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Tuning the Pulse: The Impact of Motivational Feedback on Fitness Technology Adherence

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Completed Research Paper

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Abstract

In the ever-changing field of fitness technology, it is essential to comprehend the significance of motivational feedback in relation to user persistence. The present study investigates the impact of various forms of feedback provided by fitness technology on individuals' basic psychological needs and their long-term commitment to using these devices. This study employs structural equation modeling to investigate the impact of affective, social, and informational feedback on users' autonomy, competence, and relatedness needs. The results of the study highlight the potential for particular types of feedback to either meet or frustrate users' basic psychological needs, which in turn affects their likelihood of continuing to use the technology. These insights provide helpful recommendations for designers in the creation of motivational systems that are more successful. Additionally, they assist users in selecting technologies that align with their particular interests, thereby enhancing long-term engagement.

Keywords: Fitness technology, motivational feedback, self-determination theory

Introduction

The fitness technology domain is extensive, encompassing a range of devices, apps, and services specially designed for various demographics and activity levels. The widespread use of these technologies is apparent, with a significant increase in Fitbit user engagement from around 500,000 in 2012 to over 37 million in 2022 (Statista, 2023). These technologies promote physical activity (PA) by increasing users' physical activity levels. However, the benefits are limited (Romeo et al., 2019), and sedentary behaviors are reduced (Stephenson et al., 2017). They assist in setting goals (Gordon et al., 2019), provide social support (Sullivan & Lachman, 2017), and enhance PA enjoyment through interactive games (Kari et al., 2020) and gamification strategies (Koivisto & Hamari, 2019). Feedback from self-monitoring devices raises awareness of individual PA and serves as motivation (Wang et al., 2016), although simply being conscious of PA does not guarantee sustained usage of technology (Miyamoto et al., 2016), which is crucial for maintaining PA routines (Attig & Franke, 2020).

However, user retention in PA programs remains a challenge. Statistics indicate that up to half of individuals commencing an exercise routine may discontinue within the first six months (Linke et al., 2011), with a specific study showing a dropout rate of 0.15 per six months in a year-long program specially designed for adults (Stiggelbout et al., 2005). It is imperative to explore how fitness technologies impact and sustain user engagement. The literature suggests that intrinsic motivation is a crucial factor in the maintenance of exercise behaviors among fitness tracker users (Donnachie et al., 2017), a concept rooted in Self-Determination Theory (SDT; Deci & Ryan, 1985) and its application to health contexts (Ryan et al., 2008).

Within the domain of information systems (IS), previous studies have examined motivational drivers and their influence on fitness technology usage (Hamari et al., 2018; James et al., 2019a) and the impact of social dimensions on well-being and user commitment to these systems (Rockmann, 2019; Whelan & Clohessy, 2021). These studies emphasize variability in user motivation, affecting technology interaction and outcomes. The alignment of technology features with users' basic psychological needs (BPNs)—autonomy, competence, and relatedness has been proposed as a potential explanation for variations in usage patterns (James et al., 2019a; James et al., 2019b); however, there is limited empirical evidence available regarding the impact of these psychological needs on usage outcomes (Rockmann, 2019), and only a limited number of studies have specifically examined the design of systems with these needs in consideration.

Three prominent technological frameworks emerge focusing on motivational IS design (Hamari et al., 2018): hedonic designs, which aim to enhance intrinsic motivation and enjoyment through affective feedback (Huotari & Hamari, 2017; Landers et al., 2018). Utilitarian designs use big data and wearable technology to collect and visualize accurate data (Nafus & Sherman, 2014), and social networking designs foster socio-psychological responses and community through social feedback (Chen et al., 2014).

While a single motivational IS may integrate all three design types, user preferences may tend to choose specific aspects. Investigating the effectiveness of these designs in meeting users' Basic Psychological Needs (BPNs) and fostering long-term usage is a critical area of study. The existing body of literature has not comprehensively examined the extent to which motivating feedback provided by these systems can either align with or hinder users' BPNs. Our research posits that motivational feedback aligning with users' BPNs satisfaction will likely yield positive health behaviors, such as consistent use of fitness technologies. In contrast, when such feedback frustrates BPNs, adverse outcomes may result. SDT supports this proposition and aligns with findings in IS research that link technology support for BPNs to sustained use and well-being (James et al., 2019a; James et al., 2019b).

This study contributes to the literature in several significant ways. First, it provides a comprehensive examination of three types of motivational feedback—affective, social, and informational—and their specific impacts on users' Basic Psychological Needs (BPNs) within the context of fitness technology. Second, it explores how the alignment or frustration of these psychological needs influences the continuous usage of the technology. Finally, it extends the application of Self-Determination Theory (SDT) by integrating it with feedback mechanisms specific to fitness technologies, thereby offering a novel theoretical model for understanding user engagement and adherence in this domain.

Our study addresses the following research questions: How do affective, social, and informational feedback provided by fitness technology impact users' satisfaction and frustration with their basic psychological needs (BPNs), and how users' views of their BPNs influence their continuous usage of the device? This investigation holds significant value for designers in developing systems that effectively connect with users and for consumers in making informed choices regarding technologies that promote long-lasting advantages and utilization. The acquired insights will play a crucial role in developing fitness technologies offering diverse feedback and improving users' BPNs and their dedication to the device.

Theoretical Background

Feedback is crucial as a tool, significantly impacting motivation levels when delivered appropriately. It can be positive or negative, individual or group-based, and timed correctly (Fishbach & Finkelstein, 2011). The demand for systems that provide relevant feedback is emphasized due to their ability to help users understand the system's benefits (Fang et al., 2017). However, integrating numerous features into a system while expanding user choices and increasing the likelihood of finding appreciated features can also lead to information overload and confusion, potentially causing users to discontinue system use (Willemsen et al., 2016).

In psychology and computer science, feedback is typically categorized into affective, social, and informational domains (Fishbach & Finkelstein, 2011; Hamari & Koivisto, 2015; Kluger & DeNisi, 1996). Affective and social responses, combined with performance information, constitute feedback that can bridge the gap between intended and actual behavior (op den Akker et al., 2014), guiding individuals toward their desired performance outcomes (Fishbach & Finkelstein, 2011). This highlights the importance of feedback in motivation and behavioral change, as demonstrated in various motivational research studies (e.g., Custers & Aarts, 2005; Kluger & DeNisi, 1996).

