Less Time and Guilt: When and Why Autonomous Products Increase Consumer Well-Being

Tobias Schlager
Emanuel de Bellis
Ashley Whillans
Less Time and Guilt: When and Why Autonomous Products Increase Consumer Well-Being

Tobias Schlager
University of St. Gallen, Switzerland

Emanuel de Bellis
University of St. Gallen, Switzerland

Ashley Whillans
Harvard Business School

Working Paper 24-018

Copyright © 2023 by Tobias Schlager, Tobias de Bellis, and Ashley Whillans.

Working papers are in draft form. This working paper is distributed for purposes of comment and discussion only. It may not be reproduced without permission of the copyright holder. Copies of working papers are available from the author.

Funding for this research was provided in part by Harvard Business School.
Less Time Stress and Guilt:

When and Why Autonomous Products Increase Consumer Well-Being
Autonomous products such as robotic vacuum cleaners and cooking machines function independently to complete tasks on behalf of consumers. To date, research on this novel class of technology has largely focused on when and why consumers adopt these products (Hancock 2017; Jörling, Böhm, and Paluch 2020; Leung, Paolacci, and Puntoni 2018; Puntoni et al. 2021). In contrast, the current research examines the psychological consequences of using autonomous products. Specifically, the results show that autonomous products can effectively increase consumer well-being. The studies reveal why autonomous products increase well-being by identifying consumers’ reduced perceptions of time stress (relative to non-autonomous products) and feelings of guilt (relative to delegating a task to other humans). The studies also uncover when the benefits unfold by showing that autonomous products reduce perceived guilt from delegating tasks only when human likeness of these products is low. These findings advance prior research on autonomous products by demonstrating the distinct usage consequences (instead of adoption reasons) of autonomous products (Beer, Fisk, and Rogers 2014; de Bellis and Johar 2020; Schmitt 2019). These findings also contribute to research on the psychology of time by providing the first empirical evidence for how new technologies reduce time stress and improve happiness (Aaker, Rudd, and Mogilner 2011; Whillans et al. 2017). Finally, these findings enrich prior work on anthropomorphization of products and services (Kim, Schmitt, and Thalmann 2019, Uysal, Alavi, and Bezençon 2022) by revealing potentially negative consequences: autonomous products with high human likeness can increase feelings of guilt. Overall, the current research provides novel academic and consumer insights into the psychology of using new technology that characterizes the age of autonomy.
ABSTRACT

Autonomous products complete tasks without human intervention. In taking over those tasks, autonomous products not only save consumers time, but they also become similar to (human) home helpers. This article provides a comprehensive evaluation of the effects of autonomous products on consumer well-being. Drawing from research on consumer perception of new technologies and the link between saving time, guilt about delegating tasks, and consumer well-being, we hypothesize that using these products to outsource daily chores can positively contribute to consumer well-being. Five field and experimental studies ($N = 50,683$) provide evidence for the proposition that using autonomous products increases well-being. This effect is driven not only by reduced feelings of time stress (compared to delegating to non-autonomous products) but also by reduced feelings of guilt (compared to delegating to other humans). Yet, autonomous products are only associated with lower levels of guilt and higher consumer well-being when these products are not perceived as human-like. When consumers see APs as more human-like, they experience greater perceived guilt and are less likely to reap the technology’s well-being rewards. With the increasing adoption of autonomous products, the current research provides foundational evidence for understanding the downstream usage consequences of these new technologies, including why and when these products contribute to consumer well-being.

*Keywords:* autonomous product, new technology, well-being, time stress, guilt, human likeness
Groundbreaking advances in networking technology, machine learning, and robotics are changing consumers’ lives. Products and services are becoming increasingly autonomous and able to govern their own behavior to complete tasks on behalf of consumers (Beer et al. 2014; de Bellis and Johar 2020; Jörling et al. 2020). ChatGPT can write speeches or summaries, robotic vacuum cleaners keep our homes clean, robotic lawnmowers take care of our gardens, and autonomous cooking devices prepare ingredients and implement recipes. It has been argued that new technology based on artificial intelligence (AI) “offers people a better quality of life […] by reducing the time they spend on tedious tasks” (Carmon et al. 2019, p. 2). Accordingly, autonomous products (APs) are quickly gaining popularity. This increased popularity is exemplified by the global robotic vacuum cleaner market, which is expected to grow at an annual rate of 23.2% from 2021 to 2028, reaching $15.4 billion by 2028 (Research and Markets 2021).

Although automated products that save consumers time have a long history (e.g., kitchen appliances such as food processors and dishwashers), products are only now being equipped with higher levels of autonomy (Hoffman and Novak 2018; Schmitt 2019; Wertenbroch et al. 2020) that allow consumers to entirely outsource a task. In fact, scholars argue that we are about to move past the age of automation to the age of autonomy whereby products will no longer require human intervention (de Visser, Pak, and Shaw 2018; Hancock 2017; McClean 2021; Schmitt 2019). Products in the age of autonomy are characterized by their ability to learn and cooperate, their human-like interactions, and the possibility of having a personality (Dou et al. 2019; Rijsdijk, Hultink, and Diamantopoulos 2007). Given this new reality for consumers, we focus on APs that do not require any human intervention and can complete entire tasks on their own.

Consumers can delegate an increasing number of tasks to APs, which saves them time that they can allocate to other activities (André et al. 2018; Leung et al. 2018; Rijsdijk and Hultink 2003). A few companies have started using this fact as a key argument in their marketing
communication. For instance, iRobot claims that its robotic vacuum cleaner Roomba saves each
customer as much as 110 hours of cleaning per year (Rae 2020). Out of a representative sample,
62.3% of consumers perceived that using APs increases their available time, with average
expected time gains of 2 hours and 16 minutes per week (Zimmermann et al. 2022). Given that
time may be the most limited resource in our lives, this time saving should have beneficial
effects. Consistent with the idea that APs promote well-being through time-savings, in related
research, consumers reported greater happiness when they spent money on a time-saving
purchase such as paying for house cleaning as opposed to spending the same amount of money on
a material purchase for themselves like buying new clothes (Whillans et al. 2017).

At the same time, companies seem to design APs that become more and more human-like
by, for instance, integrating them into their ecosystems of smart voice assistants (e.g., Apple’s
Siri) giving them voices and prompting consumers to give them names. What is more, the
autonomous nature of APs is unique and is attributed to living beings and less so to products.
Thus, based on their autonomy, consumers could consider APs to be more human-like than other
products. Indeed, consumers tend to easily become attached to APs (New Scientist 2020).

Given the increasing adoption of APs by consumers, it is important to understand whether
and when those two characteristics of APs translate into consumer well-being. Whereas time-
saving purchases have been shown to promote well-being (Whillans et al. 2017), there is mixed
evidence that these benefits emerge universally (Lok and Dunn 2022). For example, feelings of
guilt can prevent consumers from experiencing the emotional benefits of making time-saving
purchases (Whillans, Lee-Yoon, and Dunn 2020). While this effect of time-saving purchases
increasing consumer guilt and undermining well-being has been documented within the context
of delegating tasks to other humans, it is unclear how consumers respond to delegating tasks to
APs that operate autonomously—a characteristic that is typically ascribed to humans. If
consumers delegate their personal tasks to products that they perceive as more human-like, they may also experience feelings of guilt, which could undermine their well-being.

Building on the reviewed findings, the current paper makes two key propositions. First, APs should increase consumer well-being by providing consumers with more time for other, more desirable activities and therefore reducing the experience of time stress that consumers experience. This idea builds on research showing that prioritizing time and the experience of time affluence is linked to consumer well-being (Hershfield, Mogilner, and Barnea 2016; Whillans et al. 2017; Whillans, Weidman, and Dunn 2016). It also builds on research showing that time stress comes from feelings of goal conflict. To the extent that APs enable people to spend time in other personally important ways, these products should reduce time stress and improve consumer well-being (see Rudd 2019 for a review). Second, APs should not induce the same level of guilt as compared to other ways of saving time, such as delegating tasks to humans. To the extent that consumers experience less time stress and guilt when delegating tasks to APs, they should experience greater well-being as compared to completing tasks themselves or delegating them to humans—unless consumers ascribe highly human-like characteristics to the AP.

In this paper, we develop a theory-driven framework about the consequences of using APs, which is then tested with five field and experimental studies. The findings advance consumer research on new technologies that, as opposed to their consequences, has mainly focused on the antecedents of their adoption (Jörling et al. 2019; Leung et al. 2018; Longoni, Bonezzi, and Morewedge 2019; Puntoni et al. 2021; Schweitzer and Van den Hende 2016). Our findings underscore the important role of time savings and guilt in predicting the well-being benefits of APs (Whillans et al. 2020) and add to research on human likeness and anthropomorphization (Kim, Schmitt, and Thalmann 2019). Managerially, marketing communication should highlight the time-saving nature of APs while minimizing feelings of
guilt, and product designers should reconsider whether to maximize the human likeness of APs.

THEORETICAL BACKGROUND

The Unique Characteristics of Autonomous Products

We conceptualize autonomous products (APs) as products that function independently, without human intervention, to complete entire tasks on behalf of consumers (Beer et al. 2014; Hancock 2017; McClean 2021; Rijsdijk and Hultink 2003; Rijsdijk et al. 2007).

According to seminal work by Rijsdijk et al. (2007) and Beer et al. (2014), one key characteristic of APs is their high level of autonomy. After consumers set up the products, APs do not require direct intervention or active participation—they generally work without human guidance (Kyriazis and Varvarigou 2013; Rijsdijk and Hultink 2003). However, the degree of autonomy of these products varies (Simmler and Frischknecht 2020). APs that do not require any human intervention are still rare—the current investigation therefore contrasts products with higher (e.g., robotic vacuum cleaner) versus lower autonomy (e.g., conventional vacuum cleaner).

Importantly, APs differ substantially from automated products (de Bellis, Johar, and Poletti 2023). Automated products accomplish a specific set of largely deterministic steps that are narrowly focused on one specific task (an example is provided below). Thus, these products require some level of human intervention to complete a given task (Hancock 2017; McClean 2021). By contrast, an AP “is self-sufficient and requires no human intervention; it can learn and adjust to dynamic environments and evolve as the environment around it changes” (Mcclean 2021, p. 1; see also Beer et al. 2014; Hancock 2017; Schweitzer and Van den Hende 2016). In contrast to automated products, the focus of APs “is less on how humans complete mundane tasks faster and more on completely freeing humans from performing manual or process-oriented tasks” (Shani 2018, p. 1).
Take, for example, the case of vacuum cleaning. Conventional vacuum cleaners, such as upright vacuum cleaners, are automated to the extent that they cause suction to remove dirt from floors. To complete the task of cleaning, however, human intervention is needed. In contrast, robotic vacuum cleaners, such as iRobot’s Roomba, complete the task without any human intervention—they vacuum the floor completely on their own based on advanced technology and multiple sensors. As this example illustrates, the AP replaces consumers altogether, while the automated product merely augments consumers’ skills (Frey 2020).

APs allow consumers to delegate tasks that they used to complete themselves to technology that independently performs these tasks. These substituted tasks frequently comprise mundane chores, such as mowing the lawn (autonomous lawnmowers), cooking (autonomous cooking devices), or vacuuming the floor (autonomous vacuum cleaners), with many more tasks likely being completed by APs in the future, including commuting (self-driving cars). In the following section, we review prior work on consumer perception of APs—products that entirely take over tasks—to predict how this novel class of products is linked to consumer well-being.

Consumer Perception of Autonomous Products

Research in marketing and innovation management suggests that consumers perceive APs as riskier and more complex than other products. Yet, this research emphasizes that APs offer a relative advantage compared to non-APs that are partly manually operated (Rijsdijk and Hultink 2003). As less human input is needed, consumers perceive APs as devices that increase the efficiency of task fulfillment (André et al. 2018; Rijsdijk and Hultink 2009). At the same time, these products can trigger feelings of technological dependence, reducing consumers’ intentions to adopt them (Mani and Chouk 2017; Schweitzer and Van den Hende 2016). APs can undermine consumers’ sense of autonomy, with potential negative effects on their well-being and, especially
for those with a high desire for control, the adoption of such new technologies (André et al. 2018; Faraji-Rad, Melumad, and Johar 2017; Hoffman and Novak 2018). Furthermore, APs can hinder the internal attribution of identity-relevant consumption outcomes, therefore reducing consumption among those who strongly identify with a particular consumption domain (Leung et al. 2018). Together, these findings imply that consumers have mixed feelings about APs.

The reviewed studies have greatly improved our understanding of why and when consumers tend to adopt or reject APs. However, the well-being consequences of owning and operating APs are still unclear. In the following sections, we develop our predictions about the effects of using APs on consumer well-being and propose they operate through two key processes: feelings of time stress and guilt.

Consumer Well-Being and Time Stress

Consumer researchers have repeatedly highlighted the importance of examining consumer well-being, which is defined as “a state of flourishing that involves health, happiness, and prosperity,” as a central outcome of interest (Inman et al. 2018; Mick et al. 2012, p. 6). Prior work has shown that happy people enjoy significant benefits in life, such as having more social connections, lower divorce rates (Labroo and Patrick 2009; Lyubomirsky et al. 2005), and more energy (Csikszentmihalyi and Wong 1991), while being more successful in their careers (Walsh, Boehm, and Lyubomirsky 2018) and living longer (Diener and Chan 2011). Given these benefits, it is crucial to identify factors that add to consumers’ well-being. For example, research at the intersection of well-being and consumption has shown that variations in the products and activities that consumers choose can contribute to happiness (Etkin and Mogilner 2016).

One salient theme in the literature on well-being relates to time. Specifically, time can make consumers happier if it is spent with the right people and on the right activities, and
research suggests that consumers should try to expand their available free time to increase their happiness (Mogilner, Whillans, and Norton 2018). Large-scale studies show that consumers report having less time today than in previous decades (Mogilner et al. 2018). These feelings of time stress—the feeling of having too many things to do and not enough time in the day to do them (Kasser and Sheldon 2009; Whillans et al. 2017)—can affect consumers’ well-being. As a result of people’s increased feelings of time stress, some studies indicate that making purchases that save time can have reliable positive consequences for consumer well-being. Saving time through delegating or outsourcing everyday tasks to other people can translate into greater well-being (Whillans et al. 2017). Moreover, consumers who value time over money experience greater well-being in general (Whillans et al. 2016; Hershfield, Mogilner, and Barnea 2016) and after major life events (Whillans, Macchia, and Dunn 2019). While past research has focused on the well-being consequences of time-saving services (e.g., human house cleaners), it remains unknown whether APs have similar effects for reducing time stress and promoting well-being.

Drawing from work on people’s perception and appreciation of time (Festjens and Janiszewski 2015; Whillans et al. 2017), as well as the notion that time is central to quality of life and consumer well-being (Mogilner et al. 2018), one key proposition of this research is that the time-saving characteristic of APs have the potential to meaningfully shape consumer well-being. Thus, consumers’ adoption of APs should improve consumer well-being by reducing time stress.

**H1**: Using autonomous products (vs. non-autonomous products) increases consumer well-being.

**H2**: The effect of using autonomous products (vs. non-autonomous products) on consumer well-being (H1) is mediated by a reduction in perceived time stress.

Delegating Tasks to Humans and Feelings of Guilt
A key distinction between APs and non-APs is that the former type of products save time, as they do not require any human interaction or intervention. Yet, other ways to save time exist, and we argue that APs have unique consequences also against those. Consumers can save time in their daily lives by employing other people (e.g., house cleaners), that is, people who complete specific tasks for them (e.g., cleaning). Thus, when comparing APs with domestic workers, the former’s central advantage of saving time vanishes. However, there are characteristics by which APs differ from domestic workers, and which may differentially affect consumer well-being.

We propose that APs versus domestic workers affect consumer well-being differently, as they do not equally result in feelings of guilt. Prior work has found that delegating tasks to a visible service provider, such as hiring a house cleaner or having someone cook and prepare meals for you at your home, can undermine the positive psychological benefits of task delegation (Whillans, Lee-Yoon, and Dunn 2020). This prior research shows that consumers may not outsource specific tasks because they do not want to burden a housecleaner or lawncare provider with their personal and disliked household chores due to anticipated feelings of guilt. Feelings of guilt are a negative affective experience (Mosher 1980); people often sense guilt when they perceive that they are causing negative outcomes for others (Paharia 2020; Tangney et al. 1996).

