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Validation of the wearable acceptability range scale for smart apparel

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Abstract

The wearable acceptability range (WEAR) Scale has been a useful tool used in consumer behaviour and product development research to better identify the social acceptance of wearable devices. In this study, we aimed to introduce an extended WEAR Scale to the apparel field by (a) refining existing measurement items and (b) validating this scale for use with smart apparel. Using a quantitative research method, an online survey was conducted with a convenience sample of US consumers aged 18 years old and over. Total 663 usable data were obtained and used for the data analysis. NVivo, SPSS, and AMOS programs were used to perform (a) a content analysis of the open-ended questions to identify recurring phrases, (b) basic descriptive statistics, and (c) a structural equation model testing, here validating the WEAR Scale, respectively. A 4-factor, 15-item WEAR Scale validated for examining consumers' acceptance of smart apparel. The four WEAR dimensions are smart apparel in relation to: (a) design and aesthetics (four items), (b) self-expression (four items), (c) consequences (three items), and (d) reflection (four items). The findings of this study show the importance of these dimensions for the social acceptance of smart apparel. Therefore, this scale will be useful for the practical application in the apparel industry by providing better understanding of various aspects that smart apparel should consider during the product design and development stage. The scale can also be integrated with other consumer behavioural concepts to develop an emerging theoretical framework for the studies on smart apparel. Limitations and implications for future research were also discussed.

Keywords: Smart apparel, Social acceptability, Wearable technology, Scale development

Introduction

Wearable technology, referring to body-mounted, networked, technological devices capable of collecting data, tracking activities, and customizing experiences in accordance with users' needs and desires, enables consumers' awareness about their health conditions such as diet and physical activity (Piwek et al. 2016). A wearable device should be comfortable and well-fitting for a person's own body and wearers must often reflect on the social acceptability of wearing the device and anticipate reflection of others (Kelly 2016). Wearable technology is not only related to social acceptability, significantly identified through others' positive or negative judgements, objectives of the environment and communication, as well as reactions or thoughts from other people, but also should be

designed to be easily used and accessed (Kelly 2016; Suh et al. 2010). Wearable technology has infiltrated a variety of areas including healthcare, fitness, medical, and fashion industries (Dunne 2010; Duval et al. 2010; Geppert 2012; Kelly 2016; Perry et al. 2017).

According to the sales forecast of the worldwide wearable market (Gartner Inc. 2017), the market is set to grow from 347 million units sold in 2018 to 504 million units in 2021. The growth of wearable products (e.g., Google glasses, Apple watch, Fitbit, Bluetooth headsets) and the wide assortment of these products available on the market has been increasing and propagated rapidly to our society for the past 10 years, because of the capability for fitness and medical data tracking as well as real time data monitoring.

Despite the immense popularity of wearable technology, also called as “wearables,” few studies have empirically conducted to examine the social acceptability of smart apparel in the fashion discipline. Smart apparel, one distinctive type of wearable technology, is a wearable product that integrates information technologies and/or wearable computing devices suitable for and comfortably worn on the human body (Chen et al. 2016). These wearables may fail in the apparel market if they are not perceived as socially acceptable by the public. As a part of innovative smart apparel development and evaluation processes, examinations of the social acceptability of such wearables are urgent in the fashion discipline.

The wearable acceptability range (WEAR) scale, introduced by Kelly (2016), has been a useful tool in consumer behavior and product development research to better identify the social acceptability of wearable devices. To date, no studies have empirically applied this scale to determine the social acceptance of smart apparel. Considering that the WEAR Scale was originally developed for application in various types of wearable products, it is worth validating the scale, specifically for smart apparel. Therefore, the purpose of this study was to introduce an extended WEAR Scale to the apparel field by (a) refining measurement items in the WEAR Scale that was originally developed for wearable devices and (b) validating this extended scale for use with research on smart apparel. We believe the refined WEAR Scale can be a useful tool for examining the social acceptability of a newly produced smart apparel, which will eventually provide essential criteria for evaluating these products from the wearer’s perspective.

Literature review

Kelly’s (2016) WEAR Scale was constructed based on the statements derived from relevant literature, expert reviews, and consumer interviews. This scale originally included multiple dimensions (i.e., aesthetics, availability, consequences, ergonomics, functionality, judgements, norms, others’ reactions, others’ thoughts, self-identity, and qualities of the device or the wearer) using 97 items. The final scale, containing 14 items in two redefined dimensions—fulfillment of aspirational desires and absence of social fears, was validated for the use of wearable devices (e.g., Apple watch, Google glasses, and Bluetooth headsets). However, no items in this 14-item scale were related to aesthetics or functional attributes of the wearables, which are important when people wear clothing or its related items on the body. Although Kelly (2016) introduced the WEAR Scale, the author did not explicitly provide the descriptions of each dimension. Personal communication with the experts in the apparel field resulted to further validate the scale starting

with the extended 57 items in 11 dimensions from Kelly's (2016) study. In this study, we first redefined these 11 dimensions, as illustrated below.

Dimension 1: Aesthetics

Aesthetics refer to the visual attractiveness of a product in design (Hekkert 2006) and hold a symbolic function that influences how a product is understood and evaluated (Bloch et al. 2003). Creating aesthetics in developing the appearance of a product leads to enhance usability, durability, image of elegance, innovation and positive user experience (Forty 1986). Aesthetics influence consumers' perception and are essential to wearables to enhance their physical attributes with colors, designs, trends, and styles (Dickson and Pollack 2000). The unique design of wearables can help consumers easily recognize these products in the crowded marketplace (Schmitt and Simonson 1997; Wasik 2014).