Affective feedback, which encompasses positive or negative emotional responses, is processed by individuals in response to intrinsic or extrinsic stimuli, influencing their evaluation, maintenance, or behavior alteration (Custers & Aarts, 2005). Positive affective feedback can boost motivation and engagement, even without clear explanations, underscoring its effectiveness as a motivational tool (Fishbach & Finkelstein, 2011). Social feedback, often derived from one's social environment, including friends, family, and colleagues, provides a social evaluation of behavior that can impact engagement or disengagement decisions (Hamari & Koivisto, 2015; Teng, 2017). Social networking features facilitate user connection and interaction, resulting in social feedback through comparison, praise, or criticism (Oinas-Kukkonen et al., 2010). While social feedback can often be positive, negative social experiences, such as failure, envy, or disappointment, can also demotivate individuals (Pan et al., 2017). Informational feedback, characterized by objective data related to specific matters such as health reports or performance metrics (Hattie & Timperley, 2007), holds significant importance. Its impact on behavior change is often greater than other feedback forms, as evidenced by meta-analyses (Hattie & Timperley, 2007). Advances in wearable technology and data analytics have made self-tracking more accessible, leading to the Quantified Self-movement, which utilizes logs, geo-maps, and visualizations to support goal achievement (op den Akker et al., 2014; Swan, 2009, 2013).

Recent studies further highlight the nuanced effects of different types of feedback and the social dimensions of fitness technologies. For instance, Whelan and Clohessy (2021) examine how the social dimension of fitness apps can both enhance and undermine well-being through a dual model of passion. Ilhan (2018) explores the motivations behind joining fitness communities on Facebook, identifying key gratifications that drive user engagement. Teng and Bao (2022) investigate factors affecting users' stickiness to fitness apps, providing insights into the importance of social and informational feedback in maintaining user engagement. Rehman et al. (2023) discuss the impact of gamified experiences on user engagement, highlighting how game-like elements can fulfill users' psychological needs and enhance their commitment to fitness apps.

Despite the extensive research on individual feedback types, there remains a gap in understanding how these feedback mechanisms collectively influence users' Basic Psychological Needs (BPNs) and subsequent technology usage. This study seeks to fill this gap by examining the interplay between affective, social, and informational feedback and their impact on autonomy, competence, and relatedness within the context of fitness technology adherence.

In this context, we examine how fitness technologies influence users' perceptions of their Basic Psychological Needs (BPNs) for autonomy, competence, and relatedness. We align our definitions of BPN satisfaction and frustration with those provided by Chen et al. (2015), adapting them to the exercise context and considering fitness technologies as environmental factors that affect BPNs. Autonomy is associated with self-determination and volition in exercise activities, competence with achieving exercise outcomes, and relatedness with feelings of connection and care within a community. We explore the satisfaction and frustration aspects of these needs related to using fitness technologies.

Development of the Theoretical Model

Building upon the Self-Determination Model of Health Behavior (SDMHB) (Ryan et al., 2008), our research model considers fitness technologies as environmental factors that influence users' Basic Psychological Needs (BPNs)—autonomy, competence, and relatedness. The model integrates three types of feedback—affective, social, and informational—provided by fitness technologies. Affective feedback supports autonomy and competence through positive emotional experiences, social feedback enhances relatedness by fostering social connections, and informational feedback promotes competence and autonomy by providing performance data. These feedback mechanisms are hypothesized to influence sustained engagement with fitness technologies.

Although frustration and satisfaction might appear as opposites, Self-Determination Theory (SDT) research indicates they are distinct constructs that independently impact behavior and well-being (Deci & Ryan, 2000; Vansteenkiste & Ryan, 2013). Need satisfaction (autonomy, competence, relatedness) promotes positive outcomes like intrinsic motivation and engagement, while need frustration leads to negative outcomes such as disengagement and ill-being (Bartholomew et al., 2011). Including both in our model provides a comprehensive understanding of how feedback influences users' psychological needs and sustained engagement with fitness technologies.

These feedback forms create a motivational environment conducive to adherence and positive health outcomes (Ryan et al., 2008; Frederick-Recascino, 2002). However, the precise effects of these feedback mechanisms within the context of fitness technology have not been thoroughly explored or empirically tested. By integrating these feedback types into the SDMHB framework, our model extends Information Systems (IS) research, bridging a gap in understanding how distinct feedback types influence users' perceptions of BPNs satisfaction or frustration, and their continued use of technology (Giboney et al., 2017; James et al., 2019b).

The two critical components of our model are (1) the identification of three crucial feedback types—affective, informational, and social—as central to user adoption and sustained engagement with fitness technologies and (2) the delineation of how these feedback types uniquely influence BPNs satisfaction and frustration. Through this approach, the model provides a comprehensive view of the motivational environment established by fitness technologies and offers a framework for future research to delve deeper into these relationships. To this end, we have designed a visual representation of our model (see Figure 1).

Figure 1 illustrates our conceptual model, which explores how different types of feedback—namely affective, social, and informational—affect the satisfaction or frustration of BPNs, such as autonomy, competence, and relatedness. It then establishes a connection between these outcomes and the likelihood of continued use of the fitness device.

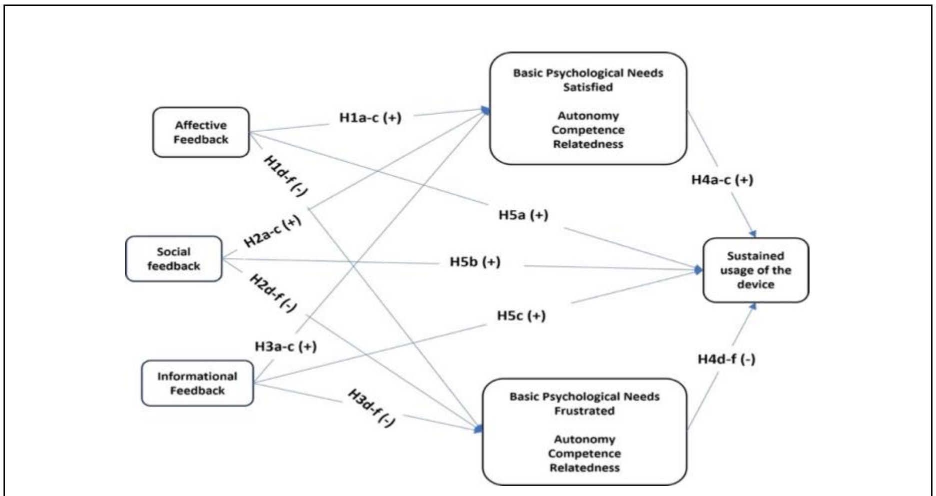

Figure 1. Conceptual Framework

Hypothesis

Affective feedback in fitness technologies, characterized by positive experiences such as enjoyment or flow, is posited to be a key determinant in satisfying BPNs of autonomy, competence, and relatedness, which are foundational to intrinsic motivation (Fang et al., 2017; Huang et al., 2018). The literature suggests that the emotional responses elicited by affective feedback are crucial for engaging users and enhancing the perceived value of fitness activities, leading to the satisfaction of BPNs (Hamari, 2015; Osatuyi & Qin, 2018). Therefore, we hypothesized **H1a-c**: **affective feedback** has a positive significant impact on satisfied basic psychological needs, autonomy (H1a), competence (H1b), and relatedness (H1c).

