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Evaluating Perceived Smartness of Product from Consumer's Point of View: The Concept and Measurement

Won-Jun Lee[1]

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Abstract

Due to the rapid development of IT (information technology) and internet, products become smart and able to collect, process and produce information and can think of themselves to provide better service to consumers. However, research on the characteristics of smart product is still sparse. In this paper, we report the systemic development of a scale to measure the perceived product smartness associated with smart product. To develop product smartness scale, this study follows systemic scale development processes of item generation, item reduction, scale validation, reliability and validity test consequently. And, after acquiring a large amount of qualitative interview data asking the definition of smart product, we add a unique process to reduce the initial items using both a text mining method using 'r' s/w and traditional reliability and validity tests including factor analysis. Based on an initial qualitative inquiry and subsequent quantitative survey, an eight-factor scale of product smartness is developed. The eight factors are multi-functionality, human-like touch, ability to cooperate, autonomy, situatedness, network connectivity, integrity, and learning capability consequently. Results from Korean samples support the proposed measures of product smartness in terms of reliability, validity, and dimensionality. Implications and directions for further study are discussed. The developed scale offers important theoretical and pragmatic implications for researchers and practitioners.

Keywords: Smartness, Intelligence, Scale Development, Multi-functionality, Human-like touch, Ability to cooperate, Autonomy, Situatedness, Network connectivity, Integrity, Learning capability.

JEL Classification Code: M15, M21, M50.

1. Introduction

Technology has been an important driving force behind the progress of the product and product smartness becomes a new source of attractive product characteristic. IPTV (internet protocol television), for example, access to the internet and send contents and programs on demand. It analyzes users' program preference and viewing behavior through data mining methods such as collaborative filtering process, and recommends customized channels and contents when a user turn on the television. Beside, numerous other example of smart product containing good intelligence can be found in the everyday life (e.g., LG's ThinQ refrigerator, iRobot's robot cleaner, Google's connected car experiment, Apple's Smart Watch, Nike's Nike + Training and other products based on artificial intelligence). Recently, the IoT (internet of things) technology that enables to remotely connect objects has given new rise to the smart products and services (Wűnderlich, Heinonen, Ostrom, Patricio, Sousa, Voss, & Lemmink, 2015). One of the IoT applications is wireless beacon device that sends signals to other devices to work together in a smart way. Beacons support multiple functions, such as checking distance and position, and pushing a proper message, and can be used in various ways (Kwon, Park, Lee, & Kim, 2014). The variety and number of smart products per user are rapidly increasing beyond anyone's expectation.

These smart ones are welcomed by consumers who are looking for better values. Product smartness is known to have a strong relationship with customer experience improvement and corporate performance enhancement (Lee & Shin, 2018). This importance holds true in modern marketing because product smartness has become a critical tool for making product differentiable.

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[1] Associate Professor, Business Department, Cheongju University, Korea. Tel: +82-10-6741-5423, E-mail : marketing@cju.ac.kr

Given the importance of developing smart products in practice, researchers have begun to address its benefits and merits. However, it is not a well-established area of academic research yet. Researches on smart products can be mainly found within the field of computer science and industrial design. On the contrary, related researches within the field of marketing, psychology and consumer studies are very sparse (Dawid, Decker, Hermann, Jahnke, Klat, König, & Stummer, 2017). In spite of smart product's increasing presence, academics lack a widely accepted definition of product smartness from consumer's point of view and its dimensions that are applicable across a broad range of product classes.

Despite the rapid increase in interest, only little empirical research has measured product smartness. To the best of our understanding, there is a little number of studies that have developed measurement for product smartness. The previous studies focus on only limited product category and the measurement development process proposed by the previous studies is not clearly presented. Also, the relationships between the developed measurements and major dependent variables are not empirically tested in many cases.

Our study is an initial step in addressing the outlined gaps, and makes two additional contributions as follows. First, this study develops and validates a new scale to measure product smartness. And this scale is also independent of the product category. To perform the research, this study follows established systemic scale development procedures. Second, before illustrating the scale development process, this paper continues with an in-depth discussion of the concept of product smartness. This paper theoretically derives the definition of product smartness and its dimensions through literature review.

