

## PERCEIVED CONTROL IN HUMAN-AGENT INTERACTION: SCALE DEVELOPMENT AND VALIDATION

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**ABSTRACT.** *With advances in technology, human-agent interaction (HAI) is becoming more common, and the intelligent agent is slowly changing the way of life of human beings. To avoid the “uncanny valley” effect in HAI, this study believes that perceived control is an essential construct in future HAI. The previous measurement of perceived control is too one-sided, so this research aims to develop a user’s perceived control scale. Based on the three-component attitude model (TCAM), this study developed a measuring scale of perceived control from affective control, cognitive control and conative control. This study obtained a robust 12-item, three-dimensional perceived control scale through validation. This study provides references for the future development and improvement of intelligent agents that users need.*

**Keywords:** Human-agent interaction, Intelligent agent, Three-component attitude model, Perceived control

**1. Introduction.** More intelligent agents (computer/robot/machine with artificial intelligence attributes) are infusing into human society, such as smart homes, intelligent customer service, and intelligent self-service terminals (SST). The interaction between humans and intelligent agents has become more important [1]; therefore, more scholars and organizations are paying close attention to HAI problems. As intelligent agents can improve efficiency (e.g., service efficiency) and reduce enterprise costs, enhancing human beings’ continued interaction with agents is increasingly important.

Many scholars have focused on the anthropomorphic degree of intelligent agents to improve HAI [2-4]. However, with the development of technology, the “uncanny valley” effect proposed by Mori may occur [5,6]. When an intelligent agent is infinitely exemplary of human beings in mind and behavior, a certain stage will be reached in which human beings will have negative emotions such as panic, fear and disgust [1] and thus refuse to continue to interact with intelligent agents. Therefore, this study believes that the people’s perceived control of intelligent agents is a good description of the future development relationship of HAI.

Perceived control is considered a representation of actual control [7]. In the real situation, on the one hand, people actually control the model of the interactive objects (such as people, intelligent agents and the environment); on the other hand, people do not actually control the interactive objects but the sense of internal control generated based on our abilities, knowledge, skills or familiarity [8]. The research on perceived control mainly draws upon Averill’s three types of control, including behavioral control, cognitive

control and decisional control [9]. Among them, perceived behavioral control (PBC) in the theory of planned behavior (TPB) [10] has been studied most. PBC measurements are based primarily on looking for relevant, belief-based direct descriptions of specific events, such as not being able to climb a mountain without equipment [8,10] and being able to operate a system with information skills [11,12]. Then, these descriptive statements are weighed and added together to obtain the degree of perceived control.

Meanwhile, in addition to behavioral control, there are other levels of control over interactive objects, such as cognitive control or emotional control. Although cognitive control has been studied, it is still in a single dimension. Therefore, this study found that the current measurement of perceived control is not universal and comprehensive.

To sum up, this study defined perceived control as the degree of confidence people have in interacting with intelligent agents; it is an overall evaluation and attitude of intelligent agents' feeling of control. Many scholars agree with Rosenberg and Hovland's TCAM that attitude has affective, cognitive, and behavioral/conative aspects [13]. Therefore, this study aims to develop a comprehensive scale for measuring perceived control based on TCAM to evaluate users' overall evaluation of intelligent agents in the three dimensions of affective control, cognitive control and conative control in HAI. This research mainly contributes twofold. First, it puts forward a relatively new concept in HAI based on attitude theory. Second, the robust and comprehensive perceived control scale developed in this study will enrich the social science research of control theory and provide some reference for organizations in developing and optimizing intelligent agents.

## 2. Literature Review and Hypotheses.

**2.1. Perceived control.** Control theory was initially used to explain that the human self-regulation system is how to adapt by assessing the situation [14]. Early theories were often used to describe computer engineering problems. Therefore, control originally refers to the actual, objective control system. With the study of human subjective perception, control extends to the perception of control.

Throughout the literature review of perceived control, the study found that human subjective perceptions of control mainly focus on two aspects. Firstly, it is PBC mentioned by Ajzen in the TPB [10]. TPB refers to people's perception of how difficult or easy it is to act, in other words, the extent to which people's actions are affected by their confidence in the ability to perform [10]. PBC plays an essential role in TPB. The current view of PBC is the most consistent with self-efficacy. For example, Bandura focused on judging a person's ability to perform actions in response to future situations [15]. TPB integrates the PBC construct with attitude, subjective norms, intention, and behavior.