Dimension 2: Availability

Availability is described as the amount of inventory that provides the response to customer demands anytime or anywhere without high costs (Jones and Chung 2008; Kelly 2016). A low level of product availability provides reduced inventory holding costs, but may result in a failure in consumers' acceptance and loss of present and future sales (Jones and Chung 2008).

Dimension 3: Consequences

Consequences are described as benefits that can help people by adding comfort and convenience to individuals or society (Kelly 2016). A wearable device not only causes people to embody the clothing and its symbolic meaning in the natural environment of the person and the public, but also has significant systematic psychological and physical impact on and behavioral consequences for wearers (Kelly 2016; Lilley 2009; Vanclay 2003).

Dimension 4: Ergonomics

Ergonomics is presented as comfort and fit of the body interacting with the device and is connected to users' acceptance of the product (Kuru and Erbug 2013). Ergonomics is necessary and valuable for the product design and establishing criteria for creating wearable products in order to adapt these products to achieve positive user experiences (Kuru and Erbug 2013).

Dimension 5: Functionality

Functionality is an important consideration in designing wearable products so they can be accepted by consumers (Bodine and Gemperle 2003). Ajzen and Fishbein 1972 mentioned that it is also associated with appropriate function for performance, usability (wearers' impression of effort required to use the application as connected to its functional and expressive qualities), and usefulness (wearers' perception of performance).

Dimension 6: Judgment

Judgment, the societal perception and judgement of personality features and social status, leads to certain behavioral or judgmental responses through nonverbal communication based on individuals' perceptions and cognitive processes (Davis and Lennon 1988; Douty 1963). Group pressure causes conformity with fashion judgements, shown to be influenced by judgement ambiguity and reference groups (Davis and Miller 1983). Therefore, the successful acceptability of wearables is variably linked to positive judgements from other consumers (Kelly 2016).

Dimension 7: Others' reactions

In the WEAR Scale, this dimension refers to actions that may be carried out by others when they see other individuals wear a wearable device or smart apparel; in this circumstance, other people's reactions serve as feedback on the social acceptability of the action in public (Goffman 1990). This societal reaction causes an individual's feeling, attitudes, beliefs, and negative or positive experience about the social acceptability of wearables (Rogers 2003).

Dimension 8: Others' thoughts

Others' thoughts refer to a form of nonverbal communication received from others (Davis 1984; Kelly 2016). Wearing apparel can contribute to the symbolic meaning of apparel and the physical experience of wearers. This has significant and systematic psychological and behavioral consequence for the wearers (Adam and Galinsky 2012).

Dimension 9: Norms

Social norms are illustrated in unstable perceptions and spontaneous situations rather than being deliberately planned, unwritten, and enforced informally (Sherif 1936). Subjective norms refer to "an individual's perception of how important others in his or her social environment wish or expect him or her to behave in a certain way" (Moan and Rise 2006, p. 719). Social norms have a great effect on users, peers, and others' environments when considering the adoption and usage of technology (Dickinger et al. 2008; Kleijnen et al. 2004). Thus, it is required to understand the interaction among technological innovation, user's concerns, and social norms when designing and evaluating a wearable product (Tene and Polonetsky 2013).

Dimension 10: Self-identity

Self-identity (expression) is a complex multidimensional concept with several components, including integrated image of a person's self-image, distinctions from other people, and understanding of and beliefs about oneself (Bernstein et al. 1994; Carson and Butcher 1992). For example, clothing or footwear may play a role in establishing one's identities. Different types of wearable products affect consumers' perception of self-identity and their potential to improve a desired self-image (Nieroda et al. 2018). According to Solomon and Panda (2011), self-product congruency for product adoption is related to establish user's self-identity. Thus, wearables should be designed considering with both consumers' self-image and product image.

Dimension 11: Qualities of the device or the wearable apparel

The quality of a product helps explain how users define the relation between ergonomics and interface features, and how clearly the product's purpose is communicated (Kuru and Erbug 2013). Researchers have found that quality affects the perception of wearables, aesthetic, expressiveness, interactivity, usefulness, and technological appeal (Kuru and Erbug 2013; Pal et al. 2019). Quality features of wearables (e.g., product safety, functionality, usability, wash-ability, privacy) also have the greatest impact on consumer satisfaction (Fortmann et al. 2015).

In Kelly's (2016) study, six main dimensions, 14-items WEAR Scale, were validated: self-identity (five items), consequences (five items), reactions (one item), norms (one item), thoughts (one item), and judgements (one item) for the following three wearable devices: Apple watch, Google glasses, and Bluetooth headset. However, each dimension did not contain enough items as a measurement model for wearable products. In addition, the social acceptability of smart apparel may be addressed by other dimensions of the WEAR Scale beyond the above six dimensions validated in Kelly's study. In this study, therefore, these 11 dimensions introduced by Kelly (2016) were redefined and navigated to determine key factors that play an important role when consumers socially accept wearables, especially for smart apparel.

Apparel designers, developers, and manufacturers should pay careful attention to social acceptance of wearables, here smart apparel, when designing and developing new products in order to fulfil consumers' needs and demands. However, little research exists with regard to wearable technology embedded products to examine their social acceptability when new smart apparel is ready to the market. Therefore, a predictive instrument for measuring wearables' social acceptability is needed to better comprehend the key dimensions that play an important role for potential users of smart apparel.