Being academically relevant, the research result is useful for marketers in that it fosters an understanding of what smartness is in a product, thus avoiding communication problems between marketing silo and R&D silo. The conceptualization of this study emphasizes that the intelligence of the smart product is more important than the product's mere functional aspects. In addition, marketing practitioners can use the scale in the field of online and offline market survey and that could pretest of the new product by using the measurement tool. The smartness scale helps benchmark and compare smart products and services with regard to smartness, both within the company and with competitors' products. For instance, engineers can evaluate and compare the products' ability to work smarter to develop products with higher smartness than competing products' intelligence.

2. Theoretical Review

2.1. Smart Product and Definition

A product with good intelligence is known as a smart product. Rijsdijk and Hultink (2009) simply define product smartness as a product that contain information technology in the form of chips, software, and sensors. Meyer, Främling, and Hőlmstrom (2009) explain the difference between smart product and other general products based on the gaps in the products' abilities such as computing power, computing speed and intelligence. However, it should be reminded that their product smartness definitions are overly technologically oriented and that the viewpoints of consumers are unreasonably excluded. As a result, it is not easy to find a generally acceptable definition of smart products in the academic literature. The definition becomes confusing because some similar concepts overlap with the concept of smart product.

To better explain the smart product, recent studies pay attention to the unique characteristics of a smart product. For example, McFarlane, Sarma, Chirn, Wong, and Ashton (2003) explain that an intelligent product has major properties such as the ability to process information, effective communication, visibility, and assisting decision making. Cook and Das (2004) include pervasive computing, machine learning, and sensor networking as characteristics of smart environments. Maass and Janzen (2007) define smart products by insisting six sub-dimensions: situatedness, personalization, adaptiveness, proactivity, business awareness and network capability. Situatedness means recognition of contextual environments. Personalization is described as the tailoring of products according to users' needs. Adaptiveness modifies a product's response according to users' requirements and tasks. Proactivity refers to the anticipation of users' intention to use the product. Business awareness is the consideration of legal and business related constraints. Network capability is the ability to communicate and connect other products.

Another major study of related research has focused on the effect of smartness on consumer attitude (Rijsdijk & Hultink, 2009; Lin, Chao, & Tang, 2017; Lee & Shin, 2018). In general, product smartness can be understood to facilitate the introduction of new technologies. Most of the consumers slowly accept high-tech products because they are fear to learn new and innovative technology that is not certain (Yi & Su, 2014). If a new innovation is based on highly intelligent function, consumers will feel less of a difficulty understanding the product and will accept the innovation more quickly. Rijsdijk and Hultink (2009) investigate the relationships between variables by measuring consumer responses to smart products in terms of the well known five innovation attributes of relative advantage, compatibility, observability, complexity and perceived risk. In the study of Shin and Lee (2014), they argue that smartness is one of the representative features of the new fin-tech (financial technology) service based on NFC (near field connection) technology, and the intelligent characteristic positively affects the acceptance of innovative technology. They find that product smartness increases perceived relative advantage and the advantage positively influences the possibility of consumer adoption. Also, Lee and Shin (2018) insist that smartness is a critical factor for customer satisfaction when a consumer evaluate a smartphone. These previous researches investigate consumers' perceptions toward smartness characteristics of product to understand the influence of product smartness on consumer attitude and behavior.

2.2. Review of Scale Study

Before this study develops the new items to measure the dimensions of product smartness scale, a review of the previous scales is provided. These measures include the product smartness scale developed by Rijsdijk and Hultink (2002), which is one of the leading studies about product smartness measurement as long as the author knows. We briefly elaborate on the previously developed scales and explain why the scale is not adequate to meet today's smart products.