For APs, the effects may be less straightforward. Technology typically is not identifiable and has no personal identity (Small and Loewenstein 2003)—all of which should reduce consumers’ level of guilt as compared to outsourcing to a specific service provider—if consumers do not ascribe human traits to the AP technology. This hypothesis is in line with research showing that consumers feel less judged by technology, such as a robot, compared to humans (Holthöwer and van Doorn 2022). Moreover, APs are specifically designed to complete household tasks such as vacuum cleaning or lawn mowing. Thus, consumers should experience less guilt when delegating a task to APs as compared to domestic workers.
However, some consumers are more prone to bond with APs (New Scientist 2020) and might establish longer-lasting relationships with this type of technology. Consistent with this possibility, past research finds that consumers can form human-robotic relationships with APs because of the high levels of intelligence and autonomy of these products, which may lead consumers to ascribe personalities to these products (Rijsdijk et al. 2007). This process of anthropomorphizing products has already been shown in product categories that remind consumers of human faces, such as car fronts and cellphones (Landwehr, McGill, and Herrmann 2011; Aggarwal and McGill 2007; Maeng and Aggarwal 2018; Welsh 2006; Windhager et al. 2010) as well as for AI (Uysal, Alavi, Bezençon 2022). Indeed, anthropomorphizing may be especially relevant in the context of APs because of the high levels of autonomy of these products (Jörling et al. 2020). As a result, consumers may treat their APs as increasingly human-like. Supporting this argument, more than 80% of consumers assign their robotic vacuum cleaner a nickname (Slate 2014), with some consumers modifying these vacuum cleaners such that they verbally react when they bump into obstacles (Thenextweb 2019).

Overall, consumers should perceive APs to be more human-like than non-APs, however, less than actual humans. Yet, the perception of APs likely varies—some individuals may perceive APs merely as an object or as closer to a human being—which could affect consumers’ feelings of guilt when they delegate their daily chores to this novel class of technology. Specifically, consumers who anthropomorphize their AP may experience feelings of guilt when delegating tasks to this technology. We propose that the extent to which consumers ascribe human characteristics to their APs will serve as a key moderator of the effect of APs on feelings of guilt.

**H3**: Using autonomous products (vs. delegating tasks to humans) increases consumer well-being.

**H4**: The effect of using autonomous products (vs. delegating tasks to humans) on
consumer well-being (H3) is mediated by a reduction in perceived guilt.

**H5:** Human likeness moderates the effect of autonomous products (vs. delegating tasks to humans) on perceived guilt. Specifically, consumers feel less (more) guilty when human likeness of autonomous products is low (high).

Figure 1 displays the conceptual framework, including the proposed hypotheses. The figure depicts the effects of APs against non-APs and humans including the proposed mechanisms: perceived time stress (for the contrast against non-APs) and perceived guilt (for the contrast against humans). The figure also shows the moderating effect of human likeness of the AP.

**FIGURE 1**

**CONCEPTUAL MODEL**

We report five studies that test our hypotheses, with two studies providing field evidence (studies 1 and 5). All controlled studies (studies 2, 3, and 4) were preregistered. Study 1 is a correlational field study of current and prospective customers of an AP, showing that self-reported AP usage is associated with a reduction in perceived stress (H2). Study 2 provides
causal evidence for the effect of APs on well-being and shows that the effect is driven by a reduction in perceived time stress (H1, H2). Study 3 provides causal evidence for the underlying mechanism by manipulating the time that consumers gain through the AP (H2). The next study focuses on delegating tasks to APs versus humans. Study 4 manipulates human likeness, providing evidence for perceived guilt as a mediator of the effect of APs versus humans (H3, H4). This study also provides causal evidence for moderation via human likeness (H5). Finally, Study 5 uses social media field data to show that the demonstrated effects materialize in consumers’ language: When referring to APs (vs. non-APs) consumers use more words related to time, leisure, and well-being.

**STUDY 1: OWNERSHIP OF AUTONOMOUS PRODUCTS AND STRESS**

The main objective of Study 1 was to examine whether APs reduce perceived stress (H2), which is a key factor that could predict the well-being benefits of APs according to our theorizing. We tested this question by collecting field evidence in collaboration with the manufacturer of a popular AP (i.e., an autonomous cooking device) that allowed us to use its newsletter directory and send out a survey to customers. Notably, the manufacturer’s newsletter directory did not only include actual customers (who already owned one of the manufacturer’s products) but also prospective customers who had not yet purchased any of the offered products. By studying both actual and prospective customers, we were able to assess whether owners of APs reported lower levels of stress as compared to non-owners of APs. In addition, it is important to mention that this product category—autonomous cooking devices—is conservative for testing effects on time stress given that consumers still need to add ingredients when using the device and given that cooking is a task that consumers oftentimes describe as positive (and not stressful).
Method

Participants. The manufacturer of the autonomous cooking device invited all actual and prospective customers who subscribed to its newsletter to participate in a short survey. The survey included multiple topics, unrelated to the current investigation. We incentivized customers to complete the survey by providing customers with the opportunity to take part in a lottery by which they could win either the newest version of the autonomous cooking device or an equivalent amount of money (depending on their preference). The newsletter directory consisted of a total of 62,300 email addresses. 22.4% or 13,981 customers opened the newsletter, and 14.2% or 8,862 customers completed the survey. This study included 8,862 customers: 8,512 who owned the autonomous cooking device and 350 who did not.

Procedure. The survey consisted of various measures to assess people’s perception and use of the AP. Among them, for owners of the APs, we included a measure of whether and how long people had owned an AP, the key benefits of using the AP, how many hours people saved by using the AP, and a measure of perceived stress. The survey was part of a larger investigation, took 13 minutes (median), and was conducted in French, German, and Italian (translation and back translation were conducted by a professional language service).

Measurement. We measured whether people owned the autonomous cooking device by providing a dropdown list, which included the specific model of the autonomous cooking device. One of the options was “I do not own any of the listed products,” which we used to code consumers as non-owners. We also measured ownership duration of the autonomous cooking device with a dropdown list, from less than one year to over ten years. We used the log of this variable as it was heavily right-skewed (s = 1.52). We measured the key benefits of the autonomous cooking device by providing eleven statements about the potential benefits, including one statement related to time savings (“One saves time by using the [product name] and...”)
thus more time is available for other things” on a 7-point Likert scale, ranging from 1 = “Strongly disagree” to 7 = “Strongly agree”). We measured perceived stress with one item (“How stressed are you in your daily life?” from 1 = “Not at all stressed” to 7 = “Very stressed”). Finally, we measured socio-demographic variables such as gender, age, and household income.

Results

Key benefits of APs. We first analyzed the key benefits of the AP based on those customers who owned the product (n = 8,512). Out of the eleven benefits provided, customers rated time savings as the second most important benefit of the autonomous cooking device (M = 6.19), after fun (M = 6.43) but before convenience (M = 6.11), ease of use (M = 5.96), and quality of life (M = 5.80; the means and individual contrasts are reported in web appendix 1). These descriptive statistics provide initial evidence that, consistent with our predictions, time savings and convenience are among the most important benefits of APs.

Perceived stress. Our key hypothesis about the reduction of perceived stress by using APs was supported by comparing the sample of actual versus prospective customers. Those who owned an AP showed less stress compared to those who did not, as evidenced by a Welch’s t-test that accounts for the unequal sample sizes between groups (M_{AP} = 4.79, SD = 1.41, M_{NoAP} = 5.01, SD = 1.30; t(384) = 3.07, p = .002, d = .15). The effect was robust when controlling for age (also included as squared), gender, and income (B = .15, SE = .07, t = 2.12, p = .034).

Duration of ownership on perceived stress. We next analyzed whether perceived stress was contingent on how long customers owned the AP, given one could argue that the longer customers operate their APs, the less stressed they should feel. Consistent with this possibility, a linear model showed a negative effect of ownership duration on perceived stress (B = -.08, SE = .02, t = -3.24, p = .001).
**Additional analysis.** Given the field nature of this study, we examined whether owners and non-owners of the AP differed in terms of their demographics. Owners differed from non-owners with respect to their age ($M_{AP} = 45.90, SD = 10.98, M_{NoAP} = 43.00, SD = 11.75$; $t(8860) = 4.92, p < .001, d = .27$) and gender ($P_{[Female]}_{AP} = 96.8\%, P_{[Female]}_{NoAP} = 95.8\%$; $\chi^2(1) = 3.87, p = .05$), but not regarding their household income ($p = .83$). Thus, we used propensity score matching to further rule out any variation in terms of the covariates that could have caused the observed effects. Results confirmed that owners perceived less stress than prospective owners (see web appendices 2-4) even after controlling for differences between the samples.

**Discussion**

Study 1 provided correlational field evidence for a necessary assumption of our research: that APs (vs. non-APs) are related to lower stress through time savings (providing initial evidence on the a-path of the mediation proposed in H2). Notably, this study examined an AP that replaced a task that consumers are likely to find identity-relevant (i.e., cooking; Leung et al. 2018)—which may explain the robust, yet small association with stress observed in this study.

One downside of this study is that we were not able to gauge consumer well-being due to the limited number of items we could include in this field study. Another concern of any field study is self-selection. Notably, the results did not change when controlling for key demographical variables and when using propensity score matching, which indicates that the usage of the AP is likely to have been a primary predictor of the variations in terms of time stress that we observed in the study. Nevertheless, current, and prospective customers might have differed on other, not measured variables in this study. Finally, this study measured daily stress in general and not time stress specifically. The next studies replicate the effect and explore the relationship between lower time stress and greater well-being in more controlled settings.
STUDY 2: CAUSAL EVIDENCE ON CONSUMER WELL-BEING

Study 2 was designed with the key objective of providing causal evidence about whether owning and operating APs increases consumer well-being (H1). A second objective was to shed light on the psychological mechanism underlying the effect, that is, to test whether perceived time stress mediates the effect of APs on consumer well-being (H2). The study was preregistered (https://aspredicted.org/blind.php?x=jw5wf3).

Method

Procedure. We recruited 303 participants from Amazon MTurk ($M_{Age} = 36.9$, $SD = 12.0$, 41% female). We slightly oversampled relative to the preregistration (three additional participants). Participants first answered several questions about themselves (e.g., busyness, time importance, and their identification to be a homemaker), which served as control variables. Participants next read a definition of APs (see web appendix 5) and were then randomly assigned to one of two conditions in a between-subjects experimental design (AP vs. non-AP).

Participants in both conditions imagined a day in which they completed several work and leisure activities (e.g., meeting friends, watching TV, going shopping; see web appendix for all stimuli and manipulations across studies). The study used three different APs (and their traditional counterparts) as products: a vacuum cleaner, a mop, and a lawn mower. In the AP condition, participants imagined that some of the tasks (i.e., vacuum cleaning, mopping, as well as lawn mowing) were completed by APs, while participants in the non-AP condition imagined that they had to complete these tasks partly manually, using conventional products (i.e., a vacuum cleaner, a mop, and a lawnmower; see web appendix 6 [of the AP condition]). All measures were preregistered and reported.
Measurement. We employed one primary measure of consumer well-being: a six-item positive and negative emotion scale, the SPANE (“Thinking about the imagined day, report how much you experienced each of the following feelings listed below”; items: “Positive,” “Negative” (reverse coded), “Good,” “Bad” (reverse coded), “Unpleasant” (reverse coded), “Pleasant”; 1 = “Very rarely / never” to 5 = “Very often / always”; α = .88; Diener et al. 2009).¹

In addition, we measured perceived time stress (“I would feel pressed for time,” “I would feel under time pressure,” “I would feel rushed,” “Compared to other days, I would feel more stressed out about my time,” “I would feel pressured for time,” “I would feel stressed out,” “I would feel like I don’t have enough time,” “Time would be my scarcest resource,” “My time would be extremely valuable to me”; 1 = “Strongly disagree” to 7 = “Strongly agree”; α = .96; Whillans et al. 2017). Web appendix 26 provides discriminant validity analyses of the key constructs in each of the studies. The discriminant validity of each of the constructs across the studies is supported.

We included additional measures that served as control variables (all assessed on 7-point Likert scales; 1 = “Strongly disagree” to 7 = “Strongly agree”): respondents’ time importance (“I always use my time to ‘get things done’,” “I do not squander away my time,” “In general, I would say I’m the type of person who values my time”; α = .75), participants’ busyness (“I am too busy to relax,” “I am often juggling my time between too many things,” “‘So much to do, so little time,’ this saying applies very well to me”; α = .85; Reed II et al. 2007), as well as the extent to which respondents’ identified as being a homemaker (“I take pride in taking care of my home,” “There are more important things in life than simply taking care of my home” (reverse

¹ We also included a one-item subjective well-being measure (“Taking all things together, how happy would you be on the imagined day in the scenario?”; 1 = “Not at all” to 10 = “Extremely”; Diener, 1999). The results on this one-item measure are consistent with the six-item measure of well-being and are reported across all studies in web appendix 7. Following research on consumption and happiness, which suggests greater variability of the mood items in response to consumption (Aknin, Dunn, Whillans 2022), we focus on mood vs. overall well-being items in text.
coded), “Taking care of my home is just something one does, nothing to feel great about” (reverse coded); α = .51; Mittal 1994).

Results

**Consumer well-being**. Consistent with our predictions, we found that product type had a significant effect on our key measure (six-item scale) of consumer well-being ($M_{AP} = 4.07$, $SD = .90$, $M_{NoAP} = 3.82$, $SD = .84$; $t(301) = 2.50$, $p = .013$, $d = .29$). This result was robust after controlling for importance of time, being a homemaker, and busyness ($p = .010$). Thus, imagining using APs increased consumer well-being relative to imagining using non-APs (H1).

**Perceived time stress**. We also found that product type had a significant effect on perceived time stress ($M_{AP} = 3.40$, $SD = 1.69$, $M_{NoAP} = 4.31$, $SD = 1.69$; $t(301) = 4.66$, $p < .001$, $d = .54$) such that the imagined use of APs reduced the perception of time stress. This result was robust after controlling for importance of time, being a homemaker, and busyness ($p < .001$).

**Mediation via perceived time stress**. As preregistered, we ran a mediation analysis (Hayes 2012, model 4) using APs (vs. non-APs) as the independent variable, perceived time stress as mediator, and consumer well-being as the dependent variable. Results supported the mediational role of perceived time stress, as indicated by the significant indirect effect via perceived time stress ($B = .25$, $SE = .06$, CI95 = [.14; .38]). The direct effect became non-significant ($B = -.003$, $SE = .09$, CI95 = [-.17; .17]), therefore indicating full mediation. Accordingly, perceived time stress mediated the effect of APs (vs. non-APs) on consumer well-being (H2; see figure 2).

![FIGURE 2](image-url)

**FIGURE 2**

PERCEIVED TIME STRESS MEDIATES THE EFFECT OF APS (VS. NON-APS) ON CONSUMER WELL-BEING
Discussion

The findings of Study 2 demonstrate the robustness of the positive impact of APs (vs. non-APs) on consumer well-being (H1). Importantly, these findings provide causal evidence for this effect and shed light on its underlying psychological mechanism. Specifically, the positive effect of APs on consumer well-being unfolds through reductions in perceived time stress (H2).

Two additional studies were conducted, which provide a conceptual replication of the results of this study (web appendix 15) and show that APs increase consumer well-being (and not that non-APs decrease it; see web appendix 17). The next study provides direct evidence for the proposed mechanism by manipulating the mediator.

**STUDY 3: CAUSAL EVIDENCE ON TIME STRESS**

Study 3 aimed at providing causal evidence on perceived time stress as the underlying process of the effect of APs (vs. non-APs) on consumer well-being (H2). The study was preregistered (https://aspredicted.org/blind.php?x=3aa56z).

Method

*Procedure.* We recruited 248 participants from Amazon MTurk (*M*<sub>Age</sub> = 41.9, *SD* = 13.5, 53% female) who were randomly assigned to one of three between-subjects conditions (AP, non-AP, AP no time gain). We slightly oversampled relative to the preregistration (eight additional
participants). The procedure resembled that of Study 2 in that participants imagined a day on which they had to complete several tasks with the help of a product. The study focused on different products (i.e., vacuum cleaners, floor cleaners, and lawnmowers; see web appendix 8) and included study 2’s AP and non-AP conditions.

