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Consumer Engagement with Self-Driving Cars: A Theory of Planned Behavior-Informed Perspective

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Purpose – This study investigates the mediating role of consumer engagement (CE) in the relationship between perceived behavioral control (PBC) and purchase intent and the moderating role of perceived safety in the relationship between PBC and CE in the self-driving car (SDC) context.

Design/methodology/approach – To test the model, a sample of 368 consumers was deployed using partial least-squares structural equation modeling (PLS-SEM).

Findings – The findings reveal that consumers' SDC engagement mediates the relationship between PBC and their intent to purchase an SDC. Consumer-perceived SDC safety also moderates the association of PBC/engagement.

Originality/value – While prior research has examined consumer-based drivers of SDC adoption, understanding of consumers' SDC engagement-related dynamics and outcomes lags behind. Addressing this gap, we propose and test a model that explores consumers' SDC engagement vis-à-vis its drivers (perceived SDC safety/behavioral control) and outcomes (SDC purchase intent).

Keywords – Consumer engagement; Self-driving cars; Theory of planned behavior; Perceived behavioral control; Perceived safety; Purchase intent.

Paper type – Research paper.

1. Introduction

Approximately 1.35m people pass away annually in vehicle crashes, 94% of which are due to human error (Waymo, 2022), leading governments and car manufacturers to make tremendous efforts to minimize this threat (Bates *et al*., 2018). One strategy to reduce the number of traffic accidents and deaths lies in the development of self-driving, autonomous, or driverless cars (SDCs), or vehicles that use artificially intelligent applications to carry out “all driving …[-related functions in a fully] automated way, …though the driver may still have a degree of interaction with the system (e.g., [by] specifying the destination)” (Baccarella *et al*., 2020, p. 1211). That is, SDCs are able to sense the driving environment and operate without human intervention using AI-based systems (Sestino *et al*., 2022).

SDCs have the potential to significantly improve the safety and efficiency of mobility (Park *et al*., 2021), including by reducing users’ travel times, traffic congestion, accident rates, and fuel consumption and emissions (Herrmann *et al*., 2018). However, as SDC adoption remains at the (pre) *introduction* stage of the product life cycle (PLC), consumer motivations, engagement, and behaviors relating to this technology remain tenuous, thus warranting further investigation.

Several attempts have been made to understand the factors influencing SDC adoption. For example, existing studies have identified a key role of consumer-perceived SDC usefulness, ease-of-use, and trust (e.g., Zhang *et al*., 2020). However, as these works have focused on SDC-related purchase decision-making, little remains known regarding consumers’ ongoing SDC engagement, meriting further exploration. Specifically, further insight into *consumers’ SDC engagement*, defined as a consumer’s (e.g., cognitive, emotional, and/or behavioral) resource investment in his/her SDC interactions (Hollebeek *et al*., 2019), is expected to clarify their SDC-related dynamics, thus offering vital insight to theoreticians and SDC manufacturers.

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Thus, while the literature suggests that consumer-perceived SDC safety and control represent major adoption-related concerns (Ha *et al*., 2020), we expect these variables to exert an *ongoing* effect on consumers' SDC engagement, which – however – remains tenuous to date, exposing an important research gap. That is, while perceived safety is pivotal at *any* stage of a consumer's relationship with his/her vehicle (Osswald *et al*., 2012), its role for SDCs necessitates further investigation. Moreover, while traditional vehicles offer elevated user control and responsibility (Schneble and Shaw, 2021), SDCs, by *minimizing* driver intervention (Lee *et al*., 2019), are expected to see lower user-perceived control (vs. conventional cars), thus potentially altering their engagement with these vehicles. Therefore, while consumers are traditionally accustomed to being in control of their driving, SDCs' *autonomous* nature requires consumers to cede their vehicle-related control to an automated system (Baccarella *et al*., 2020), which we anticipate to impact their SDC engagement, as explored in this study.

