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Boxers' Intention to Use Smart Boxing Gloves in Training Using Industry 4.0 Sports Technology

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Abstract:- The purpose of this study is to compile the correlation variables of the characteristics of boxers' use of smart boxing gloves. This study combined their behavioral characteristics, the unified theory of acceptance, and the use of technology (UTAUT) model to empirically analyze the important factors influencing the boxers' intention to use smart boxing gloves. This study used the questionnaire survey method to collect data, and intentional sampling was applied to sample the selected 250 college students. A total of 230 questionnaires were returned, for a return rate of 92%. The number of valid questionnaires was 206, for a valid questionnaire rate of 89%. The collected data were analyzed according to the measurement and structural model of structural equation modeling. The results of this study show that the performance expectancy of using smart boxing gloves had a positive and significant effect on behavioral intention. The effort expectancy (perceived ease of use) of using smart boxing gloves had a positive and significant effect on behavioral intention. The social influence of using smart boxing gloves did not have a positive and significant effect on behavioral intention; the facilitating conditions (helping conditions) of using smart boxing gloves had a positive and significant effect on behavioral intention. The degree of involvement of using smart boxing gloves had a positive and significant effect on behavioral intention. The degree of involvement in using smart boxing gloves had a moderating effect on the relationship between performance expectancy and behavioral intention, and the degree of involvement in using smart boxing gloves had a moderating effect on the relationship between effort expectancy (perceived ease of use) and behavioral intention. The degree of involvement of using smart boxing gloves had no moderating effect on the relationship between social influence and behavioral intention. The voluntary use of smart boxing gloves had a moderating effect on the relationship between social influence and behavioral intention.

Keywords:- *Boxing Training; Boxers; Smart Boxing Gloves; Industry 4.0; Sports Technology.*

I. INTRODUCTION

As the competition among companies is moving towards the trend of smart manufacturing, industrial re-scaling has become an important issue for many countries. In other words, the world is witnessing the fourth industrial revolution and the transformation of the business world towards digitalization, which is known as Industry 4.0. According to Javaid, Haleem, Vaishya, Bahl, Suman, and Vaish (2020), Industry 4.0, also known as the fourth industrial revolution, consists of advanced manufacturing and information technologies that meet people's customized needs in different areas in a shorter period. These technologies provide wireless connectivity in manufacturing and service sectors to enhance automation. By comparing the above definition of Industry 4.0 with today's industrial development trends, technologies, such as the Internet of Things, big data, cloud computing, smart machine development, and augmented reality, are gradually being introduced into service, manufacturing, and industrial/commercial sectors to enhance added value and create greater benefits. Obermayer, Csizmadia, and Hargitai (2022) shared a similar view by arguing that Industry 4.0 is considered a new industrial phase that can help companies achieve higher performance through vertical and horizontal manufacturing process integration and product connectivity.

Contemporary sports technology is also riding the wave of Industry 4.0, enabling sports participants to create unprecedented experiences through wearable devices, augmented reality (AR), virtual reality (VR), and video sensing. With the application of Industry 4.0 sports technology, athletes can further transform their training processes towards digitalization by making their training methods scientific and precise. In addition, the application of body sensing technology allows athletes to achieve better results through sports training applications.

Although boxing in Taiwan has achieved good results in international events in recent years, such as the Summer Olympics 2020 and the Asian Championship 2022, there is still room for improvement in our training methods. With the popularity of wearable sports equipment, the integration of smart boxing gloves into player-related training can be a way to diversify training. Cory and Christopher (2014) argued that wearable technology products can be used in the sports and health fields to record information about users' bodies, as such products make it easy for users to access and control their information. Currently, most products related to smart boxing gloves are equipped with sensors that track every movement of the trainer and evaluate the trainer's training in a scientific manner to avoid injuries and further improve efficiency, speed, and strength. Boxers currently train physically with a team and under the guidance of a coach, and because most research is on wearable devices of other sports, there is a lack of research on smart boxing gloves (Kim & Shin, 2015; Moon, Baker, & Goughnour, 2019; Mencarini, Leonardi, Cappelletti,

Giovanelli, Angeli, & Zancanaro, 2019; Roslan & Ahmad, 2020). Therefore, it is worthwhile to further investigate the extent to which smart boxing gloves are accepted by boxers and whether they are willing to use them. Regarding the application of Industry 4.0 in sports, Leszczyński, Metelski, and Rabczun (2022) explored how consumers representing different generations in the Polish market consume sports products through digital channels. Scarlett (2022) focused on how to combine smart technologies with sports culture communication through Industry 4.0, and how to implement spatiotemporal modeling and analysis of human behavior and behavioral traits. Duarte, Sanches, Lima, and Queiróz (2020) presented the technological evolution of sportswear production in the context of Industry 4.0 by comparing traditional and new production systems. The lack of empirical studies on sports wearable devices in the context of Industry 4.0 is clearly demonstrated by the above-mentioned literature. As more and more industries use wearable technologies to convert statistical data into intelligent management models, sports have more opportunities to enter the daily life of the public. In other words, it is an international trend to combine wearable technologies with sports through Industry 4.0. Therefore, this study compiled the correlated variables of boxers' traits when using smart boxing gloves, and empirically analyzed the important factors influencing the intention of continued use of boxing gloves according to their behavioral traits, in combination with the unified theory of acceptance and use of technology (UTAUT) model.