To provide causal evidence for the mediating role of perceived time stress, we chose to subtly manipulate time gain given that any direct manipulation of perceived time stress might lead to demand effects. To manipulate time gain, we included a third condition (AP no time gain) in which participants imagined using APs to complete their chores but without gaining any time because they would have to monitor the AP during task completion (“…your autonomous vacuum cleaner vacuums the house. You control the autonomous product by watching it” and “Your autonomous lawn mower completes this task for you, and you again closely monitor the product doing the work”).

Measurement. We used the same measures of consumer well-being ($\alpha = .93$) and perceived time stress ($\alpha = .96$) as in Study 2. As noted, we indirectly manipulated time stress via time saved. Thus, we used an additional manipulation check that asked participants how much time they had available (“How much time would you have freely available on that imagined day?”; $1 = “$No time at all,” $10 = “A lot of time”). All measures were preregistered and reported.

Results

Manipulation checks. A one-way ANOVA confirmed that the AP led to higher expected time available ($M_{AP} = 6.23$, $SD = .87$) as compared to the AP with no time gain ($M_{AP\_NoTimeGain} = 4.29$, $SD = 1.78$) and no AP use condition ($M_{NoAP} = 3.62$, $SD = 1.62$; $F(2, 245) = 76.21, p < .001$, $\eta^2 = .38$). All contrasts were significant ($ps < .001$). As expected, participants in the AP condition reported the highest expected time gain.
**Perceived time stress.** A one-way ANOVA confirmed that the AP lowered perceived time stress significantly ($M_{AP} = 2.30, SD = 1.16, M_{AP\_NoTimeGain} = 3.15, SD = 1.55, M_{NoAP} = 4.08, SD = 1.83; F(2, 245) = 29.4, p < .001, \eta^2 = .19$). All contrasts were significant ($ps < .001, ds > .56$). As expected, participants in the AP condition showed the lowest perceptions of time stress. Participants in the AP no time gained condition reported time stress that was significantly higher than the AP condition and significantly lower than the no AP condition. In short, the manipulation had the intended effect on time gains and perceived time stress.

**Consumer well-being.** A one-way ANOVA revealed that product type significantly affected consumer well-being ($M_{AP} = 4.34, SD = .78, M_{AP\_NoTimeGain} = 3.99, SD = .86, M_{NoAP} = 3.86, SD = .89; F(2, 245) = 7.70, p < .001, \eta^2 = .06$). Follow-up contrasts showed that participants in the AP condition reported greater well-being than participants in the non-AP condition ($t = 3.76, p < .001, d = .53$) and the AP no time gain conditions ($t = 2.70, p = .022, d = .42$). The contrast between the AP no time gain and non-AP condition was not significant ($t = 1.00, p = .97, d = .16$). Thus, the manipulation whereby participants used an AP that did not save time significantly reduced well-being, such that participants experienced similar well-being benefits as those assigned to the non-AP condition. These findings provide evidence that time-saved is a critical factor that drives the benefits of APs as compared to non-APs.

**Mediation via perceived time stress.** We conducted two mediation analyses: one for the contrast between the AP and non-AP condition and one for the contrast between the AP and AP no time gain condition (Hayes 2012, model 4). The first mediation analysis showed that reduced time stress explained the positive effect of APs on consumer well-being. The indirect effect via time stress was significant ($B = .25, SE = .08, CI95 = [.11; .43]$) while the direct effect became non-significant ($B = .10, SE = .12, CI95 = [-.13; .33]$), indicating full mediation. This
corroborated Study 2’s findings on the contrast between APs and non-APs by showing that APs improved well-being when they reduced time stress (see figure 3A).

The second mediation analysis (for the contrast between the AP and AP no time gain condition) provided causal evidence for the underlying mechanism. The indirect effect via perceived time stress was significant ($B = .49, SE = .11, CI95 = [.30; 72]$) while the direct effect became non-significant ($B = -.01, SE = .12, CI95 = [-.25; .22]$), indicating full mediation. Thus, by manipulating the mediator, we provided causal evidence that increasing time saved is one of the underlying causes of the effect of APs on consumer well-being (see figure 3B).
Discussion

Study 3 manipulated the time that could be saved through APs and showed that time stress significantly explained the well-being benefits consumers experience when they use this novel class of products. APs promote well-being if they reduce perceived time stress. Consumers who used APs that did not save time did not experience any well-being benefits as compared to completing the task themselves. By contrast, consumers who used APs experienced the previously documented increase in well-being via reductions in time stress. Thus, this study provides causal evidence for the importance of time savings and the subsequent reduction of time stress as being the psychological process underlying the beneficial effect of APs (vs. non-APs) on consumer well-being (H2). The next study compares APs to other ways of saving time.
STUDY 4: CAUSAL EVIDENCE ON HUMAN LIKENESS

The key objective of Study 4 was to provide causal evidence for the moderating role of AP human likeness. We manipulated the human likeness of APs, theorizing that human-like (vs. non-human-like) APs should lead to increased feelings of guilt and, in turn, to reduced consumer well-being (H4, H5). The study was preregistered (https://aspredicted.org/blind.php?x=ew28p2).

Method

Procedure. We recruited 457 participants from Amazon MTurk ($M_{Age} = 40.02, SD = 14.02, 63\%$ female). We slightly oversampled, with seven participants more in the sample relative to the preregistration. Participants were randomly assigned to one of three conditions (AP low human likeness vs. AP high human likeness vs. human). The study focused on vacuum cleaners as the product domain. Like the previous studies, participants in all conditions imagined a day in which they had to complete a task, namely vacuuming their home. In the AP low human likeness condition, participants were told that the AP (i.e., a Roomba) would complete the vacuuming for them and that it was merely a “usage object” (see web appendix 10). In the AP high human likeness condition, participants were also told that the AP would complete the vacuuming for them. In addition, they read that the AP was “more than an object” and that they would call it by a nickname (“Jenny”), making it seem “almost like a human being.” In the human condition, participants were told that a house cleaner would complete the vacuuming for them. We chose not to manipulate human likeness in the human condition, because of the systematic differences in terms of human likeness across the AP and human conditions, which would make it difficult to orthogonally manipulate this variable. In all conditions, participants imagined the same scenario. Then, participants completed measures of human likeness, guilt,
well-being, future purchase, and time stress. Participants completed the study by providing
demographical information and answering a hypothesis guessing question (see web appendix 13).

**Measurement.** We measured consumer well-being (α = .92) and perceived time stress (α = .95) as in the previous studies. Participants reported their perceptions of human likeness of the products or the house cleaner on a 7-item scale (“When you imagined [the Roomba / Jenny / the house cleaner], to what extent did [the Roomba / Jenny / the house cleaner] ...”, “... have characteristics that you would expect of a human?” “...look like a machine or mechanical device?” (reversed), “... act like a machine?” (reversed), “... act like a person?” “... look like a person?” “... have human-like attributes?” “... have machine-like attributes?” (reversed); 1 = “Not at all” to 7 = “Very much”; Clegg et al. 2023; α = .96). Participants also indicated their feelings of guilt over having to outsource the task using two items (“When thinking about outsourcing the vacuum cleaning to [the Roomba / Jenny / the house cleaner] to what extent did you feel guilty?”, ranging from 1 = “Not guilty” to 10 = “Guilty”; “Did you in any way feel bad to outsource so many tasks to [the Roomba / Jenny / the house cleaner]?”, ranging from 1 = “Not at all bad” to 10 = “Very bad”; r = .89). While we pre-registered only the first item because it has higher face validity, we also measured the second item to remain consistent with the other studies that measure guilt. The results are robust when only using the first item for the analyses. Finally, we measured future purchase intention as an exploratory variable (as the focus of the current research is on usage consequences and not product adoption; see web appendix 12). This variable was included merely for exploratory purposes (no effects were preregistered and there were no significant differences between conditions).

Results
**Human likeness.** A manipulation check demonstrated that the manipulation of human likeness was successful. A one-way ANOVA showed a significant effect of the manipulation on human likeness ($M_{AP\_Low\_Human} = 1.62, SD = .89$, $M_{AP\_High\_Human} = 2.99, SD = 1.39$, $M_{Human} = 4.59$, $SD = 2.20$; $F(2, 454) = 139.3, p < .001, \eta^2 = .38$). The contrast between the AP low human likeness condition and the AP high human likeness ($t = 7.67, p < .001, d = .88$) and human conditions ($t = 16.69, p < .001, d = 1.89$) were significant. Also, the contrast between the AP high human likeness condition and the human condition was significant ($t = -8.71, p < .001, d = -1.02$). These results indicate that the manipulation was successful. As expected, participants in the human condition rated the human to be more human-like than the high human likeness AP.

**Consumer well-being.** A one-way ANOVA tested the effects of the manipulation on well-being ($M_{AP\_Low\_Human} = 4.24, SD = .63$, $M_{AP\_High\_Human} = 4.10, SD = .75$, $M_{Human} = 4.05, SD = .72$; $F(2, 454) = 2.95, p = .053, \eta^2 = .01$). The contrast between the AP low human likeness and the human condition ($t = 2.34, p = .020, d = .27$) was significant, while the contrast between the AP low human likeness and the AP high human likeness condition was marginally significant ($t = 1.70, p = .091, d = .19$). There was no difference between the AP high human likeness condition and the human condition ($t = .61, p = .54, d = .07$). APs tended to increase well-being beyond delegating tasks to the human, but not when the AP was high in terms of human likeness.

**Feelings of guilt.** A one-way ANOVA revealed that the conditions had a significant effect on felt guilt ($M_{AP\_Low\_Human} = 1.59, SD = 1.20$, $M_{AP\_High\_Human} = 2.83, SD = 2.45$, $M_{Human} = 2.84, SD = 2.56$; $F(2, 454) = 17.91, p < .001, \eta^2 = .07$). The AP low human likeness conditions significantly reduced feelings of guilt of delegating the task as compared to the human ($t = 5.17, p < .001, d = .59$) and the AP high human likeness conditions ($t = 5.10, p < .001, d = .58$). The human condition did not differ from the AP high human likeness condition ($t = .03, p = .98, d = .004$). Thus, only APs that do not resemble humans reduce the felt guilt of outsourcing a task.
This supports the proposition that the human likeness of the AP moderates the effect of APs (vs. delegating the task to human house cleaners) on felt guilt (H5).

Feelings of guilt as mediator. In line with the preregistered procedure, we conducted a mediation analysis (Hayes 2012, model 4) with condition (AP low human likeness = 0, human = 1) as the independent variable, felt guilt as mediator, and well-being as the dependent variable. The indirect effect via felt guilt was significant ($B = -.20$, $SE = .04$, CI95 = [-.29; -.12]). The direct effect became non-significant ($B = .01$, $SE = .07$, CI95 = [.01; .15]). Thus, felt guilt to delegate the task mediated the effect of a non-human-like AP—which we consider to be still the default in terms of current consumer products—compared to delegating the task to humans.

Running the same analysis but contrasting AP low human likeness (= 0) with AP high human likeness (= 1) also produced a significant indirect effect ($B = -.19$, $SE = .05$, CI95 = [-.29; -.11]) and a non-significant direct effect ($B = .05$, $SE = .08$, CI95 = [.10; .20]). We repeated the analyses using time stress as additional control variable (see web appendix 11, also for additional analyses on a hypothesis guessing question).

Perceived time stress. As the focus of this study was to examine the role of feelings of guilt, the results for perceived time stress are shown in web appendix 14.

Discussion

This study provided causal evidence for the mediating effect of feelings of guilt about delegating tasks (H4) as well as the moderating effect of human likeness of the AP on the previously mentioned effect (H5). Manipulating human likeness has significant managerial implications: Product designers can use these results when sketching out new products and deciding on whether they want to include human attributes. A study reported in web appendix 19 corroborates this moderation effect by measuring (instead of manipulating) human likeness. The
results show that human likeness can indeed backfire, as consumers feel more guilty about delegating their tasks to a human-like AP, which ultimately undermines their well-being.

**STUDY 5: FIELD EVIDENCE ON SOCIAL MEDIA**

Study 5 was designed with the objective of obtaining evidence on whether APs are closely connected to consumer well-being, time, guilt, and stress in a naturalistic context. In this study, we collected consumer tweets from the social media platform Twitter and provided an extensive linguistic profile of how people write about their APs (vs. non-APs and delegating to humans).

**Method**

*Procedure*. We scraped tweets from English-speaking Twitter users via its application programming interface (API). Specifically, we searched for tweets that contained one of the 40 most common autonomous and non-autonomous vacuum cleaners. In addition, we searched for tweets that contained words related to delegating cleaning to other humans (e.g., “cleaning person,” see web appendix 24). To exclusively obtain tweets from consumers (and not of companies), we only retained tweets of users that did not specify a firm website in their Twitter account. This resulted in a sample of 40,813 tweets. After collecting the tweets on APs and non-APs, we collected the ones on delegating to humans.

*Measurement*. Next, we coded the tweets using dictionary-based approaches (LIWC and Lasswell dictionary) that identified words related to time, well-being, and human names (as per our hypotheses on human likeness; H5). For example, one tweet read: “Our Roomba successfully mapped our house and it just did its first cleaning without hitting any walls… you would have thought my non-existent child was walking for the first time with my excitement hahaha,” illustrating that some people consider their AP to be more than a product.
Moreover, we used the same dictionaries to code leisure- and work-related words to provide additional insights into how people talk about APs. While no measure for perceived time stress was included in either of the two dictionaries, we used all synonyms for the word “distress” (\texttt{stress*} would be ambiguous given that it also related to “emphasize”) as well as “relaxation” (\texttt{relax*}) and counted the number of occurrences in each of the tweets. This validates whether people discussed APs in terms of relaxation versus stress. All measures were divided by the number of words used in the posts to ensure that the results were not affected by the number of words, log-transformed (given that they are count measures and were right-skewed) and standardized such that the lowest value was zero.

Results

\textit{Well-being-related words}. A one-way ANOVA revealed that the products consumers tweet about are significantly associated with their well-being ($M_{\text{AP}} = .50, SD = 1.02, M_{\text{NoAP}} = .28, SD = .72, M_{\text{Human}} = .45, SD = .95; F(2, 40810) = 30.25, p < .001, \eta^2 = .001$). Follow-up contrasts showed that consumers use significantly more words connected to well-being when referring to APs than when referring to non-APs ($t = 6.65, p < .001, d = .22$) or humans ($t = 4.62, p < .001, d = .05$). The difference between human and non-APs was significant as well ($t = 4.91, p < .001, d = .17$). Thus, consumers who refer to APs are more talking about well-being than consumers talking about non-APs or delegating to humans.

All other results are reported in Table 1. Overall, it becomes evident that Twitter users refer to APs more in terms of well-being, time, relaxation, and leisure, and less in terms of work and stress than those referring to APs. Compared to Twitter users who refer to human house cleaners, Twitter users refer to APs more in terms of well-being, time, and relaxation, but less in
terms of guilt. Similarly, consumers use more words related to humans than to objects when referring to their APs.

**TABLE 1**

THE RESULTS OF APS (VS. NON-APS AND HUMANS) ON ALL WORDS RELATED TO THE PROPOSED KEY CONSTRUCTS*

<table>
<thead>
<tr>
<th>DV</th>
<th>AP</th>
<th>Non-AP</th>
<th>Human</th>
<th>ANOVA</th>
<th>AP vs. Non-AP</th>
<th>AP vs. Human</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>Well-being</td>
<td>.50</td>
<td>1.02</td>
<td>.28</td>
<td>.72</td>
<td>30.25</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Time</td>
<td>.67</td>
<td>1.00</td>
<td>.50</td>
<td>.85</td>
<td>15.32</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Stress</td>
<td>.39</td>
<td>1.03</td>
<td>.76</td>
<td>1.28</td>
<td>116.03</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Relaxation</td>
<td>.32</td>
<td>1.09</td>
<td>.18</td>
<td>.77</td>
<td>70.77</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Leisure</td>
<td>.32</td>
<td>1.05</td>
<td>.11</td>
<td>.49</td>
<td>18.72</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Work</td>
<td>.50</td>
<td>.95</td>
<td>1.63</td>
<td>1.29</td>
<td>617.67</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Guilt</td>
<td>.16</td>
<td>.97</td>
<td>.14</td>
<td>.89</td>
<td>9.59</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Figure 4 provides a profile of how consumers talk about APs (vs. non-APs and humans) showing that consumers use language that is more related to humans (vs. objects), relaxation (vs. stress), leisure (vs. work or stress), and time as well as well-being.
Moderation of human likeness on well-being. We followed up on the results about human-related words and object-related words with a moderation analysis, using APs (vs. human) as independent variable, the log number of names (obtained from the Lasswell dictionary) as a measure of human likeness and moderator, and well-being as the dependent variable. Results showed that the ratio negatively moderated the effect of APs on well-being ($B_{AP \times \text{HumanLikeness}} = -2.11, t = -2.93, p = .003; B_{\text{HumanLikeness}} = .86, t = 1.51, p = .13; B_{AP} = .06, t = 5.08, p < .001$). Thus, when consumers used names when talking about their APs, the positive effect of APs on well-being was significantly decreased. The results are illustrated in Figures 5A and 5B.