The product smartness scale measures the "degree of information technology in the form of microchips, software, and sensors and that are therefore able to collect, process, and produce information" according to Rijsdijk (2002) and Hultink (2009). It consists of five dimensions – autonomy, adaptability, reactivity. multi-functionality, ability to cooperate – and comprises 19 questions. Swallow, Blythe, and Wright (2005) insist scales such as identity, sociability, security, organization and relevance to understand product smartness. Identity is measured by asking how we express ourselves and how others perceive us. Sociability is measured by checking the ability to maintain and create social groups. Security is evaluated by the ability to protect private information. Organization is the extent which the smart product organizes personal life through smart applications (e.g., schedule plan, to-do list and e-mail, etc.). Relevance is calculated by asking the ability to appeal to a wide range of users. Mass and Varshney (2008) develop six dimensions and sub-questions to evaluate product intelligence. The six dimensions are personalization, business-awareness, situatedness, adaptiveness, network ability, and pro-activity. The table 1 summarizes the previous studies on product smartness.

Table 1: Previous Studies to Measure Smartness

Researchers	Dimensions and Scales
Rijsdijk & Hultink (2002)	autonomy, adaptibility, reactivity, multi-functionality, humanlike interaction, personality, ability to cooperate
Swallow et al. (2005)	identity, sociability, security, organization, relevance
Thompson(2005)	communications, identity and kind, memory and status tracking, sensing and actuating, controllability, maintainability, scalability, interoperability, security, privacy, reliability, survivability
Mass & Varshney(2008)	personalization, business-awareness, situatedness, adaptiveness, pro-activity, network ability
Miche et al. (2009)	multimodal interaction, procedural knowledge, emerging knowledge, distribute storage of knowledge, context, interaction, ubiquitous data storing

However, these scales and measurements focus on characteristics inherent in the early IT product and not in general products. Recent developments in technology related to product smartness have accelerated, and new technological breakthroughs such as artificial intelligence, high security technologies and big data analysis have emerged. Therefore, the previous researches do not meet this research's goal of measuring product smartness of today's product. Also, there is a need for a new and comprehensive scale study that can measure product smartness from the consumer's perspective. As a result, the new development of appropriate scales is expected to broaden the study of product by a large number of academic scholars and to lead the future research topic of product smartness in a more practical direction.

3. Developing a Product Smartness Scale

3.1. Overview of the Scale Development Process

The objectives of this research are to develop and purify scales measuring perceived smartness of product. As the previous discussion illustrates, existing scales and measurements are not suitable for measuring product smartness of today's product. Therefore, this study tries to develop an improved set of scales, which covers the rapidly changing smartness dimensions successfully and don't refer to a particular product category. To do this, this study follows established scale-development processes of item generation, item reduction, scale validation, reliability and validity test (Churchill, 1979; Gerbing & Anderson, 1988;

Homburg, Schwemmle, & Kuehnl, 2015). And, after acquiring a large amount of qualitative interview data asking the definition of smart product, we add a unique process to reduce the initial items using both text mining method and traditional reliability and validity tests. The table below summarizes the whole process that we apply in the study.

Table 2: Overview of Scale Development

Process Phase	Data and Method	Results
1. Item Generation	· Initial 456 respondents · Literature review	· Initial item sets of 4,139 items
2. Keyword selection	· Adopt text mining tool (using 'r' s/w and nVivo s/w) · Count keyword frequency	· Adjusted item sets of 183 items
3. Item reduction	· 20 consumer judges who are different from the initial respondents · Use qualitative interview and rating	· 26 non-redundant item set
4. Scale reliability and validity	· Collection of further data (new 257 consumer data set) · Cronbach's alpha, composite validity, AVE value is calculated	· Reliability and validity are satisfied
5. Scale validation and dimensionality	· Discriminant validity between the smartness dimensions: Fornell-Larcker criterion · Perform EFA Test · An additional CFA test to check discriminant validity	· Model with eight dimensions is identified · Final sets of questions could be shown

3.2. Scale development and Result

3.2.1. Item generation

At the initial stage of the scale-development process, this study explains the purpose of the research to 456 respondents and ask them to generate multiple questions to measure the product smartness concept. They are all college students and their average age is 22.71 years old. The selection of sample considers that the members of the younger generation are more familiar with IT products and have more experience in using them than the members of other generation have.