II. LITERATURE REVIEW

With technology advancements, various information technologies and integrated systems are constantly being developed, and these new technology products are readily available on the market. However, whether a new technology or technique will be widely accepted by public users is often the focus of the industry, Therefore, how to effectively measure the degree of acceptance of a new technology product or service, and assess whether it meets the needs of users, are often important references for relevant industries when making operational decisions. Abbas, Hassan, Asif, Ahmed, Hassan, and Haider (2018) suggested that a unified theory of acceptance and use of technology (UTAUT) model can be used for new technology acceptance to explore behavioral intentions and subsequent usage behaviors. The unified theory of acceptance and use of technology (UTAUT) model was proposed by Venkatesh, Morris, Davis, and Davis (2003), which integrates eight theories: the theory of reasoned action, technology acceptance model, motivational model, theory of planned behavior, a model combining the technology acceptance model and the theory of planned behavior, the PC utilization model, the innovation diffusion theory, and the social cognitive theory. Performance expectancy is defined as the degree of an individual's confidence that a system will improve job performance, which in this case refers to the degree of improvement in the training and performance of boxers after using smart boxing gloves. Effort expectancy is defined as the degree of ease of use of the system perceived by an individual, which in this study refers to the boxers' perceived degree of ease of use of smart boxing gloves. Social influence is defined as the degree to which an individual perceives that significant others believe that they should use the new system, which in this case refers to the degree of support from coaches and peers regarding the use of smart boxing gloves, as perceived by the boxers. Facilitating conditions are defined as the level of trust in the support of the existing organizational and technical structure regarding the use of the system, as perceived by an individual. In this case facilitating conditions refer to the trust of the boxing team's coaches and team members in the use of the smart boxing gloves in the training and performance of the boxers. Gender, age, experience, and voluntary use are all set as interfering variables in the UTAUT theory. In order to further understand the correlations between the abovementioned eight theories and their sub-dimensions, Venkatesh, Morris, Davis, and Davis (2003) further suggested that performance expectancy includes the five sub-dimensions of Perceived Usefulness (TAM/TAM2C-TAM-TPB), Extrinsic Motivation, Job-Fit (MPCU), Relative Advantage (IDT), and Outcome Expectancy (SCT). Effort expectancy includes the three sub-dimensions of Perceived Ease of Use (TAM/TAM2), Complexity (MPCU), and Ease of Use (IDT). Social influence includes the sub-dimensions of Subjective Norm (TRA/TAM2/TPB/DPTB/C-TAM-TPB), Social Factor (MPCU), and Image (IDT). Facilitating conditions include the three sub-dimensions of "Perceived Behavioral Control"(TPB/C-TAM-TPB), "Facilitating Conditions" (MPCU) and "Compatibility (IDT)". The above sub-dimensions show that the factors influencing usage behavior cannot be discussed in a single dimension, thus, the UTAUT model provides a more complete basis for discussion. Relevant research findings have confirmed that the application of the UTAUT model can address the issue of the public adoption of new technologies (Rahman, Lesch, Horrey, & Strawderman, 2017; Gupta, Dogra, & George, 2018). Moreover, this view shared by Venkatesh and Davis (2000), who suggested that the UTAUT model can account for more than 70% of the variance regarding the usage intentions of different technologies. The above findings indicate that the UTAUT model is an extensive and complete model that can provide management with an assessment tool to measure the acceptance of new technology introduction, as well as to predict and explain users' behavioral intentions and actual use of new technologies. However, this theoretical model also has its shortcomings. For example, many researchers added or filtered variables to fit their research purposes (Martin and Herrero, 2012), while Hsu, Hsu, and Wu (2009) pointed out that the UTAUT model ignores the influence of the contextual context, and when this influence is mentioned, it is answered from a single level of individuals. In other words, there is still some room for adjustment in the application of the UTAUT model.

The concept of involvement can refer to the mental state or behavioral representation. This concept is one of the focuses of psychological discussion, and the degree of involvement has different levels as each consumer has different characteristics. Zaichkowsky (1985) pointed out that involvement is a person's perceived relevance to the object, as based on inherent needs, values, and interests; in other words, the concept of involvement is related to self-relevance. Warrington and Anamaria (2000) held the same view and mentioned that the stronger the degree of correlation, the higher the degree of perceived self-relevance, and the greater the degree of