Secondly, perceived control mainly studies the cognitive level of the situation. For example, Li and Yin explored the influence of perceived control in the context of whether consumers want to skip advertisements [16]. Scholars often associate perceived control with perceived risk or perceived security because humans have enough control to reduce perceived risk and uncertainty [17]. For example, Le et al. discussed the relationship between users' perceived control, perceived risk, and recovery intention in SST's service recovery [14]. And they defined perceived control as the degree of users' confidence in the service provider's service recovery scenario. Zhang et al. focused on the factors that affect the behavior of mobile payment services in economic communication, among which perceived control plays a crucial role [18].

In the past studies on PBC and perceived control, most scholars regarded them as a variable at the same level as attitude or an antecedent of behavioral intention. The research believes that perceived control is the user's evaluation of the overall control perceptions of

intelligent agents, which is a subjective feeling and an attitude. Perceived control refers to the degree of users' confidence in interacting with intelligent agents. Based on TCAM, the study divides perceived control into three dimensions: affective control, cognitive control, and conative control. Affective control refers to how users perceive control over intelligent agents in terms of emotional experience. Cognitive control refers to how users perceive control over intelligent agents from an objective perspective (like knowledge, intelligence, and emotional intelligence). Conative control refers to how users perceive behavioral control over intelligent agents.

**2.2. Perceived control and continuance intention.** In academia, attitudes are often associated with behavioral intention. According to TPB [10], attitude positively affects behavioral intention. TPB believes that behavioral intention is a psychological process and a tendency expression of meaning. Based on TCAM, the study regards perceived control as an attitude with three dimensions. Many studies have also shown that perceived control (or PBC) positively affects behavioral intention [2,19]. At the same time, continuance intention is an essential variable of behavioral intention in HAI; it was introduced to verify the nomological validity of the perceived control scale. Thus, the study hypothesizes that

Hypothesis 1 (H1): Perceived control has a positive effect on users' continuance intention to communicate with intelligent agents.

Hypothesis 1a (H1a): Affective control has a positive effect on users' continuance intention to communicate with intelligent agents.

Hypothesis 1b (H1b): Cognitive control has a positive effect on users' continuance intention to communicate with intelligent agents.

Hypothesis 1c (H1c): Conative control has a positive effect on users' continuance intention to communicate with intelligent agents.

**3. Method.** The study adopted a two-stage approach to developing an adequate scale for perceived control in HAI: in-depth focus group interviews and questionnaires, and used SPSS 26.0 and AMOS 24.0 for testing reliability, validity and conceptual relationship. All participants were assured anonymity and confidentiality, and the University Ethics Committee approved the study.

**3.1. Item generation and content validity.** This study used in-depth focus group interviews to generate items among nine college students. These college students have rich shopping experiences and considerable human-agent interaction experiences. First, before the formal interview, we will give them some simple training, such as telling them about the interview process and available resources. Second, during the formal interview, we provided respondents with a complete definition of perceptual control and its three dimensions. Third, study members gained insight into the problem by having an unstructured, natural conversation with a representative respondent, followed by the gradual participation of all respondents in the discussion. Fourth, respondents were asked to list statements that could describe the three dimensions of perceived control based on their experience. The study collected an initial pool of 34 items. Finally, we invited seven market researchers to test content validity. The repeated and inappropriate items were deleted after expert judgment, and 19 items (e.g., I understand how the intelligent agent works well, and I can dictate the behavior of intelligent agents) were finally obtained to enter the pilot study.

**3.2. Data collection and participants.** A total of 567 questionnaires were distributed, and 79 invalid questionnaires were eliminated through quality control (such as short/long answer time and reverse trap questions), with an effective questionnaire recovery rate

of 86.07%. Therefore, the final valid sample consisted of 488 people (50.4% female and 49.6% male); 46.3% were aged between 26 and 35; most highly educated respondents (86.8% have undergraduate degrees or above); 59% of respondents were middle income and 94.3% had six years or above on the Internet. The data were collected within three weeks. The demographic characteristics of respondents are shown in Table 1.