To evaluate the social acceptability of smart apparel, it would be useful to have a measurable tool for practical application as well as theoretical foundation for academic research in fashion, product development, and/or interdisciplinary of those. In this study, we defined "wearables" as smart products (e.g., smart clothing and smart footwear) integrating information technologies and/or wearable computing devices that can suitably, easily, and comfortably be worn on the human body. Consequently, the existing 14-item WEAR Scale (Kelly 2016) needs to be revisited and validated to understand the factors affecting the social acceptability of smart apparel, here smart clothing and footwear. When designing and developing smart apparel (e.g., gloves, underwear, vests, hat, and socks), the evidence-based measurement scale presented in this current study would be a useful means to examine the social acceptability of smart apparel. We also hope this revised WEAR Scale can be integrated with other consumer behavioral concepts to develop an emerging theoretical framework for the studies on smart apparel in the fashion discipline.

Methods

A quantitative research method was employed for this study, using a web-based survey. The University's Institutional Review Board approval was obtained before the data collection.

Study sample

For this study, approximate sample size ($N=506$) was estimated by performing the power analysis using G-power software (Faul et al. 2009), which included participants assessing both smart clothing ($N_C=253$) and smart footwear ($N_F=253$), based on effect size ($f^2=0.15$), alpha error probability (0.05), and power (over 80%). Using a convenience sampling method, Amazon Mechanical Turk (MTurk), which serves as an online survey marketplace, was used to recruit both male and female participants aged 18 years old and over. Of the 711 participants who responded to the survey, 663 completed the entire web-based questionnaire; among those, 332 and 331 responses were based on the exposure of smart clothing and smart footwear, respectively, when completing the survey. The sample size of this study reached an over 90% power with an effect size of 0.5 at $p < 0.05$ to reduce the chance of making a type II error.

As shown in Table 1, among the 663 usable responses, 61% was female and 39% was male, ranging in age from 20 to 75 years old with a mean age of 37. Around 92% belonged to the age less than 60 years old. The majority was Caucasian/European American (72.4%), followed by African American (8.1%), Asian (5.4%), Hispanic American/Latino (5.3%), and Other (7.8%). Around 90% had completed an education higher than some college degree. The participants were employed in various fields such as education, technology-related industry, hospitality, retail, manufacturing, and health care. Table 1 also illustrates the demographic characteristics for 332 responses on smart clothing and 331 responses on smart footwear, separately.

Data collection procedure

The survey questionnaire was first pre-tested by several disciplinary experts in the fashion discipline to make sure about the clarity and consistency of the content. A web-based survey started with an informed consent form, describing the study purpose, the survey procedure and incentive, eligibility to be a study participant, and a participant's right when participating in the survey. Participants' responses were not linked to their names and their participation was voluntary in the MTurk. After agreeing to participate in the survey, participants completed the survey that took approximately 5–7 min. All participants who completed the survey received an incentive of \$0.50 as compensation.

In administering this survey to the study sample, the visual images of two existing smart apparel, smart clothing (Gerhardt 2013) and smart footwear (Miller 2016) currently available in the market, were first randomly assigned so that the participants could respond to the survey questions in relation to one smart apparel category, either smart clothing or smart footwear (see Fig. 1). These two study stimuli were chosen by (a) exploring the current smart apparel market, (b) examining what most common smart apparel items were available in the market, which can be easily approached by consumers, and (c) then deriving to these specific two smart apparel category, smart clothing and smart footwear. The stimuli used in this study also included the written descriptions of smart apparel along with visual images.