involvement. The discussion of the degree of involvement points out that the concept of the degree of involvement is often expressed through individual psychological cognition, that is, the degree of involvement is people's psychological state, and it will be affected by many factors, such as product or environment. For example, a person will determine the degree of attention to something according to the perceived effect of this external thing on him or her (Harrigan, Evers, Miles, & Daly, 2018; Jin, Xiang, Weber, & Liu, 2019). According to the above relevant literature, different degrees of involvement will affect consumers' intention to buy or use something, and the degree of involvement not only depends on the product itself but also on a variety of influencing factors. Compared with the purchase process of general items, people tend to consider more factors in the process of adopting new technology products, thus, the UTAUT model is a feasible method to further explore the factors affecting the degree of involvement. Regarding the measurement of involvement, the Personal Involvement Inventory (PII), as proposed by Zaichkowsky (1985), has been used in most studies. PII development is based on an individual's personal interests, needs, and values, and includes (1) personal: the intrinsic interest, value, or need that stimulates an individual's interest in something; (2) material: material characteristics that make a difference or increase interest; and (3) context: a temporary increase in the relevance of or interest in an object. McIntyre (1989) constructed the Enduring Involvement (EI) scale based on four measurement dimensions: (1) fun: the extent to which the participant finds the activity interesting; (2) importance: the extent to which the participant finds the activity important; (3) self-expression: the extent to which individuals express who they are through the activity; and (4) center of lifestyle: the extent to which the activity is central to the participant's daily life, and the events that occur around this activity. McIntyre and Pigram (1992) included attraction combined with self-expression and centrality as a dimension to measure involvement. According to the abovementioned literature, although different scholars have proposed different dimensions, self-relevance remains the focus of these measurement tools, which suggests that the measurement of involvement will help this study understand boxers' acceptance of smart boxing glove products, as well as the value and meaning, that smart boxing gloves place on the choice of gloves.

Regarding the relationship between variables, studies have confirmed the effect of the UTAUT model on behavioral intention. For example, Al-Saedi, Al-Emran, Ramayah, and Abusham (2020) conducted a survey on 436 M-payment users in Oman and found that the best predictor of M-payment users' intention to use the M-payment system was performance expectancy, followed by social influence and effort expectancy, respectively. Abbad (2021) used the UTAUT model to explore the behavioral intentions of college students towards online learning systems, and found that performance expectancy, effort expectancy, and facilitating conditions had a positive and significant effect on students' behavioral intentions to adopt online learning systems. The study of Baishya and Samalia (2020) on smartphones also showed that performance expectancy, effort expectancy, and social influence predicted behavioral intentions. In an empirical study on the correlation between the degree of involvement and behavioral intentions of the online group buying behaviors of 553 consumers, Sharma and Klein (2020) found that consumer involvement had a positive effect on the intention to participate in online group buying. McClure and Seock (2020) conducted an empirical analysis of brand social media pages on consumer purchase intention, and the results indicated that involvement with a brand's social media influenced future purchase intentions. Regarding the moderating effect of the degree of involvement, and taking the mobile pay App of PX Pay as an example, Yi-Jing Chen (2021) explored whether the degree of involvement had a moderating effect between PX Pay's performance expectancy and behavioral intention, PX Pay's perceived ease of use and behavioral intention, and PX Pay's social influence on behavioral intention, and the results showed that the degree of involvement had a moderating effect on the impact of social influence on the behavioral intention to use PX Pay. In addition, Venkatesh, Morris, Davis, and Davis (2003) pointed out that voluntary use had a moderating effect on the relationship between social influence and behavioral intention.

III. RESEARCH METHOD

A. Research Structure

This study adopted the UTAUT2 model to explore the training behavior of boxers using smart boxing gloves. The research structure was proposed based on the literature review, as shown in Figure 1.

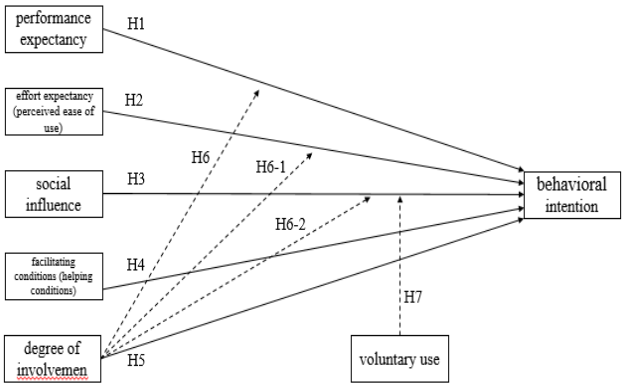

Fig 1 Research Structure

B. Research Hypotheses

This study adopted the UTAUT2 model to explore the use behavioral intention of boxers using smart boxing gloves in their training. The following research hypotheses were proposed based on the literature review and research structure: H1: The performance expectancy of using smart boxing gloves has a positive and significant effect on behavioral intention ; H2: The effort expectancy (perceived ease of use) of using smart boxing gloves has a positive and significant effect on behavioral intention ; H3: The social influence of using smart boxing gloves has a positive and significant effect on behavioral intention ; H4: The facilitating conditions (helping conditions) of using smart boxing gloves have a positive and significant effect on behavioral intention ; H5: The degree of involvement in using smart boxing gloves has a positive and significant effect on behavioral intention ; H6: The degree of involvement in using smart boxing gloves has a moderating

effect on the relationship between performance expectancy and behavioral intention ; H6-1: The degree of involvement in using smart boxing gloves has a moderating effect on the relationship between effort expectancy (perceived ease of use) and behavioral intention ; H6-2: The degree of involvement in using smart boxing gloves has a moderating effect on the relationship between social influence and behavioral intention ; H7: The voluntary use of smart boxing gloves has a moderating effect on the relationship between social influence and behavioral intention.