Drawing from the existing literature, we posit that while affective feedback can enhance the satisfaction of BPNs, it may conversely impact BPNs frustration and decrease the negative motivation (Gerow et al., 2013; Koivisto & Hamari, 2019; Morschheuser et al., 2017; Smock et al., 2011). Therefore, we hypothesize that **H1d-f**: **affective feedback** has a negative significant impact on frustrated basic psychological needs, autonomy (H1d), competence (H1e), and relatedness (H1f).

Social feedback within fitness technologies, through social influence and psychological need fulfillment mechanisms, has been demonstrated to impact BPNs' satisfaction positively (Kamboj et al., 2018; Teng, 2017). This aligns with the findings that positive social interactions, such as those within gamified systems, can enhance autonomy and relatedness and provide a sense of achievement and competence (Chen et al., 2014; Morschheuser et al., 2017). Therefore, we hypothesize **H2a-c**: **social feedback** has a positive significant impact on satisfied basic psychological needs, autonomy (H2a), competence (H2b), and relatedness (H2c).

Positive social interactions facilitated by fitness technologies contribute to decreasing the frustration of BPNs. Positive social feedback can mitigate isolation, incompetence, or coercion by reinforcing communal ties and encouraging and recognizing achievements. This is supported by literature that suggests social features such as encouragement from peers and recognition of accomplishments can alleviate feelings of inadequacy and bolster a sense of belonging and efficacy, which are critical to the satisfaction of BPNs within the domain of fitness technologies (Kamboj et al., 2018; Teng, 2017a). Thus, we hypothesized that **H2d-f**: **social feedback** has a negative significant impact on frustrated basic psychological needs, autonomy (H2d), competence (H2e), and relatedness (H2f).

Informational feedback encompasses objective data related to users' performance, and activities can enhance individuals' sense of competence by providing clear progress metrics (Kluger & DeNisi, 1996; Peterson et al., 2014). Additionally, when users can track and control their fitness activities through informational feedback, their autonomy is supported (Hattie & Timperley, 2007; Lupton, 2016; Swan, 2013, 2009). Furthermore, the customization and personalization aspects inherent in informational feedback can foster a sense of relatedness by connecting users' activities to a broader community of similar goals and challenges (Davis, 1989; Dwivedi et al., 2016). Therefore, we hypothesize **H3a-c**: **informational feedback** has a positive significant impact on satisfied basic psychological needs, autonomy (H3a), competence (H3b), and relatedness (H3c).

Informational feedback, when provided effectively, can reduce the frustration of basic psychological needs (BPNs). This aligns with SDT, which emphasizes that appropriate feedback can enhance perceived autonomy, competence, and relatedness by providing clear goals and performance metrics, thereby reducing feelings of inadequacy (Deci & Ryan, 2000; Kluger & DeNisi, 1996). Consequently, we hypothesize that **H3d-f** shows that **social feedback** has a negative significant impact on frustrated basic psychological needs, autonomy (H3d), competence (H3e), and relatedness (H3f).

When individuals feel a sense of volition in their activities (autonomy), believe they can handle challenging tasks and achieve desired outcomes (competence), and feel connected and significant within their social context (relatedness), they are more likely to continue using devices that support these feelings (Ryan et al., 2008). Therefore, the proposed hypothesis is that **H4a-c**: satisfied autonomy (H4a), competence (H4b), and relatedness (H4c) have a significant positive impact on continued device usage.

When users perceive that their interactions with technology inhibit their ability to act volitionally, feel competent, or connect with others, their engagement with the technology diminishes (Bartholomew et al., 2011). Negative experiences with fitness devices that fail to meet users' psychological needs will likely lead to reduced usage over time. Therefore, we hypothesize that **H4d-f:** frustrated autonomy (H4d), competence (H4e), and relatedness (H4f) have a significant negative impact on continued device usage.

Positive affective experiences, such as enjoyment or flow, foster a user's intrinsic motivation (Fang et al., 2017; Huang et al., 2018), while social feedback that satisfies the need for relatedness can encourage continued use of the technology (Kamboj et al., 2018; Teng, 2017). Informal feedback can reinforce competence and autonomy when it effectively informs decision-making and progress tracking, leading to persistent engagement with the device (Kluger & DeNisi, 1996). Therefore, we hypothesize that **H5a-c**, affective feedback (H5a), social feedback (H5b), and informational feedback (H5c) have a positive significant impact on continued device usage.

Research Methodology

This paper uses covariance-based structural equation modeling using IBM AMOS v.23 to analyze collected data. The measurement items for basic psychological needs satisfaction and frustration, autonomy satisfaction (two items), competence satisfaction (four items), relatedness satisfaction (four items), competence frustration (three items), autonomy frustration (three items), and relatedness frustration (three items) were adopted from Chen et al., 2015. The measurement items for the dependent variable's continued usage of the device (four items) were adopted from Bhattacherjee (2001). Affective feedback (four items), social feedback (three items), and informational feedback (four feedback) were adopted from Lin et al. (2008), Lin and Bhattacherjee (2010), and Hsu and Lu (2007), respectively. The research questions, standardized item loadings, mean, and standard deviations are available in Appendix 1.

Data Collection

We employed a questionnaire as our primary tool for data collection in this study. The choice of a survey questionnaire as the data collection instrument was considered the most suitable approach due to its cost-effectiveness, ability to gather quantifiable data on a large scale, practicality, and prompt results compared to alternative methods such as case studies or interviews. To collect our data, we utilized a nonprobability sampling strategy. Our study focused on participants from Germany.