TABLE 1. Demographic characteristics of respondents ( $n = 488$ )

Variable	Item	Frequency	Percentage (%)	Cumulative percentage (%)
Gender	Male	242	49.6	49.6
	Female	246	50.4	100.0
Age	16-25	100	20.5	20.5
	26-35	226	46.3	66.8
	36-45	138	28.3	95.1
	46-55	22	4.5	99.6
	56 or above	2	0.4	100.0
Education	High school or below	14	2.9	2.9
	Associate	50	10.2	13.1
	Bachelor	372	76.2	89.3
	Master	50	10.2	99.6
	Doctor or above	2	0.4	100.0
Income	Under \$5,000	78	16	16.0
	\$5,000-\$8,999	152	31.1	47.1
	\$9,000-\$12,999	136	27.9	75.0
	\$13,000-\$16,999	60	12.3	87.3
	\$17,000-\$20,999	44	9	96.3
	\$21,000 or above	18	3.7	100.0
Internet experience	5 years or below	28	5.7	5.7
	6-10 years	218	44.7	50.4
	11-15 years	162	33.2	83.6
	16-20 years	68	13.9	97.5
	21 years or above	12	2.5	100.0

**3.3. Measures.** Continuance intention was adapted from the mature scale by Bhat-tacherjee [20], a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree; Cronbach's alpha = 0.877,  $M = 4.97$ ,  $SD = 1.11$ ). It included such statements as "I will continue to interact with the intelligent agent in the future", "If there are other options, I will continue to interact with the intelligent agent", and "I will not interact with the intelligent agent again". Perceived control was adapted from 19-item, including a 7-point Likert scale with three dimensions.

## 4. Results.

**4.1. Exploratory factor analysis.** In order to determine the dimensions and items of perceived control in HAI, the study was conducted using exploratory factor analysis (EFA), principal component factor analysis with Varimax rotation. 244 samples (half of 488 samples) were selected for reliability and factor analysis. The other half was reserved for confirmatory factor analysis (CFA).

The result of Kaiser-Meyer-Olkin (KMO) was 0.790; the chi-squared of Bartlett's test of sphericity was 668.648 ( $df = 66$ ,  $p < 0.001$ ). According to Hair et al., the study's data was suitable for factor analysis [21]. A total of three factors were extracted, with an eigenvalue greater than 1. The variance explanation rate of the three factors after rotation was 20.832%, 17.692%, and 14.762%; the cumulative variance explanation rate after rotation was 53.286%. Based on reliability analysis and EFA results, seven items were deleted. Through expert judgment, the reasonable explanation is that the main functions of intelligent agents in the market differ significantly, resulting in the respondents not being very consistent with these statements. The study aims to develop a universal perceived control scale. Based on expert judgment, deleting these items does not affect the content validity. Therefore, the 12-item measurement instrument is finally obtained in the study. The new scale's Cronbach's alpha was 0.792, within the acceptable range [21]. The reliability analysis and EFA results of perceived control are shown in Table 2.

TABLE 2. The reliability analysis and EFA results of perceived control

Item No.	Dimensions and statements	Factor loadings			Item-to-total correlation
		F1	F2	F3	
Affective control (F1)					
AC1	The intelligent agent is always trying to entertain me.	0.673	—	—	0.714
AC2	The intelligent agent is very polite to me.	0.621	—	—	0.710
AC3	The intelligent agent only cares about me.	0.677	—	—	0.689
AC4	The intelligent agent does not get angry.	0.656	—	—	0.675
AC5	The intelligent agent makes me feel superior.	0.741	—	—	0.643
Cognitive control (F2)					
CgC1	Human beings dominate the intelligent agent.	—	0.579	—	0.637
CgC2	I understand how the intelligent agent works well.	—	0.820	—	0.549
CgC3	The intelligent agents are designed to serve us.	—	0.722	—	0.650
CgC4	I know how to use intelligent agents very well.	—	0.564	—	0.616
Conative control (F3)					
CaC1	I can dictate the behavior of intelligent agents.	—	—	0.789	0.485
CaC2	The intelligent agent obeys me.	—	—	0.775	0.464
CaC3	The intelligent agent only acts when I allow it.	—	—	0.490	0.613

**4.2. Confirmatory factor analysis.** In determining the measurement model, CFA was conducted on the other half of the questionnaires to reveal the factor structure of perceived control in HAI. The study measured model fit using AMOS 24.0. The model fit was verified by checking the fit index of the model [22], including chi-square ( $\chi^2$ ), degree of freedom (df), goodness-of-fit index (GFI), incremental fit index (IFI), comparative fit index (CFI), root mean square error of approximation (RMSEA), and standard root mean residual (SRMR). The model fit is " $\chi^2(51) = 74.152$ ;  $\chi^2/df = 1.454$ ;  $p < 0.05$ ; IFI = 0.985; GFI = 0.951; CFI = 0.985; RMSEA = 0.043; SRMR = 0.039". All the fitting indexes are in line with the standard values [22], indicating that the data fits well with the model.