C. Research Subjects

This study adopted the UTAUT model and took boxers using smart boxing gloves as the research subjects. The subjects were selected by the convenience sampling method to complete the questionnaire. From October 1 to November 1, 2022, a Google form questionnaire website was distributed on social software for boxers to complete. A total of 250 questionnaires were distributed and 230 questionnaires were returned, for a questionnaire return rate of 92%. After invalid questionnaires were excluded, the total number of valid questionnaires was 206, for a valid rate of 89%.

D. Research Tools

This study developed the content of the questionnaire by making modifications in reference to the relevant literature and questionnaires by Chen (2021) and Peng (2021). The questionnaire was divided into eight sections with 44 items, including 8 items on basic personal information, 5 items on performance expectancy, 5 items on perceived ease of use, 8 items on social influence, 5 items on facilitating conditions, 3 items on voluntary use, 5 items on the degree of involvement, and 5 items on behavioral intention. A five-point Likert scale was used, with scores ranging from 1 to 5 for "strongly disagree" to "strongly agree", respectively.

E. Data Processing and Analysis

After the valid questionnaires were counted, the invalid questionnaires were deducted, and the data were created into files with the SPSS 22.0 statistical software, the correlations between the variables were analyzed with AMOS 22.0 statistical software.

IV. RESEARCH RESULTS

A. Sample Characteristics

There were 206 valid samples in this study. The Sample Characteristics are shown in Table 1.

Table 1 Sample Characteristics

Background variables	Classification criteria	Number of samples P	Percentage %	Cumulative percentage %
Gender	Male	147	71.4	71.4
	Female	59	28.6	100.0
Age	12-14 years old	67	32.5	32.5
	15-17years old	79	38.3	70.9
	18-20 years old	23	11.2	82.0
	21-23 years old	3	1.5	83.5
	24 years old and above	34	16.5	100.0
Educational level	Junior high school (and below)	80	38.8	38.8
	Senior high/vocational high school/	70	34.0	72.8
	College and university/junior college	47	22.8	95.6
	Graduate school (and above)	9	4.4	100.0
Occupation	Students	173	84.0	84.0
	Fitness Industry	4	1.9	85.9
	Service industry	5	2.4	88.3
	Manufacturing industry	11	5.3	93.7
	Military, public servants, and teachers	7	3.4	97.1
	Others	6	2.9	100.0
Number of years in boxing	Less than 1 year	52	25.2	25.2
	More than 1 year-less than 2 years	34	16.5	41.7
	More than 2 years-less than 3 years	39	18.9	60.7
	More than 3 years	81	39.3	100.0
Number of training hours per week	Less than 5 hours	45	21.8	21.8
	More than 5 hours-less than 10 hours	28	13.6	35.4
	More than 10 hours-less than 15 hours	51	24.8	60.2
	More than 15 hours	82	39.8	100.0
Performance in national secondary school boxing championship	Ranking the 1st-2nd place	70	34.0	34.0
	Ranking 3rd-4th place	28	13.6	47.6
	Ranking 5th-6th place	10	4.9	52.4
	Ranking 7th-8th place	7	3.4	55.8

	No ranking	22	10.7	66.5
	No participating	69	33.5	100.0

B. Measurement Model Analysis

Chen (2007): The questionnaire in this study was validated by Confirmatory Factor Analysis (CFA), the items were modified by referring to the Modification Indices (M.I.), and the following items were removed: Item 2 of Performance Expectancy; Item 2 and Item 4 of Perceived Ease of Use; Items 1, 2, 3, 4 and 8 of Social Influence 8; Item 1 of Facilitating Conditions; and Item 1 of Behavioral Intention.

➢ *Validation of Convergent Validity*

Bagozzi and Yi (1988): The convergent validity of this study was checked by the composite reliability (C.R.) and average variance extracted (AVE) measures. Fornell and Larcker (1981) suggested that the C.R. value should be greater than 0.6 and the AVE value should be greater than 0.5. This study examined the convergent validity of the dimensions of performance expectancy, perceived ease of use, social influence, facilitating conditions, degree of involvement, and behavioral intention. The factor loading values of all dimensions ranged from 0.80 to 0.95; the C.R. values ranged from 0.91 to 0.96; and the AVE values ranged from 0.74 to 0.87, which all met the suggested criteria for convergent validity (Hair, Anderson, Tatham, and Black, 1998; Bagozzi and Yi 1988; Fornell and Larcker 1981), indicating that this study had good convergent validity, as shown in Table 2 and Table 3.