Moderation of human likeness on guilt. We used the same model as above but with guilt as the dependent variable. Results showed that the ratio negatively moderated the effect of APs on well-being ($B_{AP \times \text{HumanLikeness}} = 3.80, t = 5.28, p < .001; B_{\text{HumanLikeness}} = -2.71, t = -4.77, p < .001$;
$B_{AP} = -.07, t = -5.55, p < .001$). Thus, when consumers used names when talking about their APs, the positive effect of APs on felt guilt decreased significantly.

**FIGURE 5**

HUMAN LIKENESS MODERATES THE EFFECT OF APS (VS. NON-APS) ON
(A) WELL-BEING AND (B) FEELINGS OF GUILT

(A)

(B)

Notes: Shaded areas represent 95% confidence intervals.

Discussion

Study 5 extended our evidence using naturalistic and publicly available data from Twitter and showed that the linguistic profiles of how consumers describe their APs in their tweets closely follow the results provided by both the field study and the controlled experiments: APs are connected to well-being (H1), time, and relaxation, whereas conventional products are more connected to words related to work and stress (H2). At the same time, the ratio between human-vs. object-related words moderated the effect of APs (vs. humans) on well-being and guilt (H5).

Whereas the presented data constitute uncontrolled field evidence, the results were congruent with all hypotheses that potentially could be observed in these data. Thus, the results
from these naturalistic and publicly available Twitter data conceptually replicate the findings from the experimental studies by showing that perceived time stress and human likeness are key moderators of the effect of APs on consumer well-being.

**GENERAL DISCUSSION**

Products are becoming increasingly autonomous, able to govern their own behavior to complete tasks on behalf of consumers. This research examines the distinct usage consequences of this novel class of products for consumers. We conducted a series of studies in various settings to examine whether, how, and when APs can impact a key outcome—consumer well-being.

Study 1, a correlational field study, showed that owning and operating APs is related to reduced stress (H2). Studies 2 and 3 provided causal evidence for this hypothesis and revealed that the effect of APs on consumer well-being operates via reduced time stress driven by saving time through these purchases (H1, H2). Together, Studies 1 to 3 show that the key process by which APs increase well-being against non-APs is the reduction in perceived time stress. Study 4 found that whereas both entities reduce perceived time stress, delegating tasks to APs reduces guilt and results in greater consumer well-being than delegating tasks to housecleaners (H4), but only when the ascribed human likeness of the product is low (H5). Finally, Study 5 used naturalistic and publicly available field data (from Twitter) to show that the demonstrated effects also materialize in people’s language when they talk about APs.

Taken together, we found evidence for two key processes that explain the relationship between APs and consumer well-being depending on which reference category is used. Comparing APs to completing a task with non-APs, the key process is a reduction in perceived time stress. Comparing APs to delegating a task to other humans, the key process is perceived guilt. For the latter, we also identify a critical moderator: If consumers ascribe human
characteristics to APs, the effect on perceived guilt flips. In this case, consumers feel guiltier about APs, with negative implications for their well-being.

Theoretical Contributions

Our findings make several theoretical contributions: First, we examine a key characteristic of APs (i.e., to save time) and the implications of this characteristic for consumer well-being. Prior work in this area has mainly focused on the antecedents of the adoption of APs (Jörling et al. 2019; Leung et al. 2018; Longoni, Bonezzi, and Morewedge 2019; Puntoni et al. 2021; Schweitzer and Van den Hende 2016), yet the consequences of using those products in one’s daily lives have not been well-understood (see Whillans et al. 2020 for a similar argument). Thus, we advance the literature on APs by showing that these products can significantly contribute to consumers’ well-being, and we provide initial evidence that this novel class of products may have significant implications for consumers’ daily lives. It is important to note that the degree of autonomy can play a vital role as it relates to the amount of time that is saved. It is also important to consider that this investigation only focused on autonomous products, but not autonomous services. With the advent of the AI chat platform ChatGPT (http://chat.openai.com), autonomous services have reached consumers’ lives. Future work could test the consequences of AI services for perceived time stress as well as consumer well-being.

Identifying reduced time stress as the underlying process also contributes to the literature on the importance of time, which is a proliferating research field in psychology (Rudd, Catapano, and Aaker 2019; Whillans et al. 2016). While prior work examining the effects of saving time by delegating tasks has found that spending money on time-saving services can promote well-being, time-saving purchases can result in guilt when consumers delegate tasks to other people (Whillans et al. 2020). Our findings show that APs do not necessarily lead to those feelings of
guilt—unless people anthropomorphize their products and consider them as human-like beings. Thus, we advance this stream of literature by practically showing that products can potentially overcome one of the key limitations that prevent the benefits of outsourcing on consumer well-being to unfold: feelings of guilt. One avenue for future research related to guilt is that some people might replace their house cleaners with autonomous products—which again might lead to feelings of guilt for not employing the house cleaner. While our studies conclusively show that the level of guilt when outsourcing to autonomous products is lower than when outsourcing to house cleaners, future work could focus on situations in which autonomous products replace jobs and understand consumers’ feelings of guilt in response to these actions.

In web appendix Study 3 (web appendix 19), we explored whether the activities people imagined completing with their additional free time predicted the benefits of APs. We conducted this investigation based on research showing that the value of time can depend on how this time is used (Graham 1981; Okada and Hoch, 2004). For example, recent research finds that consumers’ well-being rises when they allocate more time to active leisure activities such as socializing or exercising (Holder, Coleman, and Sehn 2009; Smeets et al. 2020). While we did not find evidence that advertisements highlighting different leisure activities had a marked effect on well-being, future research could directly examine whether using the time saved by APs for such activities (vs. imagining using the time) increases consumer well-being.

We were able to collect ecologically valid samples, including a field study that used respondents to a newsletter of a manufacturer of a popular autonomous cooking device (Study 1) and observational data about how people discuss APs on Twitter (Study 5). Future research should build on these findings by conducting a field experiment to examine how consumers’ well-being develops over time in response to receiving an AP, depending on the core variables that we have identified here of anthropomorphism, perceived time stress, and guilt. Only such a
design could reveal whether the effects documented here hold over a longer period (as also indicated by the effect of ownership duration on perceived time stress) or whether the effects fade after consumers habituate to owning and operating APs.

Practical Implications

The findings of this research also make several significant practical contributions. First, our finding that the key process by which APs affect consumer well-being is linked to saving time suggests that product developers should also consider this feature when designing APs, while marketers should highlight this in their communications. For instance, the German household appliance company Vorwerk promotes their autonomous cooking device Thermomix—a multi-purpose kitchen appliance that takes over tasks such as whipping, stirring, or grinding and can cook entire meals on its own—with “more family time” and “Thermomix does the work so you can make time for what matters most” (see thermomix.com).

Second, product designers often choose to make consumers interact with their products and make them involved with their products on a regular basis such as by adjusting the settings or providing information via smartphone applications that encourage consumers to constantly interact with the product, like the smartphone application of British company Dyson. In contrast to these market trends, our findings show that less interaction between consumers and APs may lead to positive benefits for consumer well-being. To reap the well-being benefits of APs, product designers should maximize the autonomy of those products and design them such that consumers minimize time spent dedicated to operating these products.

Reviewing our findings on the effects of the human likeness of APs, product developers and designers may also refrain from designing APs that are very human-like. Instead of requiring consumers to choose names for their products or interacting with those products as if they were
humans, reminders could be set that the products have been designed for executing the tasks that they were built for to eliminate consumers’ feelings of guilt and benefit consumers’ happiness.

Finally, consumers have the potential to benefit from the implications of this research. First, consumers could avoid monitoring their APs while these products are completing work. Continuously monitoring APs could reduce the time that consumers gain from operating their APs and could also reduce the positive effects on consumer well-being. Second, consumers could refrain from considering their APs as more than just products (i.e., as human-like creatures). We found that the more consumers view their APs as similar to humans, the greater the level of guilt they experienced, which could diminish some of the benefits of these products for well-being.
REFERENCES


Lok, Iris and Elizabeth W. Dunn (2022), “Are the benefits of prosocial spending and buying time moderated by age, gender, or income?” *PLOS ONE*, 17 (6).


*Journal of Consumer Research*, 31 (September), 313–23.

Puntoni, Stefano, Rebecca Walker-Reczek, Markus Giesler, and Simona Botti (2021),


Rae, Haniya (2020), “Can a Robotic Vacuum Replace Your Upright?”

https://www.consumerreports.org/robotic-vacuums/can-a-robotic-vacuum-replace-your-canister-or-upright-a1557864633/


Web Appendix

Less Time Stress and Guilt:

When and Why Autonomous Products Increase Consumer Well-Being
# LIST OF CONTENT

Web appendix 1: (A) Means, (B) contrasts, and (C) illustration of benefits of APs (study 1) ........3  
Web appendix 2: Propensity score matching (study 1) ........................................................................5  
Web appendix 3: Difference in means and SDs by matching algorithms (study 1) .........................6  
Web appendix 4: The effect of AP on stress for different matching algorithms (study 1) ............7  
Web appendix 5: Introduction to APs (studies 2-4, web appendix studies 1-3) .........................8  
Web appendix 6: Stimuli (study 2) ................................................................................................9  
Web appendix 7: Results for the one-item measure of consumer well-being (studies 2-4) .......10  
Web appendix 8: Stimuli (study 3) ...............................................................................................13  
Web appendix 9: Manipulation check (study 3) ..........................................................................14  
Web appendix 10: Stimuli (study 4) .............................................................................................15  
Web appendix 11: Mediation analyses including perceived time stress as control (study 4) ....17  
Web appendix 12: Analysis of product adoption intention (study 4) ............................................18  
Web appendix 13: Analysis of hypothesis guess question (study 4) ..........................................19  
Web appendix 14: Analysis of perceived time stress (study 4) ....................................................21  
Web appendix 15: Web appendix study 1 “conceptual replication of study 2” .........................22  
Web appendix 16: Stimuli (web appendix study 1) .................................................................26  
Web appendix 17: Web appendix study 2 “comparison against true control” ...........................27  
Web appendix 18: Stimuli (web appendix study 2) .................................................................30  
Web appendix 19: Web appendix study 3 “APs compared to other time-saving purchases” ......31  
Web Appendix 20: Stimuli (web appendix study 3) .................................................................40  
Web appendix 21: Advertisement stimuli (web appendix study 3) .............................................41  
Web appendix 22: Results of the two-way ANOVAs (web appendix study 3) ...............................43  
Web Appendix 23: Analysis of hypothesis guess question (web appendix study 3) .................44  
Web appendix 24: Search terms and frequency (study 5) .............................................................46  
Web appendix 25: Key results across studies (studies 1-5) .........................................................47  
Web appendix 26: Discriminant validity analyses ....................................................................49  
References ......................................................................................................................................50
Web appendix 1: (A) Means, (B) contrasts, and (C) illustration of benefits of APs (study 1)

(A)

<table>
<thead>
<tr>
<th>Benefit</th>
<th>M</th>
<th>SE</th>
<th>Lower CI95%</th>
<th>Upper CI95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Better</td>
<td>5.35</td>
<td>.01</td>
<td>5.32</td>
<td>5.37</td>
</tr>
<tr>
<td>Comfort</td>
<td>5.80</td>
<td>.01</td>
<td>5.78</td>
<td>5.83</td>
</tr>
<tr>
<td>Convenience</td>
<td>6.11</td>
<td>.01</td>
<td>6.09</td>
<td>6.14</td>
</tr>
<tr>
<td>Cost</td>
<td>5.10</td>
<td>.01</td>
<td>5.08</td>
<td>5.13</td>
</tr>
<tr>
<td>Discover</td>
<td>5.74</td>
<td>.01</td>
<td>5.71</td>
<td>5.76</td>
</tr>
<tr>
<td>Ease</td>
<td>5.96</td>
<td>.01</td>
<td>5.93</td>
<td>5.98</td>
</tr>
<tr>
<td>Fun</td>
<td>6.43</td>
<td>.01</td>
<td>6.41</td>
<td>6.46</td>
</tr>
<tr>
<td>Healthy</td>
<td>5.61</td>
<td>.01</td>
<td>5.58</td>
<td>5.63</td>
</tr>
<tr>
<td>Sustainability</td>
<td>5.38</td>
<td>.01</td>
<td>5.36</td>
<td>5.41</td>
</tr>
<tr>
<td>Technology</td>
<td>5.43</td>
<td>.01</td>
<td>5.41</td>
<td>5.46</td>
</tr>
<tr>
<td>Time</td>
<td>6.19</td>
<td>.01</td>
<td>6.17</td>
<td>6.22</td>
</tr>
</tbody>
</table>

(B)

<table>
<thead>
<tr>
<th>Benefit 1</th>
<th>Benefit 2</th>
<th>B</th>
<th>SE</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>better</td>
<td>comfort</td>
<td>-.45</td>
<td>.02</td>
<td>-24.61</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>convenience</td>
<td>-.76</td>
<td>.02</td>
<td>-41.53</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>cost</td>
<td>.24</td>
<td>.02</td>
<td>13.30</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>discover</td>
<td>-.39</td>
<td>.02</td>
<td>-21.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>ease</td>
<td>-1.61</td>
<td>.02</td>
<td>-32.99</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>fun</td>
<td>-1.08</td>
<td>.02</td>
<td>-58.98</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>healthy</td>
<td>-.26</td>
<td>.02</td>
<td>-13.92</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>sustainability</td>
<td>-.03</td>
<td>.02</td>
<td>-1.80</td>
<td>.78</td>
</tr>
<tr>
<td>better</td>
<td>technology</td>
<td>-.08</td>
<td>.02</td>
<td>-4.62</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>better</td>
<td>time</td>
<td>-.85</td>
<td>.02</td>
<td>-46.00</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>convenience</td>
<td>-.31</td>
<td>.02</td>
<td>-16.92</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>cost</td>
<td>.70</td>
<td>.02</td>
<td>37.92</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>discover</td>
<td>.06</td>
<td>.02</td>
<td>3.50</td>
<td>.02</td>
</tr>
<tr>
<td>comfort</td>
<td>ease</td>
<td>-.15</td>
<td>.02</td>
<td>-8.38</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>fun</td>
<td>-.63</td>
<td>.02</td>
<td>-34.37</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>healthy</td>
<td>.20</td>
<td>.02</td>
<td>10.69</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>sustainability</td>
<td>.42</td>
<td>.02</td>
<td>22.82</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>technology</td>
<td>.37</td>
<td>.02</td>
<td>20.00</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>comfort</td>
<td>time</td>
<td>-.39</td>
<td>.02</td>
<td>-21.39</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>cost</td>
<td>1.01</td>
<td>.02</td>
<td>54.83</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>discover</td>
<td>.38</td>
<td>.02</td>
<td>20.42</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>ease</td>
<td>.16</td>
<td>.02</td>
<td>8.53</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>fun</td>
<td>-.32</td>
<td>.02</td>
<td>-17.45</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>healthy</td>
<td>.51</td>
<td>.02</td>
<td>27.60</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>sustainability</td>
<td>.73</td>
<td>.02</td>
<td>39.73</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>technology</td>
<td>.68</td>
<td>.02</td>
<td>36.91</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>convenience</td>
<td>time</td>
<td>-.08</td>
<td>.02</td>
<td>-4.47</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>discover</td>
<td>-.63</td>
<td>.02</td>
<td>-34.41</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>ease</td>
<td>-.85</td>
<td>.02</td>
<td>-46.30</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>fun</td>
<td>-.33</td>
<td>.02</td>
<td>-72.28</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>healthy</td>
<td>-.50</td>
<td>.02</td>
<td>-27.23</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>sustainability</td>
<td>-.28</td>
<td>.02</td>
<td>-15.10</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>technology</td>
<td>-.33</td>
<td>.02</td>
<td>-17.92</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>cost</td>
<td>time</td>
<td>-1.09</td>
<td>.02</td>
<td>-59.31</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>discover</td>
<td>ease</td>
<td>-2.22</td>
<td>.02</td>
<td>-11.88</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>discover</td>
<td>fun</td>
<td>-1.70</td>
<td>.02</td>
<td>-37.87</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>discover</td>
<td>healthy</td>
<td>.13</td>
<td>.02</td>
<td>7.19</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>discover</td>
<td>sustainability</td>
<td>.35</td>
<td>.02</td>
<td>19.31</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Category</td>
<td>Impact 1</td>
<td>Impact 2</td>
<td>p-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>----------</td>
<td>----------</td>
<td>---------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>discover technology</td>
<td>.30</td>
<td>.02</td>
<td>16.49</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>discover time</td>
<td>-.46</td>
<td>.02</td>
<td>-24.89</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>ease fun</td>
<td>-.48</td>
<td>.02</td>
<td>-25.99</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>ease healthy</td>
<td>.35</td>
<td>.02</td>
<td>19.07</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>ease sustainability</td>
<td>.57</td>
<td>.02</td>
<td>31.20</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>ease technology</td>
<td>.52</td>
<td>.02</td>
<td>28.38</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>ease time</td>
<td>-.24</td>
<td>.02</td>
<td>-13.01</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>fun healthy</td>
<td>.83</td>
<td>.02</td>
<td>45.06</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>fun sustainability</td>
<td>1.05</td>
<td>.02</td>
<td>57.18</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>fun technology</td>
<td>1.00</td>
<td>.02</td>
<td>54.36</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>fun time</td>
<td>.24</td>
<td>.02</td>
<td>12.98</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>healthy sustainability</td>
<td>.22</td>
<td>.02</td>
<td>12.13</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>healthy technology</td>
<td>.17</td>
<td>.02</td>
<td>9.31</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>healthy time</td>
<td>-.59</td>
<td>.02</td>
<td>-32.08</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>sustainability technology</td>
<td>-.05</td>
<td>.02</td>
<td>-2.82</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>sustainability time</td>
<td>-.81</td>
<td>.02</td>
<td>-44.21</td>
<td>&lt; .001</td>
<td></td>
</tr>
<tr>
<td>technology time</td>
<td>-.76</td>
<td>.02</td>
<td>-41.39</td>
<td>&lt; .001</td>
<td></td>
</tr>
</tbody>
</table>