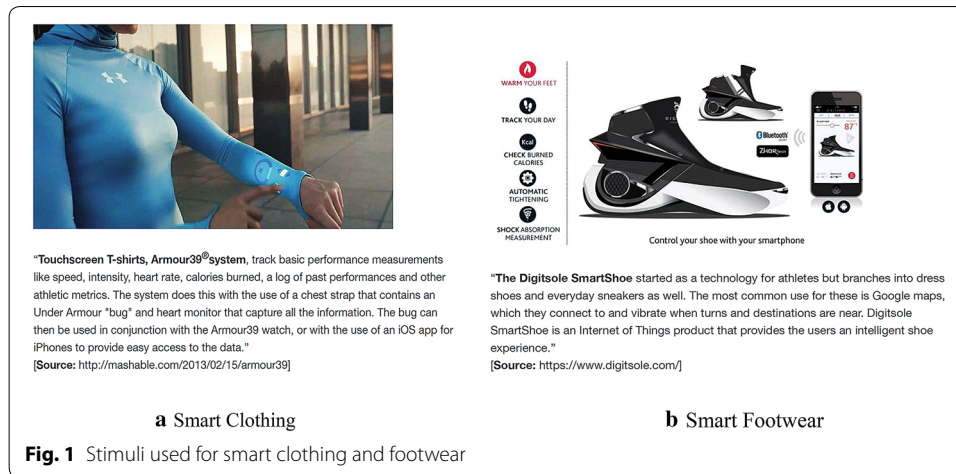
Table 1 Demographics

	Smart clothing N _C (%)	Smart footwear N _F (%)	Entire smart apparel N (%)
Gender	332 (50.1)	331 (49.9)	663 (100.0)
Female	199 (59.9)	209 (63.1)	408 (61.5)
Male	133 (40.1)	122 (36.9)	225 (38.5)
Age			
20–29	93 (28.0)	79 (23.9)	172 (25.9)
30–39	120 (36.1)	126 (38.1)	246 (37.1)
40–49	63 (19.0)	65 (19.6)	128 (19.3)
50–59	37 (11.1)	29 (8.8)	66 (10.0)
60–69	11 (3.3)	21 (6.3)	32 (4.8)
70–79	4 (1.2)	4 (1.2)	8 (1.2)
Missing	4 (2.1)	7 (2.1)	11 (1.7)
Ethnicity			
Caucasian/European American	241 (72.6)	239 (72.2)	480 (72.4)
African American	17 (5.1)	37 (11.2)	54 (8.1)
American Indian/Alaska Native	1 (0.3)	4 (1.2)	5 (0.8)
Asian	26 (7.8)	10 (3.0)	36 (5.4)
Native Hawaiian/Pacific Islander	1 (0.3)	0 (0)	1 (0.2)
Hispanic American/Latino	21 (6.3)	14 (4.2)	35 (5.3)
Other	25 (7.5)	27 (8.1)	52 (7.8)
Education			
Less than high school	4 (1.2)	3 (0.9)	7 (1.1)
High school diploma	26 (7.9)	25 (7.5)	51 (7.7)
Some college	115 (34.7)	99 (29.8)	214 (32.3)
Bachelor degree	123 (37.2)	135 (40.7)	258 (38.9)
Some graduate work	9 (2.7)	14 (4.2)	23 (3.5)
Master degree	41 (12.4)	47 (14.2)	88 (13.3)
Doctorate degree	6 (1.8)	6 (1.8)	12 (1.8)
Other	7 (2.1)	3 (0.9)	10 (1.5)
Occupation			
Business and service, finance or insurance	55 (16.6)	55 (16.6)	110 (16.6)
Health or social care	12 (3.6)	17 (5.1)	29 (4.4)
Hospitality, catering or leisure service	15 (4.5)	28 (8.5)	43 (6.5)
Manufacturing, construction or agriculture	20 (6.0)	16 (4.8)	36 (5.4)
Public sector or education	78 (23.5)	69 (20.8)	147 (22.2)
Transport, retail or wholesale	47 (14.2)	44 (13.3)	91 (13.7)
Technology industry	26 (7.8)	39 (11.8)	65 (9.8)
Other	76 (22.9)	62 (18.7)	138 (20.8)
Missing	3 (0.9)	1 (0.3)	4 (0.6)

N_C, N_F, and N mean the sample size of smart clothing, smart footwear, and smart apparel (smart clothing + smart footwear), respectively

Survey instrument

The survey questionnaire, adapted and modified from Kelly’s (2016) study, consisted of three sections: (a) demographics (e.g., age, gender, ethnicity, education, and occupation); (b) open-ended questions asking participants’ thoughts on, benefits of, and reasonable prices for wearables (e.g., what do you think the benefits of using the



wearables are?); and (c) 57 measurement items of social acceptability of wearables. This extended WEAR scale involved 11 dimensions, consisting of aesthetics (seven items), availability (two items), consequences (ten items), ergonomics (five items), functionality (three items), judgments (four items), norms (six items), reactions (four items), thoughts (four items), qualities (six item), and self-identity (six items). A five-point Likert-type scale, ranging from “Strongly disagree” (1) to “Strongly agree” (5), was used to measure each item.

Data analysis procedure

NVivo 11 software was used to run a content analysis of the open-ended questions to identify recurring phrases or themes. SPSS 20 software was used to perform basic descriptive statistics. AMOS 20 software was used to perform a structural equation model testing, here validating the WEAR Scale. In this study, maximum likelihood estimation method was used to evaluate model fit since none of assumptions were violated to run exploratory and confirmatory factor analyses (EFA and CFA).

In order to identify and consolidate potential underlying factors on the WEAR Scale, EFA with oblique rotation was run on the entire 57 items of the extended WEAR Scale. To obtain an appropriate number of factors in an overall construct, principal component analysis with scree plot, an eigenvalue greater than 1, and varimax rotation was conducted (Kaiser 1970). Moreover, an internal reliability was examined to verify the extent to which items consistently reflect a single construct using Cronbach’s α , in order to point out the degree of interrelatedness among items. The cutoff α value was set at 0.60 in this study (Nunnally 1978).

For the second step, to validate the social acceptability range scale for use with smart apparel beyond wearable devices (e.g., Google glasses, Apple watch, Fitbit, and Bluetooth headsets), CFA with a maximum likelihood estimation method was performed to evaluate the overall factor structure and to measure construct validity of the scale with the overall model fit. The following fit indices were used to examine the model fit: goodness fit index (GFI), incremental fit index (IFI); Turker–Lewis index (TLI), and comparative fit index (CFI), where greater than 0.90 or 0.95 indicates “reasonable or good fit” (Hu and Bentler 1999). Both root mean error of approximation (RMEA) and standardized

root mean square residual (SRMSR), with equal to or less than 0.08 demonstrated “good fit,” were also examined.

Results and discussion

Content analysis results

As shown in Table 2, the common phrases used for referencing wearable technology were “wearable products” (e.g., Apple watch, Fitbit, smart apparel, and Google glasses), “technology,” “fitness,” and the descriptor “expensive.” On the other hand, the phrases regarding smart clothing and footwear appeared with the terms “innovation,” “brand name,” and “comfortable.” Interestingly, most participants’ thoughts of wearable products were more related with accessories or devices (e.g., smart watch, glasses, and fitness bands) than apparel (e.g., smart clothing and smart footwear). Benefits of the wearables were assessed in relation to fitness and health (16%), following by references to technology (15%), being easy to access (10%), and providing a variety of information (7%).