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To investigate these issues, we adopt a theory of planned behavior (TPB)-informed perspective that links individuals' attitudes to their object-related behavior and engagement (Ajzen, 1991; Bitter *et al*., 2014). The theory proposes a key role of *perceived behavioral control (PBC)*, the extent to which an individual believes s/he has the resources, ability, and opportunity to perform a behavior, in impacting his/her subsequent intent to perform the behavior (Ajzen, 1991). These issues remain nebulous in the SDC-based engagement context, thus offering a suitable lens to explore the outlined issues. Moreover, we expect PBC to be impacted by the individual's *perceived SDC safety* (Roy *et al*., 2018), or the extent to which SDC "drivers or passengers …feel relaxed, safe and comfortable while driving" (Xu *et al*., 2018, p. 323), which also merits further exploration. An under-explored SDC-based tension, therefore exists: On the one hand, SDCs may feel safer than traditional cars (e.g., given their reduced proclivity for errors/accidents; Hollebeek *et al*., 2021), leading users to potentially prefer driving an SDC. However, on the other hand, consumers may feel uncomfortable relinquishing driving-related control (Ha *et al*., 2020), potentially yielding their preference for traditional cars (vs. SDCs). In this study, we further explore, and elucidate, this tension.

This paper makes the following contributions to the SDC- and consumer engagement (CE) literature. First, deploying a TPB-informed perspective, we empirically investigate the relationship of consumer-perceived SDC-related behavioral control and engagement on their intent to purchase an SDC. The findings suggest a positive relationship between consumers' PBC and their SDC purchase intent. Specifically, consumers perceiving greater SDC-related control are more inclined to purchase an SDC, echoing Hollebeek *et al*.'s (2022a) findings for consumers' video-game engagement. The results also substantiate engagement's mediating role in the association of PBC and their SDC purchase intent. Consumers' elevated behavioral control, thus, yields higher SDC engagement, in turn raising their SDC purchase intent, corroborating prior SDC-related findings (e.g., Hollebeek *et al*., 2022b). Moreover, the findings suggest that, even prior to a product's mainstream market introduction, consumers may already engage with it, thus offering further novel insight. These findings are useful to SDC manufacturers, given their vested interest in SDC adoption and engagement.

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Second, we assess the potentially moderating role of consumer-perceived safety in the association of PBC and SDC engagement. We hypothesize that the association of consumer-behavioral control and engagement is mitigated depending on whether consumers perceive SDCs to be safer (vs. less safe). We use perceived SDC safety as a moderator because user-perceived safety is vital in high-risk purchases, including SDCs (Nunes *et al*., 2018). The findings show that perceived safety exerts a negative moderating effect on the association of consumer-perceived behavioral SDC control and SDC engagement. That is, consumers perceiving an SDC to afford them higher (vs. lower) driving-related control tend to display higher SDC engagement. However, this association is weaker for consumers who perceive SDCs to be safer (vs. less safe). That is, the role of PBC in generating engagement is more important for consumers who perceive SDCs to be less safe (vs. safer), revealing pertinent implications. The findings, thus, reveal a key interplay between SDC-related safety and PBC, particularly in terms of raising SDC-related behavioral control for those perceiving SDCs as less safe.

The paper is structured as follows. Section 2 reviews relevant literature, followed by our hypothesis development in section 3. Section 4 outlines the deployed methodology, followed by a summary of the results in section 5. In section 6, we outline key implications that arise from our work.

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2. Literature review

2.1 Theory of planned behavior

Extending the theory of reasoned action (Fishbein and Ajzen, 1975), the TPB posits that individuals' behavior is influenced by their attitude toward a behavior, subjective norms, and PBC (Ajzen, 1991). While consumer *attitudes* refer to their relatively permanent disposition toward an object (Raimondo and Farace, 2013), *subjective norms* reflect an individual's perceived social pressure to (not) engage in a behavior (Fu *et al*., 2010). We argue that, for SDCs, consumers' attitudes and subjective norms are still in the formation phase, given SDCs' current developmental/introductory PLC stage. For example, SDC-related social pressure is expected to be limited to date, as SDCs are yet to enter mainstream consumer markets globally (Poo and Dalziel, 2016), leaving people with relatively low SDC-related knowledge and opinions to date.