(C)
Web appendix 2: Propensity score matching (study 1)

Study 1 provided field evidence for one of the key links of our research, that is, that APs (vs. non-APs) can effectively reduce consumers’ perceived time stress. While we controlled for key variables (e.g., time importance and busyness) in the analysis reported in the paper, the results could have been caused by other co-varying factors. To further reduce this concern, we used several matching procedures (Boichuk et al. 2019).

Perceived stress (propensity score matching). As the data used in this study were non-randomized, we matched each of the (prospective) customers in the data set who have not yet purchased an AP with one customer who shares similar demographic covariates using the exact, coarse exact, genetic, nearest, and subclass matching. This makes it unlikely that differences in covariates could affect the result (Stuart et al. 2011). The genetic and the nearest neighbor matching algorithms performed significantly worse than the others as shown by the greater mean and standard deviation differences for the covariates (see web appendix 3). Thus, we did not use those matched data sets. For all other matching algorithms, the results confirmed that owning an AP reduced perceived stress without covariates included (coarse exact matching: $M_{AP} = 4.77, SD = 1.41, M_{NoAP} = 5.01, SD = 1.30; t(396) = 3.31, p = .001, d = .17$; exact matching: $M_{AP} = 4.75, SD = 1.42, M_{NoAP} = 4.99, SD = 1.30; t(401) = 3.30, p = .002, d = .17$; subclass matching: $M_{AP} = 4.79, SD = 1.41, M_{NoAP} = 5.01, SD = 1.30; t(384) = 3.07, p = .002, d = .16$) and with covariates included (coarse exact matching: $B_{AP} = -.17, SE = .07, t = -2.47, p = .014$; exact matching: $B_{AP} = -.16, SE = .07, t = -2.24, p = .025$; subclass matching: $B_{AP} = -.15, SE = .07, t = -2.12, p = .034$).
Web appendix 3: Difference in means and SDs by matching algorithms (study 1)

<table>
<thead>
<tr>
<th>Data set</th>
<th>Age $M$</th>
<th>Age $SD$</th>
<th>Gender $M$</th>
<th>Gender $SD$</th>
<th>Household income $M$</th>
<th>Household income $SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>cem</td>
<td>-2.5</td>
<td>.8</td>
<td>.91</td>
<td>.3</td>
<td>.03</td>
<td>.03</td>
</tr>
<tr>
<td>exact</td>
<td>-2.7</td>
<td>.9</td>
<td>1.29</td>
<td>.47</td>
<td>.06</td>
<td>.06</td>
</tr>
<tr>
<td>genetic</td>
<td>-11.6</td>
<td>7.25</td>
<td>-2.06</td>
<td>-.63</td>
<td>-.82</td>
<td>.38</td>
</tr>
<tr>
<td>nearest</td>
<td>-11.6</td>
<td>7.25</td>
<td>-2.06</td>
<td>-.63</td>
<td>-.82</td>
<td>.38</td>
</tr>
<tr>
<td>subclass</td>
<td>-2.9</td>
<td>.7</td>
<td>-.04</td>
<td>-.4</td>
<td>-.05</td>
<td>-.03</td>
</tr>
<tr>
<td>full sample</td>
<td>-2.9</td>
<td>.7</td>
<td>-.04</td>
<td>-.4</td>
<td>-.05</td>
<td>-.03</td>
</tr>
</tbody>
</table>
### Web appendix 4: The effect of AP on stress for different matching algorithms (study 1)

<table>
<thead>
<tr>
<th></th>
<th>Coarse</th>
<th></th>
<th></th>
<th>Exact</th>
<th></th>
<th></th>
<th>Subclass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$B$</td>
<td>$SE$</td>
<td>$t$</td>
<td>$p$</td>
<td>$B$</td>
<td>$SE$</td>
<td>$t$</td>
</tr>
<tr>
<td>AP</td>
<td>-.17</td>
<td>.07</td>
<td>-2.47</td>
<td>.02</td>
<td>-.16</td>
<td>.07</td>
<td>-2.24</td>
</tr>
<tr>
<td>Gen: Female</td>
<td>&lt; .001</td>
<td>.04</td>
<td>.01</td>
<td>1</td>
<td>- .05</td>
<td>.06</td>
<td>-.95</td>
</tr>
<tr>
<td>Gen: None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.06</td>
</tr>
<tr>
<td>Age</td>
<td>.16</td>
<td>.01</td>
<td>14.5</td>
<td>&lt; .001</td>
<td>.18</td>
<td>.01</td>
<td>13.5</td>
</tr>
<tr>
<td>Age$^2$</td>
<td>-.002</td>
<td>&lt; .001</td>
<td>-18.7</td>
<td>&lt; .001</td>
<td>-.002</td>
<td>.0001</td>
<td>-17.3</td>
</tr>
<tr>
<td>Household income</td>
<td>.02</td>
<td>.01</td>
<td>2.92</td>
<td>&lt; .001</td>
<td>.02</td>
<td>.01</td>
<td>3.25</td>
</tr>
<tr>
<td>Constant</td>
<td>2.38</td>
<td>.26</td>
<td>9.07</td>
<td>&lt; .001</td>
<td>2.08</td>
<td>.3</td>
<td>6.89</td>
</tr>
</tbody>
</table>

$R^2$: \( .18 \) \quad Adjusted $R^2$: \( .18 \) \quad Residual $SE$: \( 1.28 \) \quad F: 285

Note: Reference group for gender was male.
Web appendix 5: Introduction to APs (studies 2-4, web appendix studies 1-3)

Autonomous products are characterized by their ability to operate largely without any human intervention, i.e., they are increasingly able to fulfill tasks on their own while their conventional, non-autonomous counterparts require guidance by people.

Examples of this novel type of product include the autonomous vacuum cleaner “Roomba” and the autonomous lawn mower “Terra”. These products are sometimes also referred to as smart products, such as smart cooking machines and smart home devices. In the future, many more products will gain autonomy, such as cars with autonomous driving capabilities. In this survey, we are interested in your perceptions and experiences of such autonomous products.

Below you can see the Roomba and the Terra:
Web appendix 6: Stimuli (study 2)

AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

- First, you talk with some of your best friends for a longer time and you go for a walk.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Then, you decide to make some purchases and go to the city.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Notably, you own multiple autonomous products. While your were involved in other activities throughout that day, your autonomous products took over the vacuum cleaning, cleaned the floor, and mowed your lawn.

Non-AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

- First, you talk with some of your best friends for a longer time and you go for a walk.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Then, you decide to make some purchases and go to the city.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Notably, on top of the other activities throughout that day, you had to vacuum the house, cleaned the floor, and mow your lawn.
Web appendix 7: Results for the one-item measure of consumer well-being (studies 2-4)

Study 2

Consumer well-being. As predicted, the t-test of product type on the one-item measure of consumer well-being was significant ($M_{AP} = 8.18$, $SD = 1.86$, $M_{NoAP} = 7.27$, $SD = 2.19$; $t(301) = 3.88$, $p < .001$, $d = .45$).

Perceived time stress as mediator. A mediation analysis (Hayes 2012, model 4) using APs (vs. non-APs) as independent variable, perceived time stress as mediator, and the one-item measure of consumer well-being as dependent variable supported the mediational role of perceived time stress. The indirect effect via perceived time stress was significant ($B = .37$, $SE = .11$, CI95 = [.18; .62]). The direct effect was attenuated for the one-item measure ($B = .54$, $SE = .23$, CI95 = [.09; .99]). Accordingly, perceived time stress mediated the effect of APs (vs. non-APs) on consumer well-being (H2) also for the one-item measure.

Study 3

Consumer well-being. A one-way ANOVA ($M_{AP} = 8.27$, $SD = 1.80$, $M_{AP_{NoTimeGain}} = 7.04$, $SD = 2.30$, $M_{NoAP} = 7.13$, $SD = 2.26$; $F(2, 245) = 9.17$, $p < .001$, $\eta^2 = .07$) revealed that participants in the AP condition rated the one-item measure of consumer well-being significantly greater than in the non-AP ($t = 3.53$, $p = .001$, $d = .54$) as well as in the AP no time gain condition ($t = 3.76$, $p < .001$, $d = .58$). The contrast between the AP no time gain and non-AP condition ($t = .26$, $p = 1.00$, $d = .04$) was non-significant.

Perceived time stress as mediator. We also conducted two additional mediation analyses, one for the contrast between the AP and the non-AP condition and one for the contrast between the AP and the AP no time gain condition, using perceived time stress as mediator and the one-item measure of consumer well-being as dependent variable (Hayes 2012, model 4).
The mediation analyses for the contrast between the AP and the AP no time gain condition showed that indeed a reduction of perceived time stress explained the positive effect of APs on the one-item measure of consumer well-being. The indirect effect via perceived time stress was significant ($B = .48, SE = .19$, CI95 = [.17; .91]) while the direct effect was attenuated ($B = .75, SE = .32$, CI95 = [.12; 1.37]), indicating a partial mediation for the one-item measure of consumer well-being. This corroborated our previous findings on the contrast between APs and non-APs by showing that APs improved well-being by reducing perceived time stress (H2).

The mediation analyses for the contrast between the AP and the non-AP condition showed that perceived time stress explained the positive effect of APs on the one-item measure of consumer well-being. The indirect effect via perceived time stress was significant ($B = 1.07, SE = .28$, CI95 = [.58; 1.66]) while the direct effect became non-significant ($B = .07, SE = .29$, CI95 = [-.50; .64]), indicating full mediation.

In sum, perceived time stress mediated the effect of AP on consumer well-being compared to AP that do not allow to gain time and versus non-APs also when operationalizing consumer well-being with the one-item measure.

Study 4

*Consumer well-being.* A one-way ANOVA for the one-item measure of consumer well-being ($M_{AP\_Low\_Human} = 7.83, SD = 1.85, M_{AP\_High\_Human} = 7.38, SD = 1.93, M_{Human} = 7.61, SD = 1.93; F(2, 454) = 2.13, p = .12, $\eta^2 = .01$) and the contrast between the AP low human likeness condition and the human was non-significant ($t = -1.01, p = .31, d = .11$) while the contrast with the AP high human likeness condition was significant ($t = 2.07, p = .039, d = .24$). The contrast between the AP high human likeness condition and the human condition was non-significant ($t = 1.04, p = .30, d = .12$). Thus, participants in the AP low human likeness condition reported
greater consumer well-being (one-item measure) than those in the AP high human likeness condition.

*Feelings of guilt as mediator.* We did the mediation analysis (Hayes 2012, model 4) condition (AP low human likeness vs. human) as independent variable, feelings of guilt as mediator, and the one-item measure of consumer well-being as dependent variable. The indirect effect via felt guilt was significant ($B = .50, SE = .12, CI95 = [.28; .75]$). The direct effect became non-significant ($B = -.28, SE = .21, CI95 = [-.69; .12]$). Thus, felt guilt to delegate the task mediated the effect of a low human likeness AP—which we consider to be still the default in terms of current consumer products—compared to delegating the task to other humans (i.e., house cleaners) on the one-item measure of consumer well-being.
Web appendix 8: Stimuli (study 3)

AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as if it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday. For this Saturday, you planned things such as going for dinner:

- You get up in the morning and have breakfast and talk with some of your best friends for a longer time and you go for a walk.
- After that, your autonomous vacuum cleaner vacuums the house.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Your autonomous floor cleaner then cleans the house.
- Then, you decide to make some purchases and go to the city.
- The next point on your list is mowing your lawn. Your autonomous lawn mower completes this task for you.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Your day is over.

Non-AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as if it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday. For this Saturday, you planned things such as going for dinner:

- You get up in the morning and have breakfast and talk with some of your best friends for a longer time and you go for a walk.
- After that, you vacuum the house.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- You then clean the house.
- Then, you decide to make some purchases and go to the city.
- The next point on your list is mowing your lawn. You complete this task.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Your day is over.

AP no time gain condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as if it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday. For this Saturday, you planned things such as going for dinner:

- You get up in the morning and have breakfast and talk with some of your best friends for a longer time and you go for a walk.
- After that, your autonomous vacuum cleaner vacuums the house. You control the autonomous product by watching it.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Your autonomous floor cleaner then cleans the house and you spend the time monitoring whether the autonomous product does the work well.
- Then, you decide to make some purchases and go to the city.
- The next point on your list is mowing your lawn. Your autonomous lawn mower completes this task for you and you again closely monitor the product doing the work.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Your day is over.
Web appendix 9: Manipulation check (study 3)

We administered an attention check in study 3 that tested whether participants indicated the available time on the imagined day.

A one-way ANOVA revealed that the manipulation was successful ($M_{AP} = 6.23$, $SD = .87$, $M_{AP\_NoTimeGain} = 4.29$, $SD = 1.78$, $M_{NoAP} = 3.62$, $SD = 1.62$; $F(2, 245) = 76.2$, $p < .001$, $\eta^2 = .38$). The contrast between the AP and non-AP conditions ($t = 11.77$, $p < .001$, $d = 1.80$) as well as between the AP and AP no time gain conditions ($t = 8.66$, $p < .001$, $d = 1.34$) were both significant. While the contrast between the non-AP and AP no time gain condition was significant as well, the effect was considerably smaller ($t = 2.88$, $p = .013$, $d = .46$). Thus, the AP no time gain manipulation significantly reduced the time available relative to the AP condition but did not reach the same level as non-APs.
Web appendix 10: Stimuli (study 4)

AP high human likeness condition

Please imagine you have purchased the Roomba. Read the scenario very thoroughly. Think of the scenario as if it would represent a real day, even while not all of the tasks might apply to your typical day.

It is a typical Thursday on which you have to work: You arrive at home after working. Besides preparing and eating dinner, you still have to vacuum your home.

• Your Roomba does the vacuum cleaning for you.
• Your Roomba is more than an object to you. You call the Roomba by a nickname, namely Jenny.
• In fact, you perceive Jenny almost as a human being.
• What makes Jenny human-like is that she completes the work autonomously and tells you where she vacuumed with her gentle voice.
• Obviously, Jenny is not just a product, but much more than that.
• Sometimes, you even feel odd to delegate all the work to Jenny, as she has become kind of a friend.

AP low human likeness condition

Please imagine you have purchased the Roomba. Read the scenario very thoroughly. Think of the scenario as if it would represent a real day, even while not all of the tasks might apply to your typical day.