This survey generates 4,139 items in total. Some of these items overlap with those of other respondents. Also, we include questions and items that are adapted from Rijsdijk and Hultink (2009)'s previous research in the initial item pool. In total, these different sources yield an initial question set of 4,158 items.

3.2.2. Keyword selection

A scale set with 4,158 items is too lengthy to be usable, and some proposed questions of respondents are remarkably similar. For instance, with regard to the responsiveness dimension, several questions are mentioned frequently and repeatedly: the response time, customized response, and response frequency. With regard to other dimensions, questions are more diverse, but the questions share many things in common.

Therefore, it is necessary to reduce the initial item pool by eliminating the overlapping items. Reducing the number of items essentially relies on both consumer judgement and statistical process for item purification (Churchill, 1979; Voss, Spangenberg, & Grohmann, 2003; Hombourg et al., 2015). This study adopts both sources of purification.

First, we use text mining technique that has been used for big data analysis by using tools such as 'r' software (version 3.23) and 'nVivo' (version 11.0) program. The following is a programming command line for extracting major keywords and their frequencies using r software. In this analysis, 'SejongDick', a Korean lexicon, was used as a synonym dictionary referred to by r software.

Based on the successful analysis of text mining, it is possible to identify major keywords and calculate their frequency of occurrence. Especially, the words with high frequency are product, ability, user, smart, function, etc. In general, high frequency could suggest high importance. In this analysis, we first extract words with frequencies more than five times and reduce the item pool by eliminating words with frequencies lower than four. Through this process, the first 4,158 items are dramatically streamlined to 183 items. The table below shows the keywords that pass the criterion successfully.

Table 3: Keyword Selection (183 keywords)

Keyword and Occurrence Frequency
product(656), ability(196), user(146), smart(135), function(106), convenience(107), multiple(72), use(67), response(66), work(65), information(61), human(60), life(57), people(55), necessary(50), connection(49), adaptation(49), thought(47), environment(46), design(43), provide(40), machine(39), consumer(36), speed(34), preference(35), portable(32), change(31), surroundings(30), capability(29), time(29), whoever(26), situation(26), wherever(26), co-work(26), everyday(26), assistance(25), recognition(25), service(24), proper(24), accuracy(24), access(23), easy(23), problem(22), inconvenience(22), internet(22), self(21), individual(20), method(20), purchase(20), autonomy(20),

cooperation(20), use(20), customer(19), real life(19), error(19), automatic(19), you(18), setting(18), influence(18), place(18), kind(17), satisfaction(17), suitable(17), everyone(16), age(16), continuous(16), characteristic(16), solution(16), ageless(15), machine(15), performance(15), operation(15), handle(15), possibility(14), thing(14), pleasant(14), compatible(14), progress(13), society(13), achievement(13), era(13), system(13), ideal(13), understand(13), phone(13), consider(12), out of order(12), device(12), order(12), generation(12), people(12), plain(12), adapt(12), simple(11), weight(11), connectivity(11), sufficiency(11), touch(11), browsing(10), skill(10), durability(10), battery(10), comparison(10), smart-phone(10), upgrade(10), input(10), compatibility(10), brevity(9), cope(9), motion(9), intimate(9), security(9), software(9), safety(9), requirement(9), computer(9), judgement(9), rational(9), share(8), data(8), context(8), reflect(8), wear(8), component(8), purpose(8), location(8), trend(8), material(8), fingerprint(8), recharge(8), wooing(7), period(7), complex(7), choice(7), communication(7), repair(7), immediate(7), danger(7), freedom(7), job(7), restriction(7), existence(7), difference(7), sufficient(7), feedback(7), behavior(7), progress(7), efficiency(7), value(6), basic(6), mass(6), happy(6), world(6), execution(6), desire(6), voice recognition(6), interface96), storage(6), kind(6), creativity(6), optimization(6), modern(6), personality(6), economic(5), space(5), symbol(5), network(5), mind(5), multi-tasking(5), protection(5), unnecessary(5), credibility(5), real-time(5), application95), update(5), remote(5), A.I(5), recognition(5), control(5), surrounding(5), effect(5).