**4.3. Reliability and validity tests.** The study strictly tested the reliability and validity of perceived control by strictly following the rigorous scale development steps. Validity tests include convergent validity, discriminant validity, and nomological validity.

Firstly, the factor loadings of the 12 items are significant ( $p < 0.001$ ); the loading range is 0.708 to 0.859, as shown in Table 3. The composite reliability (CR) of all factors exceeded the 0.7 benchmarks, with a range of 0.807 to 0.891, delivering sufficient reliability [21].

Secondly, the study calculated the average variance extracted (AVE). The AVE is ranged from 0.583 to 0.621, greater than 0.5, as shown in Table 3. Besides, all factors had significant loading ( $p < 0.001$ ) on the second-order model; the standard factor loadings were equal to or greater than 0.725. Therefore, the study believed that the construct's convergent validity was fit.

TABLE 3. The reliability analysis and convergent validity of perceived control

Dimension	Item	Unstd.	S.E.	C.R.	$p$	Std.	SMC	CR	AVE
Affective control	AC1	1.000	—	—	—	0.727	0.529	0.891	0.621
	AC2	1.369	0.110	12.483	***	0.828	0.686	—	—
	AC3	1.088	0.100	10.850	***	0.725	0.526	—	—
	AC4	1.406	0.110	12.778	***	0.859	0.738	—	—
	AC5	1.276	0.109	11.729	***	0.792	0.627	—	—
Cognitive control	CgC1	1.000	—	—	—	0.791	0.626	0.861	0.610
	CgC2	0.879	0.073	12.114	***	0.764	0.584	—	—
	CgC3	0.895	0.080	11.136	***	0.708	0.501	—	—
	CgC4	1.191	0.092	12.910	***	0.853	0.728	—	—
Conative control	CaC1	1.000	—	—	—	0.818	0.669	0.807	0.583
	CaC2	0.877	0.089	9.864	***	0.732	0.536	—	—
	CaC3	1.010	0.102	9.899	***	0.738	0.545	—	—

Note: Unstd. = unstandardized coefficient; S.E. = standard error; Std. = standardized factor loadings; SMC = square multiple correlations; CR = composite reliability; AVE = average variance extracted; \*\*\*  $p < 0.001$ ;  $n = 244$ .

Thirdly, the study calculated implied coefficients, and the diagonal is the square root of AVE, as shown in Table 4. All the diagonal values are greater than any other values. Therefore, the study believed that the dimensions of perceived control have effective discriminant validity.

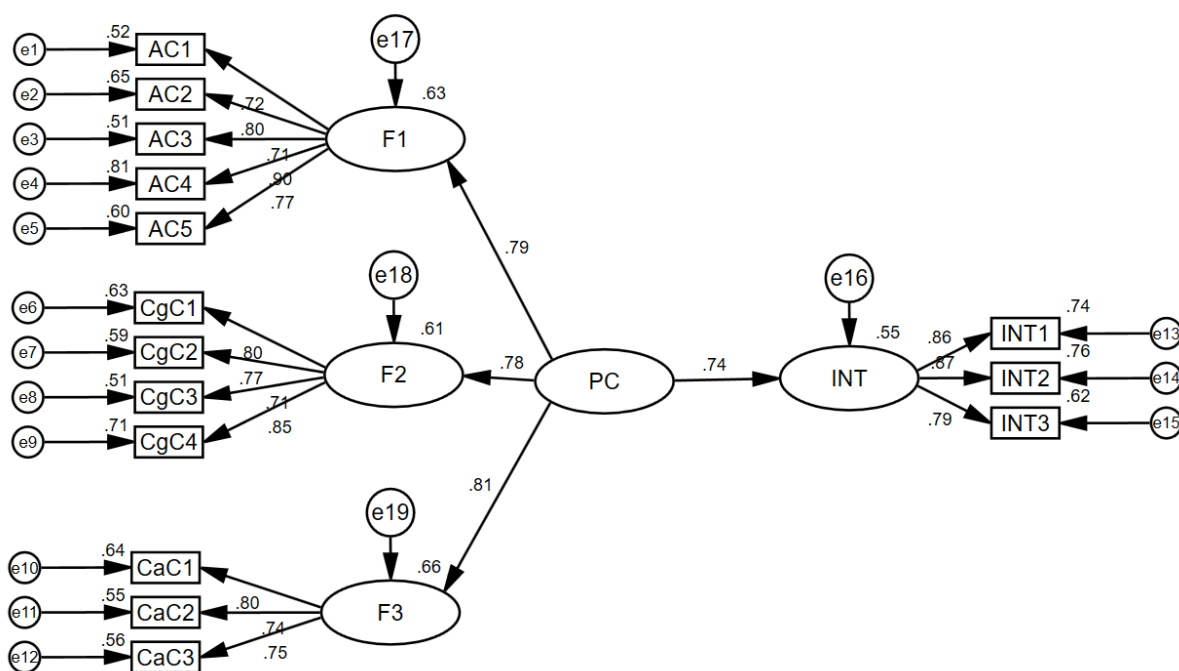
TABLE 4. The discriminant validity of perceived control