It is a typical Thursday on which you have to work: You arrive at home after working. Besides preparing and eating dinner, you still have to vacuum your home.

• Your Roomba does the vacuum cleaning for you.
• Your Roomba is just an object to you. You call the Roomba “Roboto”.
• In fact, you perceive Roboto merely as a usage object.
• What makes Roboto a usage object for you is that it merely completes your work autonomously and gives you feedback about the task with its mechanic sounds.
• Obviously, Roboto is just a product, and no more than that.
• You are glad that such objects exist, as they are meant to do the work for you.
Human condition

Please imagine you have employed a house cleaner. Read the scenario very thoroughly. Think of the scenario as if it would represent a real day, even while not all of the tasks might apply to your typical day.

It is a typical Thursday on which you have to work: You arrive at home after working. Besides preparing and eating dinner, you still have to vacuum your home.

- Your house cleaner does the vacuum cleaning for you.
Web appendix 11: Mediation analyses including perceived time stress as control (study 4)

As there were systematic differences in terms of time stress between the conditions—which all delegated the tasks—we repeated the mediation analyses. This allowed us to examine whether feelings of guilt to delegate the task (and not the systematic variations in terms of perceived time stress) could have caused the effects.

We conducted a mediation analysis (Hayes 2012, model 4) with condition (AP non-human-like vs. house cleaner) as independent variable, felt guilt as mediator, and well-being as dependent variable—and now also included perceived time stress as control variable. The indirect effect via feelings of guilt was significant ($B = .15, SE = .04, CI95 = [.08; .23]$). The direct effect became non-significant ($B = -.02, SE = .07, CI95 = [-.16; .12]$).

The results showed that feelings of guilt to delegate the task mediated the effect of a non-human-like AP compared to delegating the task to humans, even when controlling for perceived time stress.
Web appendix 12: Analysis of product adoption intention (study 4)

Study 4 employed a measure of product adoption intention. Future purchase was measured by introducing the autonomous robot mop “Braava Jet” and inquiring participants’ product adoption intention (“Please indicate how likely you would be to purchase the Braava Jet, given that you would have the money disposable”; 1 = “Not likely at all” to 10 = “Very likely”). Product adoption intention was added as an exploratory measure, as per the preregistration. A one-way ANOVA did not show a significant effect of condition assignment on product adoption intention ($M_{AP_{LowHuman}} = 6.63$, $SD = 2.95$, $M_{AP_{HighHuman}} = 6.71$, $SD = 2.69$, $M_{Human} = 6.97$, $SD = 2.68$; $F(2, 454) = .63, p = .53, \eta^2 = .003$).
Web appendix 13: Analysis of hypothesis guess question (study 4)

Study 4 employed a hypothesis guess question. This open-text question allowed us to assess whether participants in the study rightfully guessed the hypothesis and whether there were differences among the conditions.

Method

Detection of hypothesis. We first examined whether people detected the key hypothesis in this study: that participants felt less guilt in the AP conditions compared to the human condition. We first coded those participants who directly mentioned “guilt*” as 1 = “hypothesis detected,” 0 = “not detected”. We extended this procedure by using the “syn” library in R (http://syn.njtierney.com/, https://github.com/ropenscilabs/syn), which also detects synonyms of guilt. We coded all participants that used words related to guilt (using the Thesaurus dictionary) as 1 = “hypothesis detected,” 0 = “not detected”. Note that this was a particularly conservative way, as we coded only the specific terms, which does not unambiguously relate to the detection of the hypothesis across conditions (i.e., that APs should reduce felt guilt compared to other conditions).

Influence on results. We then used detection as control to examine whether the results were significantly influenced by the detection of the hypothesis.

Results

Detection of hypothesis: Guilt. Participants in the AP low human likeness condition were equally likely to detect the hypothesis as participants in the AP high human likeness

\(P_{\text{AP, LowHuman}} = 2.5\%, \ P_{\text{AP, HighHuman}} = 1.4\%; \ B_{\text{AP, LowHuman}} = -.59, \ \text{Odds Ratio} = .56, \ z = -.67, \ p = \)
.50) and the human conditions ($P_{\text{Human}} = 3.4\%; B_{\text{AP\_Low\_Human}} = .32, \text{Odds Ratio} = 1.38, z = .47, p = .64$).

**Detection of hypothesis: Synonyms of guilt.** Participants in the AP low human likeness condition were equally likely to detect the hypothesis as participants in the AP high human likeness ($P_{\text{AP\_Low\_Human}} = 8.9\%, P_{\text{AP\_High\_Human}} = 11.7\%; B_{\text{AP\_Low\_Human}} = .31, \text{Odds Ratio} = 1.36, z = .72, p = .47$) and the human condition ($P_{\text{Human}} = 11.8\%; B_{\text{AP\_Low\_Human}} = .32, \text{Odds Ratio} = 1.37, z = .74, p = .46$).

**Main effect.** We repeated the analysis on feelings of guilt and used a linear regression model, controlling for the detection of the hypothesis. In the first linear regression, we included the dummy for the detection of guilt. Participants in the AP low human likeness condition felt less guilt than in the AP high human likeness condition ($B_{\text{AP\_High\_Human}} = 1.26, SE = .24, t = 5.17, p < .001; B_{\text{Human}} = 1.24, SE = .24, t = 5.14, p < .001; B_{\text{Detection}} = 1.24, SE = .65, t = 1.90, p = .06$).

In the second linear regression, we included a dummy for using synonyms of guilt. Participants in the AP low human likeness condition felt less guilt than in the AP high human likeness condition ($B_{\text{AP\_High\_Human}} = 1.14, SE = .28, t = 4.09, p < .001; B_{\text{Human}} = 1.14, SE = .27, t = 4.18, p < .001; B_{\text{Detection}} = .53, SE = .37, t = 1.44, p = .15$).

Demand effects did not affect the results of study 4. Neither were participants likely to detect the hypothesis of guilt (even while those questions were asked explicitly before), nor were participants significantly different across conditions in terms of detection, nor did controlling for detection affect our key hypotheses tests.
Web appendix 14: Analysis of perceived time stress (study 4)

While felt guilt was the focus of the study, we also analyzed the effect of conditions on perceived time stress.

A one-way ANOVA revealed that the manipulation also significantly reduced time stress in the AP conditions ($M_{AP\_Low\_Human} = 3.29$, $SD = 1.44$, $M_{AP\_High\_Human} = 3.54$, $SD = 1.55$, $M_{Human} = 3.73$, $SD = 1.68$; $F(2, 454) = 3.14$, $p = .044$, $\eta^2 = .014$). While not hypothesized, the AP low human likeness condition reduced perceived time stress compared to the human condition ($t = 2.14$, $p = .013$, $d = .28$). None of the other contrasts were significant ($ps > .15$).
Web appendix 15: Web appendix study 1 “conceptual replication of study 2”

This study was a conceptual replication of study 2 with different stimuli to increase the generalizability of the effect of APs (vs. non-APs) on consumer well-being (H1) and perceived time stress (H2). The stimuli were designed such that they displayed each task within the descriptions during the day.

Method

Procedure. We recruited 200 participants from Amazon MTurk (M_{Age} = 39.79, SD = 12.85, 53% female). The procedure was equal to the study reported in the main document but used different stimuli, and two slightly different scenarios both for AP and non-APs (see web appendix 16). The scenarios were collapsed to APs vs. non-APs.

Measurement. Consumer well-being (α = .92) and perceived time stress (α = .96) were measured as in the previous studies. Participants answered standardized questions and demographics (e.g., age, gender, working hours, number of children, existence of home helper, income). We measured additional variables such as outcome satisfaction (“How satisfied are you with the outcome?,” “To what extent do you feel successful with the outcome?,” “How happy are you with the outcome?” 1 = “Not at all” – 7 = “Very much”; α = .95), pride in the outcome (“When I consider all the completed tasks...,” “... the feeling I have can best be described by the word ’pride’,” “... I feel proud of having accomplished something,” “... I feel proud because I did a good job”; α = .94). Participants responded also to several questions about themselves related to polychronicity (“I like to juggle several activities at the same time,” “When I work by myself, I usually work on one project at a time,” “I prefer to do one thing at a time,” “I believe it is best to complete one task before beginning another,” “I believe people do their best work when they have many tasks to complete”; α = .87), representative polychronicity (“When too much is going
on at once I really become disorganized,” “Nowadays there is so much new information thrown at a person that it is impossible to keep up with things,” “When working on a project, I take one thing at a time”; α = .62; Plocher et al. 2002), homemaker (“I take pride in taking care of my home,” “There are more important things in life than simply taking care of my home,” “Taking care of my home is just something one does, nothing to feel great about”; α = .56), being a planner (“I believe that a person’s day should be planned ahead each morning,” “Meeting tomorrow’s deadlines and doing other necessary work comes before tonight’s play,” “I think that it's useless to plan too far ahead because things hardly ever come out the way you planned anyway,” “I feel it’s more important to enjoy what you are doing than to get the work done on time”; α = .56), and time importance (“I always use my time to ‘get things done,’” “I do not squander away my time,” “In general, I would say I’m the type of person who values my time”), busyness (“I am too busy to relax,” “I am often juggling my time between too many things,” “So much to do, so little time, this saying applies very well to me”; α = .68) and perceptions of feeling smart (“I took a lot of pride in the fact that I have made a smart purchase,” “I felt good about myself,” “I felt like a winner,” “I felt like a rational consumer,” “I felt like a smart consumer”; α = .93). All the previously mentioned scales were asked on the extremes 1 = “Strongly disagree” – 7 = “Strongly agree”. Participants also replied to how many tasks they completed (“I completed ____ tasks”), how many parts the day was split into (“The day was split into ____ parts”), and whether they did tasks they disliked (“I did ____ tasks I disliked”), which all were asked on the scales 1 = “very few” – 10 = “a lot”.

Results

*Consumer well-being.* The t-tests of product type on both the six-item measure \( M_{\text{AP}} = 4.29, SD = .69, M_{\text{NoAP}} = 3.83, SD = .98; t(198) = 3.87, p < .001, d = .55 \) and the one-item
measure of consumer well-being ($M_{AP} = 8.21$, $SD = 1.89$, $M_{NoAP} = 7.02$, $SD = 2.85$; $t(198) = 3.50$, $p < .001$, $d = .50$) were significant. Thus, APs (vs. non-APs) increased consumer well-being (H1).

**Perceived time stress.** Moreover, the t-test of product type on perceived time stress was significant ($M_{AP} = 2.98$, $SD = 1.44$, $M_{NoAP} = 3.81$, $SD = 1.86$; $t(198) = 3.57$, $p < .001$, $d = .51$). Thus, APs reduced perceived time stress.

**Perceived time stress as mediator.** A mediation analysis (Hayes 2012, model 4) showed that reduced perceived time stress explained the positive effect of APs on consumer well-being. The indirect effect via perceived time stress was significant (six-item measure: $B = .25$, $SE = .08$, CI95 = [.10; .41]; one-item measure: $B = .60$, $SE = .21$, CI95 = [.24; 1.05]) while the direct effect remained significant (six-item measure: $B = .21$, $SE = .11$, CI95 = [.003; .43]; one-item measure: $B = .60$, $SE = .30$, CI95 = [.001; 1.19]), indicating partial mediations. Accordingly, the perceived time stress explained the effect of APs (vs. non-APs) on consumer well-being (H2).

Perceived time stress mediates the effect of APs (vs. non-APs) on consumer well-being.

Discussion
This study corroborated the causal evidence that APs could increase consumer well-being as compared to completing chores by oneself (H1). Moreover, this study supported that the effect was caused by the reduction of perceived time stress (H2).
Web appendix 16: Stimuli (web appendix study 1)

AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

• First, you talk with some of your best friends for a longer time and you go for a walk.
• Your autonomous vacuum cleaner then cleans the house and you spend the time relaxing.
• Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
• Your autonomous mop then cleans up at home with water and you spend the time doing some sports.
• Then, you decide to make some purchases and go to the city.
• The next point on your list is mowing your lawn. Your autonomous mower completes this task for you.
• Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed.

Non-AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

• First, you talk with some of your best friends for a longer time and you go for a walk.
• Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
• Then, you decide to make some purchases and go to the city.
• Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Notably, you own multiple autonomous products. While you were involved in other activities, your autonomous products took over the vacuum cleaning, cleaned the floor, and mowed your lawn.
Web appendix 17: Web appendix study 2 “comparison against true control”

This study was designed with the objective of testing how APs compare to situations in which consumers do not have to complete any task (i.e., a true control condition). On the one hand, one could assume that imagining a day without any tasks that are to be completed might lead to greater consumer well-being, on the other hand, consumers could assume that some work would be left for other days—eventually undermining their well-being.

Method

Procedure. We recruited 452 participants from Amazon MTurk ($M_{Age} = 42.30$, $SD = 13.45$, 61% female). Participants began by answering several questions on personal traits before being introduced to APs. After that, we randomly assigned participants to one of three conditions of the between-subjects experimental design (AP vs. non-AP vs. control condition). As in the previous studies, participants in the AP and the non-AP conditions had to imagine a day in which they had to complete several work and leisure activities. The AP condition was designed such that we told participants at the end that some of those tasks were completed by APs. The non-AP condition was designed such that we told participants at the end that participants had to complete all tasks manually. In the control condition, participants did not imagine that they had to complete any task (see web appendix 18). Finally, participants answered standardized questions and demographics.

Measurement. Consumer well-being ($\alpha = .93$) and perceived time stress ($\alpha = .95$) were measured as in the previous studies. We also measured several variables such as authentic ($\alpha = .90$) and hubristic pride ($\alpha = .84$), busyness ($\alpha = .88$), homemaker ($\alpha = .60$), outcome satisfaction ($\alpha = .97$), and added social support ($\alpha = .93$)—given that an AP could also provide social support. Participants answered standardized questions and demographics (e.g., age and gender).
Results

**Consumer well-being.** A one-way ANOVA showed that APs indeed increased consumer well-being for the six-item measure ($M_{AP} = 4.42$, $SD = .71$, $M_{NoAP} = 3.92$, $SD = .88$, $M_{Control} = 4.25$, $SD = .73$; $F(2, 449) = 16.4$, $p < .001$, $\eta^2 = .07$). The contrasts between the AP condition with both the non-AP condition ($t = 5.64$, $p < .001$, $d = .65$) and the control condition were significant ($t = 1.97$, $p = .0496$, $d = .23$). The contrast between non-AP and the control condition was significant ($t = 3.66$, $p < .001$, $d = .42$).

The results for the one-item measure were consistent ($M_{AP} = 8.34$, $SD = 1.66$, $M_{NoAP} = 7.30$, $SD = 2.15$, $M_{Control} = 7.99$, $SD = 1.89$; $F(2, 449) = 11.7$, $p < .001$, $\eta^2 = .05$). The contrasts between the AP condition with the non-AP condition was significant ($t = 4.76$, $p < .001$, $d = .55$; H1), but the contrast with the control condition was non-significant ($t = 1.63$, $p = .105$, $d = .19$). The contrast between non-AP and the control condition was significant ($t = 3.13$, $p = .002$, $d = .36$). Thus, the AP condition reported greater consumer well-being than all other conditions, at least for the six-item measure, while for the one-item measure only the hypothesized contrast to the non-AP condition was significant.

**Perceived time stress.** A one-way ANOVA ($M_{AP} = 2.73$, $SD = 1.37$, $M_{NoAP} = 3.80$, $SD = 1.70$, $M_{Control} = 3.00$, $SD = 1.62$; $F(2, 449) = 19.0$, $p < .001$, $\eta^2 = .08$) showed that the AP condition reported significantly lower perceived time-stress than the non-AP condition ($t = 5.93$, $p < .001$, $d = .68$) but not the control condition ($t = 1.48$, $p = .14$, $d = .17$). The contrast between non-AP and the control condition was significant ($t = 4.44$, $p < .001$, $d = .51$). APs therefore decreased perceived time stress compared to non-APs but not against the control condition.

**Perceived time stress as mediator.** Next, we conducted a mediation analysis (Hayes 2012, model 4) using AP (vs. non-AP) as independent variable, perceived time stress as mediator, and the measures of consumer well-being as dependent variables. The analysis showed that reduced
perceived time stress explained the effect of AP (vs. non-AP) on consumer well-being. The indirect effect via perceived time stress was significant (six-item measure: $B = .30, SE = .06$, CI95 = [.19; .44]; one-item measure: $B = .72, SE = .16$, CI95 = [.43; 1.05]). The direct effect became non-significant only for the one-item measure (six-item measure: $B = .20, SE = .09$, CI95 = [.02; .38]; one-item measure: $B = .32, SE = .21$, CI95 = [-.08; .73]). Accordingly, the reduced perceived time stress seems to explain the effect of APs (vs. non-APs) on consumer well-being (H2).