3.2.3. Item reduction

As a next step, we apply a qualitative reduction procedure to the 26 items. For the second reduction phase, we asked 20 independent judges who are different from initial 456 respondents to rate to which each of the 183 items fit the definition of its respective product smartness dimensions. Throughout the review process, similar keywords had been integrated, and unrelated keywords had been removed. Items that do not achieve a unified opinion between the judges were re-negotiated until the consensus is made. For the progress of this process, a preliminary questionnaire was prepared and the judges classified the given items into small groups and repeatedly compared and analyzed the results of the classification. As a result, we obtain a set of items consisting of 26 non-redundant keywords. The table below shows the result of this process.

Table 4: Initial Item Pool (26 items)

a1. Smart product takes the initiative.
a2. Smart product works independently.
a3. Smart product does things by itself.
a4. Smart product can learn.
a5. Smart product improves itself.
a6. Smart product keeps an eye on its environment.
a7. Smart product directly adapts its behavior to the environment.
a8. Smart product observes its environment.
a9. Smart product has multiple functions.
a10. Smart product can do many different tasks.
a11. Smart product performs multiple tasks.
a12. Smart product fulfills multiple functional needs
a13. Smart product communicates with other devices.
a14. Smart product achieves a common goal in cooperation with other products.
a15. Smart product can be attached to other products.
a16. Smart product works better in cooperation with other products.
a17. Smart product process necessary information.
a18. Smart product work like a human.
a19. Smart product is thoughtful.
a20. Smart product can be accessed from anywhere.
a21. Smart product can be accessed anytime.
a22. Smart product is error-free.
a23. Smart product has human-like touch.
a24. Smart product doesn't be out of order.
a25. Smart product has personality like human.
a26. Smart product has A.I.

3.2.4. Reliability, validity and dimensionality

After the qualitative screening, we adopt statistical reduction procedures to the 26 items. For the data collection, additional online qualitative survey is performed again by using a five-point Likert scale. Because we want to develop a product category independent measurement, we perform our analysis on an aggregate level for all products. In total, 257 respondents have visited the Google survey website to participate the survey. They rate one randomly assigned smart product. The products are smartphone, computer, smart television, and hotel reservation service. These products reflect the familiar products experienced by most consumers.

An EFA (exploratory factor analysis) with VARIMAX option identifies factors with eigen values greater than 1.0. In the test result (Kim & Cho, 2013), eight factors explaining 70.73% of total variance are extracted. The factors are multi-functionality, human-like touch, ability to cooperate, autonomy, situatedness, network connectivity, integrity and learning capability.

As a next step, this research conduct CFA (confirmatory factor analysis) with Amos software (version 23). With regard to the EFA result as having eight dimensions, we first run a model with the eight latent factors – multi-functionality, human-like touch, ability to cooperate, autonomy, situatedness, network connectivity, integrity, learning capability. This model shows acceptable fit measures in general (Bagozzi and Yi, 2012). The Chi-square value is 449.704 (p=.000, d.f=271) and not satisfactory enough. However, other fit statistics could be more proper than a Chi-square value. In the test, the model achieves acceptable fit values: GFI (goodness of fit index) = .879; CFI (comparative fit index) = .937; TLI (Tucker-Lewis index) = .924; SRMR (standardized root mean square residual) = .051; RMSEA (root mean square error of approximation) = .051. All Cronbach's alpha values are above 0.7 (the lowest is 0.747). Composite reliability and AVE (average variance extracted) are above the required threshold of 0.6 and 0.5 (Homburg et al. 2015). Also, all the covariance between constructs are significant.