We recruited our study participants from Prolific, an online platform facilitating connections between researchers and participants. Prolific offers targeted demographic sampling, equitable compensation, and high-quality data collection. We measured responses using a 7-point Likert-type scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Initially, we conducted a trial study with 100 participants to identify any survey questions and model fit issues. After making the necessary modifications, we proceeded with the research, receiving 359 responses within one week for our subsequent analysis. According to Hair et al. (2010), the sample size should be at least ten times the largest number of structural paths directed at a construct. To test nonresponse bias for both groups, we followed an approach suggested by Armstrong and Overton (1977)—we compared the first 25% of the respondents with the final 25% of the respondents on all variables using a chi-squared test. The test results showed that the two groups did not significantly differ; thereby, we concluded that nonresponse bias was not an issue in this study.

Data Description

In a survey of 359 participants, we assessed their fitness technology usage frequency. Daily usage was reported by 40.1% of participants, while rare usage was indicated by 5%. Of 359 participants, 54.6% were male, 44% female, and 1.4% identified as 'Other,' showcasing sample diversity. The largest age group was 25-34, comprising 47.6% of respondents. The next prominent group was 18-24 years old, at 23.7%. Ages 35-44 represented 18.7%, 45-54 had 5.8%, 55-64 had 1.4%, and ages over 65 were the smallest at 0.8% and 1.9% preferred not to specify.

Our survey participants had diverse educational backgrounds. A small segment, 3.1% (11 individuals), had basic education as their highest level. A substantial 17.8% (64) completed upper secondary education. About 12.8% (46) had pursued vocational education and training. The majority, 66% (237), held higher education degrees such as bachelor's, master's, or PhD qualifications. Lastly, a few individuals (0.3%, 1) followed unique educational paths noted as "Other."

Survey participants displayed diverse preferences in fitness technology usage. Notably, 48.7% (175 individuals) favored fitness trackers, while almost as many (46.2%, 166 participants) relied on mobile apps for tracking and workouts. A smaller group (0.8%, 3) mentioned heart rate monitors as their primary fitness tech, and 3.6% (13) opted for GPS sports watches. A few individuals (0.3%, 1) integrated biometric sensors. Participants also varied in the duration of their fitness tech engagement. Approximately 14.5% (52) had used it for less than six months, and 17% (61) reported a usage duration of 6-11 months, suggesting short to mid-term engagement. In contrast, 24.2% (87) had consistently used fitness technology for 1-2 years. The majority (43.7%, 157) had employed it for over two years, demonstrating long-term commitment. Additionally, a small fraction (0.6%, 2) chose not to disclose the duration of their usage.

Our study includes a diverse sample of users categorized into "Frequently," "Occasionally," and "Rarely" users based on their reported usage patterns of fitness technologies. Including "Occasionally" and "Rarely" users helps provide a comparative analysis across different usage patterns, and ensures our findings are inclusive and generalizable. This comprehensive approach informs strategies to promote consistent usage and enhances the applicability of our recommendations to a broad spectrum of users.

Furthermore, participants expressed diverse goals when using fitness technology. Most (78.3%, 281) cited physical goals, including improving fitness and weight management. A smaller segment (3.9%, 14) focused on interpersonal goals, possibly involving social interactions or group fitness activities. Notably, 17.8% (64) identified psychological goals, such as stress reduction and enhancing mental well-being, as their primary objectives for using fitness technology. For demographic and technical characteristics of the sample see Appendix 2 and Appendix 3, respectively.

Measurement Model

A confirmatory factor analysis was used to assess the measurement model. Two test validities—convergent and discriminant—were computed to validate the measurement model in this study. The reliability of the constructs was assessed using composite reliability, and the average variance was extracted. Column 2 shows the results of composite reliability, with values ranging from .72 to .94, which are all above the recommended value of .70; AVE scores ranged from .56 to .80, which are also above the recommended threshold level of .50. In addition, all standardized item loadings were above the recommended level (>0.70)

Finally, we measured the square root of the AVE to assess discriminant validity. Column 3 shows the square root of the AVE values for all constructs, indicating that the obtained values are greater than the correlations among them, thereby confirming discriminant validity. See Table 1.

Table 1. Construct-level Statistics

	CR	AVE	CPF	AF	SF	IF	CU	AUS	CPS	RES	AUF	REF
CPF	**0,853**	**0,661**	**0,813**									
AF	**0,881**	**0,651**	-0,331	**0,807**								
SF	**0,891**	**0,732**	-0,092	0,331	**0,855**							
IF	**0,853**	**0,594**	-0,281	0,607	0,354	**0,771**						
CU	**0,913**	**0,723**	0,036	0,351	0,307	0,398	**0,850**					
AUS	**0,722**	**0,565**	-0,266	0,480	0,434	0,524	0,265	**0,752**				
CPS	**0,877**	**0,642**	-0,490	0,549	0,322	0,576	0,290	0,594	**0,801**			
RES	**0,941**	**0,800**	0,010	-0,239	-0,472	-0,309	-0,246	-0,340	-0,237	**0,895**		
AUF	**0,849**	**0,655**	0,478	-0,256	-0,059	-0,225	-0,025	-0,236	-0,221	0,024	**0,809**	
REF	**0,916**	**0,785**	0,452	-0,427	-0,043	-0,428	-0,007	-0,182	-0,335	-0,021	0,323	**0,886**

Structural Model

As the measurement model exhibited good measurement properties, it was examined through structural equation modeling (SEM) using IBM AMOS v.23. According to the model fit criteria suggested by Gefen et al. (2011), the structural model fitted the data well, CFI = .95, TLI = .94, NFI = .90, GFI = .87, AGFI = .84, RMSEA = .049. Furthermore, the path coefficients were examined to test the hypotheses. Autonomy satisfaction, competence satisfaction, and relatedness satisfaction were explained by variances of 39%, 42%, and 25%, respectively. Continued usage of the device was explained by variance values of 26%. Basic psychological needs frustrated (autonomy, competence, and relatedness) were explained by variance of 24%, 34%, and 25%, respectively.

The results of the analysis, as shown in Figure 2, revealed there was a significant and positive effect of affective feedback on autonomy satisfaction ($\beta = .205$, $p < .01$) and competence satisfaction ($\beta = .293$, $p < .001$), thus supporting H1a and H1b. In contrast, the effects of affective feedback on relatedness satisfaction were found to be statistically not significant, therefore not supporting H1c. This result can be explained by the fact that the intrinsic motivation provided by affective feedback in hedonic systems may be more aligned with personal enjoyment and satisfaction of individual needs rather than the satisfaction of social or relatedness needs. This interpretation is consistent with the literature that posits affective feedback can enhance the experience of relatedness by fostering a sense of connection and belonging, which is an essential component of BPNs (Ryan & Deci, 2000; Deci & Ryan, 1985). It also aligns with studies that have found that positive feedback, even when focused on individual achievements, can still contribute to a sense of social connectedness and reduce isolation (Sheldon & Niemiec, 2006; Reis et al., 2000).

