominate. For example, Shin and Kim (2018) found that computer science majors were as likely as literature majors to anthropomorphize computers (i.e., a nonhuman entity), although computer science majors would be expected to have much richer cognitive representations of computers that could have provided a more accurate representation of the nonhuman entity.

3.2 Effectance Needs

Effectance needs represent the second factor in Epley et al.'s (2007) three-factor theory of anthropomorphism. In contrast to knowledge as a cognitive factor, effectance is a motivational factor that refers to humans' basic need to "interact effectively in one's environment" (Epley et al., 2007: p. 871). In this view, anthropomorphism might be used "to increase the predictability and comprehension of what would otherwise be an uncertain world" (Epley et al. 2007; p. 872). Thus, attributing humanlike traits to nonhuman entities enables people to render what is uncertain and insecure as more certain and controllable (Waytz, Morewedge et al., 2010). For example, people might adapt a detailed knowledge structure about themselves as a human being, so that the knowledge can be used to understand and predict the behavior of a novel, nonhuman entity and thus to regain control and to feel efficacious. Epley et al. (2007, p. 872) argue that "when effectance motivation is high, anthropomorphism should increase. When effectance motivation is low, anthropomorphism should decrease."

3.3 Sociality Needs

Sociality is the third factor in the three-factor anthropomorphism theory (Epley et al., 2017). Like effectance, it is a motivational factor. Sociality needs refer to the basic human need to establish and maintain a sense of social connection with others; it increases the tendency to actively search for social connection in one's environment (Epley et al., 2007). People feeling lonely or excluded or lacking social connection might try to escape from this often painful, isolated state by anthropomorphizing nonhuman agents and creating social connection with nonhuman agents, just as they might have done or wanted to do with human beings. For example, Epley et al. (2008, p. 342) revealed that when people are chronically isolated, they anthropomorphize pets by attributing more humanlike traits to them, "creating a sense of social support through a kind of inferential reproduction," Epley et al. (2007, p. 872) argue that when sociality motivation is high, anthropomorphism is expected to increase, and when sociality motivation is low, anthropomorphism is expected to decrease.

These three factors are no different from the ones that people use when making inductive inferences about other people. Hence, anthropomorphism has "exceptionally ordinary underpinnings" (Epley, 2018, p. 591). Anthropomorphism happens when humans treat nonhuman agents as if they were human agents.

3.4 Egocentric Biases

Just as people tend to rely on self-knowledge and think of other people as having beliefs, attitudes, experiences, and preferences that are similar to their own, their tendency to anthropomorphize relies on the same presumptions of similarity. This reliance on self-knowledge can lead to egocentric biases that are particularly rigid or inflexible when people carry out intensive anchoring on self-knowledge without making adjustments that take into account how the nonhuman agent is different from the self or from humans in general.

Egocentric biases come from and are defined by the tendency to rely too heavily on one's own perspective or to have a higher opinion of one's understanding or perspective than is appropriate or accordant with reality (Epley & Caruso, 2004). Such biases can be driven by both cognitive knowledge and psychological needs (Epley et al. 2007). As Epley et al. (2007) point out, the accessibility of self-knowledge (elicited agent knowledge), the motivation to be effective social agents (effectance motivation), and the motivation for social connection (sociality motivation) can all give rise to egocentric biases.

3.5 Moderators of the Three-Factor Theory of Anthropomorphism

Epley et al. (2007) propose moderators that explain and predict the circumstances under which people have a stronger tendency to humanize nonhuman entities. These moderators fall into three categories: situational, dispositional, and cultural (see Table 1).

Situational: The experience of being socially excluded or disconnected is a situational moderator that affects sociality needs (Shin & Kim, 2018) by heightening those needs. Hence, to satisfy these needs, people are more likely to anthropomorphize (Chen, Wan, & Levy, 2017). The sociality motivation can be lowered by, for example, situational reminders of social connection (Bartz et al., 2016).

Table 1. Three-Factor Model of Anthropomorphism and the Moderators

Moderators	Psychological factors	Elicited agent knowledge	Effectance needs	Sociality needs
Situational moderators	Social exclusion			+
	Uncertainty or unpredictability in the environment		+	
	Similarity between nonhuman and human entities	+		
	Cognitive load	+	+	+
Dispositional moderators	Chronic sense of loneliness			+
	Need for control		+	
Cultural moderators	Collectivism			+
	Individualism	+		
	Uncertainty avoidance		+	

In addition, uncertainty or unpredictability in the environment is another situational moderator, influencing the degree to which effectance needs lead to anthropomorphism. Waytz, Cacioppo et al. (2010) explored how the malfunction of computers, leading to uncertainty, caused users to anthropomorphize their computers more. Results revealed that the more frequently participants' computers malfunctioned, the more likely they were to report that the computers appeared to have minds of their own or that their computers behaved as if they had their own beliefs and desires. Thus, the tendency to anthropomorphize is associated with the level of uncertainty in users' environments.

In previous studies, one of the most common situational moderators of elicited agent knowledge is a similarity between nonhuman and human entities in appearance, movement, and actions (Yuan & Dennis, 2017). Increased cognitive load, triggered by the environment, is another situational moderator influencing people's reliance on elicited agent knowledge and engendering anthropomorphism (Epley et al., 2007). Cognitive load theory (Sweller, 1988) proposes that, under cognitive load, individuals have limited cognitive resources to allocate to the encoding, processing, and retrieval of information. Research suggests that people with higher cognitive loads engage in less in-depth thinking, causing them to adopt or rely on more accessible knowledge—particularly self-knowledge. In addition, research has found that increased cognitive loads lead to heightened effectance (Kim et al., 2016) and sociality needs (Cacioppo & Hawkley 2009).

Dispositional: People's individual differences certainly moderate, or exert an influence on, how likely they are to anthropomorphize nonhuman agents. For example, a chronic sense of loneliness is one moderator of sociality needs that increases the likelihood of anthropomorphism (Epley et al., 2008). In HCI literature, Eyssel and Reich (2013) investigated how unfulfilled sociality needs make users more likely to engage with robots. They also found that people who report feeling lonelier, and thus have higher sociality needs, anthropomorphize robots more than participants who are less lonely. Individual differences in the need or capacity for personal control (Kim & McGill, 2018) can moderate how effectance needs drive anthropomorphism and falls into the dispositional category.