Table 5: EFA Result

Construct	Item	1	2	3	4	5	6	7	8
Multi-functionality	a10	0.855	0.134	0.174	0.075	0.085	0.053	0.012	0.000
	a11	0.803	0.028	0.151	0.027	0.091	0.064	0.121	0.062
	a9	0.792	0.027	0.114	0.110	0.173	0.080	-0.057	0.009
	a12	0.749	0.005	0.272	0.031	0.052	-0.046	0.133	0.093
	a17	0.642	-0.007	0.091	-0.035	0.094	0.335	-0.030	0.150
Human -like Touch	a23	0.013	0.821	0.098	0.050	0.112	-0.052	0.158	0.021
	a18	0.063	0.817	-0.024	0.033	0.032	0.166	-0.087	0.044
	a25	-0.020	0.777	0.142	0.103	0.081	-0.154	0.140	0.096
	a19	-0.016	0.726	-0.022	0.026	0.118	0.144	0.124	0.138
	a26	0.258	0.494	0.108	0.239	-0.153	0.085	-0.088	0.076
Ability to Cooperate	a15	0.234	0.001	0.800	0.091	0.127	0.209	0.029	-0.008
	a14	0.161	0.151	0.788	0.076	0.099	0.028	-0.008	0.049
	a13	0.234	-0.066	0.753	0.033	0.141	0.173	0.004	0.054
	a16	0.111	0.136	0.639	-0.020	0.013	0.052	0.166	0.119
Autonomy	a2	-0.035	0.106	0.082	0.820	0.077	0.068	0.043	0.114
	a3	0.173	0.076	-0.021	0.767	0.154	0.052	-0.011	0.108
	a1	0.030	0.096	0.077	0.763	0.228	-0.013	0.009	0.144
Situated ness	a6	0.124	0.073	0.183	0.095	0.822	0.128	-0.091	0.009
	a8	0.187	-0.017	0.112	0.197	0.730	0.006	0.176	0.141
	a7	0.126	0.191	0.060	0.211	0.718	0.029	0.052	0.137
Network Connectivity	a20	0.163	0.093	0.154	0.024	0.096	0.869	0.178	0.078
	a21	0.144	0.068	0.275	0.113	0.051	0.842	0.188	0.021
Integrity	a22	0.052	0.145	0.032	0.032	0.046	0.121	0.857	0.090
	a24	0.069	0.072	0.127	0.001	0.047	0.178	0.855	0.058
Learning Capability	a4	0.089	0.178	0.093	0.242	0.115	0.026	0.064	0.870
	a5	0.153	0.154	0.119	0.179	0.157	0.090	0.115	0.866
Eigen Value		6.520	2.961	2.219	1.805	1.504	1.250	1.211	1.011
%		25.076	11.387	8.188	6.944	5.785	4.808	4.657	3.887
Total %		70.731							

Table 6: CFA result

Construct	Item	Standard Estimate (* = p < 0.05)	Cronbach's alpha	Composite Reliability	AVE
Multi -functionality	a10	.877*	.866	.868	.572
	a11	.792*			
	a9	.768*			
	a12	.719*			
	a17	.599*			
Human-like Touch	a23	.819*	.802	.814	.585
	a18	.711*			
	a25	.767*			
	a19	.657*			
	a26	.432*			
Ability to Cooperate	a15	.853*	.794	.812	.526
	a14	.728*			
	a13	.748*			
	a16	.534*			
Autonomy	a2	.721*	.762	.762	.517
	a3	.697*			
	a1	.738*			
Situatedness	a6	.718*	.747	.756	.507
	a8	.718*			
	a7	.701*			
Network Connectivity	a20	.833*	.881	.885	.794
	a21	.946*			
Integrity	a22	.752*	.775	.777	.636
	a24	.840*			
Learning Capability	a4	.869*	.876	.876	.780
	a5	.897*			

Table 7: Covariance matrix (*=p<0.05)

	1	2	3	4	5	6	7	8
1	1*	.164*	.523*	.217*	.408*	.343*	.181*	.288*
2		1*	.180*	.291*	.275*	.177*	.271*	.355*
3			1*	.230*	.416*	.495*	.239*	.271*
4				1*	.534*	.205*	.201*	.501*
5					1*	.274*	.210*	.429*
6						1*	.420*	.234*
7							1*	.273*
8								1*