Affective feedback directly taps into individuals' intrinsic motivations, leading to behaviors more aligned with personal goals and satisfaction (Hamari & Koivisto, 2015). However, the lack of a significant effect on relatedness satisfaction is not necessarily in conflict with the literature. While affective feedback can enhance personal satisfaction, it may not always extend to social aspects of motivation, such as the need for relatedness. This distinction is supported by the literature that differentiates between intrinsic motivations related to personal gratification and those social motivations that arise from interactions and relationships with others (Ryan & Deci, 2000; Deci & Ryan, 1985).

The findings do not negate the possibility that affective feedback can support relatedness in some contexts, as suggested by the broader research on motivational information systems (Hamari & Koivisto, 2015b; Osatuyi & Qin, 2018).

Interestingly, we found no significant effect between affective feedback and autonomy frustration or competence frustration, thus not supporting H1d and H1e. We do not consider the results surprising as the affective feedback provided by fitness technology might be more tuned to celebrating achievements and progress rather than providing support after failures. As such, it would naturally contribute to satisfaction but not necessarily mitigate frustration. This implies that, even though the feedback emphasizes individual accomplishments, it does not necessarily lead users to feel disconnected from others. The findings are inconsistent with previous studies that have often posited that affective feedback can enhance BPN satisfaction and mitigate BPN frustration (e.g., Deci & Ryan, 2000). However, affective feedback has a negative and statistically significant effect on relatedness frustration ($\beta = -.301$, $p < .001$), supporting H1f. However, the significant negative effect of affective feedback on relatedness frustration aligns with the broader literature, suggesting that positive emotions and shared experiences can enhance social connectedness and counteract feelings of isolation (Reis et al., 2000; Sheldon & Niemiec, 2006).

We found that social feedback positively affects autonomy satisfaction ($\beta = .261$, $p < .001$), thus supporting H2a. In contrast, competence satisfaction is not affected by social feedback, therefore not supporting H2b. One possible reason for this result is that users might not engage with fitness technology for social gratification but for personal tracking and improvement. Therefore, their competence satisfaction could be unrelated to the social feedback they receive from the technology. In addition, surprisingly, social feedback has a negative and statistically significant effect on relatedness satisfaction ($\beta = -.420$, $p < .001$), and we had hypothesized it has a statistically positive effect on relatedness satisfaction, thus not supporting H2c. Indeed, some features of fitness technologies often enable users to compare their progress with others. If users perceive themselves as less successful or less skilled than their peers, it can lead to feelings of inadequacy and decrease relatedness satisfaction.

The negative impact of social feedback on relatedness satisfaction is interesting, especially given the assumption that social features should foster a sense of community. The findings suggest that negative social comparison could lead to decreased relatedness satisfaction, which aligns with the literature on social comparison theory (Festinger, 1954). When fitness technology users compare themselves unfavorably with others, it can result in feelings of inadequacy or envy (Tandoc et al., 2015), which are detrimental to relatedness satisfaction. This part of the findings contrasts existing studies that typically associate social feedback with positive relatedness outcomes (Ryan & Deci, 2000; Deci & Ryan, 1985).

The only frustrated basic psychological needs statistically affected by social feedback are relatedness frustration, which is a positive significant effect ($\beta = .172$, $p < .001$); however, H2f is not supported by the model due to the reverse result. Users might expect supportive and positive interactions within their fitness community but may instead experience criticism, envy, or negative competition, which can lead to feelings of dissatisfaction and increased frustration in relatedness.

The finding that social feedback significantly positively affects relatedness and frustration is an important result. This finding aligns with aspects of the literature that recognize the potential for social comparison and competition within social networking features to engender negative feelings, such as envy or a sense of inadequacy among users (Tandoc et al., 2015).

Informational feedback has positive and statistically significant effects on autonomy satisfaction ($\beta = .323$, $p < .001$) and competence satisfaction ($\beta = .380$, $p < .001$), thus supporting H3a and H3b. These findings are consistent with the literature that values self-monitoring and objective feedback for enhancing personal decision-making and performance (Kluger & DeNisi, 1996; Peterson et al., 2014). This suggests that informational feedback effectively bolsters users' sense of control over their fitness activities and their belief in their ability to achieve desired outcomes. In contrast, informational feedback negatively and statistically significant affects relatedness satisfaction ($\beta = -.160$, $p < .05$). Therefore, due to the reverse result, H3c is not supported. The literature often posits that informational feedback should be neutral or positive regarding social needs since it is typically not directly related to social interactions (Hattie & Timperley, 2007; Swan, 2009, 2013). The negative impact on relatedness satisfaction could indicate that while users feel more autonomous and competent, the same feedback might inadvertently isolate them or reduce their perceived need for social support, thus diminishing feelings of connection and belonging within a fitness community.

We found the effects of informational feedback on autonomy and competence frustration were found to be statistically not significant, therefore not supporting H3d and H3e. In contrast, informational feedback does decrease the relatedness frustration needs ($\beta = -.305$, $p < .001$), thus supporting H3f. It indicates that when users have access to personalized information highlighting their progress and achievements, they may be less affected by negative social comparisons and the frustrations that come with them. However, we did not find any significant effect between basic psychological needs satisfaction and continued usage of the device. In addition, autonomy frustration did not have a statistically significant effect on continued usage of the device, therefore not supporting H4a, H4b, H4c, and H4d. Our findings present an interesting divergence from some established theories. According to the Self-Determination Theory, satisfying BPNs should lead to enhanced well-being and sustained activity engagement (Deci & Ryan, 2000). However, the lack of a significant relationship between BPNs satisfaction and continued use of the device is not entirely aligned with this theory.

In contrast, competence frustration ($\beta = .179$, $p < .05$) and relatedness frustration ($\beta = .161$, $p < .05$) were found to have a positive and statistically significant effect on continued usage. However, we hypothesized they have a statistically negative effect on continued device usage, thus not supporting H4e and H4b. Competence frustration might lead users to seek more feedback from the device, increasing usage to understand their performance and areas for improvement. Regarding relatedness frustration and continued usage of the device, users who feel frustrated with their social relationships may turn to the device more often as an alternative source of community or social interaction, especially if the device has social features like leaderboards or challenges.