Cultural: Hofstede (2001) proposes several major cultural dimensions that moderate the likelihood of anthropomorphizing, although they have not been empirically tested. For example, he identifies collectivism, which can be defined as "a value that is characterized by emphasis on cohesiveness among individuals and prioritization of the group over the self" (Schwarz, 1990). Individualism as the contrasting cultural dimension also plays a moderating role. Epley et al. (2007, p. 878) argue that "members of individualistic cultures tend to assess egocentric information and use their own self-knowledge more readily than members from collectivist cultures." Accordingly, those from individualistic cultures may be more prone to egocentric biases.

Epley et al. (2007) also theorized that cultural moderators might affect the three factors (i.e., sociality needs, effectance needs, and elicited agent knowledge) differently. For example, collectivism as a cultural moderator might increase the influence of sociality needs on anthropomorphism, whereas uncertainty avoidance—defined as "the extent to which the members of a culture feel threatened by uncertain or unknown situations" (Hofstede, 2001, p. 161)—might heighten the influence of effectance needs in individualistic cultures (Epley et.al, 2007).

To summarize, the three-factor anthropomorphism theory demonstrates the existence, prevalence, and moderators of anthropomorphic thinking—i.e., people's tendency to construe nonhuman entities as human. According to Epley et al. (2007, p. 864) "this theory predicts that people are more likely to anthropomorphize when anthropocentric knowledge is accessible and applicable, when motivated to be effective social agents, and when lacking a sense of social connection to other humans." The three separate but interrelated factors work together to influence the attribution of human traits, intentions, and emotions to nonhuman entities. The theory of the mind (Waytz, Gray et al. 2010) serves as the psychological underpinning for the three factors, elucidating how inductive reasoning—sometimes or often based on egocentric biases—influences how people perceive other humans. Just as these perceptions can be unduly influenced by self-knowledge and self-motivations, so can anthropomorphism be subject to egocentric biases.

Epley et al.'s (2007) three-factor theory has become widely accepted because it allows both conscious and unconscious thinking processes to play a role. Although the theory provides an empirically validated and generalized perspective of the anthropomorphism phenomenon regarding a wide range of nonhuman entities, it was not developed to explain the particular features of IT. In fact, one might argue that the theory treats technology as a "black box": It does not consider the relationship and interaction between users' psychological processes and the technology features—an important oversight. Human and technology interactions are, by nature, ongoing, ever-evolving, and mutually influential.

4 Technology Anthropomorphism: Enriching the Three-Factor Theory with the Needs-Affordances-Features (NAF) Perspective

In the next two sections, we discuss our core research question: How technology anthropomorphism leads to egocentric biases. We first advance the theory of AT by opening the black box of technology in the Epley et al. (2007) three-factor model. Following Karahanna et al.'s (2018) needs-affordances-features (NAF) perspective, we derive technology affordances from the three-factor model of elicited agent knowledge and the two psychological needs. We also illustrate how the anthropomorphic features identified by Pfeuffer et al. (2019) can be mapped to technology affordances.

We selected affordances as the way to open up the three-factor anthropomorphism model to the particularities of technology because affordances reflect the imbrication between the materiality of technology and users' subjective perception of technology (Leonardi 2011). This approach, combining technical artifacts with anthropomorphic features and with psychological needs, enables us to gain deeper insights into the socio-technical structure of TA and to generate predictions about the consequences of anthropomorphism for different types of technologies.

Affordance theory adopts a sociotechnical perspective that theorizes about particular technologies while simultaneously incorporating social and contextual elements. We acknowledge the debate about the ontology of affordances (Volkoff & Strong, 2017), and we address the issue by treating affordance as a construct derived from the user-artifact relationship and not from technology alone (Volkoff & Strong, 2017). Note that people "may or may not perceive or attend to the affordance, according to [their] needs, but the affordance, being invariant, is always there to be perceived" (Gibson, 1979; p. 11). That is to say, whether users perceive these affordances is not just a function of technology; instead, it depends on whether the affordance activates a need or the activation has sufficient strength.

4.1 Needs-Affordances-Features (NAF) Perspective

Karahanna et al. (2018) advanced the needs-affordances-features (NAF) perspective on social media to demonstrate how the use of social media applications can be explained and predicted by linking different social media affordances with different users' psychological needs. Karahanna et al. (2018) argued that technologies "have affordances that can *fulfill* certain psychological needs, and that the features of a technology enable the affordances that the technology can offer" (Karahanna et al., 2018; p. 739). They justified their prioritization of affordances, as opposed to features as follows: "There is more utility in theorizing a relationship between psychological needs and affordances rather than psychological needs and specific technology features since the affordances generalize across technology contexts" (Karahanna et al., 2018; p. 742). Karahanna et al. (2018) encouraged the study of different types of technologies in terms of how different affordances and contexts of use fulfill different psychological needs. We derive the three affordances on the basis of the cognitive factor and the two psychological needs in the three-factor model (Epley et al., 2007): human knowledge transference affordance, gaining personal control affordance, and sociality affordance.

We also link the three affordances that map to the three-factor model to the three categories of anthropomorphic *features* identified by Pfeuffer et al. (2019) (see Table 2). Pfeuffer et al. (2019, p. 6) identify three categories of anthropomorphic features that "are recognizable from an anthropocentric perspective of mental processes that involve perception and cognition through sensory information.".

Table 2. Linking Technology Features with Affordances

Technology	Anthropomorphic features	Affordances
Social robots: "an autonomous or semi-autonomous robot that interacts and communicates with humans by following the behavioral norms expected by the people with whom the robot is intended to interact" (Bartneck & Forlizzi, 2004)	Visual: humanlike facial features (Phillips et al., 2018); humanlike body features: surface/skin temperature (Park & Lee, 2014); gender features (De Angeli, 2012)	Human knowledge transference; gaining personal control; sociality
	Auditory: human voice output (Nass & Brave, 2005)	Human knowledge transference; gaining personal control; sociality
	Mental: emotional feedback (Eyssel et al., 2010)	Human knowledge transference; gaining personal control; sociality
Autonomous vehicles: vehicles that control their own steering and speed (Waytz et.al, 2014)	Mental: self-driving agency (Waytz et al., 2014)	Human knowledge transference; gaining personal control
Personal intelligent assistants: mobile software agent that can perform tasks, or services, on behalf of an individual based on a combination of user input, location awareness, and the ability to access information from a variety of online sources (Moussawi, 2016)	Visual: humanlike facial features (Kim et al., 2016)	Human knowledge transference; gaining personal control; sociality
	Auditory: human voice output (Moussawi & Koufaris, 2019)	Human knowledge transference; gaining personal control; sociality
	Mental: natural language processing (Moussawi & Koufaris, 2019)	Human knowledge transference; gaining personal control; sociality
Recommendation agents: web-based agents that tailor vendors' offerings to consumers according to their preferences (Li & Karahanna, 2015)	Visual: virtual human representation (Nowak & Rauh, 2005; Yoo & Gretzel, 2010); animation (Hess et al., 2009)	Human knowledge transference; gaining personal control; sociality
	Auditory: human voice output (Qiu & Benbasat, 2009)	Human knowledge transference; gaining personal control; sociality
	Mental: bodily gestures (Cowell & Stanney, 2005); extroverted "personality" (Hess et al., 2009)	Human knowledge transference; gaining personal control; sociality