A major evidence of the measurement's dimensionality is that the model clearly satisfies Fornell and Larcker's criterion (Fornell & Larcker, 1981; Homburg et al., 2015). Fornell and Larcker (1981) suggest that the square root of the average variance extracted (AVE) could be used to identify discriminant validity, when the calculated value is larger than other correlation values among the latent variables. The below table presents the result of the Fornell-Larcker test, where the square root of AVE is written in bold. The correlations between variables are placed in the lower left triangle of the table. For example, the square root of Human-like touch is 0.754, and this number is larger than the correlations in the column of 2 (.0.192, 0.254, 0.229, 0.182, 0.222, 0.326), and also larger than those in the row of Human-like touch (0.154). Similar result is also made for other dimensions. The result reveals that discriminant validity exists and this finding is the first indication of the adequacy of eight smartness dimensions underlying the twenty six items. Thus, the result shows that discriminant validity exists (Homburg et al., 2015).

Table 8: Fornell and Larcker Test

	1	2	3	4	5	6	7	8
Multi-functionality	0.807							
Human-like Touch	0.154	0.754						
Ability to Cooperate	0.454	0.192	0.795					
Autonomy	0.176	0.254	0.176	0.823				
Situatedness	0.335	0.229	0.316	0.414	0.816			
Network Connectivity	0.338	0.182	0.397	0.155	0.233	0.945		
Integrity	0.162	0.222	0.204	0.085	0.172	0.352	0.903	
Learning Capability	0.266	0.326	0.254	0.412	0.361	0.218	0.231	0.943

After all the procedures, the following table shows the final product smartness constructs and the items for measuring each construct. The first construct is multi-functionality. The operational definition of multi-functionality which has five measurement items refers to the extent to which a single product performs multiple functions. The second construct, human-like touch which has five measurement items, concerns to the extent to which the product resembles human beings in a natural way. The third construct, ability to cooperate, has four measurement items and means a product's ability to work with other devices to achieve a common goal more efficiently. The fourth construct, autonomy which has three measurement items, refers to the extent to which the product is able to work in an independent way without any interference of the user. The fifth construct, situatedness which has three items, concern the degree to which the product is able to understand the environmental changes and adapts its behavior to the environment. The sixth construct, network connectivity which has two items, refers to the extent to which the product is able to connect to the home network and internet. The seventh construct, integrity which has two items, refers to the extent to which the product has the quality of being whole and having strong quality performance. The eighth and last construct, learning capability which has two items, refers to the extent to which the product obtains knowledge by study.

Table 9: Final Measurement Items

Construct	Items
Multi -functionality	1. Smart product has multiple functions. 2. Smart product can do many different tasks. 3. Smart product performs multiple tasks. 4. Smart product fulfiills multiple functional needs. 5. Smart product possess necessary information.
Human-like Touch	1. Smart product work like a human. 2. Smart product is thoughtful. 3. Smart product has human-like touch. 4. Smart product has personality like human. 5. Smart product has A.I.
Ability to Cooperate	1. Smart product communicates with other devices. 2. Smart product achieves a common goal in cooperation with other products. 3. Smart product can be attached to other products. 4. Smart product works better in cooperation with other products.
Autonomy	1. Smart product takes the initiative. 2. Smart product works independently. 3. Smart product does things by itself.
Situatedness	1. Smart product keeps an eye on its environment. 2. Smart product directly adapts its behavior to the environment. 3. Smart product observes its environment.
Network Connectivity	1. Smart product can be accessed from anywhere. 2. Smart product can be accessed anytime.
Integrity	1. Smart product is error-free. 2. Smart product don't be out of order.
Learning Capability	1. Smart product can learn. 2. Smart product improves itself.

4. Discussion and Conclusion

4.1. Implication

Although product smartness is recognized as being important for both practitioner and researcher, some gaps exist with regard to its conceptualization and operationlization. This research contributes to product smartness research in closing the gap. The development of the instrument in the research relies on proper scale development procedures, supported by information gained from both qualitative interview data and quantitative survey data. More specifically, internal consistency analysis, exploratory and confirmatory factor analysis support the construct validity of eight dimensions of product smartness.