	AVE	1	2	3
1. Affective control	0.621	<b>0.788</b>		
2. Cognitive control	0.610	0.621	<b>0.781</b>	
3. Conative control	0.583	0.640	0.630	<b>0.764</b>

Note: AVE = average variance extracted; the square root of AVE is shown in the diagram (in bold); below the diagonal are the Pearson correlations

Finally, the study introduced the behavioral intention variable to test the nomological validity of perceived control, as shown in Figure 1. The measurement model's square multiple correlations (SMC) ranged from 0.51 to 0.81, indicating effective reliability. The SMC of the structural equation model (SEM) ranged from 0.61 to 0.66, showing medium SMC.

The model fit of SEM is " $\chi^2(86) = 135.699$ ;  $\chi^2/df = 1.578$ ; GFI = 0.930; IFI = 0.976; CFI = 0.976; RMSEA = 0.049; SRMR = 0.044", indicating it has a good model fit. As shown in Table 5, the parameter estimation is 0.742,  $p < 0.001$ , proving perceived



Note: F1 = affective control; F2 = cognitive control; F3 = conative control; PC = perceived control; INT = continuance intention; ei = error term;  $n = 244$ .

FIGURE 1. The second-order nomological model

TABLE 5. The testing results of structural equation models

Path	Standardized coefficient	T-value	Hypothesis	Supported
Second-order factor model				
PC → CI	0.742***	7.955	H1	Y
PC → AC	0.794***	a	—	—
PC → CgC	0.783***	7.885	—	—
PC → CaC	0.810***	7.935	—	—
Rival model: first-order factor model				
AC → CI	0.209*	2.309	H1a	Y
CgC → CI	0.244**	2.744	H1b	Y
CaC → CI	0.315***	3.438	H1c	Y

Note: PC = perceived control; CI = continuance intention; AC = affective control; CgC = cognitive control; CaC = conative control; \*  $p < 0.05$ , \*\*  $p < 0.01$ , and \*\*\*  $p < 0.001$ ; “a” denotes a fixed parameter; Y = supported;  $n = 244$ .

control had a significantly positive influence on continuance intention, which supported the nomological validity of the perceived control scale. Furthermore, the results can also conclude that all three dimensions (affective control, cognitive control, conative control) of perceived control significantly influenced continuation intention. Thus, the data supported H1 of the second-order factor model. H1a, H1b, and H1c were supported, too.

**5. Conclusion.** In this study, we pay attention to the possible “uncanny valley” effect of HAI in the future. After a lot of literature work, we propose that perceived control is an essential construct in describing future HAI. Based on attitude theory, we suggest

that perceived control is a holistic assessment of people's confidence in interacting with intelligent agents. Previous measurements of the perceived control were not general and comprehensive enough. Therefore, we developed a new perceived control scale using qualitative and quantitative methods. According to TCAM, item generation and purification were carried out from the three dimensions of affective control, cognitive control and conative control.

Through multiple data iterations, scale purification, reliability and validity testing, this study finally obtained a robust 12-item three-dimensional perceived control scale. Meanwhile, this study verifies the relationship between perceived control and people's intention to continue interacting with intelligent agents. The perceived control and its three dimensions had a significant positive effect on the continuance intention. The perceived control scale we developed further enriches studies in HAI and helps organizations better serve consumers or users in an HAI society. In addition, technology is evolving very quickly, and users' perceived control is constantly changing over time. Therefore, future studies could use the long-term investigation to optimize perceived control measurement further.

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