We found that the continued usage of the device is affected significantly by affective feedback ($\beta = .209$, $p < .01$) and informational feedback ($\beta = .295$, $p < .001$). Therefore, supporting H5a and H5c. In contrast, interestingly, the effects of social feedback on continued device usage were found to be statistically not significant. Thus, not supporting H5b. If the social feedback provided by the device is not meaningful or if it leads to negative social comparison, it may not contribute to an increase in usage. Another possible reason could be that users might experience an overload of social information, which could be overwhelming and thus not contribute to increased usage.

The findings emphasize the motivational power of feedback. Affective feedback, through its positive reinforcement of personal achievements and milestones, supports intrinsic motivation and enjoyment (Fishbach & Finkelstein, 2011; Hattie & Timperley, 2007). Similarly, informational feedback's positive impact is consistent with the literature suggesting that objective, personalized data can enhance perceived autonomy and competence, leading to sustained engagement with fitness technology (Kluger & DeNisi, 1996). However, the non-significant effect of social feedback on continued usage conflicts with previous studies that often suggest that social feedback should enhance relatedness and contribute to continued usage (Ryan & Deci, 2000; Deci & Ryan, 1985).

Human beings have an inherent need for socialization and interaction (Ryan & Deci, 2000). Technological advancements throughout history have aimed to increase connectivity and improve communication among people, facilitating intergenerational interactions (Pan et al., 2017). Individuals often rely on social feedback to determine whether to continue engaging in a behavior or discontinue it (Hamari & Koivisto, 2015; Teng, 2017) and assess their progress and behavior (Fishbach & Finkelstein, 2011). When users can connect with others who share similar goals and experiences, it fosters a sense of belonging, encourages accountability, and builds a supportive network. Sharing experiences, challenges, and support among peers can motivate and inspire, leading to continued engagement with fitness technology (Szinay et al., 2021). Users also frequently mention their enjoyment of interacting with peers through the app, including participating in challenges with friends (Ridgers et al., 2018). While some studies on social influences within social communities have suggested limited effects on post-adoption behavior on these platforms (Shiau et al., 2018), research on social influences in the context of motivational IS consistently indicates a positive connection between social influences/feedback and intentions to continue using adopted systems (Hamari & Koivisto, 2015b; Huang et al., 2018; Osatuyi & Qin, 2018). A summary of the findings is provided in Appendix 4.

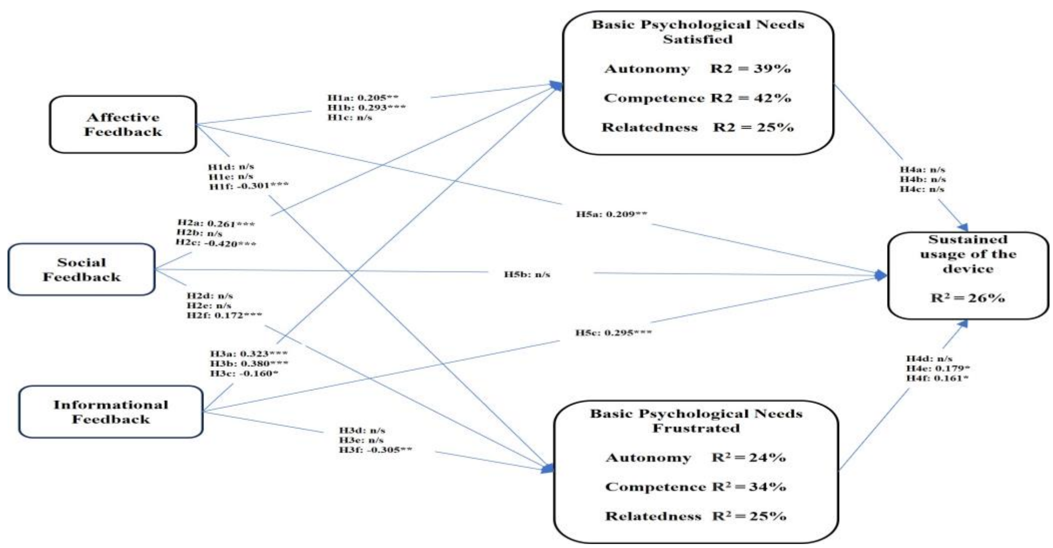

Figure 1. Analysis Results

Discussion of Findings

The differentiation between various feedback forms provided by fitness technology and its influence on users' physiological needs and usage patterns represents an intriguing subject of study. Affective feedback, known for its extensive positive effects, has increased feelings of autonomy and competence satisfaction while simultaneously reducing feelings of relatedness frustration. The aforementioned dual effect highlights the effectiveness of the system in addressing both individual and social dimensions of user experience, which is a characteristic feature of well-designed hedonic systems that aim to enhance personal fulfillment and general well-being (Fishbach & Finkelstein, 2011).

In contrast, social feedback presents a more nuanced picture. While it enhances the sense of autonomy satisfaction, it conversely diminishes the sense of relatedness satisfaction and contributes to the feeling of relatedness frustration. The findings suggest that it is crucial to manage social aspects to mitigate the potential adverse effects of social comparison or competition, which have the potential to destroy the sense of community and support (Bandura, 1991; Boyd & Ellison, 2007)

The presence of informational feedback has been found to contribute significantly to the satisfaction of autonomy and competence, reinforcing its position as a tool that empowers individuals in the context of fitness (Hattie & Timperley, 2007). Nevertheless, the influence of technology on social dynamics is ambivalent; while it reduces feelings of frustration connected to relationships, it also diminishes satisfaction, illustrating a scenario where the mere distribution of knowledge may not be enough to foster strong social connections within the online fitness community. The results indicate a nuanced balance between pursuing individualistic objectives supported by informational feedback and the collaborative aspects of physical fitness (Kluger & DeNisi, 1996). The utilization of data-driven insights is advantageous for users. However, it is crucial to enhance relatedness satisfaction by presenting these insights in socially engaging formats.

When evaluating the efficacy of these feedback mechanisms in promoting sustained utilization of the device, both affective and informational feedback demonstrate substantial and favorable impact. The finding is consistent with intrinsic motivational theories, which propose that users are attracted to these feedback mechanisms' emotional satisfaction and practical insights (Huotari & Hamari, 2017). The lack of a comparable influence resulting from social feedback encourages contemplation on the social integration within these technologies and its alignment with user expectations and preferences (Krasnova et al., 2013, 2015).