The categories are nonexhaustive and nonexclusive. First, visual features pertain to appearance, movements, gestures, mimics, and gender. Second, auditory features include speech synthesizer and gender. Third, mental features capture cognitive elements (e.g., cognitive intelligence, dialog ability, content understanding); emotional elements (e.g., emotionality, emotional intelligence); and behavioral elements (personality traits, such as compassion).

The different categories, as well as features in those categories, can support multiple affordances; for example, speech synthesis supports both the human knowledge transference affordance and the sociality affordance. The features and affordances together help to explain and predict the types of technologies with which TA is most likely to occur. The links we construct between technologies, anthropomorphic features, and the three pertinent affordances are based on studies reviewed in the Appendix

4.1.1 Human Knowledge Transference Affordance

We define human knowledge transference affordance as an affordance that first activates existing knowledge about human beings in general or about the person's self-knowledge; this knowledge then is transferred to the technology. Visual, auditory, and mental features of technology can activate this knowledge (Pfeuffer et al., 2019). For example, a widely used visual interface feature is the avatar—a representation in the virtual world with the characteristics of a person (Suh et al., 2011). Nowak and Rauh (2005) and Yoo and Gretzel (2010) found that the simple presence of an avatar in interfaces significantly increases TA in the context of websites and of social recommendation agents, leading users to apply human-related knowledge to the recommendation agents. Voice features also constitute a human knowledge transference affordance. For example, social robots with femalelike voices might trigger users' knowledge and expectations about human gender. Schroeder and Epley (2016) found that hearing a human voice rather than seeing visual cues led people to believe the content was created by a human rather than a machine.

In addition to visual features about human appearance, features such as name, gender, and human voice can be used to inductively infer anthropomorphic knowledge representations. For example, Waytz et al. (2014) found that when an autonomous vehicle is given a human name and gender and is given a voice through human audio files, users are more likely to draw on human knowledge to make sense of and predict the behavior of the vehicle, compared with users in vehicles that are not given these auditory and mental features.

4.1.2 Gaining Personal Control Affordance

Personal control affordance refers to the technology affordance that enables users to have a sense of control over the technology, particularly when they face an uncertain technology use environment. When technology's visual, auditory, and mental features resemble human beings, these features provide a sense of familiarity and reliability for users (de Visser et al., 2016). Users thus gain personal control over the technology. For example, giving autonomous vehicles a gender as an interactivity feature or giving them humanlike voice features facilitates the personal control affordance (Waytz et al., 2014). Autonomous vehicles, as a novel technology, trigger uncertainty because of their complicated functions and lack of transparency. When users drive autonomous vehicles, they can feel a loss of control because the vehicle diminishes their autonomy of driving (Rödel, 2016). Making vehicles appear human through the three categories of visual, auditory, and mental features can provide users with the personal control affordance.

4.1.3 The Sociality Affordance

In the existing literature, sociality affordances are defined as the possibilities for action that people offer one another (Gaver, 1996). For our purposes, sociality affordances provide action possibilities between humans and IT. Technology's visual, auditory, and mental features all enable users to have social interaction with the technology—interaction that resembles real human social interactions. For example, adding virtual human representation to technology artifacts can increase the sociality of technology, as Swinth and Blascovich (2002) demonstrate: When humans interact with avatars, "their [the avatars'] behavior and responses resemble those elicited during normal human-human social interaction" (p. 24). Technologies using voice over the telephone, more than text over email, were found to afford sociality (Schroeder & Epley, 2016).

Qiu and Benbasat (2009) and Hess et al. (2009) found that adding audio features to avatars as recommendation agents can strengthen sociality perceptions and enable users to act with agents in a social manner. This effect is stronger for an extroverted voice, compared to an introverted voice (Lee & Nass, 2005); the extroverted voice is perceived as more sociable. Bartz et al. (2016) found that the interactive dialog mode of the technology (mental feature) can significantly influence the extent to which IT is perceived as humanlike. Such mental features are reflected as "behavioral scripts" in users' interaction with technology and involve both the sociality and the agency of the technology. Certain behavioral scripts are more likely to trigger TA. For example, websites with avatars that can follow social conventions (e.g., asking questions or saying "goodbye") increase TA, compared with avatars that do not follow these behavioral scripts (Nowak & Rauh, 2005).

4.2 Interaction between Affordances and Three-Factor Model

4.2.1 Human Knowledge Transference and Technology Anthropomorphism

Elicited agent knowledge is the cognitive factor of anthropomorphism (Epley et al., 2007). Technology features can make human-related knowledge more accessible in users' minds and enable actions to transfer human-related knowledge to the technology. As more human knowledge transfers to the technology, users will engage in the inductive reasoning process that attributes human traits to technology, thereby leading to technology anthropomorphism. Therefore, based on the three-factor model and affordance theory, we propose that:

Proposition 1: Technology features that support human knowledge transference affordances can lead to technology anthropomorphism.

NAF argues that different social media affordances can *fulfill* users' psychological needs (Karahanna et al., 2018); similarly, we argue that the affordances of sociality and gaining personal control can satisfy, or fulfill, two psychological needs identified in the three-factor anthropomorphism theory: sociality needs effectance needs. (Since elicited agent knowledge is not a psychological need, NAF logic does not apply).

4.2.2 Sociality Needs Fulfilled by the Sociality Affordance

The three-factor theory suggests that projecting humanlike thinking onto nonhuman entities can be driven by users' sociality needs. In turn, technology's sociality affordance, which is enabled by anthropomorphic features, can fulfill users' sociality needs. For example, Eyssel and Reich (2013: p. 122) found that social robots' humanlike features, such as "mental capacities and essentially human personality traits," can provide sociality affordance. They report that "participants anthropomorphized a social robot to a greater extent after being put in a state of emotional loneliness as compared to a control group that remained in a neutral state of mind" (Eyssel & Reich, 2013; p. 122). The technology incorporated a sociality affordance that reduced participants' loneliness state. Mourey et al. (2017) found that a smartphone's sociality affordances, which are enabled by humanlike features (e.g., having humanlike names and interactivity) fulfill users' sociality needs after they are socially excluded. In other words, TA is effective in fulfilling users' sociality needs.