However, we posit that *PBC*, defined as a user's experienced level of control over an action or behavior (e.g., driving an SDC), may, indeed, affect the individual's behavior, or behavioral intention (Chen and Yan, 2019). Relatedly, while prior authors have investigated consumers' SDC adoption from a TPB perspective (Gkartzonikas *et al*., 2022; Jing *et al*., 2019), these have tended to focus on consumers' SDC *adoption*, yielding limited insight into consumers' ongoing SDC engagement, in particular vis-à-vis their perceived SDC-related behavioral control and safety. We next review key CE literature.

2.2 Consumer engagement

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While CE has gained prominence in the literature (Menidjel *et al.*, 2022; Naqvi *et al.*, 2021a), its conceptualization remains debated. For example, while Brodie *et al*. (2011, p. 258) conceptualize CE as a consumer's "psychological state, which occurs by virtue of interactive [consumer] experiences with a focal agent/object," Hollebeek *et al*. (2019, p. 166) define it as a consumer's "investment of operant [i.e., cognitive, emotional, behavioral] …and operand (e.g., equipment-based) resources …in [his/her] brand interactions." Despite this dissent, most definitions concur regarding engagement's *interactive* conceptual core (Hollebeek and Belk, 2021).

Second, CE is typically viewed as a multidimensional concept comprising cognitive, emotional, and/or behavioral components (e.g., Munaro *et al*., 2021). Here, *cognitive* engagement reflects a consumer's "level of brand-related thought processing and elaboration in a …brand interaction;" *emotional* engagement represents a consumer's "degree of positive brand-related affect in a …brand interaction;" *behavioral* engagement reflects a consumer's "level of energy, effort, and time spent on a brand in a …brand interaction" (Hollebeek *et al*., 2014, p. 154; Harrigan *et al*., 2018).

Third, while the engagement subject is made explicit in the CE concept (i.e., the *consumer*), its engagement *object* is left implicit (Hollebeek, 2011). The latter can, therefore, comprise different objects, including a brand, firm, or product (e.g., a SDC; Vivek *et al*., 2014). While published work offers insight into consumers' engagement with particular products or brands (e.g., Hollebeek *et al*., 2022a), little remains known regarding their engagement with SDCs (Clark and Feng, 2017), as therefore examined in this paper. We next develop our research hypotheses.

3. Hypothesis development

We next develop our research hypotheses, as summarized in Figure 1.

[Insert Figure 1 about here]

3.1 The perceived behavioral control/behavioral intent interface

PBC, or the extent to which an individual believes s/he has the resources, ability, and opportunity to perform a behavior, is a critical determinant of consumers' behavioral intentions (Ajzen, 1991). Under high behavioral control, consumers feel their behavior has an extensive effect on their environment (Parkinson *et al*., 2017). For example, those who believe to have high behavioral control may seek to turn around a firm's unethical behavior. These consumers also tend to speak positively about the brand, have favorable brand attitudes, exhibit greater positive (and fewer negative) brand-related emotions, and tend to pay more for the brand. Conversely, those who feel they have low behavioral control are more doubtful that their actions will have an impact their environment (Ajzen, 1991). For example, in less competitive markets, buyer bargaining power tends to remain low, as many other buyers are available, which can

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disempower individuals or give rise to their less positive emotions (De Ruyter and Semeijn, 2002).

In the TPB, individuals are predicted to be more likely to perform a behavior if they believe they have the ability to perform it well (Hollebeek *et al*., 2022a). For SDCs, PBC is expected to be primarily linked to the individual's perceived *ability* to control the autonomous vehicle (Jörling *et al*., 2019). For example, if consumers lament their loss of driving-related control (vs. traditional cars), their PBC is likely lowered, rendering them less likely to (intend to) use SDCs (Chen and Yan, 2019; Guerreiro *et al*., 2022). It is, then, expected that consumers perceiving higher SDC-related control are likely to display a greater intent to purchase an SDC (Gkartzonikas *et al*., 2022; Jing *et al*., 2019). We hypothesize:

> **H1.** *A positive association exists between consumers' perceived SDC-related behavioral control and their SDC-related intent to purchase an SDC.*