This research result offers important theoretical and pragmatic implications for researchers and practitioners. First, Product smartness has been newly identified as important determinants of product attractiveness and customer satisfaction in recent models of consumer research. Although many researches have been performed to explain the determinants of product characteristics in a traditional context, these previous researches have not been extended to the new information technology environment such as A.I, robotics and other technological innovations. On the contrary, our research integrates major elements from both HCI (human-computer interaction) framework and marketing researches on the technology innovation phenomenon.

Second, we develop a theoretically concrete and applicable conceptualization and measurement items for product smartness that provides researchers with a tool for the further study. Researchers can evaluate and compare products' smartness by using the scale we developed and they can identify the relationships between smartness and consumer attitude empirically by using the tool.

Third, we have defined product smartness as a set of elements that user perceives and understand as a multidimensional construct comprising the eight factors of multi-functionality, human-like touch, ability to cooperate, autonomy, situatedness, network connectivity, integrity, and learning capability. These extracted factors capture a wide variety of reasons why consumers prefer a smart product. When compared to the previously developed related measures, newly developed constructs such as learning capability, integration and human-like touch well explain new technology changes. Understanding the new components of smartness will provide valuable insights for product developers who need to develop new IT products.

Fourth, our research is an early attempt to operationalize the product smartness construct by developing general scale which can explain the smartness of multiple products. The developed constructs and measurement items is easy to use and is adaptable to different research contexts. For the generalization, we collected raw data using different focal products from both product and service sector.

4.2. Limitation

Our research for smartness scale lay the pavement for further research to better understand how smart product is perceived and evaluated. As with any research, our work has some limitations, which may offer a new possibility for further research.

First, the scale is developed and tested for both the smart product and service. While we have reliable evidence that the scales is proper for measuring smartness of product, continued vigilance is required, given the fast speed of artificial intelligence development. The emergence of disruptive innovations is likely to make this scale obsolete.

Second, one of the limitations of this study is the restricted representativeness of the survey sample. This study is limited to young users attending colleges in metropolitan areas in Korea. Researchers need to study other demographic groups to understand the general influence of a smart product. For example, there is a possibility that the elderly who are afraid of technology innovation show a negative reaction to the product's smartness or the result of the response may be different from the result of this study. Third, In the future, empirical studies to measure the smartness of various products will be needed to confirm the predictability of developed scales. It is necessary to overcome limitations of this study by verifying the various product types and age group.

Fourth, additional research may be needed to determine whether A.I. is a measurement item that only explains human-like touch. Allegedly, A.I. can affect not only human-like touch but also other constructs such as autonomy and situatedness. Although statistical validity has been secured in this research, it should be verified through repeated predictive research on actual products. These limitations and further research directions should be addressed in extending the proposed research.

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Appendix

```
# R programming lines: Reading data from excel
  require(readxl)
  rbig=read_excel(path="c:/data.xls", sheet="01",
col_names=FALSE)
  setwd ("c:/temp")
# Call analysis package
  require(KoNLP)
  require(RColorBrewer)
  require(wordcloud)
# Call Korean dictionary
  useSejongDic()
  mergeUserDic(data.frame("IoT"))
# Variable setting
  data1=readLines("data.txt")
  data1
# Select nouns and cleansing
  data2=sapply(data1,extractNoun,USE.NAMES=F)
  data2
  data3=unlist(data2)
  data3=Filter(function(x){nchar(x)>=2}, data3)
  data3
  data3=gsub("//d+","",data3)
# Save word and trimming
  write(unlist(data3),"cleaneddata.txt")
  data4=read.table("cleaneddata.txt")
  data4
# Calculate and count nouns
  nrow(data4)
  wordcount=table(data4)
  head(sort(wordcount, decreasing=T),20)
# Final stage: Wordcloud graphic out.
  library(RColorBrewer)
  palete=brewer.pal(9,"Set3")
  wordcloud(names(wordcount), freq=wordcount,
scale=c(5, 1), min.freq=1, random.order=TRUE, rot.per=0.1,
colors=palete).
```