Table 2 Consolidated Table of Confirmatory Factor Analysis – UTAUT2

The estimated value of model parameter							**Convergent validity**	
Potential variables	**Observation variables**	**Non-standardized factor loading**	**Standard deviation**	**C.R**	**Factor loading**	**SMC**	**Composite validity**	**Average variance extracted**
Performance expectancy	PE 1	1.00			0.86	0.75	0.94	0.81
	PE 3	1.07	0.06	18.50	0.90	0.82		
	PE 4	1.04	0.05	19.29	0.92	0.85		
	PE 5	1.01	0.05	19.69	0.93	0.87		
Perceived ease of use	PEU 1	1.00			0.82	0.68	0.91	0.78
	PEU 3	1.05	0.06	16.26	0.90	0.81		
	PEU 5	1.12	0.06	17.63	0.94	0.89		
Social influence	SI 5	1.00			0.92	0.84	0.94	0.85
	SI 6	1.06	0.05	22.81	0.93	0.87		
	SI 7	1.00	0.05	22.00	0.92	0.84		
Facilitating conditions	FC 2	1.00			0.86	0.74	0.93	0.77
	FC 3	0.94	0.06	16.08	0.86	0.73		
	FC 4	0.97	0.05	18.03	0.92	0.84		
	FC 5	0.98	0.06	16.75	0.88	0.77		
Behavioral intention	BI 2	1.00			0.93	0.87	0.96	0.87
	BI 3	0.98	0.04	26.71	0.94	0.89		
	BI 4	0.99	0.04	27.41	0.95	0.90		
	BI 5	0.98	0.04	24.19	0.92	0.84		

Source: Compiled by this study

Table 3 Consolidated Table of Confirmatory Factor Analysis – Degree of Involvement

The estimated value of model parameter					**Convergent validity**			
Potential variables	**Observation variables**	**Non-standardized factor loading**	**Standard deviation**	**C.R**	**Factor loading**	**SMC**	**Composite validity**	**Average variance extracted**
Degree of involvement	DI 1	1.00			0.80	0.64	0.93	0.74
	DI 2	1.21	0.09	13.07	0.80	0.64		
	DI 3	1.27	0.08	16.70	0.95	0.90		
	DI 4	1.25	0.08	15.17	0.89	0.79		
	DI 5	1.18	0.08	14.87	0.88	0.77		

Source: Compiled by this study

➢ *Discriminant Validity*

Torkzadeh, Koufteros, and Pflughoeft (2003): The Bootstrap sampling method was used to conduct discriminant validity analysis in this study, which calculated a 95% confidence interval for the correlation coefficient of the dimensions. The results show that the confidence interval between the dimensions was not greater than 1, which indicates good discriminant validity between the dimensions, as shown in Table 4.

Table 4 Bootstrap Correlation Coefficient 95% Confidence Interval – UATUT2

				Bias-corrected Percentile method		**Percentile method**	
			Estimate	**Lower limit**	**Upper limit**	**Lower limit**	**Upper limit**
Performance expectancy	<-->	Perceived ease of use	0.88	0.81	0.94	0.82	0.94
Performance expectancy	<-->	Social influence	0.75	0.63	0.84	0.64	0.85
Performance expectancy	<-->	Facilitating conditions	0.75	0.62	0.84	0.63	0.85
Performance expectancy	<-->	Behavioral intention	0.86	0.81	0.91	0.81	0.91
Perceived ease of use	<-->	Social influence	0.76	0.64	0.85	0.65	0.86
Perceived ease of use	<-->	Facilitating conditions	0.81	0.72	0.89	0.73	0.89
Perceived ease of use	<-->	Behavioral intention	0.86	0.80	0.92	0.80	0.92
Social influence	<-->	Facilitating conditions	0.79	0.68	0.88	0.69	0.88
Social influence	<-->	Behavioral intention	0.79	0.66	0.89	0.68	0.89
Facilitating conditions	<-->	Behavioral intention	0.84	0.68	0.94	0.70	0.95

Source: Compiled by this study

➢ *Moderating Effect*

In order to analyze the moderating effect of male and female boxers in this study model, the participation of genders was set as male (n=147) and female (n=59). The results of moderation analysis (Table 5) show that male and female boxers had a significant moderating effect on the causal relationship between performance expectancy and behavioral intention (z-score=-2.07*; p<0.05). In order to analyze the moderating effect of low-age and high-age boxers in this study model, the participation age was set as low age (n=146) and high age (n=60). The results of moderation analysis (Table 6) show that low and high ages had a significant moderating effect on the causal relationship between performance expectancy and behavioral intention (z-score=1.72*; p<0.05), as well as between perceived ease of use and behavioral intention (z-score=-3.07*; p<0.05). In order to analyze the moderating effect of low involvement and high involvement of boxers in this study model, the degree of involvement was set as low involvement (n=105) and high involvement (n=101). The results of moderation analysis (Table 7) show that low and high degrees of involvement had a significant moderating effect on the causal relationship between performance expectancy and behavioral intention (z-score=-2.75*; p<0.05), and between perceived ease of use and behavioral intention (z-score=2.10; p < 0.05). In order to analyze the moderating effect of low voluntary and high voluntary boxers in this study model, the participants' voluntary use was set as low voluntary use (n=63) and high voluntary use (n=143). The results of moderation analysis (Table 8) show that low voluntary use and high voluntary use had a significant moderating effect on the causal relationship between social influence and behavioral intention (z-score=2.58*; p<0.05).