3.2 Engagement's mediating role in the PBC/behavioral intent interface

While prior research has typically focused on PBC as a direct determinant of consumers' behavioral intent (Yang, 2012), we propose this association may be mediated by CE, as follows: A consumer's PBC is likely to impact (i.e., raise) the individual's resource investment (i.e., engagement) in his/her SDC-related interactions (Pansari and Kumar, 2017). That is, the higher one's perceived SDC-related control, the higher his/her expected SDC engagement, in turn impacting (i.e., enhancing) the individual's intent to purchase an SDC (Villagra *et al*., 2021). We posit:

> **H2.** *CE mediates the association of PBC and their SDC-related intent to purchase an SDC.*

3.3 Perceived safety's moderating effect in the PBC/engagement interface

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Perceived safety, or the extent to which an individual feels safe in a situation (e.g., while driving an SDC; Blut *et al*., 2021), has been found to play a critical role in shaping consumer behavior (Roy *et al*., 2018). Perceived *safe* products/brands are, therefore, conducive to the formation of positive attitudes to, satisfaction with, and elevated behavioral intent toward the object, and vice versa (e.g., Featherman *et al*., 2021; Zhang *et al*., 2019). For SDCs, perceived safety is pivotal in affecting consumers' product acceptance and choice (Park *et al*., 2021).

As noted, SDCs were developed to free up their users from driving, reducing their driving burden (Sparrow and Howard, 2017). These cars drive autonomously, while independently executing driving functions. When using SDCs, consumers may feel concerned about the car's safety, given their lacking mobility-related autonomy and control (Baccarella *et al*., 2020). In particular, autonomous cars without a steering wheel, pedals, or gear box are likely to elicit consumers' perceived lack of SDC-related control, potentially raising their SDC-related safety concerns (Meyer-Waarden and Cloarec, 2022; Xu *et al*., 2018). Moreover, consumers may question SDC safety under failing connectivity (Shetty *et al*., 2021), maintaining their SDC engagement at potentially modest levels (Nunes *et al*., 2018).

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We posit that the association of PBC and engagement will pan out differently for consumers perceiving SDCs to feature high (vs. low) safety. For example, those that perceive SDCs as *un*safe may make mental reference to SDC testing resulting in incidents (e.g., a woman being killed in an SDC-related accident in Arizona; McCausland, 2019). These individuals may be also concerned about the efficiency of an SDC's driving/safety features, including its automatic emergency braking, traffic sign recognition, lane-keeping capability, and hazard detection and avoidance, etc. (Baccarella *et al*., 2020), affecting the association of their perceived SDC-related control and engagement. Conversely, consumers who feel SDCs are relatively safe to use exhibit significantly fewer concerns, which may, likewise, impact the association of their SDC-related PBC and engagement. Therefore, the effect of SDC-related PBC on engagement is mitigated, depending on whether consumers perceive SDCs as safer (vs. less safe). We postulate:

> **H3.** *Perceived safety significantly moderates PBC's positive effect on their SDC engagement.*

4. Methodology

4.1 Scenario-based design

The National Highway Traffic Safety Administration (NHTSA) defines five levels of SDC automation (Anderson *et al*., 2016). Levels 0-2 cover no automation (i.e., drivers completely control the car's functions), to combined-function automation, which – despite automating some driving functions (e.g., steering/acceleration) – still require drivers to remain attentive in resuming control at any time. Levels 3-4 represent limited and full self-driving automation, respectively. As levels 0-2 are already deployed in conventional cars worldwide, we designed our experimental scenarios based on vehicle levels 3-4, which are at the (pre-)introductory stage in the PLC (Zhao *et al.*, 2018).

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Our scenarios describe a situation where the consumer is using a level 3-4 SDC, which controls and executes the vehicle's driving and safety assessment functions from start to finish, without any human intervention (Baccarella *et al*., 2020; Jörling *et al.*, 2019; see Appendix A). We used scenario-based methodology to examine consumers' SDC-related engagement because it, first, reduces potential bias (Park *et al.*, 2014), while also offering elevated internal validity by allowing researchers to control for the effect of other extraneous factors impacting the results (King and Auschaitrakul, 2021). Second, it is difficult to capture consumers' SDC interactions in real-world settings, as SDCs are not yet widely available (Payre *et al.*, 2021), yielding its widespread adoption in SDC- and marketing research (e.g., Jörling *et al.*, 2019). Correspondingly, none of our participants had used an SDC to date, suggesting the suitability of adopting a hypothetical scenario in this study.