Of the participants, 60% indicated that they own wearable technology embedded products, such as Fitbit (37%), Apple watch (18%), Samsung Gear2 (2%), and Garmin smartwatch (2%). On the other hand, 40% of the participants reported that they did not own any wearable technology embedded product, due to its high price (45%), technology

Table 2 Findings from open-ended questions

Questions	Related words	Frequency	%
Q1. What are the top 3-phrases that first come to your mind when you hear the phrase “wearable technology”?			
Watch	Apple watches, i-watch Fitbit, Smartwatch Fitbit(s), fit bit	671	21
Smart apparel	Smart shoes, clothing, jacket, pants	308	9.6
Google glasses	Google glass	115	3.6
Technology	Tech, technologies	89	2.8
Fitness	Tracker(s), tracking monitor, heart rate(s)	82	2.6
Bluetooth headphone	Headphones, headset	79	2.5
Expensive	Expensive, high price, cost	52	1.6
Q2. What are the top 3-phrase that first come to your mind when hear the phrase “smart clothing” or “smart footwear”?			
Smart apparel	Smart shoes, clothing, jacket, pants, vest, gloves	383	11
Fitness	Tracker(s), tracking monitor, heart rate(s)	277	8
Technology	Tech, technologies	157	4.5
Expensive	Expensive, high price, cost	64	1.8
Innovation	New, innovating, innovation, innovative, innovator	61	1.8
Brand name	Nike, Adidas, Puma	40	1.4
Comfortable	Comfort	36	1.0
Q3. Please list the most commonly wearing wearable products that you can think of			
Apple watch	Smartwatch, i-watch	485	28.9
Fitbit	Fitbit(s), fit bit	325	15.9
Google glasses	Smart glasses, glasses	109	4.9
Smart clothing	Shirt, clothing, pants, jacket	65	2.9
Smart shoes	Shoes	51	2.3
Fitness tracker	Tracker(s), tracking monitor, heart rate(s)	50	2.3
Bluetooth	Bluetooth headphone, phone	45	2.1

Table 3 EFA results of smart clothing and footwear: four factors with 21 items

Dimensions	Items	Component				Cronbach's α
		Factor 1	Factor 2	Factor 3	Factor 4	
Design/aesthetics	Pleasing	0.84	0.22	0.17	0.21	0.93
	Stylish	0.83	0.24	0.15	0.24	
	Goofy (R)	0.69	0.19	0.44	0.11	
	Fashionable	0.79	0.26	0.12	0.24	
	Sleek	0.79	0.16	0.14	0.20	
Ergonomics	Comfortable	0.66	0.23	0.19	0.28	0.90
Self-identity	Communicated	0.31	0.60	0.14	0.40	
	Self-image	0.32	0.71	0.15	0.26	
	Wearer's image	0.32	0.65	0.08	0.42	
	Social group	0.10	0.78	-0.07	0.10	
Consequences	Aspiring	0.26	0.79	0.14	0.12	0.84
	Appealing	0.15	0.83	0.08	0.05	
	Annoying (R)	0.17	0.11	0.80	0.17	
	Embarrassment (R)	0.18	-0.03	0.73	0.26	
	Threatening (R)	0.10	-0.11	0.76	0.17	
Judgement	Creepy (R)	0.24	0.23	0.71	0.25	0.88
	Technology (R)	0.19	0.45	0.63	0.06	
Reactions	Acceptable	0.29	0.24	0.31	0.70	0.88
	Positive	0.32	0.31	0.20	0.72	
Thoughts	Public	0.24	0.08	0.29	0.78	0.88
	Peer	0.35	0.27	0.36	0.60	

R, reverse coding

issues (e.g., no accuracy or data errors; 20%), lack of interest or consideration (e.g., unnecessary; 16%), and lack of information about the products (4%). Overall, 96% of the participants did not own smart clothing or footwear, because of a lack of information about the smart apparel including clothing and footwear (62%), high price (23%), or no interest in the specified items (10%). Forty-nine percent of the participants were willing to pay an average of 26% more for smart products than normal clothing and footwear costs, while others did not want to pay more for the products, due to their limited budgets (e.g., low income or no extra money).

Exploratory factor analysis results

Prior to conducting EFA, assumptions of multivariate normality were examined in order to avoid multicollinearity problems (e.g., variance inflation factor and tolerance). Variance inflation factor (VIF) of the overall data was less than 6, which was within the acceptable range of VIF (< 10), according to the predetermined criteria (Hair et al. 1995). A total of 11 dimensions, including the 57 items with Cronbach's α of 0.96 for the extended WEAR Scale, were initially structured and evaluated by the following three criteria: scree plot, eigenvalue, and factor loading. The model with 11 factors was supported by the scree plot test. Among the 57 items, EFA resulted in eliminating 36 items with a factor loading lower than 0.60, which yielded a four-factor, 21-item WEAR Scale. Therefore, as shown in Table 3, a four-factor component with each Cronbach's α consisted of 21 items: (a) five items in aesthetics and one item in ergonomics (0.93), (b) six

Table 4 χ^2 (*df*) and model fit indices for various model testing

Model test of WEAR scale	χ^2	<i>df</i>	GFI	IFI	TLI	CFI	RMSEA	SRMR
Kelly's model ^a ($N_k = 306$)	798.49	76	0.81	0.71	0.65	0.71	0.12	0.10
Initial model ($N = 663$)	989.33	183	0.86	0.91	0.90	0.91	0.08	0.07
Modified model ($N = 663$)	253.70	84	0.95	0.97	0.97	0.97	0.06	0.04
Model on smart clothing ($N_c = 332$)	219.46	84	0.92	0.95	0.94	0.95	0.07	0.05
Model on smart footwear ($N_f = 331$)	188.64	84	0.93	0.97	0.96	0.97	0.06	0.05
Hu and Bentler' criteria			> 0.90	> 0.90	> 0.90	> 0.90	< 0.08	< 0.08