Proposition 2: Technology features that support sociality affordances fulfill users' sociality needs and can lead to technology anthropomorphism.

4.2.3 Effectance Needs Fulfilled by the Sociality Affordance

Effectance needs can also be fulfilled by technology's affordance of gaining personal control. For example, Waytz et al. (2014) found that anthropomorphism of autonomous vehicles enables the affordance of gaining personal control because making vehicles seem human reduces users' perceived uncertainty about the autonomous vehicle. That is, they resemble human functions more, thereby fulfilling users' needs for personal control over the vehicle. Similarly, de Visser et al. (2016) examined the effects that cognitive agent affordances had in enhancing users' perceptions of personal control, thus fulfilling their effectance needs. They demonstrated that anthropomorphizing cognitive agents (e.g., smart voice assistants with humanlike voices or virtual advisors with humanlike representation) can satisfy users' needs for control and reduce uncertainty in the technology adoption and use process.

Proposition 3: Technology features that support affordances for gaining control fulfill users' effectance needs and can lead to technology anthropomorphism.

In the next section, we discuss how technology affordances can intensify psychological needs and elicited agent knowledge and lead to anchoring and adjustment processes, which can increase egocentric biases.

5 Beyond Fulfillment: Strong Anchoring, Weak Adjustment, and Egocentric Biases[2]

The three-factor model argues that inductive reasoning can anchor around self-knowledge under high cognitive loads, thus making the egocentric biases more likely to emerge. Under high cognitive loads, people will build on their own perspective, "only subsequently, serially, and effortfully accounting for differences between themselves and others until a plausible estimate is reached" (Epley et al., 2004; p. 328). Adjustment to anchoring can fail when people lack the motivation to understand how the nonhuman agent behaves differently from them or if people lack experiences to build relevant knowledge about them. We argue that the affordances of advanced technologies can intensify the anchoring, and when users' cognitive resources are limited, their capacity for adjustment is weakened, leading to more egocentric biases.

With advanced technologies, affordances are not static but ever changing—particularly when technology is self-adaptive (e.g., in taking on human functions, such as learning). To make sense of the changing affordances, people must be able to construe them through their knowledge base and, in doing so, they seek to perceive the "mind" of the technology. The most readily accessible knowledge they can apply when making sense of technology affordances is their self-knowledge (Epley et al., 2007). As advanced technologies take on mental functions long associated mainly with humans, the anchoring on self-knowledge is likely to intensify in their inductive reasoning. This anchoring leads to egocentric biases. Any correction is difficult because of the ambivalent and changing nature of the technology.

In addition, users' anchoring on self-knowledge and psychological needs is intensified under heightened cognitive load. Kang and Kim (2020) provide an empirical illustration. When users are exposed to a brand having anthropomorphic features while facing high cognitive demand in a highly interactive game (one that induces sociality needs), the intensity and the TA in that context together elicit self-knowledge, leading to increased egocentric biases.

In the following sections, we examine egocentric biases that are increased by three types of affordances under high cognitive load. Technology affordances intensify users' anchoring on knowledge and psychological needs. In addition, the adjustment and correction processes are inhibited, which leads to increased egocentric biases.

5.1 Human Knowledge Transference and Biased Perception of Technology and Self

We propose that the affordance of human knowledge transference can intensify users' anchoring on their self-knowledge and, in doing so, can diminish the likelihood of the adjustment or correction of that knowledge. This resistance to adjustment can transfer stereotypes (a self-knowledge structure) to the technology and, in turn, induce in the technology biased human knowledge and biased self-perceptions. Greenwald et al. (2003) refer to the stereotype as a generalized belief about specific types of individuals or their behavior and intended to represent the entire group of these individuals or their behaviors as a whole. Stereotypes, as a type of egocentric bias about humans (Pfeuffer et al., 2019), can be primed and more easily accessed when users' egocentric perceptions of other humans are anchored by technology's affordance of human knowledge transference (Dennis et al., 2013). For example, the humanlike appearance of social robots has the affordance of transferring human knowledge. This affordance, in turn, can strengthen the anchoring of users' self-knowledge about human appearance (e.g., gender-typical

[2] "Technology" in this section represents an aggregation of features and affordances.

features). When users' self-knowledge becomes more salient, any related knowledge structures—for example, stereotypes about gender— might also be activated. Such stereotyped perceptions represent egocentric biases.

In addition, the human knowledge transference affordance can weaken the adjustment and correction process that would help shift users away from their egocentric inferences to more accurate inferences. Because the human knowledge transference affordance makes self-knowledge so accessible, engaging users in such adjustment processes becomes more difficult (Tamir & Mitchell, 2013). Therefore, when self-knowledge structures like stereotypes become activated, sustained, and difficult to correct, users are more likely to transfer their biases to the technology with which they interact.

This transference of stereotypes is more likely to happen when cognitive resources are depleted (Bodenhausen & Lichtenstein, 1987). For example, users are more likely to apply stereotyped knowledge to technology under high processing demands (Park et al., 2008) or in low mindfulness states (Thatcher et al., 2018) because when individuals have limited cognitive resources, they may lack the ability to engage in adjustment and correction processes by reflecting on the reality of social groups (Tamir and Mitchell, 2013).

Research has demonstrated that when users interact with avatars (Dewester et al., 2009) and social robots (Eyssel & Hegel, 2012), they apply gender stereotypes in their judgment about the characteristics and capabilities of the technology. In the same ways that people anthropomorphize goods and services, they might anthropomorphize technology by applying stereotyped assessments, such as "beautiful is good" (Wan et al., 2016). As a result, technology that has an unattractive humanlike appearance would be devalued, despite its strong functional capabilities (Hanson, 2006). Stereotypes might then prevail and be reinforced—particularly if users make judgments based on the surface characteristics of the technology. An observational study on human-robot interaction revealed that people's conversations with a human robot can engender negative verbal disinhibition (i.e., expressing negative and abusive words to the robot) (De Angeli & Brahnam, 2008; Brahnam & De Angeli, 2012). Popular writing also illustrates the phenomenon of transferring bias to technology. A recent article suggests, for example, that if patients transfer stereotyped biases about the nursing occupation, they might resist assistance from nursing robots that don't fit their nursing stereotype (e.g., robots that don't have a female voice), even though all robots can perform the nursing task equally well (Simon, 2018).