Our scenarios were designed based on validated literature-based SDC scenarios (Baccarella *et al.*, 2020; Jörling *et al.*, 2019). To validate the scenarios, several colleagues were invited to assess, and check, the respective scenarios' content for clarity and relevance. Based on their feedback, necessary adjustments were made. Moreover, a pretest was conducted with 36 respondents, which indicated that the scenarios sounded realistic, and that their content was clear, concise, and understandable (Huang *et al.*, 2020; Liao, 2007). We deployed the pretest-based scenario validation as a manipulation check validating the interpretation of our scenarios for adoption in the main data collection.

4.2 Survey pretest

The data were collected by using a self-administered questionnaire distributed through Facebook in January-February 2022. The survey was first pretested with a sample of 36 respondents, 80.56% of which were male (19.44% female), and approximately 61.11% were married (38.89% single). Two-thirds of the respondents were 18-35 years old, and 33.33% were 36 or over. All respondents held their full driver's license and over 86% had at least two years of driving experience.

The pretest results show that the Cronbach's alphas for the modeled constructs exceeded the 0.7 threshold, confirming their reliability (Hair *et al*., 2010). Based on the results, minor amendments were made to some of the items' wording. Overall, the pretest results demonstrated that the survey questions were clear, and easily understood by, the respondents. The findings also

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showed that the required average time to complete the survey was 10 minutes, revealing an acceptable respondent burden (Frazer and Lawley, 2000).

4.3 Main questionnaire

The questionnaire commenced with an introduction outlining the study's objectives, while also assuring the respondents of the survey's anonymity, confidentiality, and its purely voluntary nature. The introduction also noted that there are no right/wrong answers in the survey. The questionnaire's second part started with screening questions to ensure the participants were at least 18 years old and held their full driver's license, followed by one of two scenarios describing different SDC driving situations (see Appendix A). In each scenario, participants also responded to the items measuring the modeled constructs (see section 3.4). To administer the survey, the measurement items were randomly ordered across the participants. In the questionnaire's final section, we requested the respondents' demographic information (e.g., gender/age).

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A total of 368 valid questionnaires (i.e., 186 limited self-driving scenario, and 182 full self-driving scenario) (NOT CLEAR what these scenarios are? Need to explain in a sentence) was collected using purposive- and snowball sampling (Hair *et al*., 2017, 2020). Of these, 77% were male (23% female). Given the non-probability nature of our sampling method, our objective is not to generalize to the entire population (e.g., of Facebook users), but to examine key differences across potential SDC users. In terms of age, 20.65% of the respondents were 18-25 years old, 49.46% were 26-35, and 29.89% were 36 or over. In terms of marital status, 59.51% were single (40.49% married). Moreover, over 76% has held their full driver's license for at least two years.

4.4 Measures

We deployed established multi-item scales (see Appendix B) to gauge the modeled constructs. The items were measured on five-point Likert scales ranging from *strongly disagree* (1) to *strongly agree* (5). To measure *PBC*, Collier and Sherrell's (2010) four-item scales were adapted to suit our research context (Jörling *et al*., 2019). A sample item reads: "I would feel in control using this car." Second, *perceived safety* was gauged by using Xu *et al*.'s (2018) three-item instrument. A sample item reads: "I would feel safe using this car." Third, *CE* was measured as a higher-order construct comprising three dimensions: Cognitive processing (i.e., cognitive engagement; 3 items), affection (i.e., emotional engagement; 4 items), and activation (i.e., behavioral engagement; 3 items; Hollebeek *et al*., 2014). A sample item reads: "I would feel very positive when I use this car." Finally, *intent to purchase an SDC* was measured by deploying Zeithaml *et al*.'s (1996) two-item scale. A sample item reads: "If this car is available, I would intend to purchase it in the future."

5. Results

5.1 Measurement model assessment

The data were analyzed by using partial least squares structural equation modeling (PLS-SEM). For the lower-order constructs (i.e., PBC; perceived safety; engagement; SDC purchase intent), the measurement model's construct reliability and validity were first checked, yielding the internal consistency, convergent validity, and discriminant validity results shown in Table 1 (Hair *et al*., 2017). Overall, the findings reveal that all factor loadings exceeded the value of 0.7, exception for PS3 (0.58), which was, however, retained owing to its significant loading (i.e., $p < 0.001$), suggesting the reliability of the measurement items.