Table 5 Moderating Effect Analysis – Gender

Moderating variable	**Causal relationship**	**Male (β value)**	**Female (β value)**	**z-score**
Male and female	Behavioral intention<-Performance expectancy	0.44	0.08	-2.07*
	Behavioral intention<-Perceived ease of use	0.18	0.09	-0.44
	Behavioral intention<-Social influence	0.17*	0.05	-1.00

*p<0.05

Table 6 Moderating Effect Analysis – Age

Moderating variable	**Causal relationship**	**Male (β value)**	**Female (β value)**	**z-score**
Low age and high age	Behavioral intention<-Performance expectancy	0.25*	0.57*	1.72*
	Behavioral intention<-Perceived ease of use	0.48*	-0.22	-3.07*
	Behavioral intention<-Social influence	0.02	0.07	0.38

*p<0.05

Table 7 Moderating Effect Analysis – Degree of Involvement

Moderating variable	**Causal relationship**	**Male (β value)**	**Female (β value)**	**z-score**
Low involvement and high involvement	Behavioral intention<-Performance expectancy	0.52*	-0.48	-2.75*
	Behavioral intention<-Perceived ease of use	0.06	0.95*	2.10*
	Behavioral intention<-Social influence	0.09	0.18	0.67

*p<0.05

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Table 8 Moderating Effect Analysis – Voluntary Use

Moderating variable	Causal relationship	Male (β value)	Female (β value)	z-score
Low voluntary use and high voluntary use	Behavioral intention<-Social influence	-0.03	0.25*	2.58*

*p<0.05

➢ *Structural Model Analysis*

The tests for this study were made with reference to the seven indices of Hair et al. (1998). The revised ratio of this study was 3.15, which meets the criterion that the smaller the ratio of χ^2 to its degree of freedom, the better (Bagozzi and Yi, 1988). The criterion is that the closer the values of GFI and AGFI are to 1, the better (Hair et al., 1998), and the revised values of GFI and AGFI for this study were 0.81 and 0.80, respectively. Browne and Cudeck (1993) indicated that the best RMSEA value is less than 0.08, and the revised RMSEA value in this study was 0.10; the CFI standard value should be better than 0.90, and the revised CFI value for this study was 0.92; the PCFI must be at least greater than 0.50, and the revised PCFI for this study was 0.80. These results show that the overall fit of this study was good and all seven indices were up to the standard, as shown in Table 9.

Table 9 Overall Model Fit Analysis

Fit indices	Allowable range	This study model	Model fit judgment
χ^2(Chi-square)	The smaller, the better	689.83	
Ratio of χ^2 to degree of freedom	<3	3.15	Conforming
GFI	>0.80	0.81	Conforming
AGFI	>0.80	0.80	Conforming
RMSEA	<0.08	0.10	Conforming
CFI	>0.90	0.92	Conforming
PCFI	>0.50	0.80	Conforming