Proposition 4: When users' cognitive resources are low, a technology's affordance of human knowledge transference intensifies users' anchoring on self-knowledge, weakens adjustment, and increases egocentric biases.

5.2 The Gaining Personal Control Affordance and Perceptions of Threat from Technology

Technology's affordance of gaining personal control enables users to increase their control. We propose that, under limited cognitive resources, the affordance of gaining personal control can intensify users' anchoring on effectance needs and can result in an egocentric bias toward what they perceive as threats to meeting those needs. Strong effectance needs can lead users to perceive technology with humanlike features (e.g., resembling human faces) as competent and dependable and thus exhibiting stronger *agency* (Chen et al., 2018). In addition, users who become more anchored on their effectance needs may perceive greater similarities between nonhuman agents and human agents. To illustrate, a driver with strong effectance needs might perceive an autonomous vehicle that has humanlike features to be a "reliable driver," which may threaten the user's own sense of autonomy and self-perception as a proficient driver. Such users might be less likely to accept autonomous vehicles because the agency they assign to the technology interferes with their own agency. However, such rationalizing represents an egocentric bias because the users are distorting the reality of the agency of the technology based on their psychological needs (Kunda, 1990). In the presence of TA, blurred boundaries between humans and their technology—particularly when that technology is perceived as highly competent—can cause users to perceive threats to their own agency. Moreover, this egocentric bias that leads users to perceive threats to their agency can further intensify the agency that users perceive in the technology (Kang & Kim, 2020). In this case, as users anthropomorphize the technology, they rely more and more on their self-knowledge to make inferences about the technology, thus further strengthening their egocentric biases and weakening the likelihood of adjustment.

Previous literature has demonstrated that human users perceive threats from competent technology. According to Kim et al. (2016), a digital helper that users anthropomorphize because of its interactivity and humanlike visual representation can undermine individuals' perceived autonomy. They showed that users construed the help they get from technology to be the same as the help they get from humans. When users' cognitive resources were low (e.g., when they were under time pressure), meaning that their effectance needs were heightened, this effect of perceived threat was shown to be particularly strong. This research demonstrated that the perceived threats could be mitigated when users' effectance needs were under control.

Proposition 5: When users' cognitive resources are low, a technology's affordance of gaining personal control intensifies users' anchoring on their effectance needs, weakens adjustment, and increases egocentric biases.

5.3 Sociality Affordance and Misidentification with Technology

When users anchor on their sociality needs and have limited cognitive resources, they may fail to adjust or correct cognitive resources, leading to misidentification with the technology. For example, interacting with technology that offers a sociality affordance can cause users to anchor their sociality needs. In cases of limited cognitive resources, they might then have difficulty distinguishing virtual social relationships from real ones and high-quality human relationships from low-quality ones (Turkle, 2005). Sharkey and Sharkey (2012) argue that caretaking robots for elderly people that have humanlike facial features and voice features could lead to undesirable outcomes, such as avoidance of real social interactions with human beings. The risk is particularly high when elderly people have decreased cognitive functioning and more difficulty controlling their sociality needs (Carstensen, 1992). Elderly people might not be able to adjust or correct their egocentric biases and perceptions about the social support and warmth the robots offer because of their sociality needs: They hope to have these needs met by the anthropomorphized robots, even though the robots' capacity to do so is often ephemeral and illusory (Turkle, 2005).

Stronger anchoring on sociality needs and weaker adjustment of that anchoring also might lead to excessive self-disclosure to technology. Such disclosure may be driven by users' strong need to belong, particularly when they lack authentic social connections and when they anthropomorphize technology, trust it, and engage in more self-disclosure with it. Because of their failure to adjust their egocentric biases, users may not be able to see the reality that excessive self-disclosure with anthropomorphized technology can be harmful. In addition, studies show that users who struggle with social anxiety—i.e., those who are challenged by social interaction but still have a strong need for sociality—have more difficulty controlling their sociality needs. Such individuals tend to reveal more information and more intimate information about themselves when interacting with a virtual human (i.e., an AT), relative to their disclosure in video interactions with actual humans (Kang & Gratch, 2010). In addition, Pickard et al. (2016) found that subjects preferred anthropomorphized technology over actual humans when asked to self-reveal about more sensitive topics because they perceived it as less judgmental and more trustworthy.

Proposition 6: When users' cognitive resources are low, a technology's sociality affordance intensifies users' anchoring on sociality needs, reduces adjustment, and increases egocentric biases.

Figure 1 summarizes the propositions.