Moreover, Cronbach's alphas and composite reliability (CR) were greater than 0.7, and the average variance extracted (AVEs) exceeded 0.5, indicating convergent validity (Hair *et al*.,

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2020). Moreover, discriminant validity was evaluated by examining any cross-loadings and by deploying the Fornell-Larcker test. As shown in Table 1, the item factor loadings exceeded their correlation with the other constructs and the square root of the AVE for each construct exceeded its correlation with each of the other constructs (see Table 2), confirming discriminant validity of the modeled constructs.

[Insert Table 1 about here]

We next verified the measurement model for the higher-order CE construct. As shown in Table 3, the variance inflation factor (VIF) values remained under the critical threshold of 5.0 and all indicator weights, with the exception of COG (i.e., cognitive processing), which was, however, retained owing to its significant factor loading (i.e., $p < 0.001$), and loadings were significant, validating the higher-order engagement construct.

[Insert Table 2 about here]

5.2 Structural model assessment

Table 4 shows PBC's positive effect on intent to purchase an SDC and engagement, thus supporting H1. CE, in turn, positively impacts consumers' intent to purchase an SDC. To measure engagement's mediating effect, a bootstrapping procedure with 5,000 resamples was employed (Hair *et al*., 2017). The results show that the direct/indirect effects of PBC on consumers' intent to purchase an SDC were significant. In addition, the 95% confidence intervals did not contain the value of 0 (see Table 4), suggesting engagement's partial mediating effect in the association of PBC and intent to purchase an SDC, thus partially supporting H2.

[Insert Table 3 about here]

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Next, we evaluated the moderating effect of perceived safety in the association of PBC and CE. When testing a moderating effect, the moderator's (i.e., perceived safety's) direct effect on the endogenous construct (i.e., engagement) needs to be included. The results in Table 4 show that perceived safety has a direct, positive impact on engagement and a negative moderating effect on the positive relationship of PBC and engagement, supporting H3. That is, the positive effect of PBC on engagement is weaker for consumers who perceive SDCs to be safer (vs. less safe), as shown in Figure 3. Specifically, while the green line in Figure 3 represents the respondents' high perceived SDC safety (0.33), the red line represents their low perceived safety (0.47).

[Insert Figure 2 and Figure 3 about here]

Furthermore, we evaluated the variance inflation factors (VIFs), effect sizes (f^2), coefficient of determination (R^2), predictive relevance (Q^2), and standardized root mean square residual (SRMR). As shown in Table 4, the VIFs remained below the value of 5, indicating that collinearity is not an issue in the data (Hair *et al*., 2017). To assess the effect sizes f^2 for the structural model relationships, the results show that PBC exerts a medium effect (0.25) on CE and a small effect (0.06) on the respondents' intent to purchase an SDC, while engagement also exerts a large effect (1.45) on their intent to purchase an SDC (Cohen, 1988). In terms of the moderation effect, the interaction term's f^2 effect size displayed a value of 0.01, indicating a medium effect size (Kenny, 2018). According to Figure 2, engagement's R^2 value is 0.64, and 0.79 for intent to purchase an SDC. The Q^2 values of engagement (0.49) and intent to purchase an SDC (0.67) exceeded the value of 0, confirming the model's predictive relevance. Finally, at an SRMR of 0.07 (i.e., remaining under the 0.08 cut-off), the model was found to offer a good fit to the data (Henseler *et al*., 2016).

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[Insert Table 4 about here]

6. Discussions, implications, and directions for future research

6.1 Theoretical implications

Drawing on the TPB (Ajzen, 1991), this study developed and tested a theoretical model that explores the effect of PBC on SDC engagement and its ensuing effect on SDC purchase intent. Moreover, we examined the potentially moderating role of consumer-perceived safety in the association of PBC and engagement, as outlined. The following main implications for SDC marketing researchers arise from our findings.