N, total sample size; N_c , sample size of smart clothing; N_f , sample size of smart footwear; χ^2 , Chi square; *df*, degree of freedom; GFI, goodness fit index; IFI, incremental fit index; TLI, Tucker–Lewis index; CFI, comparative fit index; RMSEA, root mean error of approximation; SRMR, standardized root mean square residual

^a Result of the model fit for Kelly's (2016) 14-item WEAR Scale

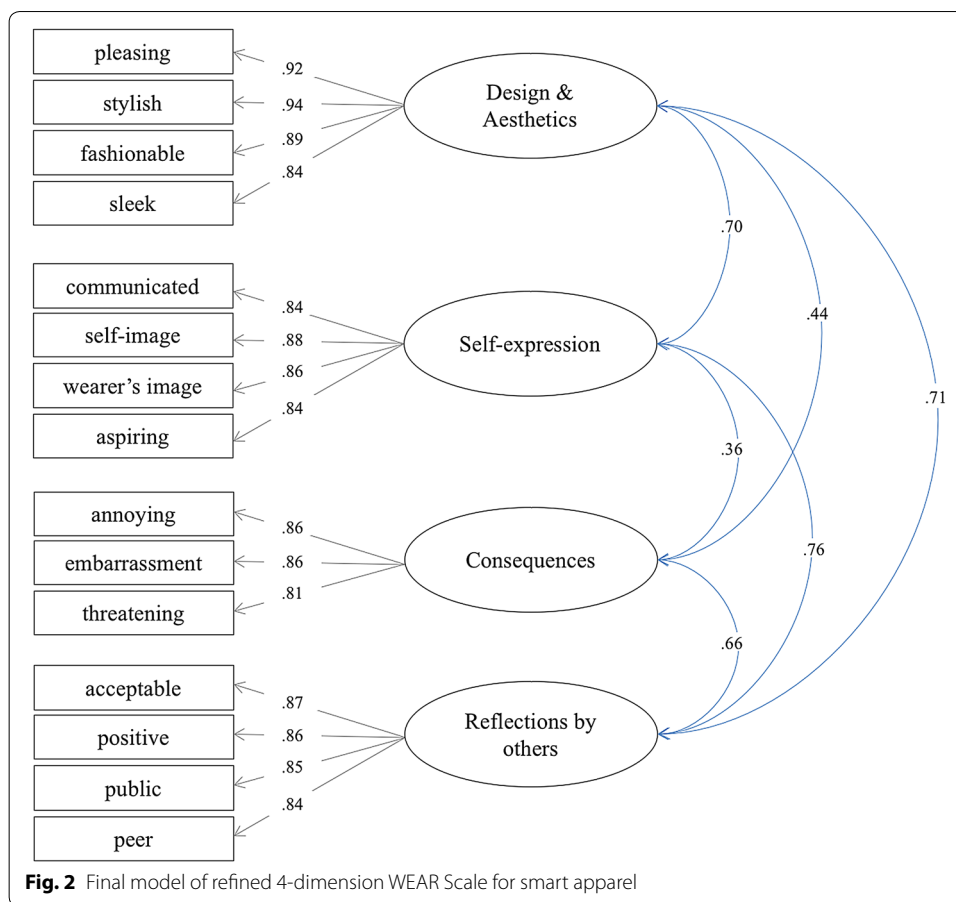
items in self-identity/expression (0.90), (c) three items in consequences and two items in judgements (0.84), and (d) two items in reactions and two items in thoughts (0.88).

Confirmatory factor analysis results

CFA was conducted to evaluate whether the proposed model of four factors with 21 items adequately measured the social acceptability of smart apparel. Based on the result of the CFA, however, the proposed measurement model through EFA did not adequately fit the data. Although CFA with a four-factor, 21-item extended WEAR Scale resulted in a partially acceptable model fit with Chi square of 989.33 (*df*=183), CFI (0.92), IFI (0.91), and TLI (0.90). However, SRMR (0.07), GFI (0.86), and RMSEA (0.08) were an unacceptance range of model fit value (Hu and Bentler 1999). Consequently, the initial model, the four-factor, 21-item extended WEAR Scale, was unacceptable (see Table 4).

Based on this evidence, factor loadings, model modification indices, and theoretical considerations (i.e., excessively high correlation between two items and low factor loadings), the completion of three rounds of CFA resulted in additional six items removed. Six removed items relate to (a) ‘goofy’ and ‘comfortable’ under the design/aesthetic dimension, (b) ‘social group’ and ‘appealing’ under the self-identify dimension, and (c) ‘creepy’ and ‘technology’ under the judgement dimension. Finally, the four-factor, 15-item revised WEAR Scale was derived to achieve a good model fit with Chi square of 253.70 (*df*=84, $p < 0.001$), GFI (0.95), IFI (0.97), TLI (0.97), CFI (0.97), RMSEA (0.05), and SRMR (0.03) (see the modified model in Table 4). The revised WEAR Scale dimensions are smart apparel in relation to: (a) design/aesthetics (four items); (b) self-identity/expression (four items); (c) consequences (three items); and (d) reactions by others (four items; combined dimensions of other’s reactions and thoughts) (see Fig. 2 and Table 5).