The potential value of affective feedback in promoting the satisfaction of psychological needs establishes it as a very effective form of feedback within fitness technology. Providing informational feedback is also noteworthy, although it necessitates careful attention to its social effects. The intricate connection between social feedback and relatedness highlights the need for reassessment, potentially suggesting adopting a more individualized and empathetic strategy in applying social features (Huang et al., 2018).

The results underscore the intricate nature of human motivation, particularly in the domains of technology and fitness, wherein various influences interact to shape user choices and actions (Venkatesh & Davis, 2000). Given these observations, fitness technology businesses face the task of effectively managing the interplay between the individual and social aspects of user experience.

Theoretical and Practical Implications

This study fills a gap in the SDT and SDMHB literature by examining the role of fitness technologies as environmental factors that shape exercisers' motivational experiences. By developing an SDMHB for fitness technologies, we explore how feedback that prompted users' adoption of their fitness technologies influences BPNs' satisfaction and frustration and how these, in turn, differentially relate to continuance intention.

Our research contributes novel insights to the IS literature on fitness technologies, which has previously focused on how elements such as recognition and rewards affect outcomes like life burnout or continuance through exercise passion or through the satisfaction or frustration of competence needs (Rockmann, 2019; Whelan & Clohessy, 2021). We extend these studies by providing a fully operationalized motivational model, the SDMHB, and by integrating the environmental factor of fitness technology into motivational constructs. This approach reveals how various feedback for fitness technology adoption—whether affective, informational, or social—can satisfy or frustrate users' BPNs.

We also address the classical view of technology acceptance, traditionally focused on utilitarian values like usefulness, efficiency, and ease of use, and propose that introducing complex features in new interface technologies necessitates reevaluating this theory. Our findings suggest that these complex features may not align with classical efficiency but are integral to user-centered design considerations. In extending emotional attachment theory to technology, we recognize that affective and social experiences contribute to a state of loyalty and continued use, underscoring the importance of these experiences in both product design and user interaction (Japutra et al., 2014; Grisaffe & Nguyen, 2011).

Furthermore, our study engages with emerging streams of research on technology acceptance, such as the habituation effect and the novelty effect (Patwardhan & Balasubramanian, 2013), offering insights into how technology design can adapt to mitigate or leverage these effects for sustained user engagement. Incorporating psychological theories into the IS field aims to enhance understanding and provide actionable insights for designing fitness technologies that support long-term user engagement and satisfaction.

Our findings underscore the importance of designing fitness technologies that provide affective feedback, fulfill users' psychological needs, and enhance satisfaction. Such feedback should celebrate personal achievements and offer emotional support, promoting ongoing use. While social features have varied effects, they should be crafted to encourage positive interaction rather than negative comparison, emphasizing cooperative elements and shared goals that could build a sense of community. Informational feedback should be clear and actionable, offering personalized insights to help users feel self-sufficient while fostering a sense of connection. Fitness technologies might also utilize user frustrations constructively by setting realistic challenges and providing support during setbacks, using these as motivational tools. The balance between individual achievement and community connection is pivotal. Including community features that are inclusive and supportive can address users' need for relatedness. Allowing users to customize their feedback preferences can also improve their experience, catering to personal motivations and needs.

Lastly, user education on the effective use of feedback can mitigate frustration and improve engagement, suggesting that a well-informed user is more likely to benefit from and continue using the fitness technology. The recommendations from this study offer a guide for creating engaging fitness technologies that align with users' psychological requirements for sustained use.

Conclusion

Our study has emphasized the critical role of motivational feedback in shaping user engagement and satisfaction with fitness technologies. Drawing from the perspective of Self-Determination Theory (SDT), we have demonstrated that the type of feedback provided by these technologies—whether affective, social, or informational—significantly impacts users' perceptions of autonomy, competence, and relatedness. Our findings highlight that certain types of feedback can deeply fulfill these psychological needs, while others may inadvertently lead to frustration, potentially affecting long-term adherence to fitness technologies. The insights garnered from this research hold profound implications for the design of fitness technology. Developers and designers are encouraged to consider the nuanced effects of different feedback types and tailor their approaches to better align with users' psychological needs. By doing so, they can enhance the effectiveness of their technologies, promoting not only sustained usage but also overall user well-being.

It is good to acknowledge the limitations of our study, primarily the reliance on self-reported data, and we should later strive to incorporate more diverse methodologies, potentially including longitudinal studies or experimental designs, to gain a deeper understanding of these dynamics over time. Also, in line with common survey-based research practices (Barker & Pistrang, 2012), we acknowledge the inherent limitations of self-reported data and self-selection biases. The findings represent the perceptions and intentions of actively engaged system users, which may not fully capture the breadth of experiences or behaviors of less active or non-users. Additionally, the potential for respondents to misinterpret survey questions poses a risk of misalignment between reported perceptions and actual behaviors, as highlighted by Pinsonneault and Kraemer (1993). Surveys offer a valuable yet distinct perspective on what individuals value, which is not always congruent with observable actions.

To build on the findings of this study and mitigate its limitations, we recommend that future research adopt a multifaceted methodological approach. Employing experimental designs and behavioral data analysis could provide a more nuanced and direct assessment of the variables of interest. Moreover, a wide variety of theoretical frameworks can be used to explore the multifaceted nature of feedback within motivational systems (Chesire and Antin, 2008). Future research could benefit from a deeper exploration of feedback, investigating its various forms—normative, formative, corrective, positive, and negative—and their implications for technology design and user motivation. Such an approach would offer a more comprehensive understanding of how feedback functions as both a technological and psychological phenomenon, thereby enriching the design and evaluation of motivational systems. In addition, we suggest conducting longitudinal research to examine the long-term effects of feedback on user satisfaction and engagement.