First, by examining the effect of PBC on SDC purchase intent, the results provide novel insight into SDCs' capacity to radically transform users' driving experience. That is, while consumers are typically found to value having an extensive level of control over their traditional driving experience, this is substantially reduced when driving an SDC, creating an interesting tension that merits further scrutiny (Baccarella *et al*., 2020; Schneble and Shaw, 2021). Thefindings suggest that the higher PBC, the higher a consumer's intent to purchase an SDC (Gkartzonikas *et al*., 2022; Jing *et al*., 2019), suggesting that SDC manufacturers should boost (vs. reduce) consumers' perceived behavioral SDC-related control (e.g., by allowing users to take over control over their SDC when needed; Herrmann *et al*., 2018).

Relatedly, while the TPB suggests that consumers' behavioral intent is *directly* affected by their PBC (Ajzen, 1991; Hollebeek *et al*., 2022a), as the present SDC-based findings corroborate, consumers' level of SDC engagement is *also* found to mediate this association. That is, PBC exhibits both a direct *and* indirect effect on the user's intent to purchase an SDC (i.e., as mediated via engagement), revealing more nuanced insight into these dynamics (Rather *et al*.,

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2022; Villagra *et al*., 2021). This result makes sense, as the higher one's perceived control when driving an SDC, the greater one's expected (e.g., cognitive/behavioral) resource investment in interacting with the SDC, thus boosting the individual's SDC engagement (Kumar *et al*., 2019; Hollebeek *et al*., 2019). This finding, therefore, counters Papagiannidis *et al*. (2014), who suggest a non-significant association of control and engagement.

Moreover, this finding extends the work of Hollebeek *et al*. (2022b), who examine the role of social influence-based control in impacting stakeholders' (e.g., consumers') engagement. While these authors, like the present findings, suggest a key effect of control on engagement, they focus on interpersonal control (vs. user-perceived control over a product), thus adding important further SDC-based insight. Specifically, by suggesting engagement as a key mediator in the association of PBC and consumers' SDC purchase intent, this finding advances scholarly understanding, which future researchers are encouraged to validate across contexts. For example, to what extent does consumer-perceived control affect their engagement across (e.g., self-driving technology-based) contexts? In which cases is the direct (vs. mediated) effect stronger? Additional factors associated with social influence and/or the consumer's psychological state may also be examined to derive further understanding of SDC-related engagement and purchase intention.

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Second, we examined the potentially moderating effect of consumer-perceived SDC safety in the association of their PBC and engagement (see Figure 1). Consistent with H3, this finding shows that perceived safety moderates the positive effect of PBC on engagement. Specifically, the interaction effects shown in Figure 3 reveal that the effect of PBC on engagement is stronger for consumers who perceive SDCs as less safe (vs. safer), revealing pertinent insight. That is, the role of perceived control in generating engagement is more important for those consumers who perceive SDCs to be less safe (vs. safer). This finding is plausible, because individuals who view SDCs to be less safe will consider their perceived behavioral SDC-related control as a major factor in their developing SDC engagement, thus extending existing research identifying the paramount role of perceived vehicle safety to the SDC context (Nunes *et al*., 2018). Put differently, if a consumer's perceived SDC safety is high (vs. low), his/her perceived behavioral SDC-related control may not necessarily raise his/her SDC engagement, and vice versa.

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Finally, this study is among the first to empirically examine consumers' engagement with SDCs prior to, or at the point of, the latter's market introduction (i.e., well before SDCs become mainstream or enter the growth phase of the PLC). Therefore, the reported findings are important for SDC theoreticians (Fu *et al*., 2010). More broadly, the findings show that even prior to a product's market introduction, consumers may already engage with it, reflecting their *pre-usage*-, *advance*- or *anticipation engagement*.

6.2 Practical implications

This study also generates pertinent managerial implications for SDC manufacturers and marketers. First, the results demonstrate the importance to design products that feature high (vs. low) SDC-related PBC, which is – in turn – expected to raise their SDC engagement. To do so, SDC marketers may wish to educate their consumers regarding how to take control over their SDC (e.g., in cases of emergency), including through the provision of detailed SDC manuals and consumer support and training facilities (Tyagi and Aswathy, 2021).