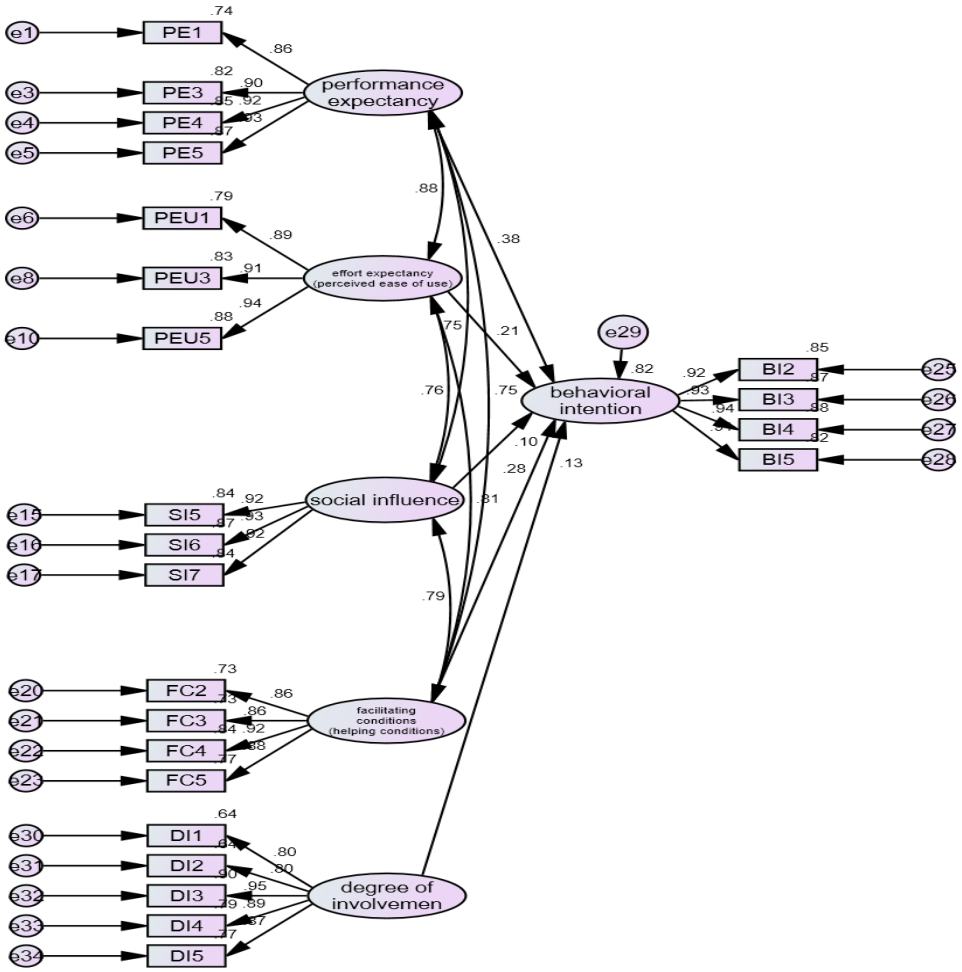

Fig 2 Model of Boxers' Behavioral Intention to Use Smart Boxing Gloves in Training

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Table 10 Empirical Results of Research Hypotheses

Hypotheses	Path relationship	Path value	Hypotheses supported or not
1	The performance expectancy of using smart boxing gloves has a positive and significant effect on behavioral intention.	0.38*	Supported
2	The effort expectancy (perceived ease of use) of using smart boxing gloves has a positive and significant effect on behavioral intention.	0.21*	Supported
3	The social influence of using smart boxing gloves has a positive and significant effect on behavioral intention.	0.10	Not supported
4	The facilitating conditions (helping conditions) of using smart boxing gloves have a positive and significant effect on behavioral intention.	0.28*	Supported
5	The degree of involvement in using smart boxing gloves has a positive and significant effect on behavioral intention.	0.13*	Supported
6	The degree of involvement in using smart boxing gloves has a moderating effect on the relationship between performance expectancy and behavioral intention.		Supported
6-1	The degree of involvement in using smart boxing gloves has a moderating effect on the relationship between effort expectancy (perceived ease of use) and behavioral intention.		Supported
6-2	The degree of involvement in using smart boxing gloves has a moderating effect on the relationship between social influence and behavioral intention.		Not supported
7	The voluntary use of smart boxing gloves has a moderating effect on the relationship between social influence and behavioral intention.		Supported

*p <.05

As learned from Figure 2 and Table 10, H1 was supported, that is, the performance expectancy of using smart boxing gloves had a positive and significant effect on behavioral intention. This finding is the same as that of Al-Saedi, Al-Emran, Ramayah, and Abusham (2020). The possible reason is that boxers think that by using smart boxing gloves, the captured motion trajectories can provide data that can be used to analyze motion mechanisms and evaluate sports performance, and thus, improve sports performance. H2 was supported, meaning the effort expectancy (perceived ease of use) of smart boxing gloves had a positive and significant effect on behavioral intention. This finding is the same as that of Baishya and Samalia (2020), and it is assumed that the possible reason is that, because they only have additional smart features for data collection, smart boxing gloves as wearable devices are not much different for boxers than normal boxing gloves. Thus, smart boxing gloves technology is easy for boxers to use and adapt to. H3 was not supported, i.e., the social impact of using smart boxing gloves did not have positive significant effect on behavioral intention, which is similar to the findings of Tsai and Lou (2019). The possible reason is that when boxers' coaches, teams, and peers generally believe that wearable devices can improve the effectiveness of self-training and effectively control training, the boxers are more willing to use smart boxing gloves. H4 was supported, that is, the facilitating conditions (helping conditions) of using smart boxing gloves had positive and significant effect on behavioral intention. This finding is similar to Chen and Fan (2020), which suggested that boxers' coaches and team members are more likely to be positive about the effects of smart boxing gloves on their training and performance. H5 was supported, meaning that the degree of involvement in using smart boxing gloves had positive and significant effect on behavioral intention, which is similar to the findings of McClure and Seock (2020). A possible cause is that when boxers use smart boxing gloves more frequently, the more they incorporate the gloves into their training, and the more likely they are to adopt smart boxing gloves. H6 and H6-1 were both supported, that is, the involvement of using smart boxing gloves had moderating effect on the relationship between performance expectancy and behavioral intention, and moderating effect on the relationship between effort expectancy (perceived ease of use) and behavioral intention. These research results are the same as those of Chen (2021). The possible reason is that in the era of Industrial 4.0, wearable sports devices combined with big data and the Internet made boxers and coaches have positive attitudes towards the benefits of using smart boxing gloves. Therefore, when boxers' perceptions of smart boxing gloves increased, the degree of involvement had a moderating effect on the impact of performance expectancy and effort expectancy on the behavioral intention toward using smart boxing gloves. H6-2 was not supported, i.e., the degree of involvement in using smart boxing gloves did not have moderating effect on the relationship between social influence and behavioral intention, which is different from Chen's (2021) findings. This is likely due to the incomplete knowledge of most of the boxers' significant others regarding smart boxing gloves, which makes it difficult for them to give substantial opinions to the boxers, thus, the degree of involvement failed to play a moderating role between social influence and behavioral intention to use smart boxing gloves. H7 was supported, i.e., the voluntary use of smart boxing gloves had moderating effect between social influence and behavioral intention, which is similar to the findings of Venkatesh, Morris, Davis, and Davis (2003). It is speculated that the possible reason is that when boxers recognize the benefits of smart boxing gloves in training, they will have a higher intention to integrate smart gloves into the training process, thus, the influence of social influence and behavior intention will be greater.