We did not conduct further mediations because the effect of APs compared to the control condition on perceived time stress was non-significant.

Discussion

This study corroborated the effects of APs on reduced perceptions of time stress (H2) and eventually consumer well-being compared to non-APs (H1). Moreover, this study included a control condition with mixed effects: Perceived time stress was only directionally lower in the AP condition and only one measure of consumer well-being was significantly different between the AP and the control condition. Notably, the control condition did not mention any work that participants needed to imagine completing. Thus, it is not surprising that this study only revealed mixed effects.
Web appendix 18: Stimuli (web appendix study 2)

AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

- First, you talk with some of your best friends for a longer time and you go for a walk.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Then, you decide to make some purchases and go to the city.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Notably, you own multiple autonomous products. While your were involved in other activities throughout that day, your autonomous products took over the vacuum cleaning, cleaned the floor, and mowed your lawn.

Non-AP condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

- First, you talk with some of your best friends for a longer time and you go for a walk.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Then, you decide to make some purchases and go to the city.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed. Notably, on top of the other activities throughout that day, you had to vacuum the house, cleaned the floor, and mow your lawn.

Control condition

Please imagine the following scenario and read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as it was a real day, even while not all of the tasks might apply to your typical day.

It is a Saturday and you do not have to work. You get up in the morning and take a late breakfast. Due to the busy week, you have planned several things for this Saturday, i.e., catch up with friends and clean the house, go for dinner:

- First, you talk with some of your best friends for a longer time and you go for a walk.
- Next, you watch some TV and bring yourself up to date concerning the latest events in sports.
- Then, you decide to make some purchases and go to the city.
- Finally, you decide to go for dinner with some colleagues and you leave the house.

After spending two hours at the restaurant, you go home and go to bed.
Web appendix 19: Web appendix study 3 “APs compared to other time-saving purchases”

This study was designed with the objective of extending the effects of APs by comparing these products to other ways of saving time. Specifically, this study tests the effects of delegating tasks to APs versus humans, that is, human house cleaners. On an exploratory basis, this study also examined whether advertising-specific ways of spending the gained time could increase the benefits.

Method

Procedure. We recruited 605 participants from Amazon MTurk ($M_{\text{Age}} = 41.43$, $SD = 12.5$, 52% female) who were randomly assigned to one of seven conditions of the 2 (task delegation: AP vs. human) × 3 (advertisement: active leisure vs. passive leisure vs. work) plus control (non-AP) between-subjects experiment. The study focused on vacuum cleaners as the focal product domain. As in the other studies, participants in all conditions imagined a day in which they had to complete several tasks (see web appendix 20).

The AP conditions were designed such that participants imagined that these tasks were completed by APs. In the human conditions, participants imagined that they delegated the same tasks to a house cleaner. Participants in the AP and human conditions were further randomly assigned to three advertisements before the scenario, in which either a house cleaning service or an autonomous vacuum cleaner manufacturer advertised that the respective service would free up time for (1) active leisure (e.g., sports), (2) passive leisure (e.g., relaxation), or (3) additional work (see web appendix 21).

In the control condition, participants imagined completing all tasks using a non-AP (i.e., a vacuum cleaner).
All participants then completed measures of human likeness, guilt, consumer well-being, and perceived time stress. Participants completed the study by providing demographic information and answering a hypothesis guessing question to test for demand effects (see web appendix 23). The manipulation of the advertisement did not interact with the task delegation conditions and did not predict any of our outcome measures (see web appendix 22). We therefore collapsed the three advertising conditions and focused on the comparisons between the AP, human, and control condition.

*Measurement.* We measured consumer well-being ($\alpha = .90$), perceived time stress ($\alpha = .96$), human likeness of the products or the house cleaner ($\alpha = .95$), and feelings of guilt ($r = .85$) as in study 4.

Results

*Consumer well-being.* A one-way ANOVA revealed that the task delegation manipulation significantly affected the six-item measure of consumer well-being ($M_{AP} = 3.99$, $SD = .73$, $M_{Human} = 3.84$, $SD = .79$, $M_{Control} = 3.00$, $SD = .82$; $F(2, 602) = 53.5$, $p < .001$, $\eta^2 = .15$). Follow-up contrasts between the AP and the human conditions ($t = 2.13$, $p = .033$, $d = .19$) and the AP and the control condition were significant ($t = 10.21$, $p < .001$, $d = 1.29$). The contrast between the human conditions and the control condition was also significant ($t = 8.79$, $p < .001$, $d = 1.10$). Thus, participants in the AP conditions reported greater well-being than those in the human conditions and the control condition (see the table for an overview of the main effects of this study).

The one-way ANOVA for the one-item measure of consumer well-being ($M_{AP} = 7.78$, $SD = 1.82$, $M_{Human} = 7.45$, $SD = 1.84$, $M_{NoAP} = 5.20$, $SD = 2.29$; $F(2, 602) = 60$, $p < .001$, $\eta^2 = .17$) showed that the contrast between the AP and the human ($t = 1.99$, $p = .047$, $d = .17$) and the
control (i.e., non-AP) condition ($t = 10.77, p < .001, d = 1.36$) were significant. The contrast between the human conditions and the non-AP conditions was also significant ($t = 9.45, p < .001, d = 1.18$). Thus, participants in the AP conditions reported greater consumer well-being than those in the human house cleaner and the non-AP conditions also when operationalizing consumer well-being with the one-item measure.
The effects of APs (vs. other conditions) on all measured constructs

<table>
<thead>
<tr>
<th>DV</th>
<th>AP</th>
<th>Human</th>
<th>Control (non-AP)</th>
<th>ANOVA</th>
<th>t-test AP vs. Human</th>
<th>t-test AP vs. Control</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-being (6-item)</td>
<td>3.99</td>
<td>.73</td>
<td>3.84</td>
<td>.79</td>
<td>3.00</td>
<td>.82</td>
<td>53.5</td>
</tr>
<tr>
<td></td>
<td>53.5</td>
<td>&lt; .001</td>
<td>.15</td>
<td></td>
<td>2.13</td>
<td>.033</td>
<td>10.21</td>
</tr>
<tr>
<td>Well-being (1-item)</td>
<td>7.78</td>
<td>1.82</td>
<td>7.45</td>
<td>1.84</td>
<td>5.20</td>
<td>2.29</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>&lt; .001</td>
<td>.17</td>
<td></td>
<td>1.99</td>
<td>.047</td>
<td>10.77</td>
</tr>
<tr>
<td>Perceived time stress</td>
<td>3.65</td>
<td>1.71</td>
<td>3.68</td>
<td>1.71</td>
<td>5.92</td>
<td>1.01</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>69</td>
<td>&lt; .001</td>
<td>.19</td>
<td></td>
<td>.23</td>
<td>.82</td>
<td>11.05</td>
</tr>
<tr>
<td>Feelings of guilt</td>
<td>2.72</td>
<td>2.67</td>
<td>3.69</td>
<td>2.92</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-9.75</td>
<td>&lt; .001</td>
<td>-</td>
</tr>
<tr>
<td>Human likeness</td>
<td>2.26</td>
<td>1.37</td>
<td>4.83</td>
<td>1.84</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-18.01</td>
<td>&lt; .001</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note:* Participants in the control (non-AP) condition responded neither to the feelings of guilt nor to the human likeness items.

*Perceived time stress.* A one-way ANOVA showed that, as expected, APs and human house cleaners had similar effects on perceived time stress ($M_{AP} = 3.65, SD = 1.71, M_{Human} = 3.68, SD = 1.71, M_{Control} = 5.92, SD = 1.01; F(2, 602) = 69, p < .001, $\eta^2 = .19$). The contrast between the AP and the human conditions was non-significant ($t = .23, p = .82, d = .02$). Both the AP conditions ($t = 11.05, p < .001, d = 1.37$) and the human conditions ($t = 10.96, p < .001, d = 1.39$) significantly reduced time stress relative to the control condition. APs therefore decreased time stress compared to non-APs but not as compared to human house cleaners. As expected, these findings suggest that both human house cleaners and APs reduce time stress as compared to completing the task themselves without the use of an AP.

*Mediation via perceived time stress.* Next, we conducted a mediation analysis (Hayes 2012, model 4) pooling both time-saving conditions against the control condition. The analysis showed that reduced time stress explained the effect of delegating tasks on well-being. The indirect effect via time stress was significant ($B = .48, SE = .05, CI95 = [.38; .58]$) while the direct effect remained significant ($B = .44, SE = .01, CI95 = [.24; .63]$), indicating partial mediation.
Next, we conducted a mediation analysis (Hayes 2012, model 4) pooling both time saving conditions against the non-AP condition as the independent variable, time stress as mediator, and the one-item measure of consumer well-being as dependent variable. The indirect effect via time stress was significant ($B = .46$, $SE = .12$, CI95 = [.23; .69]), while the direct effect remained significant ($B = 1.95$, $SE = .28$, CI95 = [1.40; 2.51]). Thus, the delegation of tasks to APs and human house cleaners reduced perceived time stress, which in turn increased consumer well-being (H2).

**Feelings of guilt.** Given that only the AP and the human conditions were asked about their feelings of guilt we used a t-test to compare the means of those two conditions. The t-test revealed that APs significantly reduced the perceived guilt of delegating the tasks ($M_{AP} = 2.72$, $SD = 2.67$, $M_{Human} = 3.69$, $SD = 2.92$; $t(519) = 3.97$, $p < .001$, $d = .35$). As predicted, delegating tasks to APs led to less feelings of guilt than delegating those tasks to human house cleaners.

**Human likeness.** A t-test confirmed that participants experienced the house cleaner to be more human than the AP ($M_{AP} = 2.26$, $SD = 1.37$, $M_{Human} = 4.83$, $SD = 1.84$; $t(519) = 18.01$, $p < .001$, $d = 1.58$). We then conducted two moderation analyses that examined whether the perceptions of human likeness moderated the effect of APs on perceived guilt and consumer well-being. The first analysis showed that human likeness moderated the effect of APs on perceived guilt ($B_{AP×HumanLikeness} = 1.09$, $SE = .14$, $t = 8.00$, $p < .001$; $B_{AP} = -3.20$, $SE = .50$, $t = -6.37$, $p < .001$; $B_{HumanLikeness} = .05$, $SE = .08$, $t = .68$, $p = .50$). Simple slope analyses showed that in the AP condition perceived human likeness significantly increased feelings of guilt ($B = 1.14$, $SE = .11$, $t = 10.36$, $p < .001$), while in the human condition human likeness did not affect feelings of guilt ($B = .05$, $SE = .08$, $t = .68$, $p = .50$). Thus, if consumers considered the AP to be human-like, they felt guiltier, which was not the case if they considered the AP not to be human-like (H5; see figure below).
The second moderation analysis showed that perceptions of human likeness also moderated the effect of AP on well-being ($B_{\text{AP} \times \text{HumanLikeness}} = -.20$, $SE = .04$, $t = -4.67$, $p < .001$; $B_{\text{AP}} = .72$, $SE = .16$, $t = 4.57$, $p < .001$; $B_{\text{HumanLikeness}} = .05$, $SE = .02$, $t = 1.97$, $p = .05$). Simple slope analyses showed that in the AP condition perceived human likeness significantly decreased well-being ($B = -.15$, $SE = .03$, $t = -4.34$, $p < .001$), while in the human condition human likeness had a positive influence on consumer well-being ($B = .05$, $SE = .03$, $t = 1.97$, $p = .05$). Thus, consumers who perceive APs as more human reported lower well-being.

A third moderation analysis showed that perceptions of human likeness did not moderate the effect of AP on the one-item measure of consumer well-being ($B_{\text{AP} \times \text{HumanLikeness}} = .02$, $SE = .10$, $t = .19$, $p = .85$; $B_{\text{AP}} = .31$, $SE = .39$, $t = .80$, $p = .42$; $B_{\text{HumanLikeness}} = .01$, $SE = .06$, $t = .14$, $p = .89$).

Human likeness moderates the effect of APs (vs. humans) on feelings of guilt

Note: Shaded areas represent 95% confidence intervals.

Mediation via feelings of guilt. We conducted a mediation analysis (Hayes 2012, model 4) with task delegation (AP vs. house cleaner) as the independent variable, felt guilt as the mediator,
and well-being as the dependent variable. Felt guilt mediated the effect of APs on consumer well-being as shown by the significant indirect effect \((B = .13, \ SE = .03, CI95 = [.06; .20])\). The direct effect became non-significant \((B = .02, \ SE = .06, CI95 = [-.10; .13])\), indicating full mediation.

We conducted a second mediation analysis (Hayes 2012, model 4) with task delegation (AP vs. human) as the independent variable, felt guilt as the mediator, and the one-item measure of consumer well-being as the dependent variable. Felt guilt mediated the effect of APs on consumer well-being \((B = .06, \ SE = .04, CI95 = [.01; .14])\) as shown by the significant indirect effect. The direct effect became non-significant \((B = .27, \ SE = .16, CI95 = [-.05; .59])\). Thus, feelings of guilt mediated the effect of APs (vs. human house cleaners) on consumer well-being (H4).

Moderated mediation analysis with perceived human likeness as moderator. Finally, we conducted a moderated mediation analysis (Hayes 2012, model 7) with task delegation (AP vs. human house cleaner) as independent variable, perceived human likeness as moderator of the first path, felt guilt as mediator, and well-being as dependent variable. We found that at low levels of human likeness \((M = 1.00)\) guilt mediated the effect of AP on well-being as shown by the significant indirect effect \((B = .16, \ SE = .07, CI95 = [.04; .31])\). However, at high levels of perceived human likeness \((M = 6.21)\), the opposite occurred, and the indirect effect became negative \((B = -.27, \ SE = .11, CI95 = [-.15; -.02])\). The moderated mediation index was significant \((B = -.08; \ SE = .03; CI95 = [-.15; -.02])\). The results are illustrated in the following figure.
Human likeness moderates the mediated effect of APs (vs. human house cleaners) via feelings of guilt on consumer well-being

Finally, we repeated the moderated mediation analysis (Hayes 2012, model 7) but used the one-item measure of consumer well-being as dependent variable. We found that at low levels of human likeness ($M = 1.00$) felt guilt mediated the effect of AP on well-being as shown by the significant indirect effect ($B = .14$, $SE = .07$, CI95 = [.01; .27]). However, at high levels of human likeness ($M = 6.21$), the opposite was true, and the indirect effect became negative ($B = -.22$, $SE = .11$, CI95 = [-.45; -.01]). The moderated mediation index was significant ($B = -.07$; $SE = .03$; CI95 = [-.14; -.01]). Thus, human likeness moderated the mediated effect via feelings of guilt on consumer well-being also for the one-item measure of consumer well-being. Thus, perceived human likeness moderated the mediated effect via felt guilt on consumer well-being (see figure).

Discussion

This study corroborated the effects of APs (vs. non-APs) on reduced time stress and eventually on consumer well-being. More importantly, the study revealed that APs compared to human house cleaners—two entities that both save consumers time—increase well-being to a greater extent and that the lower perceived guilt mediates this effect (H3, H4). Stated differently,
APs resulted in greater consumer well-being than housecleaners—even though both APs and housecleaners reduced time stress to a similar extent—because APs resulted in lower feelings of guilt. Moreover, the results showed that human likeness moderated the effect on APs (vs. human house cleaners) on perceived guilt such that consumers only feel less guilty when they do not consider the AP to be human-like (H5). This reveals anthropomorphization as a key variable determining whether consumers feel guilty or not, which translates into consumer well-being.
Web Appendix 20: Stimuli (web appendix study 3)

AP condition

Please imagine you have purchased the Roomba. Read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as if it was a real day, even while not all of the tasks might apply to your typical day.

It is a Thursday. On this Thursday, you planned several things besides such as going for dinner:

- In the morning, you get up at 6am and have breakfast.
- You arrive at work at 7:30am.
- You work until 5pm.
- Then, you go home and arrive there at 5:30pm.
- You still have to vacuum your home.
- Your Roomba then vacuums your home.
- You gain 2 hours as the Roomba completes the work and you can freely decide what you do in those 2h.
- You then go for dinner at 8pm and you leave the house.