Second, we advise marketers to favorably shape consumers' SDC safety perceptions, which can, for instance, be done by emphasizing specific SDCs as safer alternatives to conventional cars (Anderson *et al*., 2016; Herrmann *et al*., 2018). This suggestion is important, given our finding that consumer-perceived SDC safety boosts their SDC engagement, as shown in Table 4. That is, the safer consumers perceive an SDC to be, the greater their SDC engagement. In other words, those consumers who perceive SDCs as safer (vs. less safe) are likely to display higher SDC engagement, in turn favorably impacting their intent to purchase an SDC, thus offering important benefits to marketers. For example, engaged consumers have been shown to spend more, offer greater positive word-of-mouth, and to be willing to pay a price premium (Brodie *et al*., 2011; Pansari and Kumar, 2017), revealing their strategic importance for SDC manufacturers. We, thus, recommend that SDC marketing efforts to focus on nurturing consumers' SDC engagement as a key metric to support their SDC adoption.

Third, the findings have implications for policy makers, including those tasked with raising SDC accessibility to the public. For example, legislators may wish to put forward new legal bills or requirements that command SDC users to fully understand, and be able to skillfully operate, their SDC (e.g., through SDC-related driver testing or examination that differs from traditional driver's licensing requirements; Nunes *et al*., 2018). Relatedly, as SDC uptake rises, updates or upgrades to roading infrastructure are also required (e.g., by adding more 5G communication networks; Herrmann *et al*., 2018), thus offering further policy implications.

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6.3 Limitations and future research

Despite its contributions, this study also incurs limitations that offer further research opportunities. First, this study conducted a scenario-based experiment to explore the proposed TPB-informed model in the SDC context. While the findings are important for SDC researchers and marketers, future researchers may wish to extend our results, including by conducting quasi- or field experiments in real driving situations. For example, further study may invite their participants to drive an actual (e.g., Tesla, Pony.ai, or Waymo) SDC, and gauge their responses to the modeled constructs.

Second, the data was collected from potential (vs. actual) SDC users, given SDCs' limited availability to date, as outlined. However, despite SDCs being at the (pre-)introduction stage of the PLC, the category is expected to rapidly develop in the coming years (Anderson *et al*., 2016; Nielsen and Haustein, 2018). Future research may, therefore, replicate the proposed model in or across different new product or service categories (e.g., smart devices/automated personal assistants, etc.).

Third, we deployed cross-sectional data to investigate the proposed research issues. Therefore, further researchers may adopt longitudinal research designs to track the proposed dynamics over time, thus yielding further insight. Relatedly, researchers could adapt the proposed model (e.g., by adding constructs including consumer trust, perceived risk, or those that explicate consumers' sentiment toward different SDC brands, such as brand love).

Fourth, while we explored the potentially moderating role of consumer-perceived safety in the association of PBC and engagement, other moderating factors may be applied (e.g., perceived privacy, security, or coping appraisal). Likewise, while the present data was collected during the pandemic, pandemic-related issues were not directly explored. However, the pandemic context may heighten or alter consumers' SDC-related perceptions. For example, a rising demand for driverless taxis may be observed, which reduces the risk of contracting COVID-19 (Dogerlioglu-Demir *et al*., 2022). Consequently, future examination of the proposed model with direct reference to relevant pandemic-related issues (e.g., social distancing) may yield important further insight (Kapser *et al*., 2021).

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Finally, while we adopted the TPB to guide our analyses, scholars may also use other theoretical perspectives to inform their analyses. For example, given SDCs' nature as a radical innovation, technology adoption theories may be used, including the technology acceptance model (Davis, 1989), the technology readiness index (Parasuraman, 2000), or the stimulus-organism-response model (Naqvi *et al*., 2021a), which have been adopted in related research (e.g., Naqvi *et al.*, 2019, 2021b). In addition, the theory of reasoned action may be used to explore consumer attitudes and subjective norms in their SDC adoption and usage process (Ajzen and Fishbein, 1980). Finally, though the deployed dependent variable was consumers' intent to purchase an SDC, further researchers may include other potential outcome variables, including product/brand-related word-of-mouth, referrals, or actual purchase behavior, thus offering further insight.

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