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Appendices

Appendix 1: Item-level Statistics

Variable	Survey Questions	Standardized Item Loadings (lowest-highest)	Mean	Std. Deviation
Autonomy Satisfaction (AUS)	**How your fitness technology makes you feel: My fitness technology makes me feel:**	**[.73 - .77]**		
	AUS1: ... that my exercise decisions reflect what I really want		5.18	1.20
	AUS2: ... that my exercise selections align with what I truly wish for		5.09	1.23

Autonomy Frustration (AUF)	**AUF1**: … obligated to exercise even when I don't want to	**[.70 - .88]**	3.70	1.71
	AUF2: … pressured to do exercise		3.73	1.65
	AUF3: … compelled to exercise even when I don't want to		3.74	1.70
Relatedness Satisfaction (RES)	**RES1:** … my exercise friends care about me	**[.83 - .96]**	4.12	1.56
	RES2: … connected with my exercise friends		3.96	1.69
	RES3: … close and connected with my exercise friends		4.13	1.68
	RES4: … warm towards my exercise friends		4.02	1.60
Relatedness Frustration (REF)	**REF1:** … excluded from my exercise friends	**[.80 - .94]**	2.22	1.19
	REF2: … that my exercise friends are cold and distant toward me		2.08	1.16
	REF3: … like my exercise friends dislike me		2.98	1.19
Competence Satisfaction (CPS)	**CPS1:** … confident that I can exercise well	**[.70 - .85]**	5.28	1.04
	CPS2: … like a capable exerciser		5.21	1.10
	CPS3: … competent in achieving my exercise goals		5.46	1.11
	CPS4: … I can successfully complete difficult exercise tasks		5.12	1.13
Competence Frustration (CPF)	**CPF1:** … serious doubts about whether I can exercise well	**[.76 - .88]**	2.22	1.19
	CPF2: … disappointed with my exercise performance		2.08	1.16
	CPF3: … insecure about my exercise abilities		1.98	1.19
	CPF4: … like a failure because of the exercise mistakes I make		2.96	1.62
	Consider the following statements about your use of Fitness technology:			
Affective Feedback (AF)	**AF1:** … it feels very satisfying to see my exercise progress in my fitness technology	**[.71 - .87]**	6.07	0.95
	AF2: … browsing my exercise reports on my fitness technology is fun		5.71	1.06
	AF3: … it feels good to review my training logs and stats in my fitness technology		5.85	1.12
	AF4: … it's very enjoyable to see my exercise history in my fitness technology		5.75	1.15
Social Feedback (SF)	**SF1:** … I like it when other users comment and like my exercise	**[.81 - .91]**	4.07	1.66
	SF2: … I feel good when my exercise achievements are noticed		4.78	1.58
	SF3: … I like it when my peers notice my exercise reports		4.37	1.62
Informational Feedback (IF)	**IF1:** … information from my fitness technology has helped me better understand the way I exercise.	**[.70 - .85]**	5.28	1.16
	IF2: … information I receive from my fitness technology is useful for me		5.68	1.06
	IF3: … information from my fitness technology has helped me with decisions regarding my exercise goals.		5.36	1.20
	IF4: … statistics of my exercise that my fitness technology provides are useful to me		5.68	1.03
Continued Usage of the Device (CU)	**CU1:** … in the coming months, I plan to use my fitness technology more than I currently do.	**[.81 - .89]**	4.39	1.42
	CU2: … it is likely that I will use my fitness technology more often rather than less often during the next couple of months.		4.60	1.40
	CU3: … I plan to increase my use of my fitness technology even more in the future.		4.59	1.44
	CU4: … I predict that I will use my fitness technology more frequently in the coming months.		4.60	1.50

Appendix 2. Demographic information of Sample (n=359)

Age			**Gender**			**Education**		
18–24 yrs.	85	23.7 %	Male	196	54.6%	Basic education	11	3.1%
25–34 yrs.	171	47.6 %	Female	158	44%	Upper secondary education	64	17.8%

35–44 yrs.	67	18.7 %	Other	5	1.4%	Vocational education and training	46	12.8%
45–54 yrs.	21	5.8 %				Higher education	237	66%
55–64 yrs.	5	1.4 %				Prefer not to specify	1	0.3%
+ 65 yrs.	3	0.8 %						
Prefer not to specify	7	1.9 %						

Appendix 3. Technical Details of Sample (n=359)

Device type			Length of usage			Usage frequency			Aim of usage		
Fitness tracker	175	48.7 %	Less than 6 months	52	14.5%	Daily	144	40.1 %	Physical goals	281	78.3 %
Mobile apps	166	46.2 %	6-11 months	61	17%	Several times a week	141	39.3 %	Interpersonal goals	14	3.9 %
Heart rate monitor	3	0.8 %	1-2 years	87	24.2%	Once a week	23	6.4%	Psychological goals	64	17.8 %
GPS sports watch	13	3.6 %	Over 2 years	157	43.7%	Occasionally	33	9.2%			
Biometric sensors	1	0.3 %	Prefer not to say	2	0.6%	Rarely	18	5%			
Othre	1	0.3 %									

Appendix 4: Summary of Hypothesis Testing: Path Coefficients and Outcomes

hypothesis	Relationships	Path coefficient	
H1a	AF → AUS	(β = .205, p < .01)	Accepted
H1b	AF → CPS	(β = .293, p < .001)	Accepted
H1c	AF → RES	No significant effects	Rejected
H1d	AF → AUF	No significant effects	Rejected
H1e	AF → CPF	No significant effects	Rejected
H1f	AF → REF	(β = - .301, p < .001)	Accepted
H2a	SF → AUS	(β = .261, p < .001)	Accepted
H2b	SF → CPS	No significant effects	Rejected
H2c	SF → RES	(β = - .420, p < .001)	Rejected- Reverse
H2d	SF → AUF	No significant effects	Rejected
H2e	SF → CPF	No significant effects	Rejected
H2f	SF → REF	(β = .172, p < .001)	Rejected- Reverse
H3a	IF → AUS	(β = .323, p < .001)	Accepted
H3b	IF → CPS	(β = .380, p < .001)	Accepted
H3c	IF → RES	(β = -.160, p < .05)	Rejected- Reverse
H3d	IF → AUF	No significant effects	Rejected
H3e	IF → CPF	No significant effects	Rejected
H3f	IF → REF	(β = - .305, p < .001)	Accepted
H4a	AUS → CU	No significant effects	Rejected
H4b	CPS → CU	No significant effects	Rejected
H4c	RES → CU	No significant effects	Rejected
H4d	AUF → CU	No significant effects	Rejected
H4e	CPF → CU	(β = .179, p < .05)	Rejected-reverse
H5f	REF → CU	(β = .161, p < .05)	Rejected-reverse
H5a	AF → CU	(β = .209, p < .01)	Accepted
H5b	SF → CU	No significant effects	Rejected
H5c	IF → CU	(β = .295, p < .001)	Accepted

AF: Affective Feedback, **SF:** Social Feedback, **IF:** Informational Feedback, **AUS:** Autonomy Satisfaction, **CPS:** Competence Satisfaction, **RES:** Relatedness Satisfaction, **AUF:** Autonomy Satisfaction, **CPF:** Competence Satisfaction, **REF:** Relatedness Satisfaction, **CU:** Continues Usage