After spending two hours at the restaurant, you go home and go to bed around 11pm.

Human condition

Please imagine you have purchased the services of Silvia’s Housecleaning Service and agreed that Silvia will vacuum for you. Read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as if it was a real day, even while not all of the tasks might apply to your typical day.

It is a Thursday. On this Thursday, you planned several things besides such as going for dinner:

- In the morning, you get up at 6am and have breakfast.
- You arrive at work at 7:30am.
- You work until 5pm.
- Then, you go home and arrive there at 5:30pm.
- You still have to vacuum your home.
- Silvia then vacuums your home.
- You gain 2 hours as Silvia does the work and you can freely decide what you do in those 2h.
- You then go for dinner at 8pm and you leave the house.

After spending two hours at the restaurant, you go home and go to bed around 11pm.

Non-AP condition

Please imagine you the following day. Read the scenario very thoroughly. It is important that you really try to imagine the whole scenario in front of your eyes. Think of this as if it was a real day, even while not all of the tasks might apply to your typical day.

It is a Thursday. On this Thursday, you planned several things besides such as going for dinner:

- In the morning, you get up at 6am and have breakfast.
- You arrive at work at 7:30am.
- You work until 5pm.
- Then, you go home and arrive there at 5:30pm.
- You still have to vacuum your home.
- You vacuum your home.
- This takes about 2 hours.
- You then go for dinner at 8pm and you leave the house.

After spending two hours at the restaurant, you go home and go to bed around 11pm.
Web appendix 21: Advertisement stimuli (web appendix study 3)

AP work condition

![Image of Roomba while you work]

AP active leisure condition

![Image of Roomba while you socialize]

AP passive leisure condition

![Image of Roomba while you relax]
Human house cleaner work condition

While Silvia works, you can even work more!

Silvia the HouseCleaning Service
Silvia’s HouseCleaning is a housecleaning company run by Silvia. She completely eliminates the tedious work of vacuum cleaning for you.
Silvia frees up your time by taking over this tedious task! And you, you can use the time for doing even more work! So much more time for working even more!

Human house cleaner active leisure condition

While Silvia works, you can be active!

Silvia the HouseCleaning Service
Silvia’s HouseCleaning is a housecleaning company run by Silvia. She completely eliminates the tedious work of vacuum cleaning for you.
Silvia frees up your time by taking over this tedious task! And you, you can use the time for being active and socializing! So much more time for socializing!

Human house cleaner passive leisure condition

While Silvia works, you can be lazy!

Silvia the HouseCleaning Service
Silvia’s HouseCleaning is a housecleaning company run by Silvia. She completely eliminates the tedious work of vacuum cleaning for you.
Silvia frees up your time by taking over this tedious task! And you, you can use the time for being lazy! So much more time for chilling on the couch!
Web appendix 22: Results of the two-way ANOVAs (web appendix study 3)

Six-item measure consumer well-being

For the six-item measure of well-being, the two-way ANOVA revealed that the advertisements did not interact with AP (vs. human) \((F(2, 515) = .38, p = .87, \eta^2 = .001)\). The main effect of AP was significant \((F(1, 515) = 4.36, p = .03, \eta^2 = .01)\) while the main effect of advertisements was non-significant \((F(2, 515) = .11, p = .90, \eta^2 < .001)\).

One-item measure consumer well-being

For the one-item measure of well-being, the two-way ANOVA revealed that the advertisements did not interact with AP (vs. human) \((F(2, 515) = 1.27, p = .28, \eta^2 = .01)\). The main effect of AP was significant \((F(1, 515) = 4.26, p = .04, \eta^2 = .01)\) while the main effect of advertisements was non-significant \((F(2, 515) = .37, p = .69, \eta^2 = .001)\).

Perceived time stress

For perceived time stress, the two-way ANOVA revealed that the advertisements did not interact with AP (vs. human) \((F(2, 515) = 1.20, p = .30, \eta^2 = .01)\). Both, the main effect of AP \((F(1, 515) = .05, p = .83, \eta^2 < .001)\) and of advertisements \((F(2, 515) = 1.35, p = .26, \eta^2 = .01)\) were non-significant.

Feelings of guilt

For felt guilt, the two-way ANOVA revealed that the advertisements did not interact with AP (vs. human) \((F(2, 515) = .40, p = .67, \eta^2 = .002)\). The main effect of AP was significant \((F(1, 515) = 15.68, p < .001, \eta^2 = .03)\) while the main effect of advertisements was non-significant \((F(2, 515) = .06, p = .94, \eta^2 < .001)\).
Web Appendix 23: Analysis of hypothesis guess question (web appendix study 3)

In web appendix study 3, we administered a hypothesis guess question. This open-text question allowed us to assess whether participants in the study guessed the hypothesis correctly and whether there were differences among the conditions.

Method

Detection of hypothesis. We first examined whether people detected the key hypothesis in this study, which was that participants felt less guilt in the AP conditions compared to the house cleaner conditions. We first coded participants who directly mentioned “guilt*” as 1 = “hypothesis detected,” 0 = “otherwise”. We extended this procedure by using the “syn” library in R (http://syn.njtierney.com/, https://github.com/ropenscilabs/syn), which also detects synonyms of guilt. We coded all participants that used words related to guilt (using the Thesaurus dictionary) as 1 = “hypothesis detected,” 0 = “otherwise”. Note that this was a particularly conservative way, as we coded only specific terms, which does not unambiguously relate to the detection of the hypothesis across conditions (i.e., that APs should reduce feelings of guilt compared to other conditions).

Influence on results. We then used detection as control to examine whether the results were significantly influenced by the detection of the hypothesis.

Results

Detection of hypothesis: Guilt. Participants in the AP and the human conditions were not significantly different in detecting the hypothesis ($P_{AP} = 6.3\%, P_{Human} = 3.0\%; B_{AP} = .79, \text{Odds Ratio} = 2.19, z = 1.78, p = .08$).
Detection of hypothesis: Synonyms of guilt. Again, participants in the AP and the human conditions were not significantly different in detecting the hypothesis ($P_{AP} = 15.0\%$, $P_{Human} = 13.5\%$; $B_{AP} = .12$, Odds Ratio = 1.13, $z = .48$, $p = .63$).

Main effect. We repeated the analysis on felt guilt and used a linear regression model, controlling for the detection of the hypothesis. In the first linear regression, we included the dummy for detection. The negative effect of AP on felt guilt held both when controlling for directly mentioning guilt ($B_{AP} = -.95$, $SE = .25$, $t = -3.86$, $p < .001$; $B_{Detection} = -.70$, $SE = .59$, $t = -1.20$, $p = .23$) as well as when using all synonyms of guilt ($B_{AP} = -.96$, $SE = .25$, $t = -3.92$, $p < .001$; $B_{Detection} = -.66$, $SE = .35$, $t = -1.88$, $p = .06$).

Interaction with human likeness. We repeated the moderation analysis on perceived guilt with human likeness as moderator, controlling for the detection of the hypothesis. In the first linear regression, we included the dummy for detection. The interaction effect between human likeness and conditions on felt guilt held both when controlling for directly mentioning guilt ($B_{AP\timesHumanLikeness} = 1.09$, $SE = .15$, $t = 7.34$, $p < .001$; $B_{AP} = -3.26$, $SE = .55$, $t = -5.94$, $p < .001$; $B_{HumanLikeness} = .07$, $SE = .09$, $t = .77$, $p = .44$; $B_{Detection} = -.04$, $SE = .55$, $t = -.07$, $p = .94$) as well as when using all synonyms of guilt ($B_{AP\timesHumanLikeness} = 1.08$, $SE = .15$, $t = 7.20$, $p < .001$; $B_{AP} = -3.23$, $SE = .55$, $t = -5.85$, $p < .001$; $B_{HumanLikeness} = .07$, $SE = .09$, $t = .79$, $p = .43$; $B_{Detection} = -.12$, $SE = .33$, $t = -.36$, $p = .72$).

Thus, experimenter’s demand does not substantially affect the results of web appendix study 3. Neither were participants likely to detect the hypothesis of guilt (even while those questions were asked explicitly before), nor were participants significantly different across conditions in terms of detection, nor did controlling for detection affect our hypotheses tests.
Web appendix 24: Search terms and frequency (study 5)

<table>
<thead>
<tr>
<th>Search term</th>
<th>AP</th>
<th>Search term</th>
<th>Non-AP</th>
<th>Search term</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bissell ev675</td>
<td>1</td>
<td>Bissell clean view</td>
<td>144</td>
<td>Char lady</td>
<td>1</td>
</tr>
<tr>
<td>Bob sweepethair</td>
<td>3</td>
<td>Bissell feather weight</td>
<td>10</td>
<td>cleaninglady</td>
<td>1,800</td>
</tr>
<tr>
<td>Botvac</td>
<td>4</td>
<td>Dirt devil</td>
<td>190</td>
<td>Cleaning service</td>
<td>593</td>
</tr>
<tr>
<td>Deebot</td>
<td>562</td>
<td>Dyson bigball</td>
<td>5</td>
<td>Cleaning women</td>
<td>13</td>
</tr>
<tr>
<td>Ecovac</td>
<td>6</td>
<td>Dyson cyclone</td>
<td>35</td>
<td>Home helper</td>
<td>6</td>
</tr>
<tr>
<td>Ecovac deebot</td>
<td>205</td>
<td>Dyson lightball</td>
<td>9</td>
<td>Maid</td>
<td>8102</td>
</tr>
<tr>
<td>Eufy robovac</td>
<td>28</td>
<td>Dyson v11</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ilife v3s</td>
<td>16</td>
<td>Dyson v7</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ilife v5s</td>
<td>3</td>
<td>Dyson v8</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ion robot</td>
<td>6</td>
<td>Eureka mighty</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iq robot</td>
<td>10</td>
<td>gtechairram</td>
<td>46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irobot roomba</td>
<td>391</td>
<td>Hoover bh50020pc</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neato botvac</td>
<td>20</td>
<td>Hoover react</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neato robotics botvac</td>
<td>2</td>
<td>Miele compact</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>powerbot</td>
<td>42</td>
<td>Miele complete</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>roborock</td>
<td>166</td>
<td>Miele dynamic</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roborock s6</td>
<td>277</td>
<td>numaticherry</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>robovac</td>
<td>157</td>
<td>Oreck commercial</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>roomba</td>
<td>27,257</td>
<td>Shark apex</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Samsung powerbot</td>
<td>11</td>
<td>Shark duoclean</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shark ionrobot</td>
<td>12</td>
<td>Shark ion</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shark iqrobot</td>
<td>10</td>
<td>Shark navigator</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xiaomir oborock</td>
<td>145</td>
<td>Shark powered</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shark rocket</td>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shark rotator</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>tinecoa10</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>vaxblade</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Web appendix 25: Key results across studies (studies 1-5)

<table>
<thead>
<tr>
<th>Study &amp; method</th>
<th>Well-being</th>
<th>Perceived time stress</th>
<th>Feelings of guilt</th>
<th>Human likeness</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>Preregistration</td>
<td>Design</td>
<td>Condition</td>
<td>M</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Field study (N = 8,862)</td>
<td>AP</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-AP</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>aspredicted.org/blind.php?x=jw5 (N = 303)</td>
<td>AP</td>
<td>4.07</td>
<td>.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-AP</td>
<td>3.82</td>
</tr>
<tr>
<td>3</td>
<td>aspredicted.org/blind.php?x=3aa (N = 248)</td>
<td>AP</td>
<td>4.34</td>
<td>.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-AP</td>
<td>3.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AP no time gain</td>
<td>3.99</td>
</tr>
<tr>
<td>4</td>
<td>aspredicted.org/blind.php?x=ew (N = 457)</td>
<td>AP low human likeness</td>
<td>4.24</td>
<td>.63</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>AP high human likeness</td>
<td>4.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Human likeness</td>
<td>4.05</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>Twitter comments (N = 40,813)</td>
<td>AP</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Non-AP</td>
<td>.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Human</td>
<td>.45</td>
</tr>
</tbody>
</table>
Notes: In study 5, stress- (but not time stress-) related words were coded.
Web appendix 26: Discriminant validity analyses

The following table summarizes the discriminant validity analyses for the key constructs (6-item measure of well-being, perceived time-stress, feelings of guilt, human likeness) across all studies where measured. In all studies, the $X^2$ difference test was significant, indicating that fixing the relationship between the respective constructs to 1 would yield a worse overall model fit.

<table>
<thead>
<tr>
<th>Study</th>
<th>Relationship</th>
<th>B</th>
<th>CI_low</th>
<th>CI_high</th>
<th>Df</th>
<th>AIC</th>
<th>BIC</th>
<th>$X^2$</th>
<th>$X^2$ diff</th>
<th>Df_diff</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Well-being – Time-stress</td>
<td>-.65</td>
<td>-.72</td>
<td>-.58</td>
<td>90</td>
<td>13457</td>
<td>13568</td>
<td>1178.00</td>
<td>545.60</td>
<td>1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>3</td>
<td>Well-being – Time-stress</td>
<td>-.62</td>
<td>-.71</td>
<td>-.54</td>
<td>90</td>
<td>992</td>
<td>10008</td>
<td>1327.00</td>
<td>787.20</td>
<td>1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Well-being – Human likeness</td>
<td>-.36</td>
<td>-.44</td>
<td>-.27</td>
<td>249</td>
<td>32807</td>
<td>33017</td>
<td>3247.00</td>
<td>1613.00</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Well-being – Human likeness</td>
<td>-.19</td>
<td>-.29</td>
<td>-.10</td>
<td>249</td>
<td>32968</td>
<td>33179</td>
<td>3409.00</td>
<td>1774.00</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Well-being – Guilt</td>
<td>-.52</td>
<td>-.59</td>
<td>-.45</td>
<td>249</td>
<td>31863</td>
<td>32073</td>
<td>2303.00</td>
<td>1254.00</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Time-stress – Human likeness</td>
<td>.20</td>
<td>.11</td>
<td>.29</td>
<td>249</td>
<td>34598</td>
<td>34808</td>
<td>5038.00</td>
<td>3404.00</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Time-stress – Guilt</td>
<td>.32</td>
<td>.23</td>
<td>.40</td>
<td>249</td>
<td>32036</td>
<td>32247</td>
<td>2477.00</td>
<td>1441.00</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>4</td>
<td>Human likeness – Guilt</td>
<td>.48</td>
<td>.41</td>
<td>.56</td>
<td>249</td>
<td>31918</td>
<td>32128</td>
<td>2358.00</td>
<td>1304.00</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>WA 1</td>
<td>Well-being – Time-stress</td>
<td>-.64</td>
<td>-.73</td>
<td>-.55</td>
<td>90</td>
<td>8429</td>
<td>8528</td>
<td>935.30</td>
<td>484.20</td>
<td>1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>WA 2</td>
<td>Well-being – Time-stress</td>
<td>-.61</td>
<td>-.67</td>
<td>-.55</td>
<td>90</td>
<td>18252</td>
<td>18376</td>
<td>2228.00</td>
<td>1279.00</td>
<td>1</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Well-being – Human likeness</td>
<td>-.58</td>
<td>-.64</td>
<td>-.51</td>
<td>249</td>
<td>39280</td>
<td>39497</td>
<td>3607.00</td>
<td>1138.20</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Well-being – Human likeness</td>
<td>-.18</td>
<td>-.27</td>
<td>-.09</td>
<td>249</td>
<td>41868</td>
<td>42085</td>
<td>6195.00</td>
<td>3726.60</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Well-being – Guilt</td>
<td>-.62</td>
<td>-.68</td>
<td>-.56</td>
<td>249</td>
<td>38668</td>
<td>38885</td>
<td>2995.00</td>
<td>526.70</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Time-stress – Human likeness</td>
<td>.16</td>
<td>.08</td>
<td>.25</td>
<td>249</td>
<td>42131</td>
<td>42349</td>
<td>6459.00</td>
<td>3990.10</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td></td>
<td>Time-stress – Guilt</td>
<td>.45</td>
<td>.37</td>
<td>.52</td>
<td>249</td>
<td>39066</td>
<td>39283</td>
<td>3393.00</td>
<td>924.70</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>WA 3</td>
<td>Human likeness – Guilt</td>
<td>.40</td>
<td>.33</td>
<td>.48</td>
<td>249</td>
<td>39105</td>
<td>39322</td>
<td>3432.00</td>
<td>963.60</td>
<td>3</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>
References