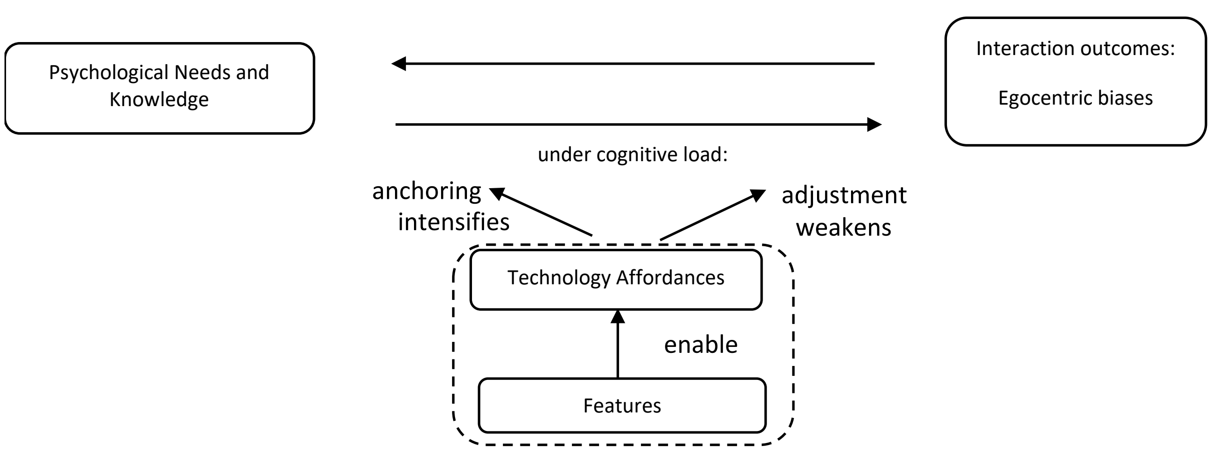

Figure 1. Egocentric Biases in TA

6 Discussion and Implications

This paper seeks to provide insight into what drives the anthropomorphizing of technology and to identify some of the negative consequences that are less often discussed in the literature. Users' prior knowledge about humans in general and their self-knowledge are brought to bear on their tendency to anthropomorphize technology. In addition to the projection of this prior elicited agent knowledge, TA is motivated by users' efficacy and sociality needs. According to the three-factor theory of anthropomorphism (Epley et al., 2007), technology is like any other nonhuman entity in terms of the psychological account of when and why people anthropomorphize nonhuman entities. People anthropomorphize by attending to and accessing prior knowledge about humans or themselves, and they do so to feel efficacious and to be socially connected—particularly when finding themselves in environments that are fraught with uncertainty and ambiguity. Under high cognitive loads, users can intensify their anchoring on self-knowledge. When this anchoring is not followed by adjustment that corrects for undue reliance on self-knowledge, egocentric biases arise.

Although the foundational cognitive factor—elicited agent knowledge—and the two needs of sociality and efficacy provide a psychological explanation as to why people associate human traits, capabilities, and emotions with technology, the existing literature has not theorized the technological antecedents of TA. This oversight has occurred despite demonstrations that a wide variety of technologies triggers anthropomorphism. In addition, attributing humanlike characteristics to technology occurs not just with complex and novel technologies, like autonomous cars, but also with simple speech-based email (Schroeder & Epley, 2016). Yet differences in the extent of TA also emerge. For instance, auditory features are associated with anthropomorphizing more than visual cues. Also, as advanced technologies incorporate more anthropomorphic mental features, the technology we use becomes more ambivalent and biased knowledge about humans affects how technology is anthropomorphized. However, the generalized and well-validated three-factor anthropomorphism theory treats all technology like any other nonhuman entity. The theory is not able to explain differences across technologies because technology is not included in the model.

6.1 Theoretical Implications

We expand the three-factor anthropomorphism theory in two ways. We integrate Karahanna et al.'s (2018) NAF perspective on technology use motivation with the three-factor theory. This research contributes to IS literature by extending the NAF perspective to the phenomenon of thinking of technology as humanlike—as an interplay between anthropomorphic features, their affordances, and users' psychological needs.

We also go beyond the NAF perspective that treats technology as static to consider changing affordances with advanced technologies. As technologies become increasingly ambivalent and self-adaptive, technology affordances can intensify egocentric biases. For example, Kang and Kim (2020, p. 46) note that "a smart thermostat (e.g., Nest Learning Thermostat) is capable of automatically adjusting temperature settings according to information acquired though interactions with linked objects in the room, such as a heater or a smartphone, to accomplish a specific goal of energy saving." Because interactions with such advanced technologies are context specific and adapted to specific users' needs, the nonhuman agent is personalized to be more similar to the user than other humans. To make sense of the self-adapting technology, users intensify their reliance on self-knowledge in their inductive reasoning without corrections that would adjust away from the egocentric anchors.

We discuss how the reliance on self-knowledge with ambivalent and self-adaptive advanced technologies can intensify the construction of egocentric biases. TA affordances can intensify the construction of these egocentric biases when cognitive resources are limited, stemming from strong anchoring on self-knowledge and leading to weaker adjustment processes. These biases are formed and accumulated and applied as a recursive process. Because users bring their self-knowledge to their interactions with advanced technologies, advanced technologies automatically collect and accumulate data from users on these biases and the technology adopts these biases. Because these biases again reflect how the user constructs the world and interacts with advanced technology, opportunities for the correction of egocentric biases are limited. In other words, the reduction of technology-imbued biases must begin with people. As long as people accumulate biased knowledge and hold discriminatory stereotypes, technology will do the same. Thus, our model goes beyond NAF and provides a starting point to consider users' psychological responses to changing affordances with advanced technologies and some of the negative consequences that might result.

6.2 Future Research Agenda

Our model not only explains TA as it relates to current technology but also provides theoretical predictions for future research on TA. As new advanced technologies come to the market, our model could be a starting point for predictions about and implications of its influence on users, based on the extent to which the contexts of use and the technologies' features influence users in anthropomorphizing the technology. For example, our model could be used to make predictions about users' experience with emerging smart home technologies (e.g., Google Home). First, the NAF perspective we adopt in our model could identify how features of this smart home technology (e.g., auditory features) provide affordances (e.g., increased personal control), and how users' psychological needs interact with these affordances. Second, as users anthropomorphize their smart homes, we predict that the inductive knowledge base will be self-knowledge because knowledge about the self is the most readily accessible form of knowledge. Anchoring on self-knowledge without adjustments may give rise to egocentric biases. The presence of low cognitive resources in interactions make corrections effortful and unlikely. Hoffman and Novak (2017, p. 9) argue that smart homes provide affordances that enable users to "exercise their capacities." Our theorizing suggests that these capacities include users' egocentric biases. However, at some point, the technologies may also begin to undermine users' perceptions of their control over and responsibility for the technology. As a result, users might experience "self-restriction" and "self-reduction," and their interaction with the smart home may shift, based on the perceptions of threatened freedom. In this case, the smart home's affordance is then seen as constraining the users' actions and experiences.

Future research should explore the implications of TA for users' privacy-related behavior. Can misidentification with technology cause users to excessively disclose sensitive information to the technology? Such misidentification might occur if individuals prefer interacting with anthropomorphized technology over real humans for self-disclosure purposes because they perceive technology to be less judgmental and more trustworthy (Pickard et al., 2016). However, an interplay between sociality and effectance needs also might complicate users' self-disclosure intentions regarding TA. On the one hand, a greater perceived sociality affordance may elicit more self-disclosure if it strengthens users' anchoring on sociality needs; on the other hand, a greater perceived affordance of gaining personal control could elicit more awareness of technology's agency and potential privacy threats, thus strengthening users' anchoring on effectance needs and inhibiting self-disclosure. Future research should explore factors that moderate the relative strength of sociality needs versus effectance needs in influencing users' privacy concerns and self-disclosure behaviors.