As shown in Fig. 2, the factor loadings among 15 items were all ranged from 0.81 to 0.94 and correlations among four dimensions were all ranged from 0.36 to 0.76, which tell that each construct is valid. The discriminant reliability of a four-factor, 15-item WEAR Scale was measured. As shown in Table 5, The Cronbach’s α value for the factors ranged from 0.80 to 0.92. The convergent validity of the measurement model was evaluated by average variance explained ($AVE > 0.5$) and composite reliability ($CR > 0.7$), according to the criterion of Fornell and Larcker (1981). The AVE and CR values for each variable were in the acceptable range: design/aesthetics ($AVE = 0.75$;



CR = 0.99), self-expression (AVE = 0.56; CR = 0.96), consequences (AVE = 0.64; CR = 0.98), and reflections by others (AVE = 0.64; CR = 0.99). Inter-item correlation matrix of 15 items is also presented in Table 6, including the values of mean, SD, as well as skewness and kurtosis, which are within the recommended range from -3 to +3 (Kline 2011). Therefore, findings from this study show the acceptable range (from -1.04 to 0.18) of skewness and kurtosis for normal distribution.

Further analyses were performed with two separate groups (smart clothing and smart footwear) to examine the overall model's fit for each product, smart clothing ($N_C = 332$) and smart footwear ($N_F = 331$) from the whole dataset ($N = 663$), which resulted to a good model fit to the overall proposed model (see Table 4). Kelly's (2016) two-factor, 14-item WEAR Scale was run to the proposed model; however, the results from the model fit of the 14-item WEAR Scale with Chi square of 798.49 ($df = 76$), GFI (0.81), IFI (0.71), TLI (0.65), CFI (0.71), RMSEA (0.12), and SRMR (0.10) was unacceptable.

Compared to this study, Kelly's study was conducted using the limited study sample of college students, ages ranged from 18 to 30 years old within one specific U.S. region, different analysis methods (Monte Carlo PAC for parallel analysis), and different wearable product categories (i.e., Apple watch, Bluetooth headsets, and Google glasses). These might be factored into the different model fit results between Kelly's original WEAR

Table 5 Factor reliabilities for smart clothing and footwear with 15 items

	λ (R^2)	Factor loading	SE	α	CR	AVE
Design and Aesthetics (4 items)				0.92	0.99	0.75
1. This wearable product is aesthetically pleasing.	0.90 (0.8)	0.92	0.02			
2. This wearable product is stylish.	0.94 (0.9)	0.94	0.02			
3. This wearable product is fashionable.	0.85 (0.7)	0.89	0.03			
4. This wearable product is sleek, not clunky.	0.76 (0.6)	0.84	0.04			
Self-expression (4 items)				0.84	0.96	0.56
1. I like what this wearable product communicates about its wearer.	0.79 (0.6)	0.84	0.03			
2. This wearable product is consistent with my self-image.	0.79 (0.7)	0.88	0.03			
3. This wearable product would enhance the wearer's image.	0.67 (0.7)	0.86	0.03			
4. I could imagine aspiring to be like the wearer of such wearable product.	0.79 (0.6)	0.84	0.04			
Consequence (3 items)				0.80	0.98	0.64
1. This wearable product seems like it would be annoying or add confusion to the typical interactions of people (R)	0.83 (0.6)	0.86	0.05			
2. This wearable product's placement on the body could cause awkwardness or embarrassment (R)	0.82 (0.6)	0.86	0.04			
3. Use of this wearable product would be more threatening than exciting (R)	0.75 (0.5)	0.81	0.04			
Reflection by others (4 items)				0.88	0.99	0.64
1. This wearable product would be generally accepted by the vast majority of people.	0.82 (0.7)	0.87	0.03			
2. The wearer of this wearable product would get a positive reaction from others.	0.81 (0.7)	0.86	0.02			
3. The majority of people probably think this wearable product is ok to wear in public.	0.76 (0.6)	0.85	0.02			
4. I think my peers would find this wearable product acceptable to wear.	0.81 (0.7)	0.84	0.03			

λ , standard regression weights; R^2 , squared multiple correlation coefficient; SE, standard error; α , Cronbach's alpha; CR, composite reliability; AVE, average variance extracted; R, reversed coding

Scale for wearable devices (two-factor with 14 items) and our refined WEAR Scale for smart apparel (four-factor with 15 items). Thus, the results of this study presented that our proposed model provides a better model fit for smart apparel than the model that Kelly (2016) proposed for wearable devices. In the future, findings from this study can prompt an examination of the proposed theoretical model, emphasizing the relationship between four dimensions of the WEAR Scale and other key drivers (e.g., satisfaction, attitudes, and purchasing intention).

Conclusion

The purpose of this study was to introduce an extended WEAR Scale to the apparel field by refining the measurement items of the WEAR Scale and validating it for use with smart apparel. Kelly's (2016) WEAR Scale with a two-factor and 14 items was not confirmed with the use of smart apparel. The findings showed that consumers consider more diverse attributes in the social acceptance of smart apparel than that of wearable devices. In this study, therefore, completion of three rounds of the CFA