V. CONCLUSION AND SUGGESTIONS

A. Conclusion

Empirical analysis supports all hypotheses, except H3 and H6-2. In other words, the performance expectancy of using smart boxing gloves had a positive and significant effect on behavioral intention; the effort expectancy (perceived ease of use) of using smart boxing gloves had a positive and significant effect on behavioral intention; the facilitating conditions (helping conditions) of using smart boxing gloves had a positive and significant effect on behavioral intention; the degree of involvement of using smart boxing gloves had a positive and significant effect on behavioral intention; the degree of involvement of using smart boxing gloves had a moderating effect on the relationship between performance expectancy and behavioral intention; the degree of involvement of using smart boxing gloves had a moderating effect on the relationship between effort expectancy (perceived ease of use) and behavioral intention; and the voluntary use of smart boxing gloves had a moderating effect on the relationship between social influence and behavioral intention.

B. Research Suggestions

- *For Industries Related to Wearable Devices*

According to the results, the top two path values were H1 (The performance expectancy of using smart boxing gloves has a positive and significant effect on behavioral intention) and H4 (The facilitating conditions (helping conditions) of using smart boxing gloves has a positive and significant effect on behavioral intention). Therefore, it is suggested that the industries related to wearable devices should use advanced sensor and inter-sensor fusion technology based on Industry 4.0, and move towards larger memory capacity, longer battery life, and an integrated sensor processing center to obtain and process data from different sources under low power conditions, in order to provide users with more required information and better user experience. In the case of boxers, they are interested in the immediate results and the real help brought by training with smart boxing gloves. Therefore, in addition to the sensors that track movements and provide information, such as strength, speed, and calories, it is suggested that physiological monitors be integrated into smart boxing gloves to provide the physiological data (e.g., heart rate, blood pressure, and blood oxygen) of boxers. For example, in recent years, biochemical sensors have been developed to measure the biochemical metabolic status of athletes, and the collection of such information is essential for optimizing athletic performance and preventing injuries caused by overtraining. Therefore, industries related to wearable devices should keep up with technological advances that design better sports wearable devices, provide more complete information to athletes and generate revenue at the same time. In other words, mastering the characteristics of big data and AI analysis under Industry 4.0 will help the development of industries related to wearable devices, because the higher the benefits of the wearable device to the user, the more valuable the data it generates. By analyzing these data, the value of the data can be exploited and the intention of users to adopt the wearable device will increase.

- *For Boxers*

According to the research results, the effort expectancy of using smart boxing gloves had a positive significant impact on behavioral intention. Therefore, it is recommended that boxers work with their coaching team to develop a training menu that incorporates smart boxing gloves for their weekly training sessions and tournament participation, as well as to gain an in-depth understanding of the operation and functions of smart boxing gloves. In an Industry 4.0 environment, the data that was previously measured by expensive scientific instruments in the laboratory can be obtained through smart boxing gloves, meaning that sports science can be implemented in various sports by integrating big data. Moreover, it is recommended that both players and coaches should actively grasp the development of wearable device technologies under Industry 4.0. For example, with the rapid development of artificial intelligence, sports wearable devices can identify key characteristics from a large amount of data to obtain important physiological, biochemical, and exercise patterns. If boxing coaches and players want to improve their effort expectancy, they should be able to interpret and analyze the data measured by sports sensors, such as the level of water and energy consumption, the balance of electrolytes, and the level of muscle activation in each body part, in order to adjust the training content and intensity to improve the efficiency of training.

In addition, this study showed that the degree of involvement in using smart boxing gloves had positive and significant impact on behavioral intention. With the increased connection and use of big data in Industry 4.0, it is suggested that smart boxing glove users raise their awareness of cyber security to protect their personal information and training patterns. Specifically, since boxers continuously train for better performance, the data generated through their wearable devices are important and worthy parameters for research and development. Moreover, because digital supply networks create many potential vulnerabilities that can span a wide geographic area and be easily exploited by individuals, systems, or devices, it is recommended that boxers manage their personal information and login processes properly, and such protective measures will increase boxers' involvement with smart boxing glove products.

- *Suggestions for Future Research*

The results of this study indicate the moderating effect of the degree of involvement in using smart boxing gloves, thus, it is suggested that future research should collect data from boxers using the same type of smart boxing gloves. As different brands of smart boxing gloves facilitate different levels of information collection, different information processing methods, and different purchase decision-making methods, the degree of involvement of boxers in smart boxing gloves varies greatly. Nowadays, as the brands and products of smart boxing gloves are gradually diversifying, this trend can be further explored in future studies.

On the other hand, since the degree of involvement played a moderating role in this study, future research could address the boxers' perceived value of smart boxing gloves. For example, from the perspective of customer value, future

research can help to understand the customer value sought by boxers with different degrees of involvement. In other words, the moderating effect of the degree of involvement can be investigated more comprehensively according to different consumption patterns due to different functional, personal, popular, and emotional values.

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