Furthermore, our model offers avenues to explore how cognitive resources might be increased in the TA process. For example, "IT mindfulness"—an IS construct related to self-control—is worth exploring in the TA process. Thatcher et al. (2018) have conceptualized IT mindfulness (i.e., mindfulness associated with IT use) as an overarching mental mindset with two characteristics: individual awareness of the context and openness to the value-adding applications of IT. IT mindfulness represents a highly attentive and self-controlled state of IT use, enabling users to better control their anchoring and channel resources into correction processes. Mindfulness as a general cognitive state has been shown to prevent the assignment of stereotypical biases and expressions of discrimination toward other humans. As Ostafin and Kassman (2012; p. 2) demonstrate, "an aim of mindfulness is to limit the ability of automatically activated verbal-conceptual content derived from past experience to bias thought and behavior." Similarly, users' IT mindfulness could inhibit them from heavy reliance on self-knowledge and prevent the transfer of biases to anthropomorphized technology. Interestingly, recent research suggests that increasing users' IT mindfulness also can backfire for some technology-based tasks. Research shows that mindfulness can decrease action motivation because mindful people focus on the present and lack an active motivation to engage in future-oriented tasks (Hafenbrack & Vohs, 2019). Because adjustment and correction processes also require an active motivation (Epley et al., 2007), future research might explore the prediction that, for some types of technology tasks that require persistence and a long-term view, increasing mindfulness can prevent biases in the short term but might decrease task performance over the long term.

Our model also suggests opportunities for the use of emerging research methods to study TA, such as the NeuroIS method (Dimoka et al., 2011). Previous research has used neuroscientific methods to reveal the similarities and differences in the perceptions of human agents and anthropomorphized agents (Riedl et al., 2014). However, to our knowledge, the neurological mechanisms leading to different consequences of TA have not yet been explored. Further neuropsychological process evidence is needed to gain deeper insights into the processes underlying egocentric biases. Neuropsychological research methods could advance our understanding of egocentric biases by disentangling the anchoring and adjustment process, by demonstrating the role of cognition, and by providing an in-depth exploration of how specific anthropomorphic features lead to specific egocentric biases. Future research also might introduce other innovative methods to study TA phenomena. For example, researchers could incorporate neuroendocrine methods (Riedl et al., 2012) to study how hormones change during the process of TA, which could provide insights into the dynamic changes in users' hormonally and neurologically influenced physiological needs as they interact with advanced technologies.

6.3 Practical Implications

Our model of egocentric biases produced by the process of TA provides practical implications for various stakeholders, including technology designers, implementers, and users. Our model implies that, in the design of new technology, designers should be mindful of designing anthropomorphic information systems (e.g., Diederich et al., 2020) because such systems can propagate egocentric biases. Designers are encouraged to avoid excessive intimacy cues, in order to decrease the ambivalence of the technology by increasing design transparency (Lyons, & Havig, 2014), and to deploy personalization that is contextually aware (Kaisler et al., 2018). Intimacy cues may involve personal labels (e.g., humanlike names) (Stoner et al., 2018), intimate language use (Bazarova et al., 2013), or touch (Abbey & Melby, 1986). We encourage designers to avoid humanlike labels or names for voice assistants (e.g., Alexa or Siri) and restrict voice assistants' use of overly intimate language in communication with users.

Design transparency—which is defined as the extent to which technology design enables users to build mental models of the technology's internal functions (Lyons & Having, 2014; Stowers et al., 2016)—can be an effective remedy for sensitized effectance needs and perceived threats. Providing users with a more transparent view of technology's internal functions can reduce the uncertainty associated with the technology. Transparency also reduces the cognitive load in the corrective processes (Fishbach et al., 2010) and can mitigate users' perceived threats to their agency from technology. This remedy is consistent with recent technical developments that require the machine's learning algorithm to "explain itself" (Ribeiro et al., 2016).

The "contextual awareness" of technology is defined as its ability to sense and react to environmental changes around it (Kaisler et al., 2018). Social robots with high levels of "mindfulness" should be able to adapt to heterogeneous, interactive environments. As users start to display stereotypes to social robots, contextually aware social robots should be capable of changing their behavioral scripts and responding in ways that do not adopt or encourage negative stereotyping, thus inhibiting the personalization in the anthropomorphized technology of users' stereotypical knowledge structure.

Organizations implementing advanced technology should be aware of "risky" anthropomorphizing conditions and should strategically minimize the negative effects stemming from TA. For example, organizations need to pay attention to the conditions under which egocentric biases are more likely to occur (e.g., where tasks require high cognitive resources). To prevent egocentric biases, organizations might consider either reducing cognitive demand for the task or providing support and training for employees to increase their resources during IT use.

For users, our model also provides practical guidance on how to prevent egocentric biases. For example, we suggest that users should be aware of the potential harmful consequences of forming an intimate relationship with their smart assistants and should be more attentive to protecting their own privacy.

Our theorizing also has limitations. First, our model is limited to individual-level technology use and does not consider collective use. Different ways of interacting with technology can happen at multiple levels, leading to a wider range of potential negative consequences. Second, other mechanisms—in addition to the anchoring and adjustment process we discuss here—might influence how TA produces egocentric and other biases.

Finally, we acknowledge that our one-to-one matching between affordances and needs might be viewed as overly simplistic. Karahanna et al. (2018) constructed a comprehensive exploration of affordances on a single digital artifact: social media. In their model, they present a more generic set of psychological needs, with each affordance satisfying several psychological needs. Our theoretical model is different from theirs in a few ways: First, our scope includes features, affordances, and needs that are relevant to TA; second, the TA phenomenon can occur across different technology types; and third, we derive affordances from the three-factor model of anthropomorphism rather than deriving them directly from technology artifacts. Additional research is needed to map affordances of technology more generally (i.e., beyond the affordances defined by the three-factor model) onto users' psychological needs as they relate to TA.

In conclusion, advanced technology that can lead to humanlike attributions has enormous economic and social value. Therefore, understanding the nature of TA, as well as its consequences for users, is both timely and critical. Our research contributes to this goal and to the IS literature on technology anthropomorphism, based on the needs-affordances-features perspective and on egocentric biases. Our theoretical investigation can provide insights for technology designers, implementers, and users on how to minimize the potential negative consequences of egocentric biases produced by TA, thus increasing the social and individual welfare made possible by advanced technology.