Table 6 Inter-item correlation matrix

Factor	D1	D2	D3	D4	S1	S2	S3	S4	C1	C2	C3	R1	R2	R3	R4
D1	1.00														
D2	0.85	1.00													
D3	0.75	0.80	1.00												
D4	0.70	0.70	0.64	1.00											
S1	0.50	0.53	0.50	0.43	1.00										
S2	0.50	0.51	0.50	0.43	0.64	1.00									
S3	0.52	0.55	0.53	0.44	0.66	0.65	1.00								
S4	0.44	0.47	0.44	0.40	0.56	0.70	0.60	1.00							
C1	0.35	0.34	0.32	0.31	0.31	0.30	0.27	0.26	1.00						
C2	0.32	0.33	0.30	0.28	0.22	0.23	0.24	0.18	0.62	1.00					
C3	0.23	0.23	0.18	0.23	0.17	0.10	0.10	0.08	0.53	0.53	1.00				
R1	0.51	0.50	0.50	0.47	0.50	0.47	0.52	0.41	0.47	0.43	0.35	1.00			
R2	0.50	0.55	0.54	0.46	0.57	0.53	0.60	0.44	0.38	0.38	0.26	0.67	1.00		
R3	0.45	0.48	0.44	0.42	0.44	0.36	0.45	0.30	0.41	0.44	0.37	0.66	0.64	1.00	
R4	0.54	0.56	0.53	0.49	0.54	0.54	0.54	0.44	0.46	0.45	0.37	0.65	0.64	0.61	1.00
Mean	3.32	3.33	3.09	3.40	3.12	2.58	2.94	2.57	3.38	3.62	3.88	3.43	3.41	3.70	3.51
SD	1.23	1.24	3.40	1.27	1.09	1.20	1.09	1.21	1.21	1.15	1.05	1.04	0.95	0.95	1.11
Skewness	-0.49	-0.45	-0.27	-0.56	-0.23	0.18	-0.03	0.20	-0.30	-0.51	-0.83	-0.49	-0.31	-0.68	-0.64
Kurtosis	-0.89	-0.89	-0.95	-0.80	-0.48	-1.02	-0.58	-1.04	-0.93	-0.68	0.08	-0.35	-0.22	0.12	-0.27

Cronbach's alpha (α), 0.93. As evidenced by this Table; the values of univariate skewness and kurtosis are within the recommended limit of -3 to +3 (Kline 2011)

D, design/aesthetics; S, self-expression; C, consequences; R, reflections; SD, standard deviation

resulted in creation of a four-factor, 15-item revised WEAR Scale for smart apparel: (a) design/aesthetics (four items); (b) self-expression (four items); (c) consequences (three items); and (d) reflections by others (four items).

The refined, four-factor, 15-item WEAR Scale is a useful tool to evaluate the social acceptability of smart apparel. This scale is useful for practical application in the fashion industry and its related fields by providing a better understanding of various dimensions (i.e., design/aesthetics, self-expression, consequences, reflections) that smart apparel should consider during the product design and development stage. Apparel is a pervasive resource in everyday life for people and smart apparel helps to promote individuals' healthy living. Considering that wearable technology embedded products have increased in popularity over time, we believe that this revised WEAR Scale can be used as one measurement tool for research and design applied to smart apparel. The findings of this study show the importance of the following four dimensions (design/aesthetics, self-expression, consequences, and reflections) when evaluating the social acceptance of smart apparel.

In this study, we refined the existing WEAR Scale for smart apparel including smart clothing and footwear, which consists of four-factor with 15 items. This is a unique evaluation tool that has not existed in the fashion discipline. This refined WEAR Scale can be used as design criteria for researchers and designers when developing new smart apparel or evaluating existing smart apparel for the further improvement, which eventually leads to provide a better understanding of and capability for the social acceptance of smart apparel in the market. For example, the fashion industry professionals may be much successful in the competitive wearable market if they fully consider each item under these four dimensions—design and aesthetics, self-expression, consequence, and reflection by others—within the product design, development, production, and marketing and promotion stage. Ultimately, this refined four-factor, 15-item WEAR Scale would help increase the integrity and efficiency of smart apparel in the wearable technology industry.

Although the four-factor, 15-item WEAR Scale for smart apparel resulted from evaluating two different wearable products (smart clothing and smart footwear), another independent test of the scale is suggested on a different smart apparel category (e.g., smart gloves, socks, and underwear) with another demographic group in diverse countries.

The majority of our study participants were female Caucasian/European American with an age of 30 s who had education higher than some college degree, which could impact the results of this study. Future studies should consider balanced samples in terms of demographic characteristics (e.g., gender, age, ethnicity, education). Majority of the participants in this study did not have any experience of wearing smart apparel, although 60% indicated their possession of other wearable technology embedded products (e.g., Fitbit, Apple Watch). This might also influence the results of this study. Thus, it is suggested to revalidate this study with the current user of smart apparel.

The sampling pool we used in this study was limited to the individuals who live in U.S. geographical locations and have access to MTurk. Several researchers (e.g., Paolacci and Chandler 2014; Stritch et al. 2017) addressed potential issues such as sample representativeness and data quality when using MTurk data. Thus, it is urged to use more reliable dataset to revalidate our study findings. The selection of two

smart apparel as the stimuli in this study might also cause bias of the participants and impact of their perception, thoughts, and opinions. Thus, it is recommended to test this scale with another smart apparel category.

If this proposed scale is confirmed again, then the 15-item WEAR Scale can be used with considerable confidence in terms of certainty about its validity and reliability. The scale also can be integrated with other consumer behavioral concepts to develop an emerging theoretical framework for the use of smart apparel. Further study is suggested examining the proposed theoretical model, emphasizing the relationships among the four dimensions of the revised WEAR Scale and other key drivers (e.g., satisfaction, motivation, and purchasing intention) for smart apparel.

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Authors' contributions

YL conceptualized and design the study. Both CN and YL involved in the data collection, analysis, and interpretation. CN drafted the first manuscript and both authors contributed in the manuscript writing. Both authors read and approved the final manuscript.

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