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Appendix A

Table A1. Reinterpretation of Empirical Research Related to Elicited Agent Knowledge

Source	IV	DV	Major conclusion	Moderator	Mediator	Psychological antecedents	Technological Features	Affordances	Fulfillment or anchoring and adjustment process
De Angeli & Brahnam (2008).	Observational study	Negative verbal disinhibition (IT misuse)	Conversations with Jabberwacky (a human robot) often bring about the expression of negative verbal disinhibition.			Elicited agent knowledge	Visual and mental	Human knowledge transference	Human knowledge transference affordance intensifies anchoring on elicited agent knowledge and weakens the adjustment
Brahnam & De Angeli (2012).	Quantitative textual analysis of interaction logs	Negative verbal disinhibition, Sexual attention (IT misuse)	People are more likely to attribute negative stereotypes to female-looking chatterbots than male-looking chatterbots, expressing sexual attention and swear words.			Elicited agent knowledge	Visual , auditory and mental	Human knowledge transference	Human knowledge transference affordance intensifies anchoring on elicited agent knowledge (negative gender stereotypes and weakens the adjustment
Puzakova et al. (2013).	Anthropomorphized vs Non-Anthropomorphized Product	Attitudes	Individuals who believe in personality stability (i.e. entity theorist) have more negative attitudes towards anthropomorphized products with negative publicity than objectified products, because entity theorists attribute single	Lay theories about whether personality is fixed or malleable (entity vs incremental theorist).	Product Responsibility	Elicited agent knowledge	Visual	Human knowledge transference	Human knowledge transference affordance intensifies anchoring on elicited agent knowledge and weakens the adjustment

			negative events to dispositional traits.						
Wan et al. (2017)	Anthropomorphized vs. non-anthropomorphized products	Information search behavior, choice	Consumers put more weight in product appearance for anthropomorphized products (vs. non-anthropomorphized products) versus because consumers apply the "beautiful is good" stereotype to the anthropomorphized product.	Discounting the beautiful-is-good belief	Accessibility of the beautiful-is-good belief	Elicited agent knowledge	Visual	Human knowledge transference	The human knowledge transference affordance intensifies anchoring on elicited agent knowledge and weakens the adjustment

Table A2. Reinterpretation of Empirical Research Related to Effectance Needs

	IV	DV	Major conclusion	Moderator	Mediator	Psychological antecedents	Technological Features	Affordances	Fulfillment or Anchoring and Adjustment Process
Waytz et al. (2014).	Anthropomorphized vs. non-anthropomorphized autonomous vehicle	Trust, liking, stress level, distraction, blame for the vehicle	Anthropomorphism of autonomous vehicles increases trust in that car.			Effectance needs	Visual, auditory, and mental	Gaining personal control	Gaining personal control affordance fulfills users' effectance needs, thus increasing trust.
de Visser et al., (2014)	Anthropomorphized vs. non-anthropomorphized cognitive agents	Trust resilience	Anthropomorphic agents were associated with greater trust resilience, a higher resistance to breakdowns in trust	Uncertainty		Effectance needs	Visual, auditory, and mental	Gaining personal control	Gaining personal control affordance fulfills users' effectance needs, thus increasing trust.

Kim et al. (2016)	Anthropomorphized vs. non-anthropomorphized digital assistants	Enjoyment	Users enjoy a computer game less when they receive assistance from a virtual helper with humanlike features than from an objectified helper.	Time pressure, Task framing	Perceived autonomy	Effectance needs	Visual and mental	Gaining personal control	Gaining personal control affordance intensifies anchoring on effectance needs and weakens the adjustment
Złotowski et al. (2017).	Anthropomorphized vs. non-anthropomorphized robot	Perceived threats, negative attitudes towards robots, opposition to robot research	Participants perceived anthropomorphized robots as more negative, more threatening than non-anthropomorphized robots; they are also more opposed to robots research after viewing anthropomorphized robots.		Realistic threats, identity threats, negative attitudes towards robots, opposition to robot research	Effectance needs	Visual and mental	Gaining personal control	Gaining personal control affordance intensifies anchoring on effectance needs and weakens the adjustment
Ferrari et al. (2016).	Anthropomorphized vs. non-anthropomorphized robot	Perceived damage to humans and their identity	Human-looking (versus non-human-looking) robots induce higher perceived damage to humans and human identities because undermining human uniqueness		Undermining human-machine distinctiveness	Effectance needs	Visual and mental	Gaining personal control	Gaining personal control affordance intensifies anchoring on effectance needs and weakens the adjustment

Table A3. Reinterpretation of Empirical Research Related to Sociality Needs

	IV	DV	Major conclusion	Moderator	Mediator	Psychological antecedents	Technological features	Affordances	Fulfillment or anchoring and adjustment process
Mourey et al (2017).	Anthropomorphized technology vs. less anthropomorphized technology	Estimation of social connections on Facebook, anticipated future social needs, intention	Interaction with anthropomorphic technology (i.e., technology featuring characteristics of being alive through design, interaction, intelligence, responsiveness, and/or personality) can also satisfy (at least partially) sociality needs, ultimately mitigating previously documented effects of social exclusion.			Sociality need	Visual and auditory	Sociality	Sociality affordance fulfills users' sociality needs.
Eyssel & Reich (2013)	Anthropomorphized robots vs. less anthropomorphized robots	Anthro-pomorphism tendency	Lonely people anthropomorphized the robot more than less lonely people because anthropomorphism satisfy their sociality needs.			Sociality need	Visual and auditory	Sociality	Sociality affordance fulfills users' sociality needs.
Pickard et al. (2016).	Avatars interviewers vs human interviewers	Self-disclosure	People prefer to disclose sensitive topics to avatars (versus human) interviewer because they perceive avatars interviews as less judgmental and easier to approach.	Sensitivity of the topics	Feelings of being judged	Sociality need	Visual and auditory	Sociality	Sociality affordance intensifies anchoring on sociality needs and weakens the adjustment

Kang & Gratch (2010)	Virtual human agent vs. real human vs. real human with degraded facial images	Self-disclosure, and self-disclosure of intimate information	Social anxious individuals disclose both more information and more intimate information with virtual human agents (versus two real human conditions).	Social anxious level		Sociality need			Sociality affordance intensifies anchoring on sociality needs and weakens the adjustment
Turkle (2007)	Conceptual article including historical review of robots as human companion		Social robots' companions are evocative but not authentic.			Primarily focused on sociality need	Mental	Sociality	Sociality affordance intensifies anchoring on sociality needs and weakens the adjustment
Sharkey & Sharkey (2012)	Conceptual article on the potential ethical issues related to care-robot as companion with elderly people		Accompanying elderly people with care-robots may cause negative consequences including loss of human contact, deception and infantilization.			Primarily focused on sociality need	Visual, auditory and mental	Sociality	Sociality affordance intensifies anchoring on sociality needs and weakens the adjustment

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